ASSESSING FLOOD IMPACTS ON THE REGIONAL PROPERTY MARKETS IN QUEENSLAND, AUSTRALIA

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ABSTRACT: Weather-related disasters such as floods have become more frequent over the last fifty years in regional communities of Queensland. Between December 2010 and January 2011, three-quarters of Queensland was declared as a disaster zone as a result of flooding. The Central Queensland (CQ) region was severely affected by this flood. To assess potential impacts on property markets, this study examined flood impacts through a case study of Rockhampton within the CQ region by using longitudinal data of the number of quarterly sales and median property price of all three segments of property market (i.e., total house sales, new house and land package sales, and land only sales), before and after the 2011 flood. In addition this study tested changes in the number of sales with a key regional economic impact i.e., mining boom, to test whether the flood impact has been offset by impacts of growth in the mining sector. This study found that flooding has affected the total number of house sales compared to the other two housing submarkets, and also that the flood impact has been relatively offset by the impact of mining.

KEY WORDS: Flood, regional economic driver, property market, Queensland

ACKNOWLEDGEMENT: The research involved in this paper was funded by CQUniversity Australia

1. INTRODUCTION

The main driver behind the growth of Australian regional towns in recent years, especially those in Queensland, has been the development of resources such as minerals, coal and natural gas. Regional communities in Queensland are the economic power house of the state; contributing more than 80 per cent of goods and services exports, as well as about 16 billion dollars each year to the state's economy (Queensland Government, 2008). However many regional towns and local governments areas in Queensland were flooded in 2011 with at least seventy towns and over 200 000 people affected (Australian Government, 2014). Rockhampton is one of the regional cities within central Queensland that was severely affected by flood in 2011, as it was disconnected from the state's administrative and commercial capital (Brisbane) by road, air and rail for more than one week. Rolfe *et al*. (2013) have estimated that the direct economic impact of the flood on Rockhampton and the associated highway and airport closure was approximately $66.7 million.

There is potential for longer term impacts of floods on housing markets, as residents re-assess flood risks and the personal and economic disruption that they cause. Several studies have been conducted to identify flood impacts on the property market in Australia (Eves and Wilkinson, 2014; Small *et al.*, 2013), finding minor and short term impacts on property prices. Similar studies elsewhere (Bin and Polasky, 2004; Chou and Shih, 2001) have showed significant impacts of flood and inundation events on the property market. However, none of these studies have been able to identify which segment of the property market was most affected.

This study focuses on identifying market vulnerability by comparing segments of the property market i.e., number of total house (TH) sales (old and new houses), new house and land (HL) package sales and land only (LO) sales before and after the 2011 floods. This study also made efforts to test whether flood impacts had been offset by the impact of mining growth in this region.

The paper has been organised as follows: following this introductory section, Section 2 provides contextual background for the study; Section 3 gives a brief background of the study area; Section 4 describes data and methods; and Section 5 provides the findings and analysis of the study. The paper concludes in section 6.

2. CONTEXTUAL BACKGROUND: FLOOD IMPACTS ON HOUSING

Floods have always had some level of impact on property markets depending on their severity and inundation level (Worthington, 2008; Troy and Romm, 2004). A number of studies have been conducted in the USA, Germany, Taiwan and Australia to find out the effect of flooding on local residential property markets (Eves and Wilkinson, 2014; Small *et al*., 2013; Kropp, 2012; Bin *et al*., 2006; Bin and Polasky, 2004; Merz *et al*., 2004; Chou and Shih, 2001). Most of these studies have found that a flood event can decrease the value of inundated property or the inundated part of the town, but not the overall property market at a local or regional level (Figure 1). However, none of these studies have estimated the effect of flooding on the local property market or what segment of the property market is most affected.

The effects of flooding on property markets can be offset by the effects of other local or regional factors such as resource developments, regional population growth, new social facilities development and increases in employment (Kropp, 2012). However, no one has tested the effect of one or all of these factors on flood impacts on property markets or whether impacts vary across subsets of those markets.

The focus of this study is to test whether there are any differences in flood impacts between the property submarkets at a local level. Subsequently the study tests whether any local or regional economic determinants can offset or enhance the flood impacts on housing markets at a local level. Testing these hypotheses is very important in predicting future housing markets as well as providing empirical evidence to support policy makers in deciding what measures should be undertaken in the aftermath of flooding. This type of research is becoming essential for community and property investors because major floods in this area previously occurred approximately every fifty years but now appear to be happening at 10 to 25 year intervals (Kropp, 2012; BOM, 2013).

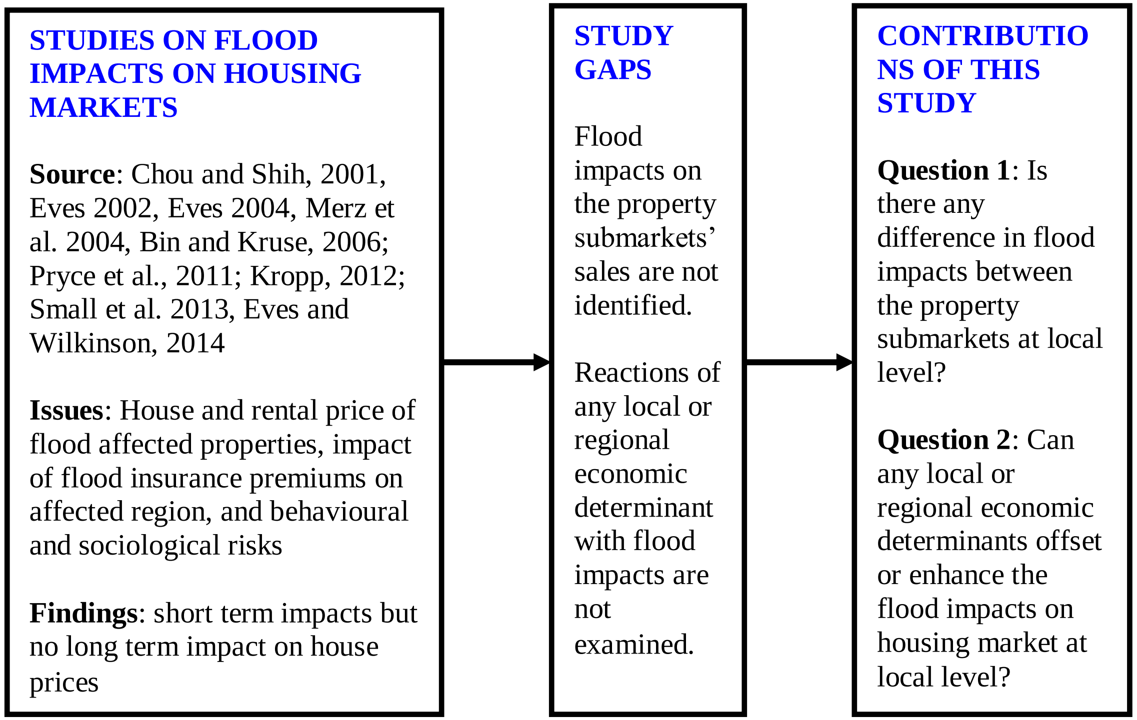

Figure 1. Study Context and Contributions. Source: the Authors.

3. STUDY AREA

This study focuses on Rockhampton, which is a regional city near the mouth of the Fitzroy River in central Queensland (Figure 2). The Fitzroy is the second largest externally draining catchment in Australia, and experiences large floods in some seasons, including 2011, with subsequent impacts on Rockhampton. There are advantages in using Rockhampton as a case study; the city is large enough to generate substantial property data, there are some areas of housing that are affected by floods while others are not, and the use of a single city minimises the impact of other confounding factors.

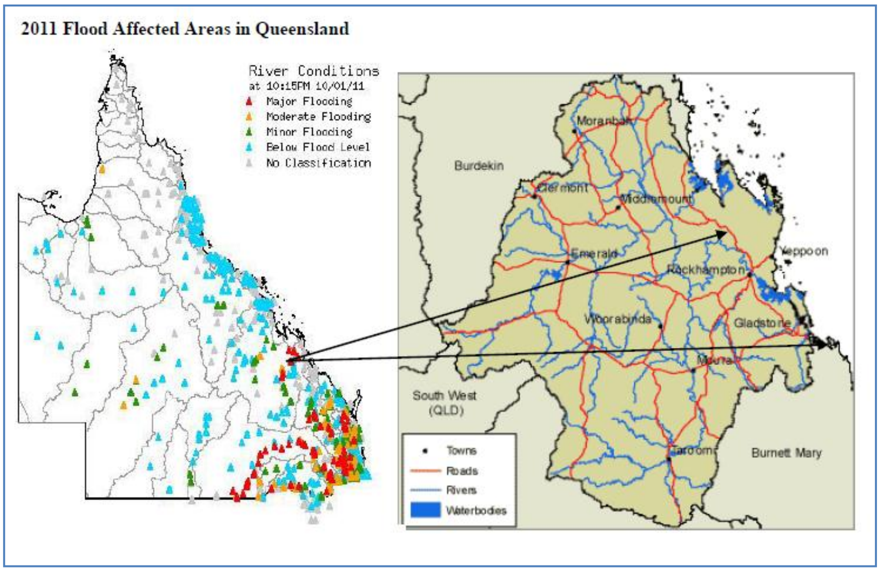

Figure 2. Study Area – Rockhampton Region in Queensland.
Source: Google Images, 2014 and Bureau of Meteorology (BOM), 2013, Queensland Flood Map.

Figure 3 indicates major and minor flooding events that have occurred in Rockhampton including five major inundations since 1890. Small *et al*. (2013) examined resident opinions in comparison to market realities of the impact of flooding on property value. They found that over 50 per cent of respondents believed that the flood event had a negative impact on property values causing a decrease in values. Despite the beliefs of respondents, a weak relationship between floods and the dynamics of property markets was found. However, the reason for such weak relationship was not explored. In contrast, CCIQ (2011) found evidence of minor to major impacts of flooding in Queensland businesses within the flood affected towns, including Rockhampton.

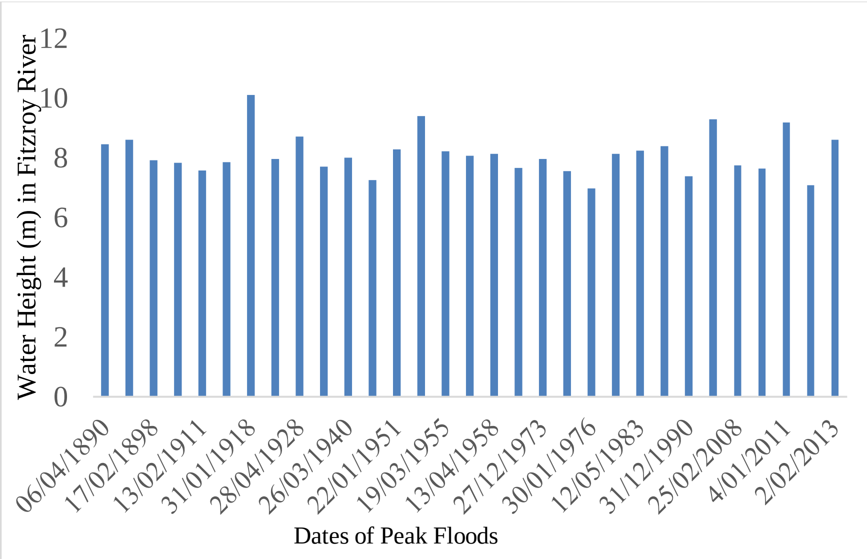

Figure 3. Major Floods in Rockhampton Since 1890. Source: BOM (2013).

Rockhampton is an administration, service and population hub in central Queensland. Its economy has been growing strongly since 2003 because of the mining boom in the nearby Bowen Basin region (Akbar *et al.*, 2010). In addition, large scale natural gas and infrastructure development projects in the nearby port city of Gladstone contributed to an increase in the resident population in Rockhampton, as Gladstone had been suffering with housing availability and affordability difficulties between 2009 and 2013 (Akbar *et al.*, 2013). These growth pressures in the regional economy may have offset any negative impacts of the 2011 flood event.

4. METHODS

A number of studies used qualitative, quantitative or mixed methodology to identify the impacts of flooding on property market (Table 1). However this study used a quantitative methodology with longitudinal data of house sales, inundation levels and mining impacts to answer the two research questions. Longitudinal data of property sales in three segments of property markets in Rockhampton Regional Council (i.e., a local government area in central Queensland region) were collected from the Queensland Treasury and Trade (QTT) database on residential land development activity profile (QTT, 2014; 2008). This longitudinal data includes quarterly median price and number of sales between quarter 1, 2000 and quarter 4, 2014. Flood inundation level data was collected from the Australian Bureau of Meteorology (BOM). We used dummy variables (i.e., no impact = 0, having impact = 1) for flood and mining impacts between quarter 1, 2000 and quarter 4, 2014.

This study used independent t-Test with a 95 per cent confidence level to identify the significant difference between property price and sales before and after the 2011 flood in Rockhampton. We used the SPSS Package-PASW Statistics 22 to do Independent Samples t-Tests.

Subsequently this study used multivariate regression models to establish the relationship among the number of sales, median property price, flood and mining impacts on the property markets. We used JMP-Pro software for applying regression models and visualising the flood and mining leverages on the number of property sales. The formula and the findings from these models are described in the next section.

Table 1. Methods Used in Flood Impacts on Housing Market Studies.

Author and year	**Study Area**	**Methods/Techniques/data source**
Eves and Wilkinson, 2014	48 suburbs out of 190 suburbs in Brisbane, Queensland, Australia	Weekly change analysis in sales, rental listings and volumes of sales over a 12 month period Using RP database for housing data and Australian Bureau of Statistics for socio-demographic data
Small *et al*, 2013	Rockhampton, Queensland	Mixed methods: Longitudinal median sales price sourced from RP Database and a survey on the flood affected families
Pryce *et al*., 2011	Theoretical construct	Using a framework for modelling the housing market response to flood impact considering g myopic and amnesiac risks. Using contemporary theories and empirical evidences.
Lamond and Proverbs, 2006	Barby, North Yorkshire, UK	Case study with comparative analysis and applying semi-logarithmic regression model. Using longitudinal property sell and flood data from the Land Registry and Environmental Agency
Bin and Pollasky, 2004	Pitt Country, North Carolina, USA	Hedonic property price function and comparison within and outside the floodplain area Using Pitt Country's Geographic Information Systems (GIS) and Management Information Systems (MIS) for distance, property parcel records and property's physical attributes data.
Eves, 2004	England and Wales, UK and Sydney, Australia	Survey method and data analysed by descriptive statistics Using questionnaire survey and property sales data

5. FINDINGS AND ANALYSIS

The January 2011 flood, with a peak water height of 9.2m, was the most severe and devastating flood in the Rockhampton region over the last twenty years. However, there were three other floods within this period in 2008, 2010 and 2013, with flood peaks vary between 7.1m and 8.6m (Figure 3). The 2011 flood was chosen as a market intervention point because of its severity. Data for quarterly median property price and number of sales of all three segments of the property market are only available between 2000 and 2014 from the Queensland Government's published source (i.e, QTT, 2014 and 2008). Therefore we used quarter 1, 2000 to quarter 4, 2010 property price and number of sales data as before flood data and quarter 1, 2011 to quarter 4, 2014 as after flood data. Then we carried out independent t-tests to examine whether any significant differences existed between property median price and number of sales before and property median price and number of sales after the 2011 flood's for each segment of the property market. Here, the null hypothesis and the alternative hypothesis (termed as H_o and H_a respectively) are as follows:

H_o = There is no significant difference between before and after the 2011 flood's property median price or number of sales of a particular segment of the property market, and

H_a = There is a significant difference between before and after the 2011 flood's property median price or number of sales of a particular segment of the property market.

The decision rule is given by: if $p \leq \alpha$, then reject H_o.

Considering the empirical results presented in Table 2, the condition is satisfied for total house (TH), and new house and land (HL) package sales (both for the median price and the number of sales variables), but not the number of land only (LO) sales (Table 2). For both total house sales and new house and land package sales, the independent samples t-test had a significance level between 0.000 and 0.001, which is less than α (0.05) (Table 2). So these primary results exhibited that flood affected significantly two segments of the property market (i.e., TH sales and new HL packages sales). In contrast some studies such as Small *et al.*, 2013 and Eves and Wilkinson, 2014 reported a very minimal or short term impact of flood on property markets in flood affected areas of Australian cities. To further explore this contradiction, this study tested property sales with property price, flood and mining impact variables, to conclude the magnitude and direction of the effects on the property market and determine the flooding and mining leverages on the property markets.

Table 2. Independent Samples t-Test: Results for Median Price and Number of Property Sales.

Property sub-market	**Test variable**	**t-test for equality of Means (equal variance assumed)**	
		df	Sig. (2-tailed)
Total house sales	Median price	58	0.000
	Number of sales	58	0.000
New house and land package sales	Median price	58	0.001
	Number of sales	58	0.001
Land only sales	Median price	58	0.000
	Number of sales	58	0.086

Source: the Authors

Multivariate regression models (MRM) were used to add flood and mining impacts in different quarters between 2000 and 2014. The median value for houses in a quarter of a year (for example, quarter 1, 2000) were regressed against the number of house sales in that particular quarter. Essentially each quarter becomes an "observation" and therefore we had 60 observations. Our generic formula to regress the number of house sales in a quarter of a year is:

$$Y = \beta_0 + \beta_1 X_1 + u \qquad (1)$$

Where Y is the number of predicted sales, X_1 is the median sales prices, β_0 is the constant or intercept term, β_1 is slope parameter and u is an unobserved random variable, known as the error or disturbance term.

As there are two more predictors in equation 1 to capture flood and mining impacts, our general MRM equation for predicting the number of sales is thus:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + u \qquad (2)$$

Here X_1 is median price for "total house (TH) sales" or "new house and land (HL) package sales" or "land only (LO) sales" and X_2 represents either flood impact or mining impact, and the following six equations predict the number of sales of each market segment either considering flood or mining impact (Equations 3-8).

Number of total house sales (TH) = 969.114 - 0.002 * Median Sale Price (TH) -72.766 * Flood impact (3)

Number of new house and land package sales (HL) = 34.588 – 0.0392 * Median Sale Price (HL) - 1.218 * Flood impact (4)

Number of land only sales (LO) = 193.485 - 0.001 * Median Sale Price (LO) - 7.108 * Flood impact (5)

Number of sales (TH) = 909.558 - 0.002 * Median Sale Price (TH) + 284.667 * Mining impact (6)

Number of new house and land package sales (HL) = 34.163 – 0.0436 * Median Sale Price (HL) + 3.216 * Mining impact (7)

Number of sales (LO) = 178.497 - 0.001 * Median Sale Price (LO) + 111.378 * Mining impact (8)

Flood usually affects the property market negatively (Lamond and Proverbs, 2006) and mining affects the property market positively (Akbar *et al.*, 2013) in terms of number of property sales and median property price in regional towns. Therefore we either considered flood impact or mining impact at one time in each equation. Quarter 1, 2003 to Quarter 4, 2007 and Quarter 1, 2010 to Quarter 4, 2013 were considered as having mining impact (dummy variable- having impact=1) on the Rockhampton property market. On the other hand, the global financial crisis hit the mining sector between quarter 1, 2008 and quarter 4, 2009 and the price of coal started falling from quarter 1, 2014, so these years were considered as no impact (i.e., 0) of mining along with the initial period (quarter 1, 2000 to quarter 4, 2002) of not significant mining activities in this region.

Based on these equations, an effect summary of the models is provided in Table 3.

Table 3. Effect Summary of the Models.

Impact indicator	**Mining impact**			**Flood impact**		
	Total house sales	New house and land package sales	Land only sales	Total house sales	New house and land package sales	Land only sales
Parameter estimates	284.667	3.215	111.378	-72.766	-1.218	-7.108
P-Value	0.000	0.249	0.000	0.345	0.703	0.804
LogWorth	6.581	0.604	6.554	0.462	0.153	0.095
Rsq value	0.559	0.271	0.401	0.306	0.256	0.046

Source: the Authors

Here in Table 3 parameter estimates refer to magnitude and direction of that relation i.e., mining or flooding impact with the number of sales; the p-value is the result of the test of the following null hypothesis, a p-value less than 0.05 means that the coefficient is statistically significant. However, for a large or very significant effect, the associated p-values are often very small and it is hard to visualize these small values graphically. When transformed to the LogWorth (-log10(p-value)) scale, highly significant p-values have large LogWorths and non-significant p-values have low LogWorths. A LogWorth of zero corresponds to a non-significant p-value of 1. Any LogWorth above 2 corresponds to a p-value below 0.01 and so on (JMP, 2015). Rsq value represents the proportion of variation in the dependent variable (i.e., number of sales).

We need to consider all four values (parameter estimate, p-value, LogWorth value and Rsq value) (Table 3) to find out the significance and direction of the flood or mining impacts on the property market. Table 3 exhibited that mining had very significant and positive impact on the number of total house (TH) sales in Rockhampton compare to a moderate impact on land only sales and little or no effect on new house and land (HL) package sales. On the other hand, flooding had moderately significant but negative impact on the number of total house (TH) sales and almost no or little impact on new house and land (HL) package sales and land only (LO) sales.

Therefore our multivariate regression models indicate that both mining and flooding affected the number of total house (TH) sales significantly but positively and negatively respectively. We are yet to understand how these factors (i.e., mining and flooding) leverage the total house sales. The coefficient of each predictor variable is the effect of that variable, which is termed as the leverage of each impact i.e., either flood or mining. Here, the effect leverage plot for x_2 (flood or mining impact) is essentially a scatterplot of the X-residuals against the Y-residuals (Figures 4a and b).

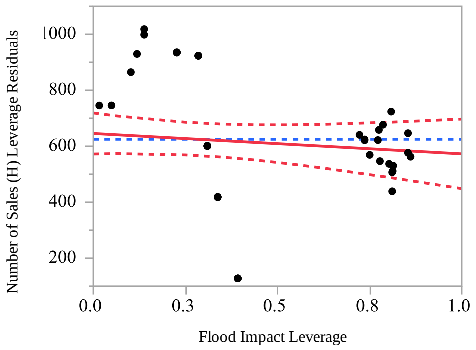

Figure 4a. Flood Impact on the Number of Total House Sales.

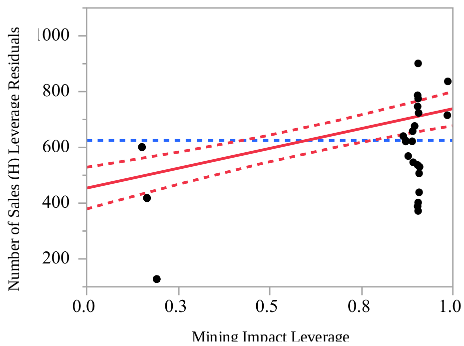

Figure 4b. Mining Impact on the Number of Total House Sales.

NOTE: Here the **dashed horizontal blue** line (in both figure) is set at the mean of the Y leverage residuals. This line describes a situation where the X residuals are not linearly related to the Y residuals. The **red solid lines** are the fitted regression equations with the effect in the models and the confidence bands are shown as **dashed red curves**. For both leverage plots, the confidence curve crosses the horizontal line. Source: the Authors.

These leverage plots (Figures 4a and b) show the impact of adding mining or flood effects to the models at a 5% level of significance. In addition, a visual indication of a significant effect of both mining and flooding is the fitted regression line (i.e., red solid line). As the mining impact leverage points are more horizontally distant from the centre of the plot compared to that of flood impact, it shows that the mining effects exert more influence than the flood effects. Both interpretations (i.e., numeric LogWorth values (Table 3) and visual observation of the leverage points (Figures 4a and b)-exhibited that multiple regression models observed statistically significant impacts of mining and flood on the number of total house sales but in opposite directions. Growth in the mining sector had positive impacts on the number of sales during this period and also offset the flood impact on sales.

6. CONCLUSION

Flooding appears to have had an impact on the number of total house sales in the property market of Rockhampton. Eves and Wilkinson (2014) investigated the house price impact of the same flood in Brisbane and they came to similar conclusions in terms of changes in median house price over a short term. They did not specify the reasons for the low impact of flooding on the property prices which suggests that a separate study on the metropolitan market may be useful given its distinctive economic bases and demographic characteristics. Earlier, Bin and Polasky (2006) found a very significant value loss in the housing market after Hurricane Floyd in September 1999 in North Carolina and again their findings are almost the opposite to the primary findings of this study.

The primary finding in this study is that flooding has had a significant effect on the number of total house (TH) sales in contrast to the other two segments (i.e., new house and land packages sales and land only sales) which were not significantly affected. By contrast, this study differs from others (CCIQ, 2011; Lamond and Proverbs, 2006) in its finding that the floods did not have a significant impact on house prices.

It has also been found that the impacts of flooding on housing markets in Rockhampton had been offset by mining impacts which explains why the devastating 2011 flood did not significantly affect new house and land package sales and land only sales. Also the mining impact on total house sales is very significant and in a positive direction but the flood impact on this market segment is low to moderately significant and in a negative direction.

A single test or model cannot explain the impact of flooding on regional property markets in Australian regional cities. However, a method containing several models and effect assessments such as the one used in this study can explain the flood impact more rigorously. Both the method and the models can be used for further study. A lesson that can be taken from this study is that local or regional development factors can offset any flood impacts on housing markets either partially or significantly at local and sub-regional scales. Therefore the policy makers should emphasise enhancing the pre-existing development projects through providing monetary or infrastructure support that can help the local economy and help maintain housing markets.

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