Housing market dynamic and affordability in resource-based communities

A University of Melbourne Affordable Housing Hallmark Initiative Seed Funding Project

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Executive summary

Extractive industries are fundamental to the economic wellbeing of resource-based communities and their nation states, but also exposing them to commodity price cycles. So far there is a paucity of thorough analysis of the relations between housing market dynamics, housing affordability, and the economic fortunes of resource-based regions and communities. Specifically, there is a lack of: evidence on the economic connections between housing and commodity price cycles; distinction between housing market dynamics on national, state and local levels; research on property sector responses to commodity cycles; and review and evaluation of policy interventions related to mining boom-and-decline.

As a first step towards addressing some of these knowledge gaps, this seed-funding project examines the connections between housing and commodity price cycles in Australia, and the manifestations of such macro-cycles on the local level (with case studies of Perth, Bunbury, Geraldton, and Kalgoorlie-boulder from Western Australia). Key mineral prices and housing price data were collected from the Mineral Market Index and the Real Estate institute of Australia respectively. The observing period is from June 2001 to December 2020.

Descriptive analysis of housing and commodity price cycles showed that:

- Gateway city (Perth) has smoother housing price cycles compared to mining towns, which indicates that the latter are subjected to more frequent housing price fluctuations.
- Commodity price cycles were more frequent than housing price cycles, reflecting the former's market fluidity which were in turn influenced by global market conditions.
- The housing prices of mining towns and commodity prices experienced similar numbers of peaks and average durations during the market expansion periods. But such synchronous pattern was not noticeable in the gateway city. This may suggest that the housing prices in mining towns are under upward pressure when commodity market booms, but not so much in gateway cities.
- House prices in the mining towns and gateway city were found not in tune with the commodity prices during market recessions. This implies that housing prices tend to be stickier (less elastic) when commodity market is sluggish.

More meticulous analysis was conducted with the Vector Error Correction (VEC) model to estimate the short-term dynamic patterns along with the long-term equilibrium relations between housing and commodity price cycles. After deciding the optimal lag, Granger Causality Analysis and Variance Decomposition Analysis were conducted to further testify the relationships between commodity prices and housing prices. Key findings are:

- Overall, mining commodity prices were found to have causal relationship with housing prices in the mining cities/towns.
- Such relationship was highly significant in the long run (over ten periods of observations).

- Commodity price changes two quarters ago were found to best explain housing price changes in the short-run dynamic model.
- Copper emerged as the mineral that could explain a high proportion (20-25%) of housing price variances in all the mining cities/towns in the long run.
- Reginal divergence was recorded in the long run:
  - Housing price in Perth had significant causal relationship with all three mining commodity prices. Specifically, the prices of coal and copper could explain over 40% of its house price variance after 10 quarters;
  - House price in Bunbury was causally affected by the coal price while the house price in Kalgoorlie-Boulder was affected by iron ore and copper prices;
  - Insignificant causal relationship was found between the house price in Geraldton and the commodities prices.

To further unpack such regional divergence, especially the impact of commodity price cycles on the housing prices in mining towns in the short run, a hedonic regression analysis was conducted and compared between Geraldton and Kalgoorlie-Boulder. It was found that:

- Bigger houses (e.g., 4 bedrooms, 2 bathrooms, 2 garages, approx. 800 square meters land size) dominate these two mining towns.
- Broader economic and environment factors (e.g., Covid effect) and the house structural factors were found to influence the local house prices significantly in the short run (2 years in our analysis).
- In the short term, commodity price cycles were found not to have significant impact on housing prices. This might imply that the boom of the mining industry in WA fails in attracting capital nor human resources to the remote regions effectively. The gateway city (i.e.,Perth) and the national centers (e.g., Sydney and Melbourne) therefore, are likely to benefit more from the inflow of labour and investment.
- Above interpretations should be read in the context of COVID and the strict inter-state travel restrictions. Many Flying-In-Flying-Out workers for example, have to stay/rent in the mining towns due to the boarder closure of Western Australia from April 2020.

Research Rationale

Housing affordability is a key challenge in resource-based communities.

The world consumption of raw materials is set to nearly double by 2060. The production of raw materials is spatially concentrated in mining regions, which are supplying the raw materials for the future. Australia is a major raw materials producer. The resources industry contributes to over half of Australia's export (Constable 2018) and over 50% of Western Australia's gross value add (Commonwealth of Australia 2013). The figures are even more extreme for Chile and its major mining region Antofagasta (OECD 2013). The competitiveness of mining and extractive industry can deliver significant benefits through jobs, investment and technological innovation, and therefore, is directly related to the national prosperity.

Housing in resource-based communities has important connections with the industry's productivity primarily through the labour market (Akbar et al. 2017; Bond 2000). Yet empirical studies have suggested that housing affordability is one of the severest challenges facing these regions and communities both in Australia and worldwide (Akbar et al. 2017; Bond 2000; Commonwealth of Australia 2013). It is reported that a three-bedroom house in Moranbah or Port Hedland can attract double or even triple the rent of a property with harbour views in Sydney's Double Bay. In some areas liveability is becoming so eroded that the choice to 'live-in' rather than Flying-In-Flying-Out (FIFO) is simply not available (Commonwealth of Australia 2013).

This unaffordability in turn is derived from the unique market demand and supply characteristics of the mining regions. On the demand side, an OECD report (2021) noted that regions with the highest shares of the population employed in coal mining tend to have a lower per capita GDP compared to the national average. Moreover, resource-rich communities often experience chronic demand pressures associated with the commodity super cycles out of their control, such as the super cycle taking place between 2003 and 2014 (Juneja 2022; Knop and Vespignani 2014). The large proportion of transient workforce stresses the local housing availability and pushes up the housing price and the costs of living, making it difficult for workers, service providers, and even current residents to live locally. This can threaten the long-term economic growth and social coherence of these regions.

On the supply side, the volatility of resource-based communities often deters risk-averse builders, investors, and financiers, with those remote towns suffer more than the gateway cities. The introduction of the Fringe Benefits Tax Assessment Act 1986 further discourages the provision of company housing as an alternative choice (Commonwealth of Australia 2013). High housing prices in mining regions and communities have likely: discouraged permanent residents; reduced attachment to place and participation in civic affairs; squeezed out key workers; exacerbated the socio-economic conditions of vulnerable groups (Maclennan et al. 2015); heightened skill shortages for mining and supporting industries, and; limited the capability for a resource-based region to diversify its economic structures for a more resilient future (Commonwealth of Australia 2013; Hajkowicz et al. 2011; OECD 2021).

Existing housing interventions are limited and insufficient.

The role of the state in providing public goods and services in mining regions has been evolving. The discovery and exploitation of mineral resources in sparsely populated regions of Australia started in the 1960s and 1970s. Company towns, where the mining industry was responsible for constructing, funding and administering the physical and social infrastructure of the town, including housing, were favoured by the states as a mechanism for achieving regional development at minimal cost to the government (Barclay and Everingham 2020). From the mid-1980s, there was a push by mining companies to lower their operational costs by disentangling themselves from directly providing and managing the infrastructure of company towns and relinquishing town ownership. They were able to reduce expenditure on infrastructure and social services in some cases and to transfer many of the facilities they once operated to autonomous local governments or to State government agencies in others (Marais et al. 2018). The role of state governments in ensuring a minimal service standard at these mining communities, therefore, has increased thereafter. Different governance styles and efficiency are noted. Depending on the extent to which the state governments enable, influence, or harness private sector action to deliver public services, Barclay and Everingham (2020) suggested four typologies of welfare state, minimal state (e.g., South Australia), enabling state (e.g., Western Australia), and influencing state (e.g., Queensland).

Yet given the market dominant logic in the housing sector, our preliminary review of existing policies reveals that housing interventions in resource communities has not attracted greater attention from the Federal and State Governments. Housing challenges have been treated primarily as a metropolitan issue (Warren et al. 2015), hence targeted and effective policy interventions are rare in Australia and almost completely missing in Chile. The lack of accurate and comprehensive data on federal, state and local levels further constrains effective policy interventions (Commonwealth of Australia 2013). The current major affordable housing support program, the Social Housing Initiative, for example, constructed very few social housing dwellings in resource communities, e.g., three dwellings in Karratha; two in South Hedland; nine in Roebourne and fourteen in Kalgoorlie (Commonwealth of Australia 2013). Funding with more general purposes includes the Financial Assistance Grants and The Regional and Local Community Infrastructure program. The allocation of funding for both programs, however, is directly connected to the residential population of a local government area. Resource communities, whose residential populations are dwindling whilst transient populations continue to increase, are placed at a significant disadvantage under these funding structures. Local governments who are directly facing the housing affordability challenges, on the other hand, are not well integrated in the housing planning process and they lack the capacity and personnel in efficient managing funding, such as the Australian Government's 'Royalties for Regions' program (Maclennan et al. 2015).

Severe housing crisis in mining communities, therefore, has been recorded partly due to the dominant neo-liberalist policy regime which values market principles, individualism, and immediate capital gain over and above structural responses to social and community issues (Warren et al. 2015, p104). These authors also reported that Aboriginal and Torres Strait Islander homelessness has not been well profiled in research on Australian mining communities, neither have there been dedicated policies supporting the housing needs of Aboriginals living in/working for these mining communities (Scambary 2013). This is peculiar given so many mining communities have been established in regions with traditional landowners.

Multidisciplinary disciplines and methods are needed to quality the extend of housing affordability challenges.

Sound housing interventions need sound evidence, which is currently missing for resource-based economies. Extant studies tend to blame data availability and comparability for the lack of sophisticated analysis (Warren et al. 2015), and many have adopted qualitative approach to capture the extend and impact of housing challenges in mining regions and towns (Commonwealth of Australia 2013; Maclennan et al. 2015). The multi-scale (e.g., federal, state, local) and multifaced (e.g., demand, supply, finance, construction, NGOs, mining corporates) characteristics of the housing market dynamics in these regions, towns, and communities also make any single methodological approach inadequate in this task. In this project we have put together an excellent team, each with their specialised knowledge on housing related issues, to explore social-economic factors, demand-supply dynamics, multi-level geographical coverages and cross-national comparisons. We adopted a 'Hub-and-Spoke' organisational model borrowed from the nationwide Housing Evidence Centre in the UK for which CI Miao was the Shadow Director. Specifically, Miao, Phelps and Arias-Loyola have formed the project 'Hub' and undertaken investigation/coordination of all activities. Atienza and Vergara-Perucich (based in Chile), Wiesel,Wood, Ong and Leishman were the 'Spokes' of the network, who have contributed specialised insights and/or reports related to the project objectives. The research assistant, Dr Le, had contributed to data collection and statistical analysis.

Research Aim and questions

Responding to above knowledge gaps and policy challenges, our project aims to generate evidence to guide policy addressing housing affordability in resource-based communities. Specific questions addressed are: What are the connections between housing and mining commodity price cycles in Australia, and how are such macro-cycles manifested on regional and local levels?

Methodology

In our original proposal, we had outlined the following methodological approach:

Comparative study: This long-established method has been used for contextualising and establishing whether shared phenomena can be explained by the same causes, which in turn facilitates cross-territory Policy learning. Chile, like Australia, has long been relying on resource industries for growth. This sector contributes over 50% of export and 12% of national GDP. In Antofagasta region, the mining industry accounts for 93.7% of exports and have resulted in severely over-heating of the local housing market, especially in the gateway city Antofagasta. More broadly, Chile and Australia are both liberal market with limited public interventions in housing. A companion of this kind is most appropriate for obtaining useful data (Yin 2003). In project delivery, however, we have to make the hard decision of dropping the Chile comparison due to the poor dataset available there both on the national and regional levels. It was also proven difficult in collecting first-hand data during the pandemic.

Document Analysis: was implemented in three stages to achieve an unprecedently comprehensive coverage. The first stage involved collecting and synthesising international literature on the housing market features in resource-based economies. Second stage focused on screening national and local government economic development and housing strategy plans in Australia. The last stage canvassed these plans with a view to testing the extent and ways in which thinking about housing affordability has shaped these plans.

Econometric Modelling: Two hypotheses were tested here. First: commodity cycles lead property cycles (hence important to track commodity cycles to mediate its impact on the property markets); Second: impacts of commodity cycles on housing prices are the strongest on the local level, followed by reginal level, and then national level (hence a one-size-fit-all housing intervention is ineffective). Measures of dynamic correlation, coherence, and phase angle would be used to rest hypothesis 1 by evaluating the structure of the co-movements between housing and commodity cycles (Igan et al. 2011). Vector Error Correction (VEC) model and hedonic model were used to approach hypothesis 2 which measure the effect of commodity price fluctuation on house price corrections on different geographical levels (Breitenfellner et al. 2012).

After considering plausible cases in Australia, we have selected Perth, Kalgoorlie-Boulder, Geraldton, and Bunbury as focus. The latter three are major mining cities in Western Australia. We include Perth as benchmark to test our hypothesis 2. For Resource (Commodity) prices (RP), *Mines and mineral deposits (MINEDEX)* show that the common resources in the observing regions are Copper, Iron ores and Coals (http://www.dmp.wa.gov.au/Mines-and-mineral-deposits-1502.aspx). The monthly prices of Copper, Iron Ore and Coal were collected from Market Index (https://www.marketindex.com.au/iron-ore), which is freely available and provides a long time series for analysis. In order to unify the frequency of the data, the monthly commodity prices have been transmitted into the quarterly prices by using the mean prices of the three months in the corresponding quarters.

For House prices (HP): Quarterly median house prices from 1989 were purchased from the Real Estate institute of Australia (REIA) (https://reia.asn.au/product/reia-data-subscription-remf-3/). Other databases do not offer such long record for our research purpose.

Interviews: were planned to further unpack the housing challenges in resource-based communities. Four categories of interviewees were to be recruited, including: property developers active in resource-based communities (3-5 per case); resource companies (2-3) and their employees (both local resident and transient workers, ~20 in each case); local government officials in resource-based towns (3-5); and regional and national government officials (2-3). In project delivery, we have to drop this qualitative approach due to COVID related travel constrains and focused instead on econometric modelling.

Empirical Analysis

This paper adopts time-series and cross-sectional analysis to investigate the relations between the resource prices and median house prices in WA. Time-series analysis is able to reveal longitudinal relation between the two variables; whereas cross-sectional analysis provides meticulous analysis of the resource price impact on housing market by controlling for other factors.

1. Descriptive analysis of the price cycle

There is a large number of research focusing on the definition and measurement of economic cycles. Here, we use the classical definition of the business cycle based on the turning points in the (log-)level of aggregate economic activity (Burns and Mitchell 1946) to date the cycles in the variables of interest. The algorithm adopted to locate turning points in cycles in this research was suggested by Igan et al. (2011), who followed the approach originally suggested by Bry and Boschan (1971) and Harding and Pagan (2002). In a nutshell, the algorithm searches for maxima and minima over a given period of time and defines a peak (trough) at time t as occurring when the series $y_t > (<) y_{t\pm2}$, ensuring that peaks and troughs alternate. Another restriction is that a cycle phase, being it either the contraction (from peak to trough) or the expansion (from trough to peak), lasts at least two quarters, and a complete cycle (from one peak to the next) lasts five quarters at a minimum.

In addition to dating cycles, the two main characteristics of cyclical phases, namely, duration and amplitude, are identified (Harding and Pagan, 2002). The duration of a contraction (expansion) phase is the number of quarters between a peak (trough) to the next trough (peak). The amplitude of a contraction (expansion) phase is the change in the series of interest from a peak (trough) to the next trough (peak).

This algorithm is in line with the methodology used by the NBER and the CEPR to date business cycles in the United States and the Euro area respectively. We apply the same methodology to date housing and mining commodity cycles. The observing period in this research is from June 2001 to December 2020 (figures 1-2).

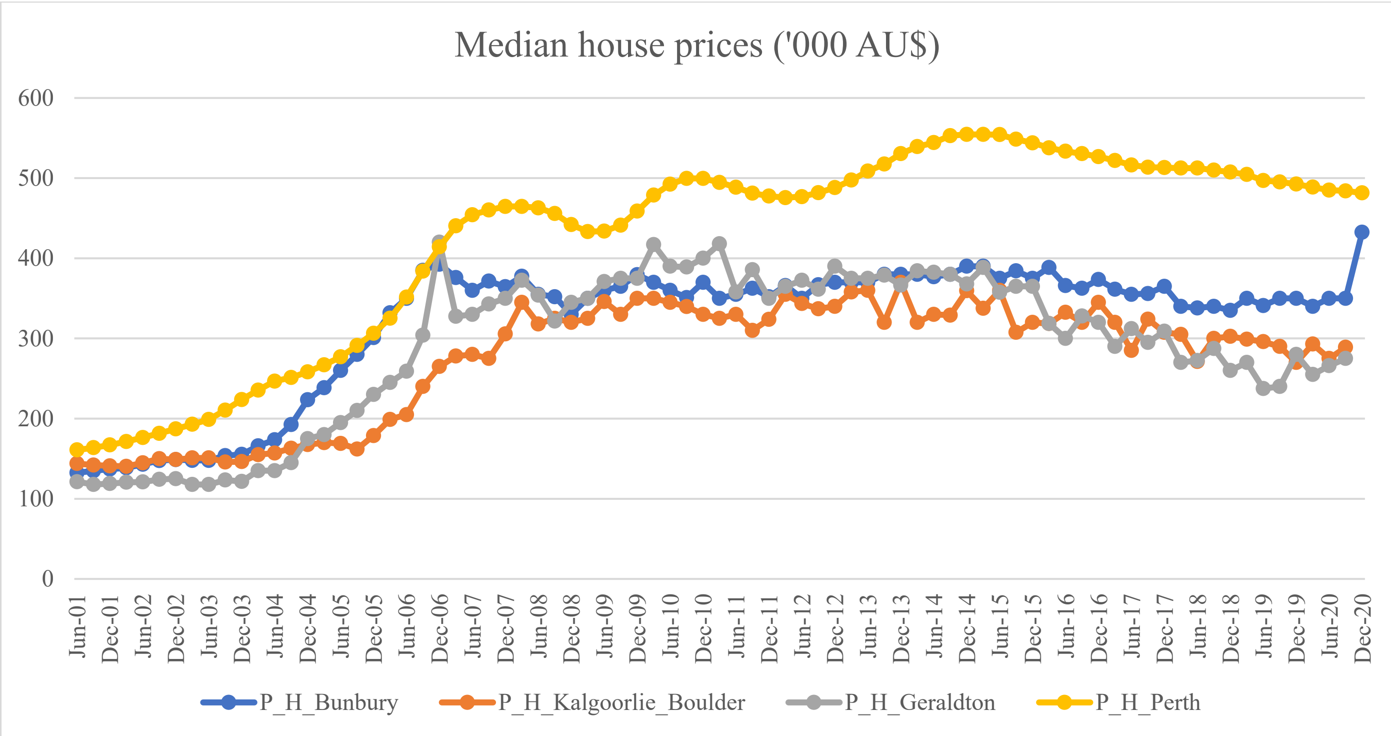

Figure 1: The median house prices in the Western Australian cities
Source: the authors

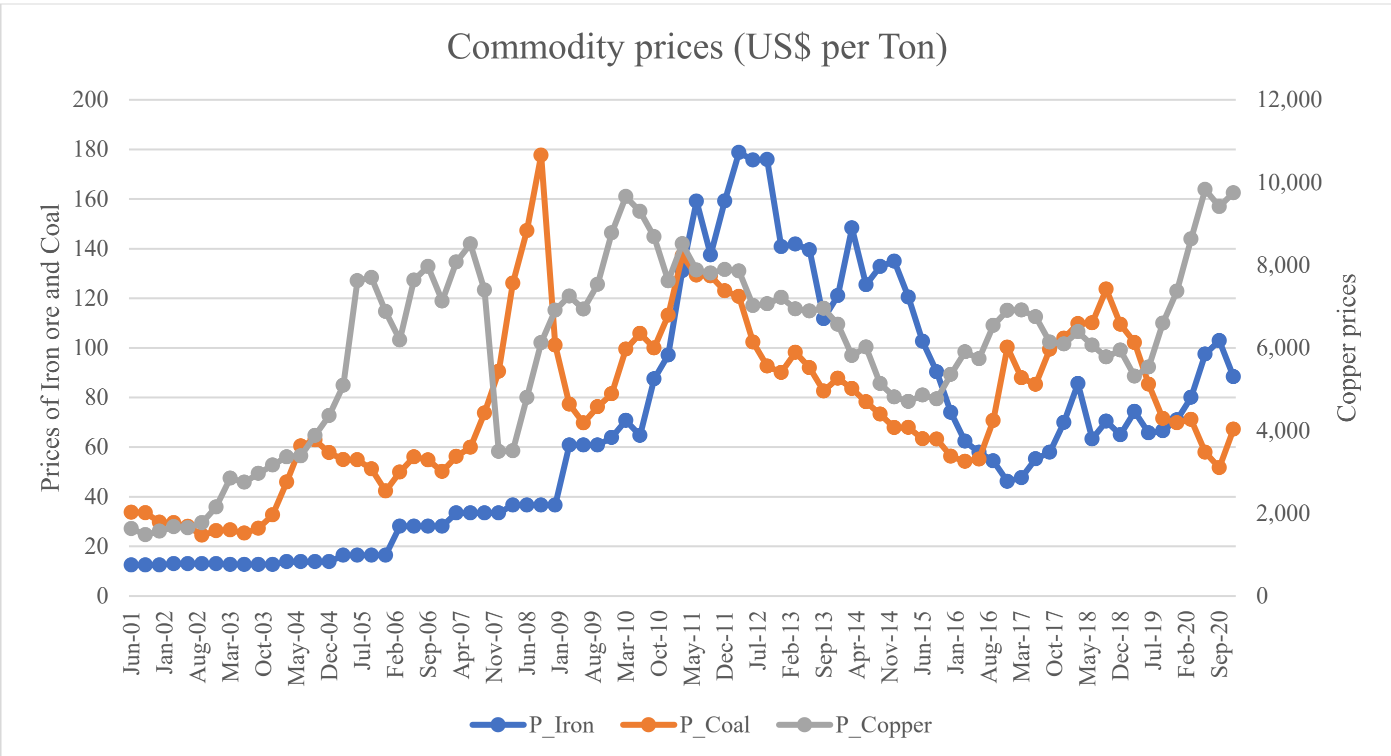

Figure 2: The commodity prices
Source: the authors

Table 1 Cycle characteristics

	Price Peak to Trough						
	HP_Bunbury	HP_Kalgoorlie_Boulder	HP_Geraldton	HP_Perth	P_Iron	P_Coal	P_Copper
Frequency	6	7	5	4	2	11	10
Average duration	11.5	10.7	12.8	22.7	31.5	7.1	7.0
Average amplitude	7.40%	10.71%	15.51%	1.75%	144.77%	14.79%	48.08%
	Price Trough to Peak						
	HP_Bunbury	HP_Kalgoorlie_Boulder	HP_Geraldton	HP_Perth	P_Iron	P_Coal	P_Copper
Frequency	7	8	8	3	7	8	11
Average duration	9.6	8.9	9.4	18.3	11.1	8.8	7.0
Average amplitude	5.69%	9.19%	23.09%	2.75%	120.44%	41.80%	26.64%

*: % changes reference to the level at the June 2000

Source: the authors

The resulting duration and amplitude of the two cycles, by city/town, are presented in Table 1. It appears that house prices in the three mining towns were relatively more volatile. A typical price cycle in these three towns consists of a contraction phase of 12 quarters and an expansion phase of 9 quarters; whereas in Perth, the cycle is significantly longer (smoother) with a contraction phase of 23 quarters and an expansion phase of 18 quarters. All mining city/towns emerge as places with asymmetric housing cycles with the contraction phase lasting much longer than the expansion phase. Such cyclical asymmetricity may relate to the structure of Australian financial system and housing markets such as the share of mortgage debt and owner-occupation. A systematic testing of these potential reasons is beyond the scope of the present stylised facts analysis, and would be an interesting topic for future research.

For commodities, Coal and Copper have similar cyclical patterns of 8.8 and 7 quarters as expansion phase and 7 quarters as contraction phase, while the iron cycle has a much longer downturn phase of 31.5 quarters. Over the down-turning period, the coal and copper prices experienced the troughs the most and second most frequently, having the shortest and second shortest average trough durations. On the other hand, the iron ore price had the least troughs, but the longest durations. The asymmetricity between the commodity prices and the housing price cycles in mining towns was noticeable in the contraction periods.

During the expansion phase, the house prices and the prices of the iron ores, copper and coal experienced similar number of peaks and length of average durations, except for the house prices in Perth. Although this descriptive analysis does not reveal any causation relations, we could tentatively argue that the regional housing prices exhibited similar expanding trends along with the iron ore, copper, and coal prices, but the house price in Perth (or big city) are influenced by broader factors, hence its property market is more elastic (hence smoother).

The average amplitude reflects the relative percentage of the average changes in the peak/trough period against the initial price level over the observation period. The findings show that the iron ore price have the highest magnitude in the price change over the booming and recession periods. The change magnitude of the coal and copper prices appear lower than that of iron ore, but higher than the house prices. This again reflects the fact that mining commodity prices are more volatile since they are influenced by global capital flows and trade.

To sum up, the commodity prices tend to have longer and more severe booming/recession periods than the housing prices. Moreover, the house prices in the bigger city appears to be more elasticate than the house prices in the reginal areas.

2. Time-series analysis

The methodological roadmap followed in this step of analysis is presented in figure 3 blow.

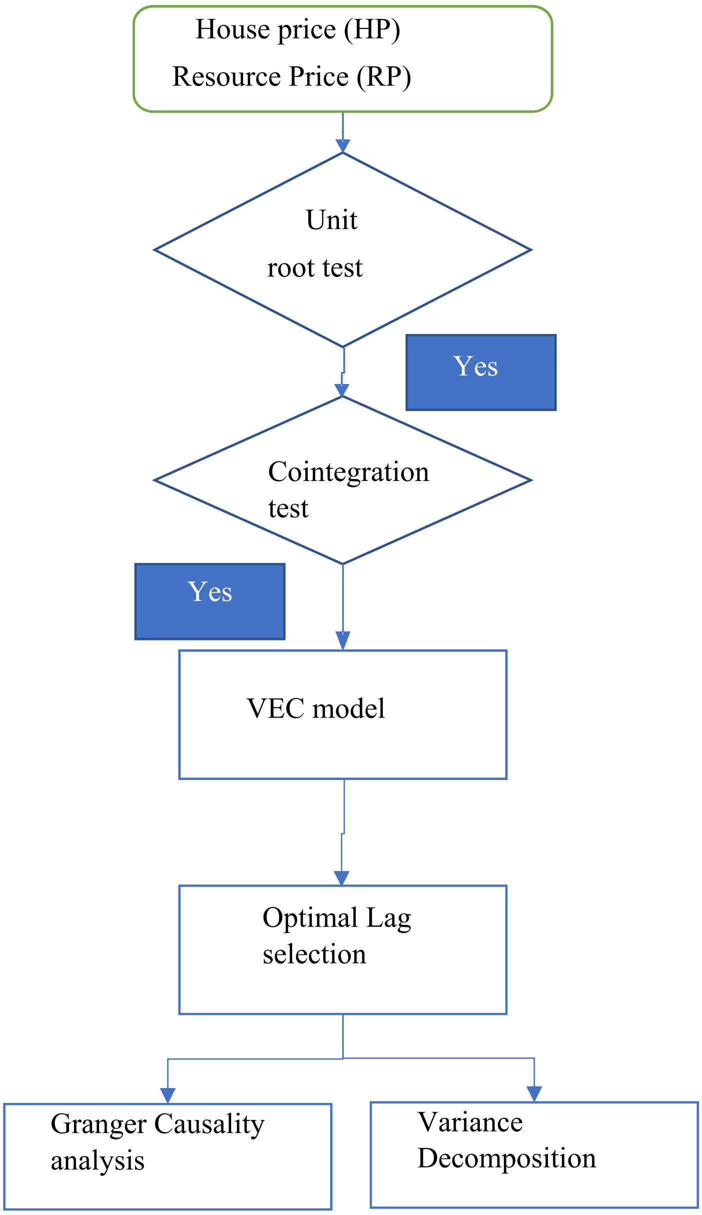

Figure 3: VEC analysis process

The Vector Error Correction (VEC) model is used to forecast the dynamic patterns along with the long-term equilibrium of economic variables, which was first developed and introduced to the economic research area by Sims (1980). A VEC model is composed by a long-run model simulating a stable equilibrium between the variables of interest, and a short-run model explaining the dynamic patterns of the variables moving towards (or away from) the equilibrium. Meanwhile, the lagged or past values of the variables are included in the short-run model to capture the temporal effects on the dynamic patterns. In the underlining study, it is assumed that the local house prices in Western Australia should have a long-run equilibrium relation with the prices of the mining commodities, namely the iron ore, copper, and coal. Meanwhile, the dynamic patterns between the house prices and the commodity prices coverage to the equilibrium. In addition to capturing the regional distinctions and interconnections, the panel regression method is employed to formulate the long-and short-run relationships between house prices and commodity prices in the four cities in WA.

2.1) Expression of the VEC model

Unit root test (see Appendix 1) showed that housing prices in the WA regions and the Iron Ore, Copper and Coal prices are not stationary at the levels but stationary at the first differences. Moreover, the cointegrations are identified among the house prices and three commodities' prices. Therefore, the panel VEC model is used to interpret the long-run and short-run relationships as the follows:

Long-run equilibrium model:

$$HP_{it} = a_{i0} + b_{i1}PIron_{i,t} + c_{i1}PCoal_{i,t} + d_{i1}PCopper_{i,t} + ecm_{it}$$

Short-run dynamic model:

$$\begin{aligned}\Delta HP_{it} = \alpha_{i0} + \rho_i ecm_{i,t-1} + \alpha_{i1}\Delta HP_{i,t-1} + \alpha_{i2}\Delta HP_{i,t-n} + \beta_{i1}\Delta PIron_{i,t-1} + \beta_{i2}\Delta PIron_{i,t-n} \\ + \gamma_{i1}\Delta PCoal_{i,t-1} + \gamma_{i2}\Delta PCoal_{i,t-n} + \delta_{i1}\Delta PCopper_{i,t-1} + \delta_{i2}\Delta PCopper_{i,t-n}\end{aligned}$$

2.2) Optimal lag selection

One of the common approaches in identifying the appropriate lag length is to re-estimate the VEC model for all variables from a possible large number of lag length (if the data are sufficient enough), then reducing the numbers one by one until zero. The optimal lag order is selected for the VEC model by three criteria, including Akaike information criterion (AIC), Schwarz criterion (SC) and Hannan–Quinn (HQ) information criterion. In each of criteria, the smallest value indicates the optimal lag. The test (see Appendix 2) shows that the optimal number of lags is 2 for the VEC model, which is expressed as:

$$\begin{aligned}\Delta HP_{it} = \alpha_{i0} + \rho_i ecm_{i,t-1} + \alpha_{i1}\Delta HP_{i,t-1} + \alpha_{i2}\Delta HP_{i,t-2} + \beta_{i1}\Delta PIron_{i,t-1} + \beta_{i2}\Delta PIron_{i,t-2} \\ + \gamma_{i1}\Delta PCoal_{i,t-1} + \gamma_{i2}\Delta PCoal_{i,t-2} + \delta_{i1}\Delta PCopper_{i,t-1} + \delta_{i2}\Delta PCopper_{i,t-2}\end{aligned}$$

The VEC model estimation is included in Appendix 3. This test supports our hypothesis 1 that mining commodity price cycles lead property cycles in mining cities/towns (by 2 quarters in our analysis).

2.3) Granger Causality Test

First proposed in 1969 (Granger 1969), The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another. Granger defined the causality relationship based on two principles: first, the cause happens prior to its effect, and second, the cause has unique information about the future values of its effect (Granger 1980). Intuitionally, we say that a variable X that evolves over time Granger-causes another evolving variable Y if predictions of the value of Y based on its own past values and on the past values of X are better than predictions of Y based only on Y's own past values.

The Granger causality test is conducted based on the specified VEC model produced in the last step, and the result is presented in table 2 below.

Table 2 Granger Causality Test results

Null Hypothesis	Bunbury	Kalgoorlie-boulder	Geraldton	Perth
P_Iron does not causality HP	0.9671	0.0951*	0.6792	0.0477**
P_Coal does not causality HP	0.0338**	0.1263	0.9121	0.0067**
P_Copper does not causality HP	0.2331	0.0075**	0.5502	0.0038**

Note: ** and * indicates the corresponding hypothesis is rejected significantly at the critical level of 5% and 10% respectively.
Source: the authors

From the long-run perspective, the findings show that mining commodity prices tend to have the causal relationship with the house prices in the mining cities. Local variations emerge in this step as well. The house prices in Perth have significant causal relationships with all the three commodities prices. The house price in Bunbury is causally affected by the coal price while the house price in Kalgoorlie-Boulder is affected by the iron ore and copper prices; but insignificant causal relationship is found between the house price in Geraldton and the commodities prices.

This finding suggests that in the long-run, housing prices in the mining gateway cities tend to be influenced by the prices of the major minerals in the region. Price cycles of different minerals might not always go in the same direction, hence the impact of some of the cyclical movements might be concealed (or aggregated). This could potentially explain why the housing price cycle in Perth has been smoother compared to mining towns. The latter, however, tend to rely on one or a few minerals as their major economic production. The highly specialised industrial structure of many mining towns makes them vulnerable to the fluctuations of a single (or a few) mineral prices.

2.4) Variance Decomposition Analysis

The variance decomposition technique splits up the forecast error variance into components which can measure the contribution of every target variable in each of the future period (Sims 1980). It provides insight into the relationship between variables by measuring the contribution of all variables to the variance. This method is further applied to analyse the residuals of the VEC model.

As shown Figure 4, the findings are complying with the results from the Granger Causality Test. The proportion of house price in Perth that can be explained by the commodity prices (especially the copper prices) keeps increasing along with time. The finding shows that the prices of coal and copper could explain as much as over 40% of the house price in Perth after 10 periods (quarters in this study). In addition, Figure 5 shows that the explanatory power of the mining commodity prices to the house prices in the mining city/towns was less than 10% until the fifth periods. It is therefore suggestive that the mining commodity prices may not have noticeable influence on the house prices in the short run. This might be explained by the near perfect elasticity of mining commodity prices as part of the global commodity market on the one hand, and the inelastic of housing prices and their local embeddedness in the short run.

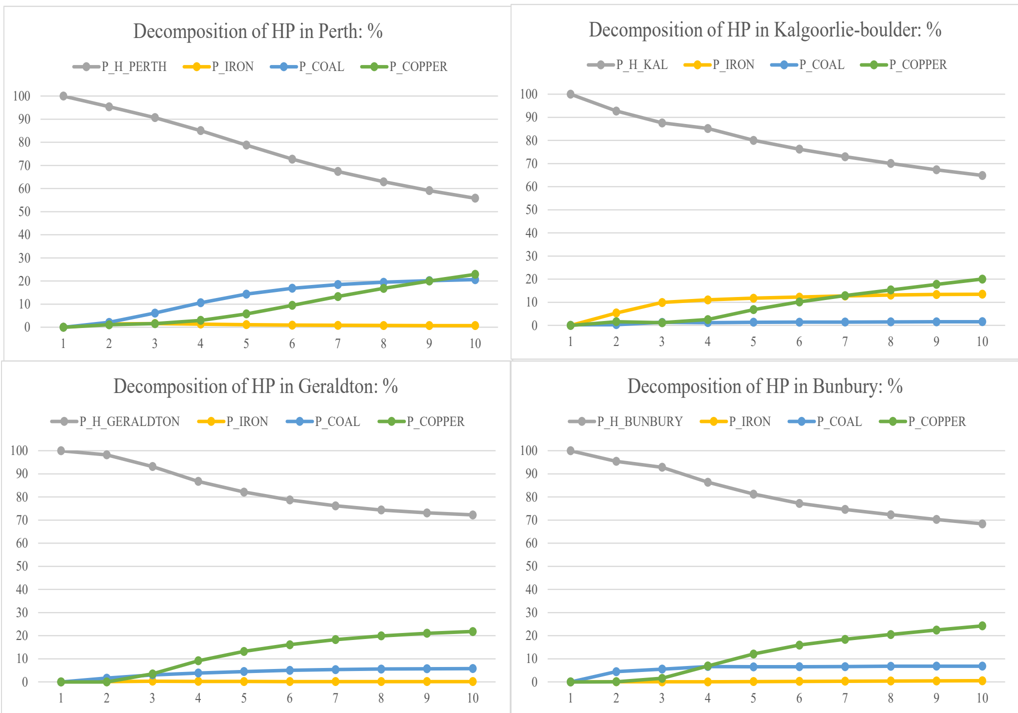

Figure 4: Variance Decomposition

Source: the authors

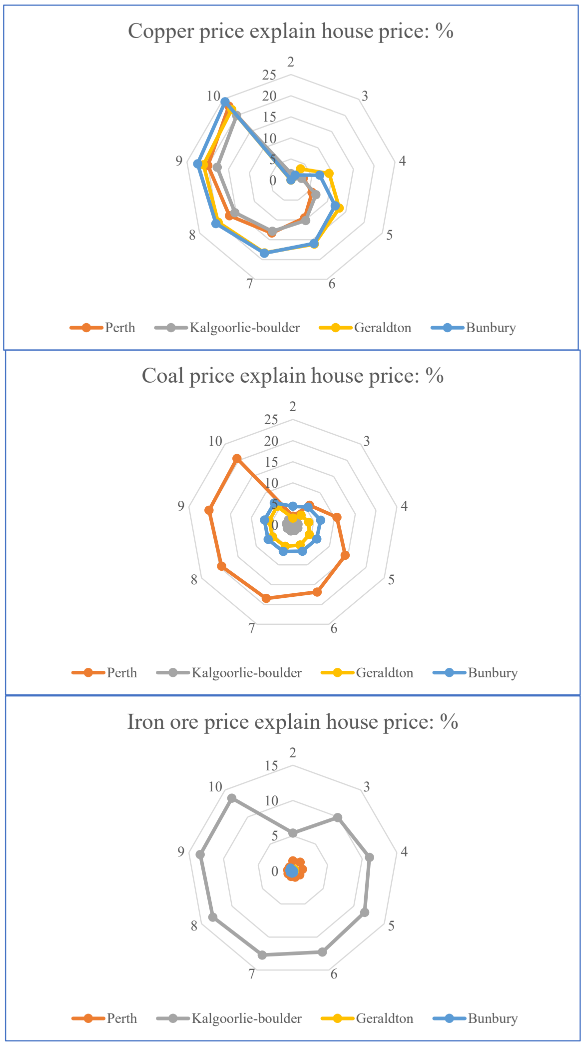

Figure 5: Explain power of the commodity prices to the house prices in the WA cities

Source: the authors

The situation of COVID, coupled with a record-high spending on resource exploration and predictions of an elongated commodities boom, might have tempered the picture. According to Domain, one of the biggest real estate agencies in Australia, the roaring housing/rental prices are being felt most acutely in Western Australia. In Port Hedland, Australia's biggest bulk export port servicing the iron ore mines inland, rents have soared by 45.4 per cent to a weekly median of $618. This is followed by Broome, booming with offshore oil and gas, where rental price has increased by 36.4 per cent to $750 a week. Comparatively, rental price in Perth has risen by 13.9 per cent in a year (Williams 2021). The sharp increase of rental costs in these remote mining towns is a direct result of severe imbalance between demand and supply. On the one hand, fly-in-fly-out workers were told they had to come and stay because of state border closures in Western Australia. On the other, new housing supply (especially family homes) in these mining towns has been lagging for a long time due to the lack of qualified builders servicing the regional areas and the high cost of transporting materials. Moreover, the pool of homes for rent is drying up as many homeowners are selling because of the high property prices, making the situation for tenants even more dire. To further identify the potential drivers for such skyrocketing housing prices, hedonic analysis is conduced below.

3. Hedonic analysis and Comparison across regions

As a first-step explorative analysis, hedonic model is used to unpack the influential factors on housing prices in mining towns. 902 and 686 sales have been manually collected from one of Australia's biggest real estate transaction agencies, www.realestate.com.au, between June 2019 and May 2021 for Geraldton and Kalgoorlie-Boulder respectively. The relatively short transaction data we use means that this analysis is only for exploration, and more thorough studies with longer and wider datasets are needed.

A Hedonic model is a revealed preference method of estimating the demand for a good, or equivalently its value to consumers. It breaks down the item being researched into its constituent characteristics, and obtains estimates of the contributory value of each characteristic. This requires that the composite good being valued can be reduced to its constituent parts and the market values of those constituent parts. There are of course limitations with this method. For example, one assumption of the model is that everyone should have prior knowledge of the potential positive and negative externalities that are associated with purchasing the real estate property. This assumption, however, is generally seen as unrealistic. Moreover, this method estimates people's willingness to pay for the supposed variation in environmental qualities and their consequences. However, if the people are unaware of the relation between the environmental qualities and their benefits to them or the property, then the value will not be reflected in the price of the property. Bearing these limitations in mind, our analysis intends to offer a can-opener for more thorough statistical analysis in the future.

3.1) Descriptive analysis

The descriptive statistics are presented in table 3.

It shows that: first, none of the series of data are normal distribution. Second, the common types of houses in the two regions are similar to each other: i.e. 4 bedrooms, 2 bathrooms, 2 garages, and with the land size around 800 square meters. Third, the median house prices in the two regions stand at a relatively lower level compared to the prices in other regions across Australia. The median sales price in Kalgoorlie-Boulder is $40,000 higher than the price in Geraldton; and Four, House market in Geraldton contains more properties with extremely larger land than the market in Kalgoorlie, where the mean of the land size (3,592 sqm) is much lager than the median (810 sqm) in Geraldton.

The two cases in our study, therefore, have not experienced soaring housing prices as showed in other parts of Western Australia as reported by Domain. Nonetheless, house prices are on the rise in both Kalgoorlie-Boulder and Geraldton, which recorded an annual increase rate of 12.8 per cent and 25.5 per cent in 2021 (Pamintuan-jara 2021).

Table 3 Summary of descriptive statistics

Geraldton

	SOLD_PRICE	NUMBER_OF_BEDROOM	NUMBER_OF_BATHROOM	NUMBER_OF_GARAGE	LAND_SIZE (m^2)
Mean	311,716.10	3.57	1.61	2.20	3,592.69
Median	300,000	4	2	2	810
Maximum	9200,00	10	10	12	18,2500
Minimum	3,000	1	1	1	68
Std. Dev.	156,865.2	0.7340	0.6264	1.2308	1,4736.46
Skewness	0.7356	1.0075	2.9471	3.5638	8.4476
Jarque-Bera	124.8133	1961.992	47,786.62	15,610.78	250,539.7
Probability	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	901	901	901	901	901

Kalgoorlie-Boulder

	SOLD_PRICE	NUMBER_OF_BEDROOM	NUMBER_OF_BATHROOM	NUMBER_OF_GARAGE	LAND_SIZE
Mean	349,299.9	3.6	1.6	1.8	801.4
Median	340,000	4	2	2	820
Maximum	950,000	6	4	8	5,500
Minimum	50,000	1	1	1	89
Std. Dev.	137,407.2000	0.6867	0.5435	0.8169	382.0261
Skewness	0.7725	0.2161	0.1172	2.8240	4.6800
Jarque-Bera	95.3361	22.0440	3.9078	5,917.1270	50,133.7700
Probability	0.0000	0.0000	0.1417	0.0000	0.0000
Observations	475	475	475	475	475

Source: the authors

3.2) Hedonic-price model estimation

The Hedonic model is used to interpret the recent sales prices of the houses in Geraldton and Kalgoolie-Boulder. The model is expressed as

$$HP = c + \alpha_1 * No.of\ Bedrooms + \alpha_2 * No.of\ Bathroom + \alpha_3 * No.of\ Garages + \alpha_4 * Land\ szie + \alpha_5 * Lifecycle\ Iron + \alpha_6 * Lifecycle\ Coal + \alpha_7 * Lifecycle\ Copper + \ \alpha_8 Covid$$

The price cycles of Iron Ore, Coal and Copper are included in the model in the format of dummy variables. Specially, we assume the variables take the value of '1' if the mining prices are at their peak quarters (as identified in the Descriptive Analysis of the Price Cycles) when a particular house sale occurs, and the value of '-1' if the mining prices are at the trough quarters. Otherwise, we allocate '0' to the dummy variables.

$$Lifecycle \begin{cases} = 1,\ if\ the\ Iron\ Ore\ (Coal, Copper)\ price\ is\ at\ the\ Peak\ when\ the\ house\ sale\ occurs; \\ = -1,\ if\ the\ Iron\ Ore\ (Coal, Copper)\ price\ is\ at\ the\ Trough\ when\ the\ house\ sale\ occurs; \\ = 0, if\ the\ house\ sales\ occur\ other\ time\ points \end{cases}$$

Since our data series spreads across the COVID outbreak, we include a dummy variable to capture the impact of this pandemic. Taking March 2020 as the cutting-line (when Australian borders were closed to all non-residents. Four states and one territory also introduced their border restrictions as part of their responses to the COVID-19 pandemic), the variable takes the value of '1' when the transaction happened after that and '0' when before.

$$Covid \begin{cases} = 1,\ if\ the\ house\ sales\ occurs\ after\ March\ 2020 \\ = 0,\ if\ the\ house\ sales\ occurs\ before\ March\ 2020 \end{cases}$$

Table 4 summarises the estimation result.

Table 4 Hedonic model regress results

	Geraldton			*Kalgoorlie-Boulder*		
Variable	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.
Constant	-62,144.27	-2.8671	0.0042	-122,269.10	-5.1679	0.0000
NUMBER_OF_BEDROOM	35,772.31	4.6457	0.0000	43,830.06	5.7590	0.0000
NUMBER_OF_BATHROOM	99,542.70	11.0180	0.0000	110,300.70	12.0867	0.0000
NUMBER_OF_GARAGE	24,036.54	7.0088	0.0000	15,917.31	2.9612	0.0032
LAND_SIZE	1.41	5.1095	0.0000	107.89	9.1504	0.0000
COAL_PRICE_CYCLE	1,406.00	0.1414	0.8876	17,472.82	1.1889	0.2351

IRONORE_PRICE_CYCLE	8,858.24	0.6764	0.4990	13,574.50	1.2827	0.2002
COPPER_PRICE_CYCLE	11,667.29	1.0860	0.2778	1,878.95	0.1578	0.8747
COVID_EFFECT	38,314.29	4.2462	0.0000	23,456.85	2.5257	0.0119
R-squared	0.4075			0.563628		

The results show that the house prices in Geraldton and Kalgoorlie-Boulder are significantly influenced by the broader economic and environment factors (Constant and Covid effect), and the house structural factors (numbers of bedrooms, bathroom, garages, and the land size). However, the prices are hardly influenced by the cyclical movements of the mineral prices.

Specifically, the major and significant contributors to the house prices are the structural factors of the properties in the reginal areas in the WA. Meanwhile, the influential magnitudes of the land sizes (1.42/sqm and 107.87/sqm in Geraldton and Kalgoorlie-Boulder respectively) are relatively small in comparison. Since it is the land that tends to hold/appreciate its value whereas the price of housing structures is depreciating along time, our regression result seems to suggest that the local housing transactions are primarily driven by the use value of housing rather than for economic returns. In addition, the negative coefficients of the constant indicate that the broad social and economic conditions of the remote regions (transportation, infrastructure, amenity, public services, etc.) might have dragged down the local housing prices significantly. It is suggestive that the investment capacity of the local housing markets in the WA regional areas has not been fully developed yet. The stagnant local housing market might have further discouraged housing supply and related investment, exacerbated market inelasticity, and aggravated speculative opportunities/behaviours. Therefore, it can be argued that the existing regional development vision and policy should be reviewed and improved to enhance the broad local social and economic quality and dynamics.

The large magnitude and significant coefficient of the COVID dummy variable in both cases might be caused by multiple reasons. First of all, there are now needs for FIFO workers to live in these mining towns due to the regional border control measures. As a mitigation measure, there is growing desire of mining companies to have a more localised workforce (Pamintuan-jara 2021). Secondly, more people might be willing to move out of the densely populated urban areas to live in regional Australia. There was a two percent increase of the number of capital city residents moving to regional areas during the September quarter in 2021 for example (Commonwealth Bank of Australia 2021). The possibility of working-from-home also facilitate this process. Thirdly, a certain level of speculation might be occurring in the local housing markets since the outbreak of COVID. The urgence of hedging against investment risks and the relatively lower price level in the regional area of WA makes it a haven for both national and international investors. From a short-to-median term perspective, it can be expected that more capital may come into the regional housing market. This could augment the local revenue and give the local governments an opportunity to deliver certain community and infrastructure upgrade. It is nonetheless advisable for the local governments to focus on long-term, strategic investments instead of adopting a fixer-upper approach.

The insignificant coefficients of the mining commodity price cycles are in line with our VEC model estimation result in showing that, the short-term cyclical movements of mineral prices do not have significant impact on local housing prices. In other words, the boom of the mining industry in WA might have attracted increasing capital and human resources to its gateway city (Perth), but failed to spread the benefits to remote regional towns effectively. Adding the effect of COVID might have further shadowed the influence of commodity cycles in mining towns. It is suggested that more meticulous analysis is needed to trace and compare the impact of commodity price cycles and COVID in the future.

Summary

In this research we have tried to generate evidence to guide policy addressing housing affordability challenges in resource-based communities. Specific questions addressed are: first, what are the connections between housing and mining commodity price cycles in Australia? and second, how are such macro-cycles manifested on regional and local levels?

Our descriptive and statistical analyses show that there is a long-run, stable relationship between housing prices in mining city/towns (examples from Western Australia) and the mining commodity price cycles (e.g., Iron, Coal, and Copper). The explanative power of the commodity prices for the house prices appears to be weak in the short term (around 1 year), but is increasing and maintains at a relatively high level (20-25%) after 2.5 years. Copper in particular, emerged as the key mineral that could explain a substantial proportion of the housing prices in the observing mining cities.

In particular, all three mining prices were found to Granger-cause the changing housing prices of Perth, and the prices of coal and copper could explain as much as over 40% of the house price in Perth after 10 periods. The housing prices of the three mining towns, in comparison, were found to causally relate to one or two mineral prices, reflecting their economic speciality.

From a short-run perspective (cross-sectional analysis), the commodity price trends were found not to influence the prices of local housing sales in remote mining towns significantly. Yet in observation, they were under upward pressure when mining commodity cycles were in expansion. Relatively, the aggregate environment (economic or social), like COVID, is found to have played a more significant role in the house prices of mining towns.

Some key policy implications from this report are:

- It is important to improve the broad physical, economic and social conditions of remote mining communities in order to make them attractive as residential/working places and to dynamise their local housing markets.
- It is important to think strategically and long-term for these mining towns' revitalisation instead of resorting to quick fix-up solutions.
- Diversifying local economic basis in these regional mining towns might be a potential solution to increase their housing market elasticity and efficiency.
- COVID-assist measures might have wider and unexpected side-effects on the capital city and regional housing markets, which warrants a holistic analysis.

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Appendix 1: Unit root test results

	Level	First difference
HP_Bunbury	0.9737	0.0039
HP_KALGOORLIE_BOULDER	0.8694	0.0000
HP_GERALDTON	0.7644	0.0000
HP_PERTH	0.8368	0.0554
COAL Price	0.4626	0.0000
IRON Ore Price	0.6105	0.0000

Appendix 2: **Optimal lag selection test**

		AIC	SC	HQ
Bunbury	Lag 1	24.6452	25.0276	24.7973
	Lag 2	24.7416	25.4108	25.0077
	Lag 3	24.7993	25.7554	25.1795
Kalgoorlie-boulder	Lag 1	24.9793*	25.3647*	25.1324*
	Lag 2	25.0660	25.7405	25.3339
	Lag 3	25.0217	25.9853	25.4045
Geraldton	Lag 1	25.6851*	26.0705*	25.8382*
	Lag 2	25.9015	26.5761	26.1695
	Lag 3	25.9996	26.9633	26.3824
Perth	Lag 1	21.9252	22.3076*	22.0773
	Lag 2	21.7593*	22.4286	22.0254*
	Lag 3	21.7755	22.7315	22.1557

Note: AIC: Akaike information criterion; SC: Schwarz information criterion; and HQ: Hannan-Quinn information criterion

The tests results show that the optimal lag number for the VEC model in Perth should be 2; while the optimal lag number for the VEC model in the other cities should 1. To maintain the comparing consistency, this research chooses 2 lags.

Appendix 3: VEC model estimations

The estimation for Bunbury

Cointegrating Eq:	CointEq1			
P_H_BUNBURY(-1)	1			
P_IRON(-1)	0.635868			
Standard error	-0.24301			
t-statistics	[2.61660]			
P_COAL(-1)	0.190907			
Standard error	-0.39572			
t-statistics	[0.48243]			
P_COPPER(-1)	-0.055909			
Standard error	-0.00573			
t-statistics	[-9.75817]			
C	-39.62809			
Error Correction:	D(P_H_BUNBURY)	D(P_IRON)	D(P_COAL)	D(P_COPPER)
CointEq1	-0.080631	-0.08708	-0.077494	3.246299
Standard error	-0.02893	-0.02363	-0.02624	-1.49778
t-statistics	[-2.78686]	[-3.68447]	[-2.95344]	[2.16741]
D(P_H_BUNBURY(-1))	-0.021502	-0.098253	-0.12114	3.707633
Standard error	-0.13878	-0.11337	-0.12586	-7.18436
t-statistics	[-0.15494]	[-0.86668]	[-0.96251]	[0.51607]
D(P_H_BUNBURY(-2))	0.280297	0.006573	0.049572	22.25885
Standard error	-0.13274	-0.10844	-0.12038	-6.87193
t-statistics	[2.11155]	[0.06062]	[0.41178]	[3.23910]
D(P_IRON(-1))	-0.02969	-0.093487	-0.211113	6.54718
Standard error	-0.14618	-0.11941	-0.13257	-7.56734
t-statistics	[-0.20311]	[-0.78291]	[-1.59249]	[0.86519]
D(P_IRON(-2))	-0.024897	-0.110938	-0.044151	3.631847
Standard error	-0.14556	-0.11891	-0.13201	-7.53551
t-statistics	[-0.17104]	[-0.93297]	[-0.33445]	[0.48196]
D(P_COAL(-1))	-0.309331	-0.062792	0.149925	0.485363

Standard error	-0.12768	-0.1043	-0.11579	-6.60979
t-statistics	[-2.42269]	[-0.60203]	[1.29477]	[0.07343]
D(P_COAL(-2))	-0.033899	0.084504	-0.077627	-2.16968
Standard error	-0.12832	-0.10482	-0.11637	-6.64285
t-statistics	[-0.26418]	[0.80617]	[-0.66706]	[-0.32662]
D(P_COPPER(-1))	-0.003713	-0.00252	-0.00701	0.39927
Standard error	-0.0023	-0.00188	-0.00208	-0.11889
t-statistics	[-1.61682]	[-1.34332]	[-3.36588]	[3.35835]
D(P_COPPER(-2))	-0.001633	-0.004543	-0.007205	-0.075601
Standard error	-0.00273	-0.00223	-0.00248	-0.14142
t-statistics	[-0.59787]	[-2.03561]	[-2.90843]	[-0.53459]
C	3.858365	2.23577	2.493628	-11.33966
Standard error	-1.82447	-1.49037	-1.65459	-94.4492
t-statistics	[2.11479]	[1.50014]	[1.50709]	[-0.12006]
R-squared	0.289375	0.195592	0.283015	0.265432
Adj. R-squared	0.192471	0.0859	0.185244	0.165264

The estimation for Geraldton

Cointegrating Eq:	CointEq1			
P_H_GERALDTON(-1)	1			
P_IRON(-1)	13.02453			
Standard error	-5.70943			
t-statistics	[2.28123]			
P_COAL(-1)	33.42591			
Standard error	-8.96327			
t-statistics	[3.72921]			
P_COPPER(-1)	-0.661453			
Standard error	-0.13614			
t-statistics	[-4.85863]			
C	224.7399			
Error Correction:	D(P_H_GERALDTON)	D(P_IRON)	D(P_COAL)	D(P_COPPER)
CointEq1	-0.006715	-0.001547	-0.00568	0.123994
Standard error	-0.00263	-0.00132	-0.00126	-0.08199
t-statistics	[-2.55347]	[-1.16990]	[-4.51349]	[1.51230]
D(P_H_GERALDTON(-1))	-0.422246	0.048019	0.004747	5.540305
Standard error	-0.12122	-0.06096	-0.05801	-3.77957
t-statistics	[-3.48329]	[0.78770]	[0.08184]	[1.46586]
D(P_H_GERALDTON(-2))	-0.17838	0.023326	-0.064179	7.408443
Standard error	-0.12154	-0.06112	-0.05816	-3.7895
t-statistics	[-1.46768]	[0.38164]	[-1.10345]	[1.95499]
D(P_IRON(-1))	0.158288	0.053398	-0.079448	-1.132779
Standard error	-0.24197	-0.12169	-0.1158	-7.54447
t-statistics	[0.65416]	[0.43882]	[-0.68611]	[-0.15015]
D(P_IRON(-2))	0.134143	0.03821	0.019593	-2.48793
Standard error	-0.24622	-0.12382	-0.11783	-7.67682
t-statistics	[0.54482]	[0.30859]	[0.16628]	[-0.32408]
D(P_COAL(-1))	-0.091059	-0.040078	0.17418	-3.665594
Standard error	-0.22151	-0.1114	-0.106	-6.9066
t-statistics	[-0.41108]	[-0.35977]	[1.64313]	[-0.53074]

D(P_COAL(-2))	-0.005607	0.132779	0.073589	-0.884781
Standard error	-0.21658	-0.10892	-0.10364	-6.75279
t-statistics	[-0.02589]	[1.21909]	[0.71002]	[-0.13102]
D(P_COPPER(-1))	-0.003932	-0.000427	-0.006124	0.377955
Standard error	-0.00389	-0.00195	-0.00186	-0.12118
t-statistics	[-1.01163]	[-0.21868]	[-3.29272]	[3.11908]
D(P_COPPER(-2))	0.002375	-0.000672	-0.00812	-0.182691
Standard error	-0.00444	-0.00223	-0.00212	-0.13841
t-statistics	[0.53496]	[-0.30095]	[-3.82216]	[-1.31993]
C	3.180495	1.031981	1.817322	60.667
Standard error	-2.99459	-1.50596	-1.43306	-93.3692
t-statistics	[1.06208]	[0.68526]	[1.26814]	[0.64975]
R-squared	0.236833	0.060882	0.389422	0.196322
Adj. R-squared	0.131164	-0.069149	0.304881	0.085043

The estimation for Kalgoorlie-boulder

Cointegrating Eq:	CointEq1			
P_H_KAL(-1)	1			
P_IRON(-1)	1.215961			
Standard error	-0.46134			
t-statistics	[2.63573]			
P_COAL(-1)	-0.146323			
Standard error	-0.74217			
t-statistics	[-0.19716]			
P_COPPER(-1)	-0.061068			
Standard error	-0.01098			
t-statistics	[-5.56109]			
C	20.60404			
Error Correction:	D(P_H_KAL)	D(P_IRON)	D(P_COAL)	D(P_COPPER)
CointEq1	-0.079339	-0.054655	-0.045076	1.069286
Standard error	-0.02194	-0.01502	-0.01691	-1.03817
t-statistics	[-3.61640]	[-3.63944]	[-2.66602]	[1.02997]
D(P_H_KAL(-1))	-0.45379	-0.004624	-0.079777	4.158031
Standard error	-0.11371	-0.07784	-0.08764	-5.38096
t-statistics	[-3.99073]	[-0.05941]	[-0.91033]	[0.77273]
D(P_H_KAL(-2))	0.020774	-0.15875	0.081369	8.119005
Standard error	-0.11449	-0.07837	-0.08823	-5.41772
t-statistics	[0.18146]	[-2.02569]	[0.92219]	[1.49860]
D(P_IRON(-1))	-0.278702	0.001006	-0.158751	-1.152717
Standard error	-0.16673	-0.11413	-0.1285	-7.88988
t-statistics	[-1.67158]	[0.00881]	[-1.23545]	[-0.14610]
D(P_IRON(-2))	-0.230101	-0.021081	-0.066877	-1.165468
Standard error	-0.17035	-0.11661	-0.13129	-8.06125
t-statistics	[-1.35075]	[-0.18078]	[-0.50940]	[-0.14458]
D(P_COAL(-1))	0.074878	-0.121717	0.146584	0.227918
Standard error	-0.15122	-0.10352	-0.11655	-7.15615
t-statistics	[0.49514]	[-1.17584]	[1.25773]	[0.03185]
D(P_COAL(-2))	-0.29316	0.130534	-0.06569	-2.753784
Standard error	-0.14411	-0.09865	-0.11107	-6.81968

t-statistics	[-2.03422]	[1.32323]	[-0.59145]	[-0.40380]
D(P_COPPER(-1))	-0.00789	-0.001968	-0.006174	0.370048
Standard error	-0.00265	-0.00181	-0.00204	-0.12519
t-statistics	[-2.98241]	[-1.08666]	[-3.02809]	[2.95585]
D(P_COPPER(-2))	-0.002492	-0.003689	-0.0065	-0.173963
Standard error	-0.00311	-0.00213	-0.0024	-0.14734
t-statistics	[-0.80041]	[-1.73108]	[-2.70878]	[-1.18069]
C	4.492991	2.08614	1.792426	59.87837
Standard error	-2.04077	-1.39693	-1.57279	-96.5721
t-statistics	[2.20162]	[1.49337]	[1.13965]	[0.62004]
R-squared	0.376932	0.219381	0.289531	0.169439
Adj. R-squared	0.290661	0.111295	0.191158	0.054438

The estimation for Perth

Cointegrating Eq:	CointEq1			
P_H_PERTH(-1)	1			
P_IRON(-1)	1.305488			
Standard error	-0.46534			
t-statistics	[2.80544]			
P_COAL(-1)	1.56534			
Standard error	-0.86536			
t-statistics	[1.80889]			
P_COPPER(-1)	-0.08889			
Standard error	-0.01226			
t-statistics	[-7.25306]			
C	-97.92403			
Error Correction:	D(P_H_PERTH)	D(P_IRON)	D(P_COAL)	D(P_COPPER)
CointEq1	-0.011958	-0.04708	-0.0416	-0.01394
Standard error	-0.00338	-0.01319	-0.01423	-0.87309
t-statistics	[-3.53826]	[-3.56866]	[-2.92306]	[-0.01596]
D(P_H_PERTH(-1))	1.21259	-0.63632	0.296995	42.61971
Standard error	-0.09745	-0.38042	-0.41037	-25.1753
t-statistics	[12.4430]	[-1.67268]	[0.72372]	[1.69292]
D(P_H_PERTH(-2))	-0.440484	0.126947	-0.45102	-53.2083
Standard error	-0.09508	-0.37116	-0.40039	-24.5626
t-statistics	[-4.63279]	[0.34203]	[-1.12645]	[-2.16624]
D(P_IRON(-1))	-0.068311	-0.063	-0.17975	-1.15296
Standard error	-0.03016	-0.11772	-0.12699	-7.79064
t-statistics	[-2.26518]	[-0.53517]	[-1.41542]	[-0.14799]
D(P_IRON(-2))	0.027828	-0.11636	-0.02381	-0.58226
Standard error	-0.03073	-0.11995	-0.12939	-7.93777
t-statistics	[0.90567]	[-0.97010]	[-0.18398]	[-0.07335]
D(P_COAL(-1))	-0.06957	-0.00364	0.142521	-0.31151
Standard error	-0.02713	-0.1059	-0.11424	-7.00826
t-statistics	[-2.56447]	[-0.03441]	[1.24756]	[-0.04445]
D(P_COAL(-2))	-0.037387	0.150267	0.053929	4.09721

Standard error	-0.02754	-0.10751	-0.11598	-7.11492
t-statistics	[-1.35749]	[1.39768]	[0.46499]	[0.57586]
D(P_COPPER(-1))	-0.0000287	-0.00251	-0.00713	0.276484
Standard error	-0.0005	-0.00194	-0.00209	-0.12823
t-statistics	[-0.05775]	[-1.29479]	[-3.41305]	[2.15618]
D(P_COPPER(-2))	-0.001862	-0.00384	-0.00742	-0.27914
Standard error	-0.00056	-0.00218	-0.00235	-0.14419
t-statistics	[-3.33514]	[-1.76374]	[-3.15465]	[-1.93586]
C	1.187706	3.974533	2.899801	157.0741
Standard error	-0.45037	-1.75807	-1.89652	-116.346
t-statistics	[2.63720]	[2.26073]	[1.52901]	[1.35006]
R-squared	0.908684	0.180602	0.310432	0.184028
Adj. R-squared	0.896231	0.068866	0.216399	0.072759