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Housing Markets and Resource Sector Fluctuations: A Cross-Border Comparative Analysis

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Abstract: Recent research has sought to better understand resource and housing market cycles longitudinally and define clear phases in order to understand interactions between the two over time. This is a necessary step forward in housing market knowledge for this under researched area, particularly in an economically unique context. This paper expands knowledge by undertaking a comparative study of town housing markets in Queensland's coal mining Bowen Basin and Sweden's northern municipalities—specifically Gallivare and Kiruna—where a long history of iron ore mining exists. This paper analyses these housing markets using longitudinal data spanning two decades, which includes two resources cycles in two geographically disparate locations. The results indicate that the housing market in Queensland, Australia, is far more volatile than the housing market in the Swedish municipalities. The regional housing market in Sweden's municipalities tend to be less dependent on resource price and output from mines than their Australian counterparts. Part of the explanation for this is that the Swedish towns examined are less of the traditional mining town known from previous studies, and more a town with mining. Developing and improving understanding of markets over the duration of a cycle is important. Particular value is apparent in the comparison and contrasting of two separate resource regions encompassing resource reliant communities in two different countries. Importantly, the linkage of research regions through resource relationships leads to groundbreaking research which will have practical benefit to multiple economies, housing markets and for policy-makers alike.

Keywords: mining towns; volatility; housing markets; Australia; Sweden

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1. Introduction

Volatility in the resources sector, particularly since the turn of the century, has driven discourse and research into housing markets, investment opportunities and socioeconomic change in Australian resource towns. This volatility has come from rapid shifts in demand for both coal and iron ore over short periods of time [1]. Subsequently, fluctuations in market values drove industry contractions and expansions, leading to broad reaching socioeconomic changes in towns and regions supporting mining activity [2,3]. International research has shown that even in established mining towns, little is known about the trajectory of housing market throughout a resources cycle, and indeed, defining a 'resources cycle' remains challenging.

There is consideration given in this research to important publications that have examined other types of resource communities and resource cycles. It is posited that the cross-over between resources is considerable with respect to their overall patterns of growth; for the economic implications this has, particularly on housing markets, see [4] who, in their analysis of gas industry impacts introduce the concept of the industry-community interface. Moreover, improved understanding of the economic impacts of mining would appear an important early-stage consideration in economic theory, and has connotations for

housing market analysis [5]. However, this research contends that a more focused analysis on housing market dynamics is often needed as broader analysis has modelled longer term relationships—it is not implausible to see the peak of a cycle pushing up rents and sale values. However, we know in Australia that the decline following this peak rarely mirrors of the growth of the boom phase. Importantly, economic modelling does not provide an overview of the socioeconomic trickle-down impacts of a disrupted property market.

Australia's economic reliance on the resource sector and sequential boom periods that affected Western Australia's iron ore regions and, later, Queensland's coal mining regions generated considerable media interest, examining issues at a certain point—usually peaks or troughs [6], while academic researchers sought to better understand the complex relationships between variables during resource-driven change [7]. Recent research into Australian mining towns showed that there were significant knowledge gaps relating longitudinal analysis of how housing and mining interacted. This is of course important when considering that these are both cyclical in nature. A very small amount of recent research, in Australia or other international settings, has focused on the interplay of cycles, save for perhaps the seminal work of [2], who drove the idea of a 'roller coaster' type cycle representing the mining town throughout the phases of a cycle.

The resurgence of mining in Australia following the year 2000 reinforces the need for an increase in research in this area. Many considered the iron ore and subsequent coal 'booms' the most significant since the gold rush [8] and, from an economic perspective, in need of increased understanding and analysis. The need to establish models or metrics that can be applied to differing resource communities is an important step forward in understanding cyclical interactions and the implications for housing in the short, medium and long term relative to resource volatility.

Sweden also has a rich tradition of resource reliance and mining; as a major European producer of resources, iron ore in particular, the economy is reliant on the mining and ancillary industry [9]. In this geographical setting, too, little research has been undertaken examining housing markets exposed to resource cycles, or even more broadly, towns and communities that were unique in their key economic drivers. Hence, this research will allow for the establishment of knowledge in the setting of Sweden's major resource producing towns and their housing markets, while also establishing baseline measures that will propagate cross-border, multi-dimensional analysis drawing in Australian coal mining towns in Queensland, ipso facto, adding to collective knowledge around unique housing markets. This comparative study will deepen understanding of these unique housing markets, but is also important in exploring the linkages between international resource markets and economic cycles.

2. Background and Context

2.1. Previous Studies and Justification

The evidence from countries in which single-industry resource towns are predominant is that using a longitudinal study will greatly increase the quality of the research and also the outcomes for the community [10]. Development of a narrative around community wellbeing is greatly improved by studies that explore the community in light of changes to the underlying resource base and the town's position in the cycle, but also relative to a myriad of other variables that indicate change over time [11].

Literature from international resource communities and regions has shown that management is critical for a town, community or region reliant on exhaustible resources [12]. The emphasis on a management approach from government, private industry and individuals has been discussed in a number of resource contexts, and in both emerging and developed economies [13,14]. Increasingly, academic research is exploring management and operational approaches that includes all stakeholders, and has been identified as critical to successful socioeconomic outcomes in these communities [15–17]. Research from countries that have a historic reliance on varying resource bases has illustrated that manage-

ment of the community will impact on the town's trajectory throughout the resources cycle, and plays a role in the post-boom trajectory, particularly in the 'recycling' of a town [18].

There is more updated research that has addressed new mining approaches and the complexity of economic interactions around mining and housing, particularly where resource cycles are presenting volatility. The review of mining impacts economically and extending analysis to understand how these economic fluctuations impact mining regions is an important analytical consideration [19]. These researchers examined the knock-on effects on household economics (cost to hold, spending and saving) following positive economic effects associated with emergent resource sector activity linking increased production linked to a decreased chance of mortgage default, there was a stronger indication too that during the boom the chances of a mortgage repayment being missed fell considerably.

This is not surprising considering the time frame of the above study and the assessment of properties owned 'pre-boom'. Building on concepts discussed in this paper like population movement and demographic shifts [20], it is a relatively reasonable conclusion that boom-time conditions will generally affect housing markets positively—up until demand drops, values decline or mining companies introduce new housing models [21]. Therefore, it is incumbent on the authors to extend this knowledge down to a more granular level. With an analysis that "only include (d) observations from loans that were originated prior to the discovery of shale oil and gas in a given area" [19] (p. 165) a somewhat incomplete picture of conditions is derived as there is little knowledge added to understanding of housing markets over time, but moreover, to how household and personal wealth is used in the boom phase of a cycle.

This article researches two distinct housing markets: those mining iron ore in northern regions of Sweden and those located in central Queensland's Bowen Basin, a major coal-mining region in Australia. The interconnected nature of the resources on which these regions rely makes this analysis particularly interesting, the necessity of coal in the smelting of iron ore [22] means that as economies grow and require resources to undertake construction projects demand for iron ore and coal rises, often in unison [23]. There is strong evidence of this in studies confined to Australia, which means any comparative study is particularly interesting as it will look at these two distinct resource-reliant regions over time and be able to track changes impacting on and interacting with housing markets, and will also allow the researchers to compare geographically disparate regions that produce resources that influence one another. By virtue of their complimentary resource bases, there is already an established relationship.

2.2. Critical Factors

In Australia mining towns have reported a different set of challenges stemming from rapid population movements, a changing relationship with mining companies and resources, and a shift in how mining is perceived. The rapid population variations have been found to be particularly impactful as resource markets fluctuate, whereby social, or socioeconomic change identified is occurring in addition to the changes that are driven by resource market volatility [24]. At the same time mining companies have been altering their operational praxis which has been found to be contributing to structural change in towns, meaning resource sector volatility consists of a multitude of factors, all exerting an element of change on towns and communities.

Sweden is by far the largest producer of iron ore within Europe with a market share of 90% for the past decades [25]. The production of high-grade iron ore has increased over the past decades, reaching an all-time high in 2018 [26]. According to the latest forecast, the iron ore will last until at least 2035 [27]. Mining in the Northern part of Sweden has a long tradition which dates back to the 17th century when a number of mines were opened along the Ferroscandinavian shield which is a mineral rich region in Scandinavia [28]. The current iron ore mining operations expanded rapidly from the 1890s owing to innovations within transportation and processing [29]. As with most manufacturing and extraction industries in Sweden, the mining sector was going through a period of rationalization and

streamlining starting in the 1970s, which led to massive job losses in the northernmost regions. The downturn in the world economy in the 1970s also influenced the perceptions and mood within the Northern part of Sweden [30]. From the 1990s onward, however, a strategy of attracting international investors and companies together with increased demand for minerals has fueled the local and regional economy.

Sweden's two largest iron ore mining towns, Kiruna and Gallivare, have had problems with a decreasing and ageing population for decades. The municipality of Kiruna had its largest population around the year 1975 and Gallivare peaked somewhat earlier (around the mid-1960s). Besides experiencing a declining population, both municipalities have issues with an ageing population and also and increasing gender imbalance. This is a common problem among small communities in the Swedish countryside as well [31]. Even though the mining towns of Northern Sweden have experienced difficulties they differ from the mining towns in American and Canadian research. To some extent they are a town with mines, rather than a mining town. The issue of fly-in fly-out (FIFO) commuting is less of an issue since the majority of the workforce live within an hour of commuting from the mines [31,32] Furthermore, the iron ore mines are all operated by the state-owned company LKAB that acquired all mines in the late 1950s.

In the Swedish mining towns examined, the volatility in the resources mined has not been the same as Australian towns; the iron ore mined in Sweden has benefited from stable demand within Europe. What can be seen is, in an Australian setting, resource towns are smaller, more numerous and more reactive to policy changes, while the Swedish model has developed larger towns, more replete with services and structures, which led to bigger populations and higher populations numbers. While the interaction of the resources in question is important, this analysis too will be able to examine challenges faced by a variety of town typologies and justify this study. The issues of rapid population shift in Queensland contrasted with the issues of declining and ageing population and demographic imbalance in Sweden necessitates a comparative study.

2.3. Rational Underpinning Approach

This paper will develop this emerging area of housing research by, for the first time, undertaking an international comparative study whereby housing in Australia's Bowen Basin coal mining region and housing markets in Northern Sweden's iron ore mining regions are compared and contrasted. This paper builds on the work of [31,32], which established clear relationships between mining resource regions and changing housing market dynamics. This seminal research, amongst others, illustrated that housing markets and communities were influenced by resource cycles and markets, but a complete picture of these relationships is lacking.

The rationale for this research is based on [33–35] and will explore linkages between towns and communities impacted by mineral resources. It has been shown in numerous studies of the most recent mining 'booms' in Australia that there is an implicit need to understand nuanced facts about towns and communities that are inextricably linked to the resource that a town mines. Because of this, understanding how a mining town functions over time is critical in understanding how the housing market will behave longitudinally. Previous studies [36,37] have sought to understand the housing market (or another aspect of a town) with little analysis of critical economic factors linked to its main economic influencers (resources) over time.

Extending knowledge of the economic interactions with property markets in the context of mining is an important objective of this study and also forms rationale for this study. This extends knowledge disseminated through the body of research into fracking and shale mining operations; these new extraction approaches have opened up regions previously not mined, and as a result allows for extended range of impacts analysis [33]. The emergence of these new technologies in the early 2000s also increased production of resources and drove a refreshed body of knowledge that set a tone for looking more wholistically at resource market behaviour [19].

Important ideas of resource sector specifics and their impacts on housing values were extrapolated upon by [4], who sought to understand the negative impacts of both environmental amenity loss and health risks posed by mining activities on house prices. The basis for the work carried out by [4] is rooted in the use of hedonic modelling, which reduces the scope of any economic analysis. This research builds on the work of [38], among others, who looked at impacts on land price from hazardous waste, which is useful in quantifying direct monetary impacts on property at a point in time, but ultimately struggles to meet the objective of mapping economic relationships in a mining-town context, and the outcomes in the property market over time.

Further to the importance of analysis based on economic understanding of market dynamics affected by mining, there is an imperative to consider the longer-term economic trajectory of towns that rely on exhaustible resources which are increasingly being phased out or divested from as more sustainable energy sources are developed. In light of the global strategy to reduce reliance on non-renewable energy sources such as coal, the discussion on the resource–housing interconnectivity is therefore of utmost importance for policy-makers and practitioners alike.

3. Literature Review

3.1. Understanding Resource Towns

In Australia, the notion of what a resource town is is shifting and evolving, especially in light of recent cycles and the changes that accompanied these. International researchers have examined the resource town in the context of a mining cycle more holistically and more completely. In Canada, where resource-based industry is prolific and not limited to mining, the development of a suite of research examining all facets is apparent. The bust stages of the boom and the implications of this 'wind down' on the community have been examined [39], an aspect of the most recent boom that must be further researched in an Australian setting. While Australia too has produced historical research around mining-driven growth, it has little applicability to the most recent boom due to the boom's significant structural differences.

The emergence of fracking in North American and Canada has also driven a considerable amount of recent research building on the seminal work of [40] who set out to analyze if resource abundance was good for economic growth. This question is simple, but increasingly complicated, especially as mining cycles, particularly the booms, change. It is also necessary to explore what economic growth constitutes on a local level, and how one monitors change. Notably, reference [5] used 44 years of data to track this over time, however used rental amounts, rather than house prices, in their models to look more closely at the impacts on property. Although in geographical settings there are identified challenges with rental data being either unavailable or thin in areas where mining is common [21]. Importantly, it is stated "house prices presumably capitalize expectations of future market conditions, including the future duration of a natural resource boom or bust" [5] (p. 17), which raises further questions around forecasting capacity and gaps in knowledge.

There is an overarching theme of forward-looking research carried out in the United States and Canada with a view to understanding how certain communities survived into the post-boom phase [41,42]. The notion of 'community survival' will be explored further in a modern-day Australian context, particularly by examining the idea of 'critical mass' of population, amenities and facilities in mining towns in Queensland's Bowen Basin. This idea is then extended to Gallivare and Kiruna to facilitate a comparative analysis. This concept of resource town lifecycle analysis is not new in an international setting with early research from [43] examining the growth and decline of Skagway, Alaska, as well as modern research from the region of Zasavje in Slovenia [44].

The need for longer-term, lifecycle-focused analysis of resource communities is established and researchers from Canada and the USA have illustrated the breadth of factors impactful on community wellbeing. Research in Canada [39] was some of the earliest to identify housing as a critical component of wellbeing in mining towns and a focal point

in analysis of any resource community 'winding down'. This research was followed up by [45] which identified housing as a critical resource in communities more than two decades before the first, similarly focused research was produced in an Australian context.

In general, mining towns share certain similarities with regional and rural markets, but experience a range of unique fluctuations and volatilities due to the inherent nature of resources and mining [22]. The severity of impacts is compounded for mining towns where housing and property policy has lagged, and changes within the resources sector have been significant [46]. Mining regions and towns have only received limited research highlighting critical policy considerations relating to housing supply, land release, affordable housing development, and infrastructure and amenity [47]. Critically, as social changes occur and the roles of mining companies shift, very little new policy has been developed or put in place. Research must lead the way in developing and driving policy responses to changing economies.

Increasingly pervasive is the sentiment that many mining companies are failing to contribute to the communities that are enabling their operations: "Arguing that they are paying substantial royalties to the government, companies publicly resist calls to provide infrastructure and services that they see as being the responsibility of the government" [8] (p. 376). This increasing separation of company and town is critically important in the analysis of housing markets during a resources cycle, and in particular, the post-boom phase and the wind-down of operations, as this transcends town typologies. Besides lacking in infrastructure and service development, many small mining towns have experienced problems in the post-mining era in that the landscape, including ground water, is polluted owing to the operations of the mining companies. Therefore, an important strand of research has focused on experiences of communities, post-mining, in European regions [44].

Leading research has illustrated a clear need to diversify and develop alternative industry bases, as the single-industry, resource-reliant model is not sustainable [48]. The 'hub' phenomenon has been widely reported in Australia [49] and has brought "very different regional impacts . . . as compared to earlier growth in the industry" [50] (p. 142). The proliferation of more efficient mining technologies and increasingly withdrawn private sector governance will only accelerate mining communities away from the historic model and necessitate new, future planning. In Europe, the importance of the Cohesion and Regional Fund has been emphasized as the continent has experienced numerous mine de-commissioning waves since the 1970s. The challenge has been to revitalize the often-lagging mono-economic communities across Europe, ranging from Galicia in Spain to Bohemia in the Czech Republic [51,52].

3.2. Mining Economies and Their Behaviours

The Swedish mining industry has a long and colorful history. From the 13th century onwards, the mining of precious metals has been the backbone of the Swedish economy. Regarding the number of mines, the industry peaked around 1910 with roughly 250 mines in operation. Following prolonged crisis in the 1970s with a decrease in demand and strikes in a number of mines, the current number of mines still in operation in Sweden is 12. The most important product is iron ore, but Sweden is also the largest producer of zinc and lead within the European union [25]. Unlike most international competitors, the mining of iron ore is not done in open pits in Sweden; instead the mining is currently done up to 1250 m underground. Whilst the Swedish mining communities have issues with an ageing and decreasing population, the income levels are above the Swedish average and, as of 2018, the average income in Kiruna and Gallivare is roughly 15 percent above the Swedish average.

As a considerable resource producer, there are extant studies that can be useful in forming localized knowledge for that market within this study. In research that focused specifically on Sweden's iron ore towns and regions [53], it was shown that, ultimately, in the short-medium term, expansion of mining operations and associated processing facilities was good for regional economic growth and, unsurprisingly the 'maximum production

phase' yielded the greatest number of positive knock-on effect (in terms of jobs created) within communities. Importantly, though, this long-run study used models to determine an employment multiplier for each project; however, the practical limitations of this expansion were also raised by the authors, suggesting that the full benefit of a new project would unlikely be fully realized within the community and surrounding region. This links to the current research and supports the notion that policy research is now required to understand how to manage and capitalize on mining cycles.

Research that examined Nordic regions, as part of a larger analysis, also found evidence of Dutch disease occurring due to the size of the resource sector and the operational praxis, and moreover, that income inequality was prevalent [54]. This is an important finding for the comparative analysis undertaken herein. Firstly, reference [54] undertook long run analysis for a large number of countries reliant on resources (90); general findings suggested that at the peak of booms wealth inequality was at its lowest, but quickly began to return to pre-boom levels. An Australian-context research had shown that while Dutch Disease did exist [55], peaks of cycles of accentuated inequality, and the population influx and demographic shifts at this time increased median incomes, for example, but generally resulted in a two-speed economy developing. This is an interesting analysis of differing trajectories and further reinforces the need for this comparative study.

As Australia's mineral fortunes continue to decline and the short-term economic benefits are forgotten, there is a critical need to draw on literature from a range of disciplines that relate to mining in order to make important comparisons and establish a body of knowledge for future resource cycles. The direct comparison in this research which compares Bowen Basin towns directly with Swedish iron ore communities provides further levels of contrast and analysis. This will also lead to a far more all-encompassing understanding of cycles in their entirety and will lead to modeling of housing that can fit a variety of markets.

3.3. Housing in Resource Communities

This study, which compares a range of town typologies that rely on two different, but related, resources in disparate geographical settings extends the current knowledge in numerous areas, but in particular, in understanding of housing market behaviours and their cycles in economies that are built around resources, which, too, are cyclical. This research expands the idea of interacting cycles, that is, the respective resource and the housing market, and extends Australian studies that have been carried out around the most recent resources cycle (e.g., [56,57]). By comparing complimentary resources in two geographically separated locations, this study advances the understanding of resource economies and is able to make a sound contribution around cyclical interactions, particularly in relation to housing market outcomes.

Recent research exploring economic implications of new mining technologies and the expansion of fracking operations has sought to understand the gamut of economic impacts, and this has often extended to property and housing. From these papers there is important factual understanding derived regarding the interplay between a resource sector, economic change and the housing market [32,33,54].

The emergence of socioeconomic factors as part of any mining town analysis is a critical step forward and leads into a more comprehensive review of housing markets as a critical component of mining and resource communities [58]. Increasingly, socioeconomic analysis of communities subject to resource fluctuations is being undertaken, and the importance of socioeconomic wellbeing in light of massive economic growth is being recognized [59]. Here, international research must guide this research as towns and regions move into the post-boom phase.

Research from American and Canadian researchers have focused heavily on socioeconomic wellbeing, to which housing and accommodation is fundamental [60]. Several key pieces of research identify the examination of housing as a crucial part of any broader socioeconomic analysis in the context of resource reliance [57,58,61]. The research that is discussed in the following section has examined, in far greater detail than any of the

recent Australian literature, the impacts and outcomes on communities associated with an exhaustible resource, particularly with respect to their housing markets.

The Australian Housing Urban Research Institute (AHURI) presents a strong tradition of research in non-urban areas and researchers who have contributed to AHURI papers have also examined aspects of housing markets in the resources cycle, perhaps most notably the catalogue of work by [8] confronted the complexity of housing market development and management in a strong economy, in which it was demonstrated "how unprecedented international demand for mineral resources resulted in critical, local housing issues in mining communities". In this case, it was housing stress due to uncapped demand; however, as the boom busted, the inverse was true with high vacancy rates and value loss. Critically, they conclude that, "without careful strategic planning and understanding of the economic and social role of housing, international market dynamics can create local housing situations that are vulnerable to market and social failures" [8] (p. 373).

The AHURI positioning paper 105 [62] explores housing market dynamics in the context of the cycle's boom phase. This seminal paper also examined 'housing' as it relates to remoteness and isolation in resource dependent communities; that is, housing market analysis in resource towns is not simply a relationship between two variables. This research, published at a point when commodity prices were high and rising, also examines policy intervention designed to address critical issues around development, availability and affordability [59]. Thus, pioneering the idea that while housing and mining cycles are being examined the exogenous factors which impact here are significant, and in the context of recent resource sector volatility, have been underexamined.

Development and supply of housing in mining communities in the recent boom is another way in which this boom differed from those which preceded it, further necessitating this research as FIFO commuting was increasingly common and the work camp model became preferred. Issues around housing in particular have underpinned the broader socioeconomic issues identified in the research [63,64]. Comparatively, much of the population in the Swedish mining communities are dependent on the mining operations for their income, but the housing market is not in the hands of the mining companies. The most common type of dwelling is small detached houses, followed by apartments and condominiums. Even though the prices are below the Swedish average, prices have nearly quadrupled during the investigated period, despite a decreasing population (see Figure 1 below). Figure 2 (below) illustrates the volatility experienced in Australian mining towns over the corresponding period.

The economic implications of mining camp development have been overwhelmingly negative for communities reliant on the economic inflows that increases in mining activity bring, specifically where changes to housing and management of employees reduced economic inflows into specific communities [65]. This is clear evidence of mining company operational praxis impacting on housing markets, with broader, wide-ranging impacts on community. With housing shortages in the Bowen Basin necessitating the development of camps at the height of the cycle, it is reasonable to assert that significant change will occur in mining towns as booms bust or as minerals are exhausted.

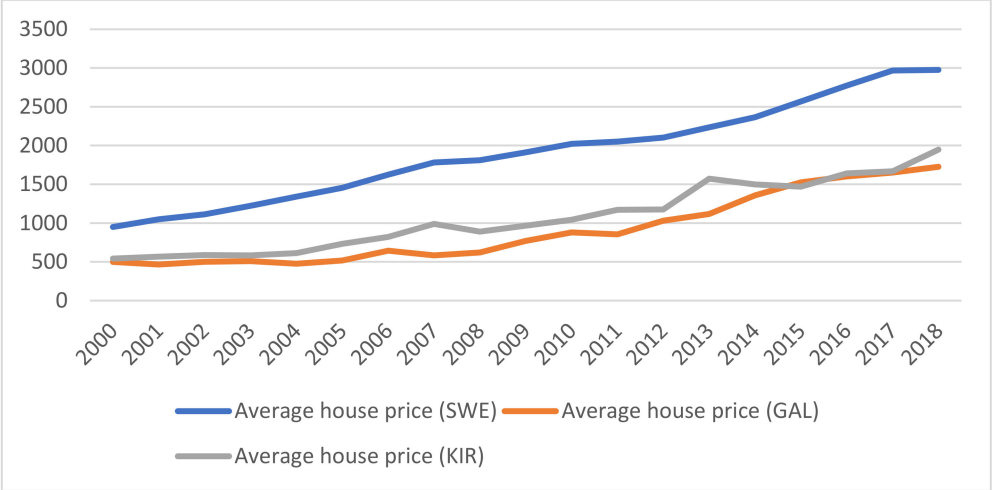


Figure 1. Average house price in Swedish mining towns (TSEK). Source: [30].

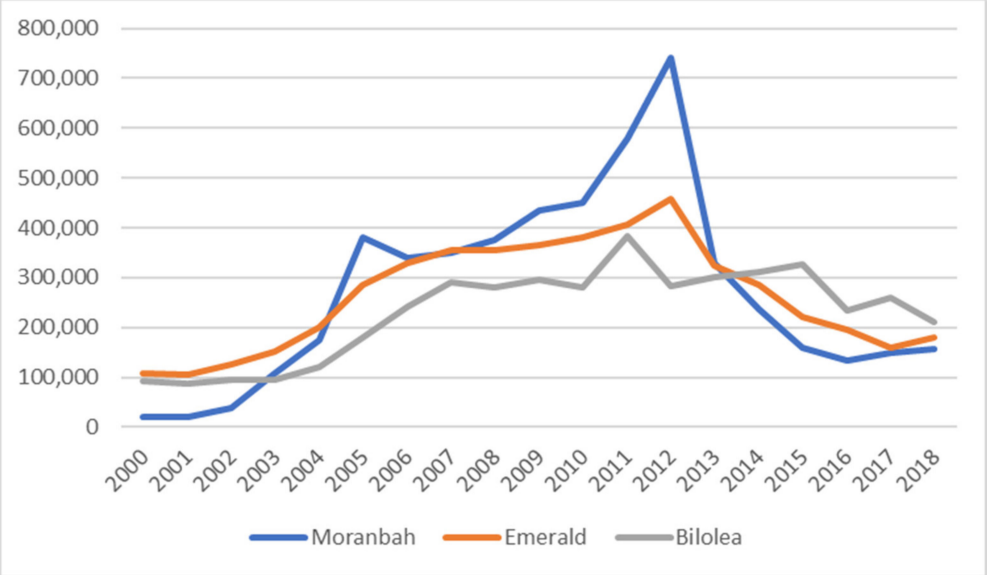


Figure 2. Average house prices in Australian mining towns (AUSD). Source: [66].

4. Methodology and Data

4.1. Methodological Underpinnings

This paper adopts a quantitative approach with a particular focus on housing sales data and a suite of resource-specific measures in order to map these interactions over time and explore town and community change at different points along a resources cycle curve.

Key comparisons are made around change within resource sector markets, and across housing markets. There is an established need to set up analytical models that can examine and then compare the towns based on mining metrics, housing metrics and measures of socioeconomic wellbeing [67]. While research in this field has examined small, resource-reliant towns, too little of this research has sought to understand the antecedents of a mining cycle or, more specifically, the boom phase. Research has established that examination of any one of these measures in isolation leads to imbalanced analysis as outcomes have been proved to develop from all three areas interacting, even unequally, over time. Moreover, these interactions change over time, leading to shifting interaction patterns and changing outcomes as resource cycles progress [21].

Similarities and differences between the towns clearly exist. The two towns in northern Sweden present a range of similarities in key demographic and statistical measures;

however, this is less so for the Australian mining towns examined. Compared to the Swedish towns they are smaller (population, geographically) and less remote, although equidistant from the nearest capital city. There are differences between the Australian towns, too, in how they developed, their population sizes and their type or level of reliance on the mining industry.

4.2. Data Comparability and Cleansing

Data was gathered as previously indicated by [21]. Both of the regions analyzed, northern Sweden and regional Queensland in Australia, are remote, and there are a myriad of data challenges present. While data sourcing can be undertaken, there are issues in micro level data sourcing in an Australian context.

The Bowen Basin region presented numerous data challenges, while the Swedish mining municipalities, which, for the most part, had very complete data sets for numerous metrics across the period examined. Consistent (annual) data for regional Australian towns does not exist, making time series analysis challenging. The house price series was created by averaging all house sales completed in the year for each town. Only house sales of 3000 m^2 or less were included to avoid farms, and only normal sales were included. This data was then modelled against a range of resource-specific metrics, as detailed in Table 1 below. Data relating to the two Swedish municipalities was much more fine-grained and the development of database of housing data required less cleansing.

This research was looking specifically at mining and resource-reliant communities and analyzing the effect of mining, and from this we analyzed if mining factors were a significant influencer for housing in the area. All data was then logged (Ln) to remove scaling issues.

The data used is highlighted in Table 1 below.

Table 1. Data Sources.

Variable	Source
Australia	
House Prices	
Moranbah, Emerald, Biloela	Queensland Valuer General
Coal Data	
Average Value and Export Volume of coal	Department of Natural Resources, Mines and Energy (DNRME)
Coal Output per sub-region	DNRME
Sweden	
House Prices	Statistics Sweden
Kiruna, Gallivare	Statistics Sweden
Iron Ore Data	
Iron Prices	Geological Survey of Sweden (SGU)
Iron Output	SGU
All data annual 2000–2018	

Because the Swedish housing data trend appeared so different to that of the Australian data, both sets were examined for stationarity issues using an Augmented Dickey–Fuller test for all housing data, and the results are shown in Table 2. While Moranbah and Emerald passed the test (at least at the 10% level), Biloela and the Swedish towns were only stationary at first difference. This highlighted the different structural form of the two countries' data and lack of any real correlation despite all being in resource-driven towns.

Table 2. Results of an Augmented Dickey–Fuller test.

		Augmented Dickey–Fuller Result	
Variable	**Mnemonic**	**Level**	**Difference**
House Prices			
Moranbah	NHP	−3.56	N/A
Emerald *	CHP	−2.96	−2.05
Biloela	SHP	−1.74	−3.63
Kiruna	KIR	−0.19	−5.46
Gallivare	GAL	0.47	−3.70
Demand Data			
Coal Output-North	NCO	−2.21	−2.57
Coal Output-Central	CCO	−3.28	N/A
Coal Output South	SCO	−1.18	−3.16
Average Coal Export Price	AVER	−1.51	−3.92
Average Coal Export Volume	VOL	−1.65	−3.70
Iron Output	IOUT	−2.12	−5.00
Iron Prices	IPRI	−1.65	−3.95

Sample period 2000–2018; Critical values—Passes at 5% significance −3.26, 10% significance −2.77; * Passes in levels at 10% confidence level, but not 5%.

Given the limited amount of data available within regional towns, modelling advanced techniques for non-stationary variables such as co-integration analysis were not possible for the non-stationary towns. It is possible that, for example, the iron variables could cointegrate with the Swedish towns but the sample is too small to test. The data for these towns was thus analyzed considering trends, differences and moving averages (to create a MAX model). It also used a choice of 0 or 1 lag and a general to specific linear analysis. Close attention was paid to error term signals to ensure that, as best as possible, stationarity issues had been addressed.

From the above information, it is implied that the analysis would move from the function:

$$HP_t = f(D_t) \text{ to } LHP_t = f(LD_t)$$

where L is the natural log to remove scaling issues.

Expanding out to a final model used of

$$LHP_t = f(LD_t, TREND)$$

in the linear form

$$LHP = c + LD_t + LTREND$$

where:

HP = Average house price;
D = An indicator of the mining side impact on house prices from the variables listed in Table 1;
TREND = a simple log trend variable.

From this point all possible permutations (including a lag element of one time period) of the demand side variables was carried out. The incorporation of trends and a possible moving average element was also combined into the modelling of the data.

The Australian analysis went in a similar vein to that previously published by [21]. As highlighted in the previous paper, the initial analysis over the full time period was unsatisfactory. As highlighted in Figure 3 examining the error terms of one of the Australian

markets, there are clear structural issues at the start and end of the time period within the Australian data. This was due to structural issues around the specific cycles in the market. More importantly the development of mining camps and FIFO within the region towards the end of the sample period removed the relationship between mining and the local economy (and housing in particular). This made the initial models meaningless with, for example, no significant coal demand variables within the equations.

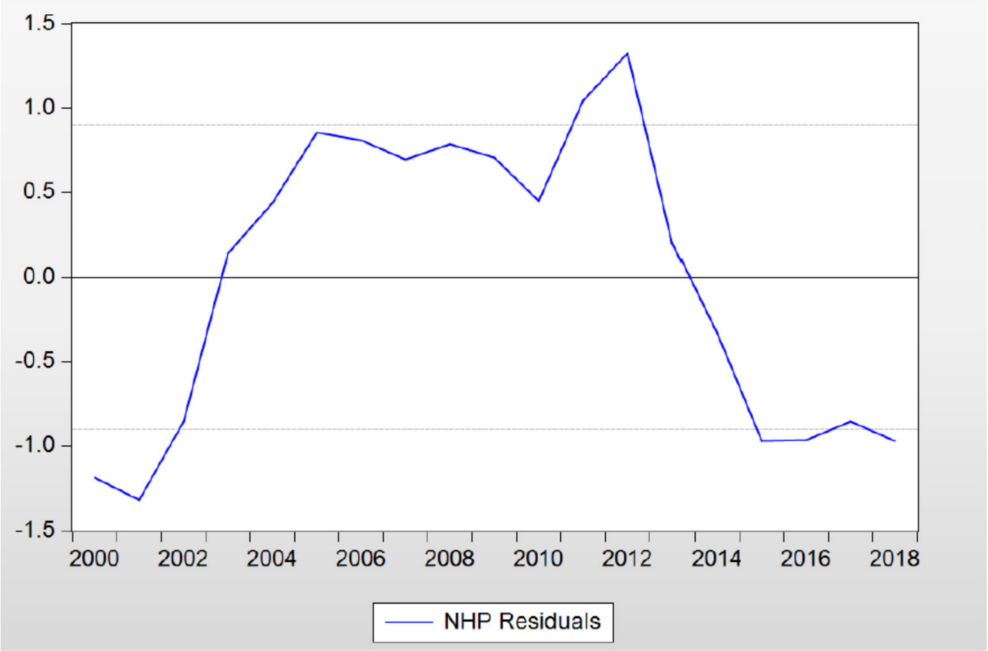


Figure 3. Error terms from initial model for Northern (Moranbah) house prices. Source: [21].

The sample size was adjusted (by as little as possible) for the Australian models, in line with the previous analysis [21], until a stable series was obtained. To reduce repetition, the final results—including data periods—are provided in Table 3. Further analysis is available from the authors.

Table 3. Final results and sample dates—Australia (all modelling in natural logs).

Dependent Variable	Independent Variables					Durbin Watson	R Bar Squared	Data Sample
North NHP =	−120.75	+	7.41 * NCO	+	−1.38 * D10	1.6	0.91	2000–2012
***t*-statistic**	−10.17		11.18		−10.17			
Central CHP =	−9.09	+	0.76 * AVER	+	−0.50 * D9	1.7	0.80	2003–2014
***t*-statistic**	−16.81		6.59		−2.76			
Southern SHP =	−27.93	+	2.31 * SCO			1.8	0.81	2002–2014
***t*-statistic**	−4.98		7.17					

Note: Where D9 is a dummy for 2009 and D10 a dummy for 2010. Source: [58].

The main period of useable data for the analysis was from early 2000 out to 2014. From this period onwards the relationship between mining and house prices broke down with the full impact of FIFO making it meaningless. The differing coal variables and coefficient magnitudes also highlighted the different reliance levels the towns had on coal, the different types of coal and consequently the different markets they served. The dummy variables are actually perfectly timed with the first appearances of mining camps within

the two towns which were most coal dependent and indicate the first negative impact from their initial appearance.

For full discussion of the nuances of the equations and the implication of the dummy variables, see [21].

The Swedish results were in stark contrast. Whilst they also had some similar issues in their analysis, they had very different results. Analysis using moving averages, trends and differences proved either insignificant or presented serious statistical issues (very low Durbin–Watson results, for example). The sample size was cut at the start as a different trend to the rest of the equation was present, as with much of the Australian data. This could possibly be different world impacts such as the dot com crash. Starting from 2004, the data provided much more meaningful results, as shown in Table 4.

Table 4. Final results and sample dates—Sweden (all modelling in natural logs).

Dependent Variable	Independent Variables					Durbin Watson	R Bar Squared	Data Sample
Gallivare GAL =	−8.86	+	4.88 * IOUT(−1)	+	1.63 * D10	1.5	0.73	2004–2018
***t*-statistic**	−3.60		6.37		4.56			
Kiruna KIR =	−6.68	+	4.25 * IOUT	+	1.36 * D9	1.8	0.80	2004–2018
***t*-statistic**	−3.62		7.44		5.19			

Initial comments on the results in comparison to the Australian findings are as follows. Clearly, the explanatory power is slightly lower—implying less impact from resources costs than in Australia. More interestingly, the coefficients of the dependent variable are within 1 standard error of each other, implying close if not equal impact of iron on the two separate towns. This implies greater certainty and stability of impact of resources within the markets. On top of this, with no major development of FIFO within the towns, the relationship continues to the end of the sample with no collapse in relationship as was seen in the Australian towns.

There is some excess impact from iron ore when it reaches its highest prices around 2008–2010 (as witnessed by the positive dummy variables). Overall, however, the equations illustrate a more stable relationship with some benefit from iron but not everything and not destroying the towns.

5. Results and Discussion

5.1. Results

The findings from the statistical analysis are interesting and show two distinct types of resource reliance. Importantly, they build on the findings of [21], whereby the resource cycle in Australia was found to be unique—in both its volatility and contributory factors. This comparative research showed Swedish iron ore communities to be far more stable, and in doing so reinforced the unique nature of resource towns in Queensland's Bowen Basin.

Analysis of housing markets in particular has reinforced certain views around stability of markets, while in other areas it has raised further questions and merits further research. With both Swedish mining towns indicating far more stability over the duration of the cycle, even in 2008–2010 when global demand and values for iron ore were at their peak. Correspondingly, the values of the properties increased in a measured fashion, as did iron ore metrics—suggesting that certain demand markets played a role in stabilizing the resource sector, and by association the town and its housing markets.

This makes sense with reference to the findings of the above analysis which show no evidence of inter-country correlation. This is interesting because it further reinforces that in an Australian context the socioeconomic wellbeing of towns, and housing markets in particular were impacted by two specific factors:

- Extreme growth, and subsequent volatility in demand from Asian markets, particularly China, through their development boom.
- Significant operational changes by mining companies during the resources cycle changed town dynamics, and directly, and indirectly impacted on housing markets.

The literature review showed that Australia's resource history is based in cyclical boom–busts and moreover, because of the major consumers of our resources, this presents a structural difference to European mining nations. The Kiruna mine specifically is the largest underground iron ore mine in the world [25]. With a strong steel production sector and defined exports borne of the Hanseatic League agreement [68], one can infer a more stable sector, with long term government investment and lesser demand volatility. The data analysis for housing in this instance clearly shows that any volatility in resource production or value was limited, and moreover, that it was controlled and did not trickle down into local economy. It never affected housing markets in the two Swedish towns analyzed, and it could be therefore assumed that far more traditional supply–demand drivers for residential property would be applicable in these towns, while, increasingly, Queensland resource town's housing markets required new analytical approaches.

The data analysis shows far greater stability, the adjusted R-squared statistic is less meaningful for Sweden's two major mining towns suggesting that the reduced volatility of these towns could be influenced too by non-mining factors. In the wake of the GFC, the Swedish Central Bank embarked on a strategy which included a low repo rate and in the years 2015–2019 was actually negative [69]. The unprecedented low interest rate together with a reduction in property taxes, fueled the property market in these years [70].

Indeed, the size and the more permanent establishment of these towns, in concert with government-run mining industry, is contributory. Increased control and influence by government means that mining-specific factors and non-mining-specific factors differentiated these two resource markets, which, logically, should have had some level of interaction. This points to issues of volatility, specifically housing market price and availability issues, being driven by governance failures and policy shortfalls in an Australian setting.

5.2. Mining and Housing in Australia and Sweden

The results indicate two ways to manage resource-rich regions and the towns that rely on them, with the key differences traced back to the linkages with government, levels of intervention, and ultimately the difference between public vs. private operation of a nations resource sector. It also points to two different types of demand markets operating globally, even for complimentary resources.

There is numerous linkages and important factors that have been found to influence behaviour and performance of property markets in towns that are subject to resource-sector volatility.

Australian mining towns have reported a different set of challenges stemming from rapid population movements, a changing relationship with mining companies and resources, and a shift in how mining is perceived in these towns. The rapid population variations in an Australian context have been found to be particularly impactful as resource markets fluctuate, whereby social or socioeconomic change identified is occurring in addition to the changes that are driven by resource market volatility.

The relationship between coal and iron ore justifies the study; moreover, the issues of rapid population shift in Queensland compared to issues of declining population and demographic imbalance in Sweden required a comparative study.

6. Conclusions and Future Research

The findings from this research are informative and are important in continuing to update knowledge of housing markets subject to unique economic influences and volatility. The housing markets in mining towns and regions, and housing markets further from mines but affected by resource volatility, require further research.

This research has reinforced the existence of a connection between mining metrics in a region and the local housing market (and by extension, the wellbeing of the community). If there is significant volatility in value or levels of production this trickles down into local housing markets, resulting in broader social disruption down the track, whereas resource stability has the opposite effect, ensuring stable growth in towns and their housing markets. More research is required here to determine importance of a town's 'critical mass', as it is hypothesized by the authors that there is a defined tipping point above which resource cycle volatility can be absorbed, and, will have a lesser impact.

A third critical outcome from this paper is the complexity of relationships between resources. Coal and iron ore are closely related because of the implicit need for coal to fire the smelters where much of the extracted iron ore is turned into steel [71]. These complimentary markets are not uncommon for resources and this relationship between iron ore and coal was exemplified in Australia following the turn of the century, where, driven primarily by China's infrastructure boom, demand (and value) of iron ore increased rapidly [72].

This research was important to expand knowledge of resource town housing markets in Australia and to begin the exploration of resource towns in a Swedish setting. It was hypothesized by the authors that, given the complimentary resource bases mined, there would be some similarities between markets over the period examined. The outcome, distinct patterns of performance in both resources and housing markets, is just as important as a finding that had shown a close relationship and speaks to the importance of management of mining towns and regions being important to ensure stability in markets. Moreover, it shows that even in a globalized world with easy trade routes market demand and key markets are important, clearly Swedish iron ore had stable, long-term demand (in Europe) and China's infrastructure boom did not extend to resource sourcing from more distant producers.

The stability of Sweden's resources and the related property markets contrasted with Australia's Bowen Basin over the corresponding period, but this in itself was interesting and the stark nature of this contrast proven in Section 4 raises further questions and warrants further research.

6.1. Housing Market Fundamentals: Challenges in This Unique Economic Setting

The findings from this research require questions to be asked about volatile housing markets in equally volatile resource regions. In several ways, the findings from Sweden, while requiring further analysis, present a measure of achievable stability, and longevity, for resource regions and towns. The results definitively show that town size has a relationship to socioeconomic stability, and that resource stability trickles down.

It should also be noted that despite the fact that mining companies are important for employment in the investigated municipalities, they are not the largest employer, even though about 20 per cent of the adult population are employed within the state-controlled mining company LKAB. This points to an idea of critical mass in employment by sector (in addition to population).

There is also an ongoing debate in Sweden concerning the distribution of the revenues from mining operations and water power (hydroelectricity). Typically, these companies are situated in rural areas in the north, but the revenues and taxes tend to migrate south. As the mineral taxes are extremely low in comparison with for instance Ontario, Canada, there has been a movement towards increasing those, but to no avail. It remains to be seen whether the changes within the sector to reduce the need for coal and increase the value added within the steel and mining sector can increase the regional income from these sectors.

Coming back to housing market fundamentals has proven difficult in traditionally volatile resource towns in Australia; however, the findings illustrate the importance of the management of a town and its resources, and raise questions about the benefit of privatization and how a country's resources impact on towns, all the way down to property

markets. This research suggests that accepted housing market fundamentals could be applied to the Swedish mining towns analyzed. Previous research [2,21] has shown housing to be critically important to socioeconomic wellbeing, and generally under-regarded when undertaking town longevity analysis.

6.2. Behaviours and Cycles: What We've Learned

It is evident that government-run mining operations and the lack of disruptive factors (both resource sector change and operational changes) created increased levels of stability. This shows that a government's views of resources and management and investment, even at a macro level, have significant influence. Both Swedish towns analyzed present far greater longevity than the Australian examples. The institutional setting of Sweden should also be considered. By law, the Swedish government owns all iron ore in Sweden, which is similar to that of the neighbouring country of Norway in that the Norwegian state owns all oil in Norway. The fact that the state controls the minerals means there is an expectation within the general public that the government should take care of any problems that the local communities might face, including housing shortages. During the past decade, the entire municipality of Kiruna has been moved two kilometers east due to the mining operations. The cost for this remarkable transformation has been covered by the mining corporation [73].

There is considerable evidence presented in these findings that the volatility of coal towns in Queensland was extreme, while at the other end of the scale, the stability that Swedish towns demonstrated throughout a time of global economic fluctuation growth was also unique. The finding really brings into focus the emergent model in Australia and emphasize the significance of, and the need for, further research, FIFO/DIDO commuting, work camps and extreme operation cycles at mines.

The nature of isolated, regional living in Australia needs attention as this has been an area of ongoing demand with outmigration and population loss being an issue plaguing many regions [74]. In Sweden the two towns examined are far more established, and represent levels of permanence, while, for numerous reasons, many mining and non-mining regions in Australia are experiencing population declines which links with the idea of critical (population) mass, and concept of 'place', and the stability that comes from this.

These findings improve knowledge of the cyclical nature of two respective resources where overlap was expected, but not found in the current analysis. There is further research needed to expand analysis to other property asset classes and other resource bases to understand the interaction over time. There is validity in the idea that rather than examining complimentary resources (iron ore and coal) there may be great value and more definitive outcomes by comparing iron ore markets between nations, and focusing further on their main demand markets.

6.3. Looking Forward and Planning: The Ability to Forecast

There is further research required in these, and other geographical settings to meet the objective of developing a long-run forecasting methodology for housing markets in resource-dependent communities. The comparative analysis has shown its merit and here reinforces two important points:

1. Australia's resource cycle was unique; such volatility in resource values or production is not the norm. Moreover, markets being supplied appear to dictate town and region outcomes.
2. A myriad of factors impact on housing markets, even more so in small, regional, isolated, resource-reliant communities. This research shows evidence of market export control, state ownership, town investment and management of populations to all work in reducing volatility in housing markets.

What this research has done is show two complete cycle periods affecting two mining regions on opposite sides of the world, and has shown that even where a relationship in resources exists and, therefore, a relationship was believed likely to exist between the

studied towns and their housing markets, there was no overlap. Because of this, more analysis of the export markets may be required. This shows that over a period of resource market growth, socioeconomic volatility is not bound to occur; with growth in the value and production of a resource, the town's wellbeing does not necessarily decline.

This research, and that which has preceded it in an Australian context, has shown a damaging relationship between resource cycles and housing markets, with both extreme growth in values and rapid declines which occurred post-boom to be damaging to town and community—rapid house price rise, or decline, created socioeconomic instability.

Future research must expand study range, and, where possible, increase timeframes. There is also a clear need to undertake more focused analysis of policy and planning in conjunction with comparative studies of housing and resources. This Swedish–Australian comparison has shown very distinct growth trajectories over the same period, and for resources that, while different, have historically shown similar levels of volatility. The stability in Sweden's housing markets strongly supports the ideas of improved socioeconomic wellbeing over the duration, as opposed to the increased socioeconomic volatility reported in Queensland mining towns.

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