Determinants of housing prices in Papua New Guinea—an ARDL approach

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Determinants of housing prices in Papua New Guinea—an ARDL approach

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Contents

Abstract

This paper investigates the determinants of housing prices in Papua New Guinea using the quarterly data from 2000 to 2018. The study employs the Autoregressive Distributive Lag Model (ARDL) bounds testing approach and finds that in the long-run, monetary policy rate and nominal money supply have a negative effect on housing prices while real GDP and housing loan affect housing price positively. In the short-run, lag housing prices and nominal money supply have a positive influence on the current period housing prices, while the current nominal money supply and real mortgage lending rate have a negative effect on current house prices. The Global Financial Crisis and the Papua New Guinea Liquefied Natural Gas project shocks had negative and positive effects, respectively, on housing prices in PNG.

Keywords: housing prices, Papua New Guinea, autoregressive distributed lag

1. Introduction

There has been a surge in literature in the recent period that aims to establish macroeconomic determinants of housing prices. This growing interest was sparked by the sub-prime mortgage crisis in the United States (US), which led to the Global Financial Crisis (GFC) of 2008–2009 that had devastating effects on the global financial system and the economies worldwide. The GFC, while unearthing the critical link between the housing market and the real economy, also generated interest in understanding the macroeconomic fundamentals that drive asset prices such as housing price. Mohanty (2019) pointed to an interplay between macroeconomic and microeconomic factors that were responsible for the crisis, which among others include excessive accommodative monetary policy pursued by major advanced economies, lack of recognition of asset prices for policy formulation, and acceleration in credit growth. This was supported by Taylor (2007) who blamed loose monetary policy in the US for being responsible for high housing credit growth that fuelled high housing prices, which spiralled into a price bubble and a subsequent crash.

Against this backdrop, policymakers and researchers have been focusing on establishing the relationship between macroeconomic factors and housing prices. Broadly, the outcome of these studies varied based on different study areas, sample periods, approaches employed, and selected measures of variable inputs into the analysis. For instance, Adams and Fuss (2010) studied the short and long-run relationship between housing prices and macroeconomic factors for 15 countries and found economic growth to be a critical determinant of housing prices. In other studies, Williams (2015) found monetary policy through the short-term interest rate to have a significant effect on real housing prices for a sample of 17 countries, while Goodhart and Hofmann (2008) provided evidence of multidirectional linkages between housing prices, broad money, private sector credit, and the macroeconomy for 17 industrialised countries.

Although literature is numerous for the developed countries and other emerging and developing countries and regions, similar studies related to the determinants of housing prices in the Pacific Island Countries (PICs) is scarce. This study is one of the first to use a longer time series data to study both the short and long-term macroeconomic factors that explain the variation in the housing prices in the PICs. This is crucial given the fact that housing is considered a key primary asset and is held as a financial security for most individuals in this region. Further, the housing sector has amassed a large portion of loanable funds and investments from banks, financial institutions, property developers, and institutional investors such as superannuation funds. Hence, an unanticipated adverse shock to the housing sector poses a significant threat to the stability of the banking and financial systems. To close the literature gap, this study aims to answer two critical research questions:

(1) What are the key macroeconomic factors that influence housing prices in PNG?
(2) Is there any relationship between monetary policy and housing prices?

We employ quarterly PNG data from 2000 to 2018 and the Autoregressive Distributed Lag Model (ARDL) to establish macroeconomic factors that influence housing prices in both the short and long-run in PNG. We find that in the long run, while monetary policy rate and the nominal money supply have a negative influence on housing prices, housing loan and real GDP affect housing prices positively. In the short-run, past housing prices and the lags of nominal money supply have a positive effect on housing prices, while real mortgage interest rate and current nominal money supply affect housing prices negatively. In addition, housing prices in PNG responded positively to PNG LNG project shock, while they displayed a negative response to the shock emanating from the GFC.

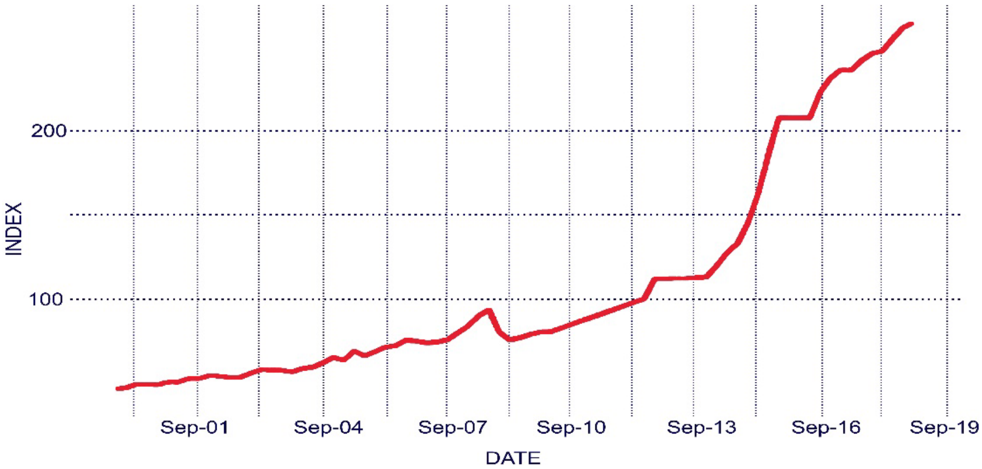
The findings have important policy implications for PNG with a need for stringent oversight and monitoring of housing prices during periods of high economic growth to ensure housing price stability and affordability for the general urban population. The Bank of PNG has limited influence on housing prices through the monetary policy interest rate channel, but by controlling money supply it could have some indirect influence. Close monitoring of housing prices is crucial, as a negative shock to the economy emanating from the housing price bubble and collapse may have severe implications on the financial sector and the broader economy. The findings could also assist housing market participants, state agencies, and regulators in their decision-making processes.

We structure the paper in the following manner: Section 2 presents the stylised facts of the housing market in PNG, Section 3 provides a theoretical and empirical literature review, Section 4 outlines the empirical approach and methodology, Section 5 presents the empirical results, Section 6 discusses the results with policy implication, and Section 7 concludes the paper.

2. Housing market in Papua New Guinea

The housing market in Papua New Guinea (PNG) has thrived in recent years, with notable developments evident in urban areas, particularly in the cities of Port Moresby and Lae. In these urban areas, housing demand has significantly increased, but the supply has not been able to accommodate the demand, resulting in excess demand that has induced exponential growth in housing prices over the past decade (Affordable Housing Institute and Athena Infonomics, 2018). Figure 1 depicts this increasing trend in housing prices from 2000 to 2018.

Figure 1: Housing price index (2012=100)

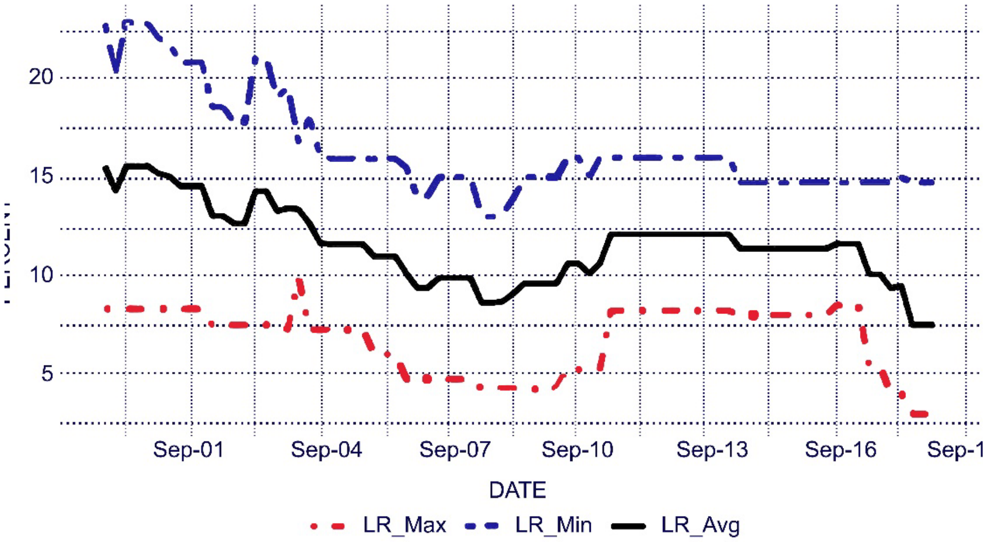


Source: Bank of PNG

The high demand for urban housing stems from various economic and demographic factors. Housing prices have risen in tandem with PNG's economic growth, evident in Figure 1, which depicts three distinct periods of price growth. From 2000 to 2007, steady economic expansion occurred, followed by a boost from 2007 to 2012 due to high commodity prices and exports. Since 2013, housing prices surged due to the PNG LNG project and government stimulus budgets. Ezebilo et al. (2016) attribute this surge to increased aggregate demand from the project. Moreover, PNG's real GDP per capita increased by about 27.0 percent over the decade leading up to 2018, reaching an average of K7142.4 (US$2,121.3), compared to K5618.2 (US$1,668.6) in 2007.

The increase in economic activity and income levels, particularly during the second and third episodes of economic growth, acted as significant pull factors inducing high rates of rural–urban migration. Many individuals migrated to urban centres, especially the cities, in search of improved welfare opportunities. This trend was further fuelled by the country's high population growth rate. According to the World Bank, PNG's population growth averaged about 2 percent per annum, while its urbanisation rate grew to about 13.3 percent in 2019. Consequently, the government faced immense pressure to provide essential services, including affordable housing, water, and electricity, to meet the needs of the growing urban population, particularly in Port Moresby and Lae.

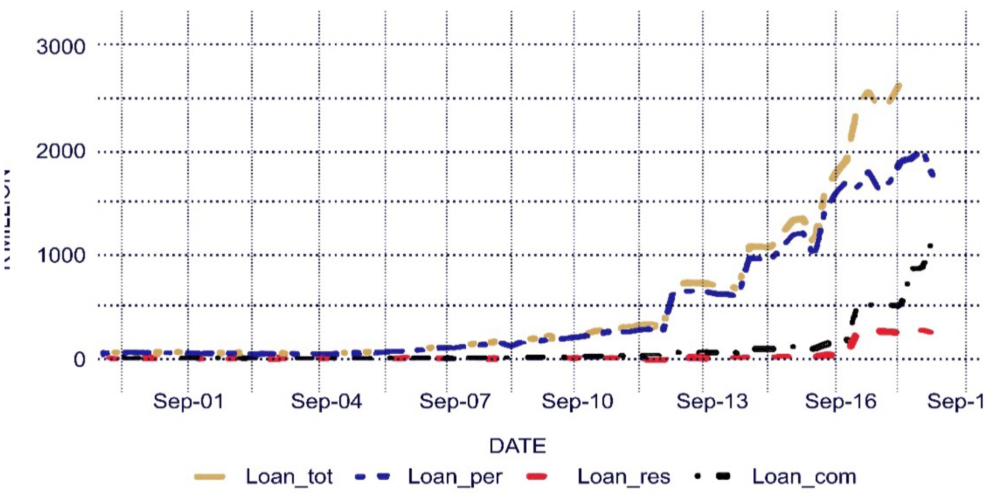
Figure 2: Mortgage lending rates (percent)



Source: Bank of PNG

Credit market also played a vital role in boosting housing demand in PNG. There was a notable increase in lending to the housing market and a decline in housing interest rates over the study period (Figure 2). Until 2011, lending to housing remained stable, but it surged from approximately K294.0 million in September 2012 to about K3,158.7 million by December 2018 (Figure 3). Housing mortgage loans as a percentage of total private sector loans also rose significantly from 4.1 percent to about 31.0 percent during this period. By the end of 2018, total mortgage loans (Loan_tot) were composed of 55.0 percent personal home loans (Loan_per), 8.0 percent residential property loans (Loan_res), and 37.0 percent commercial property loans (Loan_com). This growth in mortgage lending coincided with increased demand in the economy due mainly to the resource sector boom, which also stimulated real estate and housing activities. Average housing lending rates (LR_Avg) in PNG declined from around 14.0 percent in 2000 to about 7.0 percent by the end of 2018, potentially driving greater housing demand in urban areas.

Figure 3: Mortgage loans (K'millions)



Source: Bank of PNG

Moreover, the government implemented a housing subsidy program in 2013 aimed at providing affordable and accessible credit to first-time home buyers. This program, previously non-existent in the country, supported the surge in housing mortgage lending. The government introduced the First Home Ownership Scheme (FHOS), injecting about K200 million with the Bank of South Pacific (BSP), offering first-time home buyers the opportunity to fund their housing purchases at a reduced interest rate of 4 percent and a longer maturity term of up to 40 years.

Despite increased demand for housing, affordability remains a major issue in PNG, particularly in urban centres where high housing prices outstrip low-income levels. Yala (2010) discovered that most Port Moresby residents still struggle to afford housing, leading many middle and low-income earners to relocate to city outskirts where they can build or rent homes. Unfortunately, these areas often lack essential services like electricity, water, sewerage, and garbage collection. In Port Moresby, approximately 45.0 percent of residents live in such settlements, a figure expected to rise to 56.0 percent by 2030 (World Bank, 2015). Access to housing credit remains a challenge due to factors like inadequate collateral and the inability to make down payments, driven by widespread poverty, financial exclusion, and a larger portion of the population engaged in the rural and informal sectors of the economy (Affordable Housing Institute and Athena Infonomics, 2018). PNG has the lowest mortgage to GDP ratio in the Asia South Pacific region, a reflection of the recent uptick in housing loans following increased real estate and housing activity. Furthermore, the housing finance sector is underdeveloped, with commercial banks monopolising the market due to the oligopolistic nature of the banking sector, which limits competition for mortgage lending.

The supply side of the housing market has not been able to match the rise in housing demand in main urban centres, such as Port Moresby and Lae, resulting in an upward pressure on the housing prices and rental rates in the cities (Ezebilo and Thomas, 2019). Over the past years, the government has attempted to provide affordable housing mainly to urban residents. For example, through the National Housing Corporation (NHC), the government has historically provided housing for its public sector employees. More recently, the government departments and statutory organisations have been providing housing projects to their employees under their home ownership schemes to counter housing affordability issues faced by their employees. More so, the private sector—mainly the superannuation funds, in addition to various other national as well as foreign private developers—played a key role as suppliers of housing through undertaking large housing projects. Two successful privately sponsored housing projects include the Edai Town and Skyview Estates in Port Moresby. Nonetheless, these efforts to close the housing gap by both the private and public proponents has been inadequate.

Recent government, public, and private initiatives to provide large-scale urban housing have faced insurmountable challenges. These include limited state-owned land, land ownership disputes, high construction costs, credit limitations for property developers, and private investors' reluctance due to government's failure to provide necessary infrastructure and regulatory delays. For instance, the Duran Farm housing project, approved by the government in 2014 with a plan for 40,000 units, was revised to a more realistic 2,500 units. The National Housing Corporation (NHC) was supposed to offer subsidised land and infrastructure, but the project has made minimal progress due to infrastructure and land ownership issues. Similarly, programs aiming to unlock customary land for housing markets have often failed to take off. Private developers like those behind Skyview and Edai Town estates must absorb the high construction costs, leading to elevated home prices for buyers.

The State-titled land is becoming limited as accounted by Ezebilo and Thomas (2019). In addition, the banks only accept land with a state-ownership title as collateral since the customary land is perceived to be associated with higher risks, as it does not have clear demarcation of property rights and constitutes of higher transaction costs. This exerts enormous pressure on city residents who want to build their houses, resulting in a high demand for state land, hence their associated cost of acquisition.

In addition, the costs of housing construction are usually reflected in the final selling price of houses. High housing prices in PNG over the recent years also reflect the increasing construction costs, which appear to be mainly attributed to high cost of input materials sourced domestically as well as from abroad. High domestic inflation amidst low kina exchange rate, high cost of skilled labour due to shortage, high land cost, and high transaction costs such as costs involved in acquisition of land and connections of trunk infrastructures are some of the key factors influencing the high cost of inputs for PNG (Affordable Housing Institute and Athena Infonomics, 2018). High house construction costs, which are fed into higher housing prices, prohibit prospective homeowners' ability to purchase a home.

3. Literature review

3.1 Theoretical literature

Despite numerous attempts to establish a standard theoretical framework for housing demand, such efforts have failed due to the complexity of the housing market and the various characteristics of housing such as high cost of supply, durability, heterogeneity, and its spatial immobility. Hence, early literature has often relied on the neoclassical consumer theory for housing demand analysis, where rational consumers maximise utility, within mainly, income and price constraints.

A typical housing demand function usually considers household income, housing prices, other commodity prices, and consumer preferences. However, this model's rigid assumptions, including utility optimisation, homogeneity of housing, and perfectly competitive markets, fail to capture the housing market's imperfections and non-competitive aspects (Megbolugbe et al., 1991). For example, housing homogeneity assumes houses and apartments are interchangeable, which differs from the real-world housing market's heterogeneous nature. Furthermore, assuming a perfectly competitive and equilibrium market overlooks structural barriers, information asymmetry, market power, regulatory hurdles, transaction costs, and the non-substitutability of housing units, which hinder market efficiency. For instance, sellers often possess more information about house quality than buyers, leading to issues like adverse selection and moral hazards.

A key housing characteristic of “durability” has implications for the understanding of the concept of housing demand and how it is integrated into the model, how housing decisions are specified in the housing utility function, and how income, price, and credit market constraints are captured in the model (Megbolugbe et al. 1991). On the concept of housing demand, an understanding of housing durability enables one to distinguish between demand for housing services and housing stock, where investors are typically seen as demanders of housing stock based on investment theory, and consumers demand housing services based on consumption theory. This was not the case in the early literature where housing demand for the services that houses provide was not distinguished from the demand for housing stock, as both were measured through housing expenditure.

With regards to appropriate measure of income, while permanent income is conceptually correct, current income is often used in economic models because measuring permanent income can be complex. Income plays a crucial role as it covers expenses like mortgage payments, property taxes, insurance, utilities, and rent. On the measurement of housing prices, different definitions and measurements have made it difficult to estimate price elasticity for housing demand. Nevertheless, researchers frequently utilise two housing price indices: an index of rent or house value that varies across metropolitan areas and the price of a standardised housing unit generated from hedonic regression.

In addition, incorporating durability in housing analysis requires considering both quantity and tenure, which calls for the use of "user cost." This concept expresses the price constraint faced by both owners and renters in equivalent terms, enhancing the understanding of tenure decisions and the impact of taxes, inflation, and mortgage variations on housing demand (Chinloy, 1980). User cost is essential when modelling both housing investment and consumption.

Credit constraints also play a vital role in housing demand, as many buyers rely on mortgages to purchase homes. Mortgage market conditions significantly influence homeownership decisions and household spending. To address the interplay between housing and credit markets, which neoclassical economics often overlooks by assuming perfect competition and market equilibrium, it's crucial to account for simultaneous interactions. Additionally, policy and regulatory institutions, including central banks, can influence housing credit and mortgage interest rates through their control over the money supply, policy rates, and macro-prudential requirements.

The standard neoclassical model for housing demand needs adjustments to account for housing's heterogeneous characteristics. Since house is a multidimensional commodity, households assign value to it based on diverse features of house including its size, bedrooms, location, age, condition, and access to amenities and public services, all of which interact to determine overall property value. Modelling housing heterogeneity assumes that each attribute generates utility for households. Researchers often use the hedonic technique to analyse housing attributes, where this method estimates the value of each individual characteristic. Essentially, it determines how much value is added or subtracted based on the presence or absence of these attributes.

Further, housing possesses an overlooked characteristic in neoclassical economic theory: spatial fixity or immobility, meaning it's fixed to a specific location. This has substantial implications for both housing demand and supply. On the demand side, households prioritise location when buying homes, as it greatly affects access to jobs, schools, and amenities. On the supply side, housing's immobility means the quantity and quality of housing stock in a location remain relatively fixed in the short term. This can result in housing market imbalances, like shortages or surpluses, affecting prices and affordability. Location encompasses proximity to essential places such as the Central Business District (CBD), job centres, schools, hospitals, and transportation.

Earlier studies, including Follain and Jimenez (1983) and Smith, Rosen, and Fallis (1988), expanded upon the standard neoclassical housing demand model to address unique housing characteristics. These efforts led to modifications of the base model and the development of partial models like tenure choice models, search models, mobility models, and trait demand models, which aim to account for housing market imperfections. For instance, the tenure choice model introduced by Arnott and Stiglitz (1979) is widely used to analyse how individuals decide between renting and owning homes. These models assume households select the housing tenure that maximises utility, depending on factors like housing costs, expected residency duration, and future prices. Similarly, housing search models, based on Diamond's (1981) search and matching framework, recognise that finding a suitable house involves costs and is not instantaneous. Households search until expected benefits align with search costs, explaining the search duration and the chosen house's characteristics.

3.2 Empirical literature

Many empirical studies have investigated the factors that influence housing prices. These factors include both macroeconomic variables, such as income, aggregate demand, relative price of related goods, and credit availability, which align with established theoretical housing models as well as other factors specific to housing, such as demographics, location, and various housing-specific characteristics that are not explicitly captured by the theoretical models. The empirical literature and their related findings on the theme are diverse and varied by different areas of study; that is, developed to developing countries, different approaches employed for analysis, and different sample periods for the estimations. Table 1 shows selected literature on determinants of housing prices that have been studied for various countries and regions.

Table 1: Selected literature on determinants of housing prices

Authors	Countries/Region	Methodology	Findings on key determinants of housing price
Tsatsaronis and Zhu (2004)	17 Industrialised countries	SVAR	Inflation, the interest rate, bank credit, and national differences in the mortgage market
Adams and Fuss (2010)	15 Countries	Panel cointegration	Economic activity and construction costs (positive), interest rates (negative)
Williams (2015)	17 Countries	SVAR	The increasing monetary policy rate reduces real housing prices, but at the cost of real GDP (macroeconomic and financial stability conflict)
Goodhart and Hofmann (2008)	17 Industrialised countries	Fixed-effects panel VAR	Evidence of multidirectional linkages between house prices, broad money, private sector credit, and the macroeconomy. Money growth affects housing prices and credit, credit impacts money and housing prices, and housing prices influence money and credit
Panagiotidis and Printzis (2016)	Greece	VECM	Mortgage loans and retail sector critical determinants
Akkay (2021)	Turkey	ARDL	Housing interest rate (negative), exchange rate and employment (positive)
Gaspareniene et al. (2017)	Lithuania	Correlation and regression analysis	Interest rate, bank loan, inflation
Kolisi and Phiri (2017)	South Africa	ARDL	Inflation and disposable income

While the literature on macroeconomic determinants of housing prices is vast in other countries and regions, the related empirical studies in the Pacific Island Countries (PICs) is sparse. Few discussions and studies have identified several underlying structural factors that potentially impact higher housing prices and affordability in the PIC region. Some of these factors include high population growth rates and rapid urbanisation inducing high demand (Juswanto and Kelkar, 2019), limited access to housing finance owing to lack of security of tenure rights to land (Sprigg, 2018), weak land administration, high construction and regulatory costs, and lack of serviced land (Hassan, 2018).

For PNG, several studies and discussions revealed some critical underlying factors that influence high housing prices and affordability issues. For example, according to a review of the housing and real estate market by the Independent Consumer Competition Commission (ICCC), inefficient and insufficient supply of land, irregularities in land allocation to developers, institutional deficiencies, and lack of government policy on housing were highlighted to have impacted the housing and real estate markets (ICCC, 2012). Endekra et al. (2015) used monthly advertised housing prices from 2012 to 2013 for Port Moresby and found the distance from the CBD to be a key factor influencing housing prices. The study also uncovered that the prices for housing in the historically low income, low covenant suburbs—even in the absence of basic infrastructures and security measures—have increased, which may be due to the increased demand for housing attributed to the increased economic activity during the construction of the PNG LNG project. In addition, the study established that the high selling price of apartments and units were due to the absence of strata titling laws.

Ezebelo et al. (2016), in the same vein as Endekra et al. (2015), used advertised prices from 2014 to 2015 for Port Moresby and confirmed location and property type, that is, whether they are a standalone house or an apartment, to be vital for housing price setting. Ezebilo et al. (2017), again using price data for 2015–2016 and a combination of descriptive and ordinary least squares (OLS) analysis, revealed that the number of bedrooms, location, and house type are critical factors affecting housing price. Furthermore, Wangi and Ezebilo (2021) examined housing price factors from the housing real estate property supplier's perspective using interview-based data for the analysis. Using both qualitative and quantitative measures, the study established that the landlords determine residential property prices by considering the prices that other landlords have set for their properties as well as economic fundaments of the housing market, such as buyer affordability and including the security of location. Real estate agents most often consider location of the residential property, improvements made to the property, and availability of infrastructure and services. The scarcity of land is a significant factor driving higher housing prices for Port Moresby, as highlighted in the studies by Wangi and Ezebilo (2017) and Wangi and Ezebilo (2021).

Based on existing literature in the region, it is obvious that there is still a large literature gap regarding the housing market. There is no study establishing the macroeconomic determinants of housing prices. For PNG, past studies focused on the hedonic characteristics of housing such as number of bedrooms, types of houses, and spatial factors such as location of the residential properties, while leaving out the assessment of macroeconomic variables. In addition, the method of housing price data collection was based on advertised housing prices as well as interview data that could potentially bias the findings. More so, the periods for study only include a year, which may not reflect the trend of the relationship between housing price and other macroeconomic factors. Finally, the literature lacks more rigorous empirical analysis in modelling the macroeconomic determinants of housing prices, for PNG as well as the PIC. This study attempts to fill this literature gap by addressing the limitations.

4. Data and methodology

4.1 Data description

We employ quarterly data for the period 2000 to 2018 for the analysis of housing market price. The variables used in the empirical analysis are presented in Table 2. Most of the variables are transformed into logarithms for ease of interpretation of the model results, except interest rate variables. We show the trends of all the variables in Figure 4 and discuss the respective variables.

Table 2: Key variables used in the analysis

Variables	Initials	Proxy	Source
Dependent variable			
Housing price index	LHPI	Level of housing prices	Constructed based on growth rates of housing prices from National Statistics Office CPI housing component
Independent variables			
Kina facility rate	KFR	Monetary policy rate	Quarterly Economic Bulletin (QEB), Bank of PNG
Housing loan	LHOUSING_NGDP	Total house lending/nominal GDP	Internal BPNG data and Quarterly Economic Bulletin (QEB) BPNG
Real mortgage lending rate	LR_AVG_REAL	Weighted average mortgage lending rates/inflation rate	Internal BPNG data and Quarterly Economic Bulletin (QEB) BPNG
Total money supply	LM3_NGDP	Total money supply/nominal GDP	Quarterly Economic Bulletin (QEB) BPNG
Real GDP	LRGDP	Nominal GDP/CPI	Quarterly Economic Bulletin (QEB) BPNG
Global financial crisis	Dum2008_4	Dummy variable 1	
PNG LNG project construction	Dum2012_3	Dummy variable 2	

House Price Index (LHPI)

The Housing Price Index (LHPI) is constructed based on the growth rate for the housing rental rates collected for the low to medium cost houses by the National Statistics Office (NSO)[1]. This proxy housing price index, although it is a crude measure of housing prices, broadly reflects the underlying trend of housing market prices as it impacts a larger proportion of the urban population who demand mostly low to medium cost houses. Thus, the prices on the high-end property market are not captured by this measure. Nonetheless, this measure is sufficient for our study as we are interested in the trends of housing prices to establish a long-run relationship, as well as short-run factors. Housing price index, as constructed, has been on an upward trend over the study period.

Kina facility rate (KFR)

This is the Bank of Papua New Guinea's monetary policy interest rate. Theoretically, a negative relationship is expected between the monetary policy rate and the housing prices. Typically, an increase in monetary policy rates, and subsequently, the short-term interest rates should be accompanied by a fall in housing prices as demand for houses would decline, since it would be expensive for home buyers to access housing credit. The opposite is true for any declines in monetary policy interest rate. However, in practice, the extent of the impact depends on a variety of factors. One important factor is the effectiveness of the transmission of monetary policy to the retail bank interest rates. Past PNG studies relating to the monetary policy transmission in PNG such as Ofoi et al. (2019) and Tumsok (2017) established that monetary policy has limited influence on short-term interest rates due to excess liquidity in the banking system. Therefore, we expect a negative relationship but negligible effect of the monetary policy rate on the housing prices. The KFR broadly declined over the period under study, reflecting a general expansionary monetary policy over the period, which is anticipated to positively impact on housing prices.

Figure 4: Plots of variables

Housing loan/NGDP (LHousing_NGDP)

Housing loan is the sum of a commercial bank's personal home loan and the residential property loan but excludes the commercial property loan. This is expressed as a percent of the nominal GDP, a widely used demand-side factor to the house price modelling. Higher mortgage credit growth is expected to stimulate demand for housing as it provides home buyers with necessary financing capacity to make housing purchases. Hence, a positive relationship is expected between mortgage housing credit and housing prices. Further, increases in housing prices could further generate demand for credit and push housing prices further due to the higher securitisation value of houses.

Real mortgage lending rate (LR_AVG_REAL)

The real mortgage lending rate is the nominal average mortgage lending rate accounting for inflation. As most housing purchases are undertaken through mortgage financing, an increase in the real housing interest rate should generally discourage housing demand and hence, diffuse any upward pressure on housing price. On the contrary, a decline in mortgage interest rate reflects a decline in borrowing cost and hence, should stimulate demand for housing and exert an increase in housing prices. Over the study period, the real average lending rate for PNG's commercial banks declined from the highs of about 16 percent in the year 2000 to around 8 percent in 2018.

Money supply (L_M3_NGDP)

The money supply is the total money supply measured as a percentage of total nominal GDP. An increase in growth of money supply indicates that money is available for borrowing within the economy. An increase in total money supply means that there is more credit available to access for housing purchases. This is expected to drive down mortgage interest rates and induce higher lending, which could further push housing demand and increase prices even more. Although we expect a positive association of money supply and housing prices for PNG, a negative relationship is not out of the picture as it can manifest in circumstances where an increase in money supply is inflationary. High inflation could pose as a restraint on an individual's demand for housing. After declining in the initial study period to around 2003, the total money supply as a percent of nominal GDP in PNG increased from 2004 until 2008 and stabilised broadly thereafter.

Real Gross Domestic Product (RGDP)

We employ the real GDP, that is nominal GDP accounting for the effect of inflation, as an indicator for real economic activity, and/or the general aggregate income level for the country. In theory, higher GDP implies higher income level and hence, higher aggregate demand in the economy. This is expected to positively affect housing price level in the country. The discussion on the trend of the real GDP has been accounted for in the earlier sections of the paper.

Global Financial Crisis (GFC) (Dum2008_4)

This dummy variable represents the exogenous negative shock that emanated from the widely known GFC that occurred in 2008. Since PNG is economically and financially interconnected to the rest of the world, this crisis is expected to have a dampening effect on the level of housing prices either through its impact on aggregate demand in the economy or through the lending behaviour of the commercial banks amidst perceived risks brought about by the crisis. The GFC had its roots from the burst-in housing price bubble in the US, which adversely impacted on the mortgage-backed securities and hence, financial institutions within the US, and eventually spilled over to the global financial system including PNG.

PNG LNG project (Dum2012_3)

This dummy variable captures the exogenous positive shock from the construction of the US$19 billion PNG LNG project. As discussed in the earlier section, the magnitude of this resource shock was so large that it was expected to double, if not triple, PNG's economy. Amidst such a large positive shock, higher housing prices are highly likely to be a consequence as a high demand induced aggregate price level is anticipated. In particular, the construction phase of the PNG LNG project saw a huge influx of construction-related workers from both within PNG and abroad who migrated to major cities, notably, Port Moresby and Lae. We anticipate a positive impact of the shock on the housing price level due to this urban migration coupled with the excess cash liquidity injection into the PNG economy over the construction phase of the LNG project.

4.2 Methodology

We deploy the Autoregressive Distributed Lag (ARDL) bounds testing approach, developed by Pesaran and Smith (1995), Pesaran and Shin (1997), and Pesaran et al. (2001), to model both the short and long-run relationship of housing prices and the macroeconomic variables due to its popularity in the housing market literature and the convenience of its features, especially in modelling long-run cointegrating relationships of time series variables. The popularity of ARDL bounds test approach stems from the fact that it provides several advantages compared to other econometric models. A key advantage of the technique is that it overcomes the problem of the order of integration that is often found in Johansen likelihood approach (Johansen and Juselius, 1990). In addition, the ARDL approach is more robust and efficient in the analysis of data with a small sample size (Pesaran et. al., 2001). Furthermore, ARDL identifies cointegrating vectors in the case of multiple cointegrating vectors. However, this technique has some limitations. For example, it is not suitable for variables that are integrated of order two, I (2) or more. In addition, since ARDL is a single-equation model, it could not model interactions between the exogenous variables themselves.

Although the ARDL approach employs variables that are I(0) and I(1), or a combination of both, unit root test is essential in order to identify the order of integration as failure to do so may result in inclusion of I(2) variables, which could generate spurious results (Nkoro and Uko, 2016). We, therefore, first evaluate the order of integration by subjecting the variables to the Augmented Dickey Fuller (ADF) unit root test proposed by Dickey and Fuller (1979). We then employ the ARDL bounds testing approach to establish the long-run cointegrating relationship between the variables and re-parameterise them into the Error Correction Model (ECM) to establish the short run dynamics of the variables.

In addition, we subject the estimated model to various diagnostic tests to ensure that the model is stable and is devoid of problems of serial correlation, which would otherwise affect the validity of the inferences drawn from the estimated model results. Although time series data may exhibit a long run relationship between two or more variables over time, their mean and variances may not be constant over time because of seasonality and structural breaks. The Breusch-Godfrey LM test is often applied to validate the model especially when the regression includes autoregressive terms, while the misspecification in the model, which can result in biased and inconsistent OLS estimates along with erroneous t-statistics, could be checked by performing the Ramsey's (1969) regression specification error test (RESET). We employ the above approaches for diagnostic testing.

4.3 Unit root test

The unit root test result for the Augmented Dickey Fuller (ADF) test using the Schwarz Information Criteria (SIC) is shown in Table 3. According to the ADF test, most variables with constant, and constant and trend, specifications were found to be I(1). The long-run average mortgage interest rate (lr_avg_real) is significant at the 10% level of significance when only constant was specified. The log of real GDP (lrgdp) is the only variable that has unit roots even after first differencing, therefore may possibly be stationary at second or higher order of integration. If ignored, the inclusion of log of real GDP (lrgdp) may generate spurious regressions.

We therefore apply the Phillips and Perron (1988) unit root test to confirm if the initial ADF unit root test result is robust across different unit root tests. The Phillips and Perron (PP) unit root test has a similar null hypothesis to the ADF test; that is, a variable has a unit root against the alternative of a variable having a stationary process. The decision rule is the same, that is, the rejection of null hypothesis implies that the variable is stationary. However, the unit root tests differ on the underlying process of accounting for serial correlations. While the Phillips and Perron unit root test uses the Newey–West (1987) standard errors to account for serial correlation, the ADF employs lags of the first-differenced variable. The PP unit root test results indicate that the log of real GDP (lrgdp) is stationary at first difference.

Table 3: Unit root tests / Stationarity test

	Levels		First difference	
Variable	Constant	Trend	Constant	Trend
Augmented Dickey Fuller				
lhpi	0.782	-1.453	-6.377***	-6.5274***
	(-2.587)	(-3.162)	(-3.519)	(-4.083)
kfr	-1.78	-2.273	-4.744***	-4.761***
	(-2.587)	(-3.162)	(-3.519)	(-4.083)
lhousing_ngdp	0.317	-2.568	-9.669***	-9.935***
	(-2.587)	(-3.162)	(-3.519)	(-4.083)
lr_avg_real	-2.748*	-3.077	-7.568***	-7.478***
	(-2.587)	(-3.162)	(-3.523)	(-4.089)
lrgdp	-0.226	-2.604	-2.561	-2.396
	(-2.587)	(-3.162)	(-2.589)	(-3.164)
lm3_ngdp	-1.537	-1.56	-4.852***	-4.831***
	(-2.587)	(-3.162)	(-3.520)	(-4.085)
Phillips and Perron				
lrgdp	0.634	-2.337	-3.899***	-3.952**
	(-2.587)	(-3.162)	(-3.519)	(-3.470)

Notes:

*1. *, ** , *** respectively represent the 10%, 5%, and 1% level of statistical significance.*

2. Figures without brackets are the t-statistics while those with brackets are the test critical values. The critical values

for the levels column are for the 10% level of significance while the first difference column is mainly 1% level.

4.4 Model specification

The conditional ARDL error correction form is specified as follows:

$$\Delta lhpi_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1,i}\,\Delta lhpi_{t-i} + \sum_{i=0}^{q1} \alpha_{2,i}\Delta kfr_{t-i} + \sum_{i=0}^{q2} \alpha_{3i}\Delta lhousing_{ngdp_{t-i}} + \sum_{i=0}^{q3} \alpha_{4i}\Delta lr_{avg_{real_{t-i}}} + \sum_{i=0}^{q4} \alpha_{5i}\Delta lm3_{ngdp_{t-i}} + \sum_{i=0}^{q5} \alpha_{6i}\Delta lrgdp_{t-i} + \beta_1 lhpi_{t-1} + \beta_2 kfr_{t-1} + \beta_3 lhousing_{ngdp_{t-1}} + \beta_4 lr_{avg_{real_{t-1}}} + \beta_5 lrgdp_{t-1} + \beta_6 DUM2008_4 + \beta_7 DUM2012_3 + \varepsilon_t \quad (1)$$

where lhpi represents the log of Housing Price Index; kfr is the Kina Facility Rate; lhousing_ngdp is the log of the ratio of housing loan to total nominal GDP, lr_avg_real is the real average mortgage lending rate, lrgdp is the log of real GDP, lm3_ngdp is the log of the ratio of nominal money supply to nominal GDP. DUM2008 and DUM2012 are dummy variables, which respectively represent the exogenous shocks of the GFC and the PNG LNG project.

The betas $\beta_{1,}, \beta_2, \ldots\ldots.\beta_6$ represent the respective long-run coefficients while the alphas $\alpha_1, \alpha_2, \ldots\ldots\ldots.\alpha_6$ are the short-run coefficients. p represents the pth lag for dependent variable and the $q_{1,}\ldots\ldots..q_5$ represents qth lag, respectively, for explanatory variables. The difference operator (Δ) is associated with short-run equation and ε_t is the disturbance (error) term.

The optimal lag lengths for both the dependent and the explanatory variables are determined using the Eviews software's in-built automatic lag selection method under the ARDL operation. According to the Akaike Information Criteria (AIC), the selected ARDL model specification is ARDL (2, 1, 1, 1, 3, 0). The model expressed in lag lengths representation is as follows: ARDL $(p, q1, q2, q3, q4, q5)$. Specifying the above model, the long-run representation is:

$$lhpi_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} lhpi_{t-i} + \sum_{i=0}^{q1} \beta_{2i} kfr_{t-i} + \sum_{i=0}^{q2} \beta_{3i} lhousing_{ngdp_{t-i}} + \sum_{i=0}^{q3} \beta_{4i} lr_{avg_{real_{t-i}}} + \sum_{i-0}^{q4} \beta_{5i} lm3_{ngdp_{t-i}} + \sum_{i=0}^{q5} \beta_{6i} lrgdp_{t-i} + \varepsilon_t \quad (2)$$

The short-run or error correction model is represented as:

$$\Delta lhpi_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\Delta lhpi_{t-i} + \sum_{i=0}^{q1} \alpha_{2i}\,\Delta kfr + \sum_{i=0}^{q2} \alpha_{3i}\,\Delta lhousing\_ngdp_{t-i} + \sum_{i=0}^{q3} \alpha_{4i}\Delta\, lr\_avg\_real_{t-i} + \sum_{i=0}^{q4} \alpha_{5i}\,\Delta lrgdp_{t-i} + \sum_{i=0}^{q5} \alpha_{6i}\,\Delta lm3\_ngdp_{t-i} + \lambda ECT_{t-1} + \alpha_7 DUM2008\_4 + \alpha_8 DUM2012\_3 + \epsilon_t \quad (3)$$

where ECT_{t-1} is the speed of adjustment or the error correction term. It indicates how fast the adjustment parameter can return to the long-run equilibrium after a shock. The mean reverting process implies that lambda (λ) should be negative and significant (Pesaran et al. 2001).

5. Empirical results

5.1 ARDL estimates

The estimated ARDL model in Table 4 presents a summary of the long and short-run estimated coefficients together with the summary results of the F-bounds test and t-bounds test, and the model diagnostics tests. For the long-run, KFR and nominal money supply have negatively signed coefficients of 0.024 and 0.661 and are statistically significant at the 5 percent and 10 percent level, respectively. In addition, housing loan and real GDP reported positive coefficients of 0.212 and 1.626 and are also statistically significant at the 5 percent and 10 percent levels, respectively. The estimated coefficient for the real mortgage interest rate is -0.006 but is not statistically significant. For the short-run coefficients, statistically significant variables include the one quarter lag of housing price index (0.266), real mortgage interest rate (-0.005), current nominal money supply (0.005) and lagged (first lag -0.275; second lag -0.212) of nominal money supply, dummy variables including dum2018_4 (-0.166) and dum2012_3 (0.032). The above variables are all statistically significant at the 1 percent level except the current nominal money supply, which is statistically significant at the 10 percent level. The non-statistically significant variables include current KFR (0.004) and housing mortgage loan (0.002).

The error correction term, ECT (-1), has a negative coefficient of 0.227 and is statistically significant at the 1 percent level. This result confirms a mean reverting equilibrium process of the long-run relationship of housing price and its macroeconomic determinants. The statistical significance of the ECT term is based on the critical values derived from the t-bounds test, which shows a test statistic of -6.12, which is higher, in absolute terms, than both the 1 percent critical values of -3.43 and -4.79, respectively, for the low and upper bounds.

Table 4: Estimated housing price model using ARDL

Long-run relationships (Levels equation)			
Variables	Coeff.	Std.Error	t-Stat
KFR	-0.024**	0.009	-2.68
LHOUSING_GDP	0.212**	0.08	2.641
LR_AVG_REAL	-0.006	0.004	-1.541
LM3_NGDP	-0.661***	0.104	-6.326
LRGDP	1.626***	0.301	5.41
Short-run relationship (Error correction form)			
ΔLHPI(-1)	0.266***	0.078	3.414
ΔKFR	0.004	0.005	0.815
ΔLHOUSING_NGDP	0.002	0.022	0.072
ΔLR_AVG_REAL	-0.005***	0.001	-4.666
ΔLM3_NGDP	-0.091*	0.052	-1.744
ΔLM3_NGDP(-1)	0.275***	0.058	4.743
ΔLM3_NGDP(-2)	0.212***	0.055	3.877
DUM2008_4	-0.166***	0.026	-6.333
DUM2012_3	0.032***	0.008	3.899
ECT(-1)	-0.227***	0.037	-6.117
C	-3.002***	0.494	-6.08
R-squared	0.694		
Adjusted R-squared	0.647		
F-Bounds test	5.749*** (3.41, 4.68)		
t-Bounds test (CECM)	-5.29***(-3.34,-4.79)		
t-Bounds test (ECM)	-6.12***(-3.43,-4.79)		
Residual diagnostics and stability tests			
Tests	Test statistics	p-value	
Coefficient Wald test	Chi-Sq=171267.9 (df=15)	Prob=0.00	
BG-Seriel Correlation LM test	Obs*R-squared=14.96	Prob.Chi-Sq(12) = 0.244	
Normality test	Jarque-Bera =1.536	Prob = 0.464	
BPG-Heteroscedastic test	Obs*R-squared=11.74	Prob.Chi-Sq(15) = 0.698	
Stability-Recursive Est. Cusum	Stable (all residuals within 5% stat.sig error bands)		
Stability-Recursive Est. Cusum of Squares	Stable (all residuals within 5% stat.sig error bands)		

*Note: ***, **, * statistical significance at 1%, 5%, and 10%.*
() brackets indicate the t-statistics of the estimated coefficients
Sample period: 2000–2018
#BG-Breusch-Godfrey Serial Correlation LM test
#BPG-Breusch-Pagan-Godfrey-Heteroskedasticity test

In the estimation of the F-bounds test, the F-critical values are the critical values computed under an asymptotic scheme (sample size equal to 1000) referenced from Pesaran et al. (2001) in addition to the critical values for finite sample regimes (sample sizes running from 30 to 80 in increments of 5) and referenced from Narayan (2005). The F-statistics derived are 5.75, which is above all the upper bound, I(1), and the lower bound, I(0), critical values for the 1 percent, 5 percent, and 10 percent levels of significance for both the asymptotic and the finite sample schemes. For instance, at the 1 percent level of significance, the critical value of the upper and lower bounds based on the critical values of the asymptotic scheme are 3.41 and 4.68, respectively, both lower than the F-test statistics of 5.75. We therefore reject the null hypothesis of no cointegration, or levels equation and conclude that there exists a long-run cointegrating relationship among the variables employed in the model. This is also supported by the result from the estimated error correction term.

Based on the argument that the p-values associated with the estimated coefficient are derived from a non-standard distribution of the test and cannot be used to make statistical inferences regarding the lagged value of the dependent variable, the t-bounds test is performed. The result of the test shows that the t-statistics from the t-bounds test is -5.29, higher in absolute terms, compared to both the lower bound critical value (-3.43) and upper bound critical value (-4.79) of the 1 percent level of significance. This implies that the estimated lagged coefficient of the housing price index is statistically significant at 1 percent. This also holds for the 5 percent and 10 percent statistical significance levels (Table 1: Appendix).

We conduct various model diagnostic tests including the coefficient and the residual diagnostics, and the model stability test to establish the validity of the estimated coefficients of the ARDL model results. First, using the Wald test, we test the joint statistical significance of the estimated coefficients of the conditional error correction model. Based on the Chi-square test statistics of 2544998 and a corresponding p-value of 0.000, we reject null hypothesis of no joint statistical significance of the coefficients and conclude that there is evidence of joint statistical significance of the estimated coefficients. We then examine the residual diagnostics to ensure the model coefficients are unbiased, efficient, and void of any serial correlation, which would otherwise invalid the results. We first assess the residual autocorrelation. As shown in the correlogram (Table 3: Appendix), the residuals are within the standard error bands, implying that there is no evidence of residual autocorrelation. The residuals are also normally distributed as Jarque–Bera statistic is statistically insignificant; that is, we failed to reject the null hypothesis of normality of the residuals (Chart 1: Appendix).

Furthermore, we apply the Breusch–Godfrey serial correlation LM test with up to twelve lags to detect any form of serial correlation in the residuals. Since the p-value from the Chi-squared distribution of the Obs*R-squared test-statistics of 0.24 is higher than all levels, we fail to reject the null hypothesis that there is no serial correlation; that is, the errors are serially uncorrelated, hence, white noise (Table 4: Appendix). Next, we run the Breusch-Pagan-Godfrey Heteroscedasticity test to uncover if the errors are homoscedastic in nature; that is, their variance are time invariant, which is desirable for a consistent and unbiased model result. Again, since the p-value associated with the Chi-squared distribution of the Obs*R-squared test-statistics is 0.70, we fail to reject the null hypothesis of homoscedasticity of residuals (Table 5: Appendix). Hence, there is evidence that errors are homoscedastic, thus diffusing concerns of the problem of heteroscedasticity.

In addition, we apply the Ramsey Regression Specification Error Test (RESET) to further validate the fulfilment of the assumptions underlying the Least Squares (LS) method. In particular, the test provides an insight into possible model specification errors including the omitted variable bias, misspecification of the correct functional form, and the correlation between the explanatory variables and the error term, which could potentially be caused by a measurement error in the explanatory variables, simultaneity bias, or serial correlation between lagged dependent variable and disturbance term. Under these specification errors, the least square estimator, which is employed in the ARDL model, will be unbiased and inconsistent, thus invalidating any possible statistical inferences. According to the test results, that is, F-statistics of 0.73 and a p-value of 0.397, we fail to reject the null hypothesis of multivariate normality of the distribution of the error term or specification error and conclude that the model is devoid of misspecification (Table 6: Appendix).

Finally, we employ the model stability tests to ensure that the model is stable and sound for making economic inferences and predictions. We employ the CUSUM and the CUSUM of squares tests to test the stability of the model. The results of the test are presented in Charts 2 and 3, respectively, in the Appendix. On the charts, the CUSUM and CUSUM of squares reflect the cumulative sum of the recursive residuals and the cumulative sum of the recursive squared residuals, respectively, with the dotted lines representing the 5 percent critical value lines. According to the test, if the cumulative sum and cumulative sum of squares deviates outside of the critical value lines, the model is said to be unstable. Our results from both Charts 2 and 3 depict stability of the estimated model as the respective test-statistics broadly lie within the 5 percent level of significance for upper and lower bound.

5.2 Robustness checks

We use cointegration methods of Fully Modified Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) to validate the long-run coefficient estimates of the ARDL model. Both techniques are employed as they correct for any potential simultaneity (Stock and Watson, 1993) and endogeneity bias and residual serial correlation (Phillips and Hansen, 1990). Tables 5 and 6 show the results of the FMOLS and DOLS estimates, respectively. Both estimates broadly confirm the results generated from the ARDL model except the coefficient estimate for housing loan to nominal GDP is statistical insignificant, although the sign is anticipated.

Table 5: Fully modified ordinary least squares (FMOLS) estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
KFR	-0.003	0.001	-2.047	0.045
LHOUSING_GDP	0.01	0.012	0.873	0.386
LR_AVG_REAL	0	0	0.681	0.498
LM3_NGDP	-0.084	0.019	-4.494	0
LRGDP	0.366	0.048	7.629	0
C	-3.166	0.465	-6.807	0
LHPI_2012(-1)	0.826	0.022	38.084	0
R-squared	0.996			
Adjusted R-squared	0.995			

Table 6: Dynamic ordinary least squares (DOLS) estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
KFR	-0.009	0.005	-1.952	0.056
LHOUSING_GDP	0.044	0.036	1.204	0.234
LR_AVG_REAL	0.001	0.002	0.502	0.618
LM3_NGDP	-0.18	0.056	-3.226	0.002
LRGDP	0.496	0.13	3.806	0
C	-4.057	1.26	-3.22	0.002
LHPI_2012(-1)	0.708	0.068	10.436	0
R-squared	0.997			
Adjusted R-squared	0.996			

6. Discussion

The results in Table 4 show that real GDP, mortgage loan, money supply, and the monetary policy rate are statistically significant in explaining movements in the level of housing prices in the long run. The signs of the estimated coefficients are largely consistent with theoretical expectations. All else equal, real GDP has a positive elasticity of 1.63, which implies that a 1 percent increase in real GDP will lead to an increase of 1.63 percent in the housing prices in PNG, on average, holding all other factors constant. This result is anticipated as an increase in real GDP results in an increase in aggregate income level, hence, puts an upward pressure on aggregate demand in the economy, which also includes the demand in the housing sector, and thus, housing prices. Previous empirical studies such as those by Adams and Fuss (2010) and Tripathi (2019) have also provided support for this relationship, attributing variation in housing prices to be influenced by real GDP growth and aggregate income level of the country. This impact has featured prominently over the last decade where the construction phase of the PNG LNG project had a notable impact on the aggregate demand level in the economy.

For mortgage home loans, the estimated coefficient is 0.21. This implies that a 1 percent increase in the ratio of total home loan to nominal GDP results in an increase in the housing prices by 0.21 percent, on average, holding all else constant. This direct relationship is consistent with theoretical expectations since housing finance and credit is a key factor for house purchases especially in the developing and low-income countries, such as PNG. The availability of loanable funds earmarked for the housing sector induces higher demand for houses. With a sluggish response of the housing supply to meet the increased demand, upward housing price pressures often occur. Empirical evidence, such as Gaspareniene et al. (2017) for Lithuania, Panagiotidis, and Printzis (2016) for Greece and Tsatsaronis, and Zhu (2004) for a number of industrialised countries, also backs this finding.

The estimated coefficient for the nominal money supply is -0.67, which implies that a 1 percent increase in the ratio of nominal money supply to nominal GDP results in a decline in housing prices, on average, by 0.67 percent, holding all else constant. Although, statistically significant, this result is inconsistent with existing theoretical expectations. A plausible explanation of the negative relationship between money supply and housing prices could reflect the impact of the increase in money supply on inflation and interest rates. Higher level of money supply, if inflationary, could hamper savings of the individuals, thus disincentivising them from pursuing debt-financed property purchases. In another channel, high money supply could exert downward pressure on mortgage interest rate, which could have a bearing on the asset securitisation, thus, increase the cost of owning a house, and deter housing demand for individuals. In PNG, rising cost of living, albeit at the low-income level, has been predominant for a long time. This has heavily weighed on people's demand for housing as inflation erodes their savings, which could have otherwise been used for house purchasing costs such as equity contributions, collaterals, or other associated transaction costs.

The monetary policy rate, the KFR, has a negative estimated coefficient of 0.024, implying that a 1 percentage point increase in the KFR has an associated average decline of 0.024 percent in the housing price in the long run, holding all else constant. This result is generally consistent with standard economic theory whereby a monetary policy expansion through

lowering of monetary policy rate is expected to reduce the short-term interest rates, which is then expected to lower retail mortgage lending rates. This in turn stimulates demand for housing purchases, which eventually leads to higher housing prices. This is also consistent with existing literature on monetary policy transmission in PNG such as those by Tumsok (2018) and Ofoi (2019) who found weakness in the monetary policy transmission from policy rates to retail banking rates due mainly to excess banking system liquidity.
The average mortgage lending interest rate is statistically insignificant in explaining variation in the housing prices for the long-run. This directly contradicts the results of the KFR. It also contravenes the established theory; that is, a lower cost of housing finance should stimulate demand for housing finance and hence, encourage demand for housing. This finding of the insensitivity of short-term interest rate to housing prices is not unique to PNG as it is also found in other countries. For example, Sutton et al. (2017) found modest reductions to policy rates did not affect house price increases although the US interest rates did affect house prices outside of the United States. Other studies including that of Suljoti and Hashorva (2011) and Crowe et al. (2010) find similar evidence of the disconnect between cost of housing finance and housing prices.

In the short run, the first quarter lag of housing price index, mortgage real lending rate, and current and up to two quarter lags of nominal money supply and the two dummy variables are statistically significant in explaining the movement in housing prices. From the model results, a 1 percent increase in the previous quarter's house prices will increase the current quarter's house prices by 0.27 percent, on average, holding all else constant. The effect of lagged house prices on the current house price could illustrate that for PNG, many homeowners are not market observers as there is a large gap in data collection and lack of regulation of the housing market. Hence, the sellers often do not follow current market fundamentals but rely on the past housing prices to set current prices. In addition, as a house reflects a lifetime asset for individuals, many are price inelastic; sellers may not necessarily set their market price in response to current housing market dynamics, but instead resort to using past house prices, which is usually artificially maintained at the high levels.

More so, this could be a fulfilment of the market efficient theory, which stipulates that sellers in an efficient market consider all relevant and available information before setting prices for goods. This presumption implies that all past information as well as future expectations are incorporated into the priced value of assets or goods for trade. House price increases induces increase in housing demand, especially from investors due to expectations of future gain. This in turn leads to a rise in housing prices in the market, which could lead to a further housing price increase. Similarly, price increases attract new home buyers to enter the market. This depicts the impact of recent past housing prices on current prices, which tend to take prominence until other factors offset its effects. In PNG, the study by Wangi and Ezebilo (2021) confirms this channel of influence by establishing that the landlords determine residential property prices by capturing prices that are set by other landlords, coupled with other factors.

The effect of mortgage lending rate is statistically significant but is negligible. A 1 percent increase in mortgage lending rate leads to a decline of housing prices by 0.01 percent, on average, holding all other factors constant. Nominal money supply affects housing prices both contemporaneously and with lags. For the contemporaneous effect, the sign is negative implying that a 1 percent increase in nominal money supply as a ratio of nominal GDP results in a 0.1 percent decline in the housing prices. However, the lagged effect of nominal money supply is positive with the one quarter lag recording a coefficient of 0.28 and two quarter lag recording a coefficient of 0.21. This implies that a 1 percent increase in nominal money supply as a ratio of nominal GDP results in 0.28 percent and 0.21 percent increases in the first quarter and second quarter lags, on average, holding all else constant. The negative contemporaneous effect of money supply on housing prices could be fed indirectly through the inflation channel. When money supply increases, it impacts aggregate demand resulting in an increase in economic activities and eventually, inflation because of an increase in overall spending in the economy. Since inflation erodes the purchasing power of consumers, this in turn results in lower demand for housing and a decline in housing prices in the short run.

In an alternate supply-side view, higher costs of input resulting from increased money supply could also provoke house sellers to pass on the cost through higher house prices. This positive relationship is evident in the first and second quarter lag effect of nominal money supply on housing prices. Moreover, this could also reflect the impact of nominal money supply on housing credit availability as expected. Higher nominal money supply reflects higher availability of housing credit, which drives down mortgage interest rates and encourages higher demand for housing loans and eventually house prices.

The coefficients of the dummy variables, Dum2008_4 and Dum2012_3, are negatively and positively signed, respectively, as expected. Dum2008_4, which captures the impact of Global Financial Crisis (GFC), reports a negative coefficient of 0.17. Since the GFC had its origins from the housing market in the US, this adversely affected demand for housing globally and placed restraints on banks and financial markets lending into the housing sector due to the high perceived risks to the sector. This low demand had a negative implication on housing prices even in the case for PNG. The Dum2012_3, which reflects the effect of the PNG LNG construction on housing prices, reports a positive coefficient of 0.03. As discussed widely throughout this paper and in related PNG studies, this positive effect is largely anticipated as the shocks emanating from the PNG LNG project increased demand for housing in the towns and cities in PNG where the income level of PNG citizens increased. As expected, the Error Correction Term (ECT) is negative and statistically significant with an associated coefficient estimate of 0.23. This implies that the speed of adjustment towards the long run equilibrium is 23 percent. In other words, in the event of a shock to the long-run equilibrium, the disequilibrium is corrected and reverts to the long-run mean at a speed of 23 percent per quarter. Hence, it would take a little over a year to fully adjust to the long-run equilibrium. This result also supports the existence of the long-run relationship between the housing prices and the macroeconomic variables employed in the study.

7. Conclusion

Motivated by the recent increasing trend of housing price level in PNG and given sparse literature on housing market in PNG, this study established key macroeconomic factors that influence housing prices in PNG. With employment of PNG data from 2000 to 2018 and the ARDL bounds test approach, the study finds real GDP, nominal money supply, mortgage loans, and the monetary policy rate as key determinants of housing prices in the long run. The study also finds mortgage real lending rate to be insignificant in influencing housing prices in the long run. In the shorter term, the study revealed that variation in house prices is mainly attributed to lagged housing prices, mortgage real lending rate, current and lagged nominal money supply, and the dummy variables for the Global Financial Crisis and the PNG LNG project.

The findings of the paper re-emphasise the need for other structural and industry specific policies to address the issue of high housing prices complemented by macroeconomic policies such as the monetary and macro-prudential policies. The other structural policies are made in reference to previous PNG-based studies including the encouragement of private–public partnerships in undertaking large housing projects, formation of a regulatory body in the housing and real estate industry, better coordination of the agencies involved in the industry, and unlocking of unused state and customary land for housing development, among many others.

As far as monetary policy is concerned, there is evidence of the impact of monetary policy on the housing prices. This implies that the Central bank could influence housing prices indirectly, and at the cost of inflation. For example, increase in money supply could negatively impact the rising housing prices in the short run contemporaneously and in the longer term, as it could dampen housing demand. However, its short-run lagged effect is positive and hence, it could offset the negative effect. Given the negligible impact of the monetary policy rate on housing prices, it is essential that macro prudential policy tools are applied for the purposes of controlling high housing prices.

A key limitation for the study is that there is no officially collected data relating to house and rental prices; hence, we only employ a proxy for housing prices. In addition, the study did not consider the implication of macro-prudential tools on house lending, and hence, housing prices. This can be pursued in future studies.

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Notes

1 In the absence of an official compiler of the housing price statistics, advertised housing sales data has been the main source of housing price data for the recent studies in PNG. This advertised sales price data, however, was only observed over a year. For our purpose, annual advertised data would have limitations as there is no adequate time series to analyse the longer-term relationships among the variables. In line with the aim of this paper, the study requires a longer time series; hence, we construct a longer time series housing price index.

Appendix 1

Table 1: F-bounds and T-bounds tests				
F-Bounds test				
Null hypothesis: No levels relationship				
Test statistic	Value	Signif.	I(0)	I(1)
Asymptotic: n=1000				
F-statistic	5.749	10%	2.26	3.35
k	5	5%	2.62	3.79
		2.50%	2.96	4.18
		1%	3.41	4.68
Actual Sample Size =75			Finite Sample: n=75	
		10%	2.38	3.515
		5%	2.802	4.065
		1%	3.772	5.213
t-Bounds test				
Null hypothesis: No levels relationship				
Test statistic	Value	Signif.	I(0)	I(1)
	-5.289	10%	-2.57	-3.86
		5%	-2.86	-4.19
		2.50%	-3.13	-4.46
		1%	-3.43	-4.79

Table 2: Wald test			
Test statistic	Value	df	Probability
F-statistic	159062.4	(16, 59)	0
Chi-square	2544998	16	0

Null hypothesis:
C(1)=C(2)=C(3)=C(4)=C(5)=C(6)=C(7)=C(
8)=C(9)=C(10)=C(11)=C(12)=C(13)=C(14)=C(15)=C(16)=0

Table 3: Residual autocorrelation (Correlogram)

Date: 08/25/23 Time: 15:00
Sample (adjusted): 6/01/2000 12/01/2018
Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.084	-0.084	0.5532	0.457
		2	0.015	0.007	0.5698	0.752
		3	-0.180	-0.179	3.1680	0.366
		4	0.007	-0.024	3.1722	0.529
		5	0.030	0.031	3.2464	0.662
		6	-0.096	-0.128	4.0130	0.675
		7	-0.089	-0.116	4.6810	0.699
		8	-0.200	-0.222	8.1326	0.421
		9	0.083	-0.004	8.7369	0.462
		10	-0.019	-0.067	8.7703	0.554
		11	-0.057	-0.167	9.0663	0.616
		12	0.093	0.069	9.8584	0.628

*Probabilities may not be valid for this equation specification.

Chart 1: Residual histogram

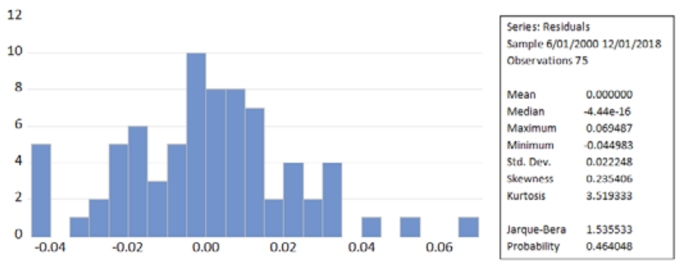

Chart 2: CUSUM (Stability test)

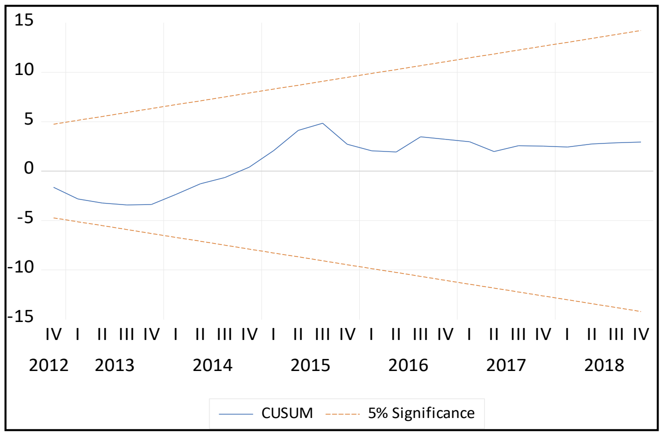

Chart 3: CUSUM of square (Stability test)

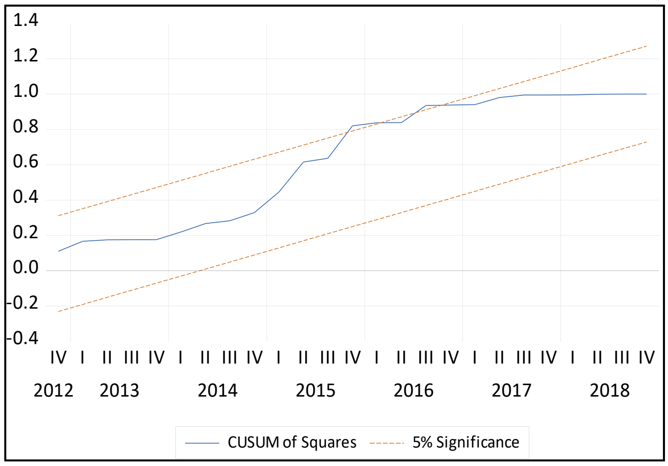

Table 4: Breusch-Godfrey Serial Correlation LM test			
Null hypothesis: No serial correlation at up to 12 lags			
F-statistic	0.97586	Prob. F(12,47)	0.4847
Obs*R-squared	14.95945	Prob. Chi-square(12)	0.2437

Table 5: Breusch-Pagan-Godfrey Heteroskedasticity test			
Null hypothesis: Homoskedasticity			
F-statistic	0.730135	Prob. F(15,59)	0.7445
Obs*R-squared	11.74236	Prob. Chi-square(15)	0.6984
Scaled explained SS	9.153609	Prob. Chi-square(15)	0.8693

Table 6: Ramsey RESET test

Omitted variables: Squares of fitted values
Specification: LHPI_2012 LHPI_2012(-1) LHPI_2012(-2) KFR KFR(-1) LHOUSING_GDP LHOUSING_GDP(-1) LR_AVG_REAL LR_AVG_REAL(-1) LM3_NGDP LM3_NGDP(-1) LM3_NGDP(-2) LM3_NGDP(-3) LRGDP DUM2008_4 DUM2012_3 C

	Value	df	Probability
t-statistic	0.852802	58	0.3973
F-statistic	0.727272	(1, 58)	0.3973
Likelihood ratio	0.93459	1	0.3337

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