Flood in Blood: Assessing Housing Market Vulnerability within the Fitzroy Basin Region, Australia

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ABSTRACT
Regional communities in Queensland, Australia are the life-blood of the state; contributing more than 80% of exports goods and services, as well as about 16 billion dollars each year to the state’s economy. Weather-related disasters such as floods have become more frequent over the last fifty years in those communities. Between December 2010 and January 2011, three-quarters of the state was declared as disaster zone as a result of flooding. At least seventy towns and over 200,000 people were affected by these floods. The Fitzroy Basin is the largest coastal catchment in Queensland and the second largest catchment in Australia; and the most towns in this basin have been affected by this flood. This study examined the vulnerability of the housing market through a case study of Rockhampton region within this basin by using longitudinal data of total house sales, new house and land package sales, land sales before and after the 2011 flood and also tested the results with a key regional economic factor (mining development) whether the flood impact has been relieved by this factor. This study found that the flood has affected the total house sales compared to new house and land sales and land only sales; and also flood impact has relatively relieved by mining impact.

1. INTRODUCTION
The main driver behind the growth of Australian regional towns, especially of those in Queensland is the continuous development of resources such as coal and natural gas. Regional communities in Queensland are the life-blood of the state; contributing more than 80% of exports goods and services, 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 have been flooded in 2011 and at least seventy towns and over 200,000 people were affected by this flood (Australian Government, 2014). Rockhampton is one of the regional towns in Queensland, which 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. Several studies have conducted to identify the flood impacts on housing market in Australia (Eves and Wilkinson, 2014; Small et al, 2013) and they found little and short term impact on housing but similar studies elsewhere (Bin and Polasky, 2004; Chou and Shih, 2001) showed that there were significant impacts of flood and inundation events on the housing market; however all of them have failed to identify what segment of the property market was mostly affected. This study focuses on identifying market vulnerability by comparing segments of housing market i.e., overall house sales (old and new houses), new house and land package sales and only land
sales before and after the flood. This study also made efforts to test whether flood impacts had been relieved by the mining impacts in this region.

The paper has been organised as follows: Section 2 provides contextual background of study; Section 3 gives a brief background of the study area; Section 4 describes data and methods; and Section 5 provides results of the study. The paper concludes in section 6 with discussions and conclusions.

2. CONTEXTUAL BACKGROUND: FLOOD IMPACTS ON HOUSING

Floods have always had some level of impact on housing markets depending on their severity in 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 housing market (Eves and Wilkinson, 2014; Small et al, 2013; Kropp, 2012; Bin et al, 2006; Bin and Polasky, 2004; Merz et al, 2004; Eves 2002; Chou and Shih, 2001) and 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. Also none of them has estimated how long the flood can continue its effects on the local housing market.

Flood affects can be offset by any other local or regional affect such as resource developments, regional population growth, employment level and development of social facilities (Kropp, 2012) but no one has tested all or one of these impacts with the flood impacts. Also within the housing market, there are three types of submarkets (except rental market) such as only house sales (old and new separate houses, flats and units), new house and land packages sales and new land sales and it is yet to be known what submarket are highly affected by flood or any other natural disaster.

**Figure 1: Study Context and Contributions**

<table>
<thead>
<tr>
<th>PREVIOUS STUDIES ON FLOOD IMPACTS ON HOUSING MARKETS</th>
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<tbody>
<tr>
<td><strong>Source:</strong> Chou and Shih, 2001; Eves, 2002; Merz et al, 2004; Bin and Kruse, 2006; Pryce et al, 2011; Kropp, 2012; Small et al, 2013; Eves and Wilkinson, 2014</td>
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<tr>
<td><strong>Issues:</strong> House and rental price of flood affected properties; impact of flood insurance premiums on affected region; and behavioural and sociological risks.</td>
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<td><strong>Findings:</strong> short term impact but no long terms impact in house price declining.</td>
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<tr>
<th>STUDY GAPS</th>
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<tbody>
<tr>
<td>Flood impacts on the property submarkets’ sales are not identified.</td>
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<td>Reactions of any local or regional economic determinant with flood impacts are not examined.</td>
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<tr>
<th>CONTRIBUTIONS OF THIS STUDY</th>
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<tr>
<td><strong>Question 1:</strong> Is there any difference in flood impacts between the property submarkets at local level?</td>
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<tr>
<td><strong>Question 2:</strong> Can any local or regional economic determinants offset or enhance the flood impacts on housing market at local level?</td>
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Therefore this study tests first whether there are there any differences in flood impacts between the housing submarkets at local level and second whether any local or regional economic determinants can offset the flood impacts on housing market at local level. Testing these hypotheses is very important in predicting future housing market as well as providing
empirical evidence to policy makers to decide what measures should be undertaken in the aftermath of flooding. This type of research is becoming essential for the community and property investors because major floods previously occurred about every fifty years but now appear to be happening at 10 to 25 year intervals (Kropp, 2012; Small et al, 2013).

3. STUDY AREA

This study has chosen Rockhampton Regional Council within the Fitzroy basin in Queensland (Figure 2). The Fitzroy is the largest river basin in Queensland containing the Rockhampton region which was severely affected by flood in 2011 (Figure 2).

Figure 2: Study Area – Rockhampton Region in Queensland


Figure 3 indicates major and minor flooding in Rockhampton including five 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% of respondents believed the flood event had a negative impact on property values of whom the majority believed the impact was a large decrease in values. By contrast they found a weak relationship between floods and the dynamics of housing markets. In contrast, CQIG (2011) found minor to major impacts of flooding in Queensland businesses within the flood affected towns include Rockhampton.

However Rockhampton is the capital of Central Queensland region and its economy has been growing stronger since 2003 because of mining boom in the nearby Bowen Basin region (Akbar et al, 2010). Especially just before the 2011 flood, large scale natural gas and infrastructure development projects in a nearby port city of Gladstone contributed to increase the resident population in Rockhampton because Gladstone had been suffering with housing availability and affordability difficulties between 2009 and 2013 (Akbar et al, 2013).
This study further examines the flood impacts of housing with comparing with mining impacts by using longitudinal data on house and land prices and number of sales. The next section provides a detail description of the methods.

4. METHODS

A number of studies have used both qualitative or quantitative or mixed methodology to identify the flooding impacts of housing (Table 1). However this study uses a quantitative methodology with longitudinal data of house sales, inundation levels and mining impacts to answer its two questions. Longitudinal data of price and number of three segments of property markets (house sales - old and new, new house and land packages sales and land sales) have been collected from the Queensland Treasury and Trade database on residential land development activity profile (QTT, 2014 and 2008). Flood inundation level data has been collected from Australian Bureau of Meteorology.

Table 1: Methods Used in Flood Impacts on Housing Market Analysis

<table>
<thead>
<tr>
<th>Author and year</th>
<th>Study Area</th>
<th>Methods and Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eves and Wilkinson, 2014</td>
<td>Brisbane, Queensland</td>
<td>Quantitative – descriptive</td>
</tr>
<tr>
<td>Small et al, 2013</td>
<td>Rockhampton, Queensland</td>
<td>Mixed methods</td>
</tr>
<tr>
<td>Pryce et al, 2011</td>
<td>UK and other areas</td>
<td>Mixed</td>
</tr>
<tr>
<td>Lamond et al, 2009</td>
<td>UK</td>
<td>Repeat sales</td>
</tr>
<tr>
<td>Bin et al, 2008</td>
<td>North Carolina, USA</td>
<td>Hedonic model &amp; spatial analysis</td>
</tr>
<tr>
<td>Lamond and Proverbs, 2006</td>
<td>UK</td>
<td>Regression</td>
</tr>
<tr>
<td>Bin and Pollasky, 2004</td>
<td>North Carolina, USA</td>
<td>Hedonic model</td>
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This study first used both linear and multivariate regression models to predict the sales and establish the relationship between actual and predicted property sales before and after the 2011 flood in Rockhampton. It then estimates the level of significance between and among the variables by using t-test with 95% confidence level. We used JMP-Pro software to apply regression models and also used SPSS Package-PASW Statistics 22 to do the relationship test (t-test). The formula and the findings from these models described in the next section.

5. RESULTS

First we used bivariate linear regression model (LRM) to predict the number of sales of all three components of property market sales (Equation 1).

\[ Y = \beta_1 + \beta_2 X + u \]  

\( Y \) is an observed response variable, here the number of sales. \( X \) is a conditioning or predicting variable. \( \beta_1 \) is an unknown population parameter, known as the constant or intercept term. \( \beta_2 \) is an unknown population parameter, known as the coefficient or slope parameter and \( u \) is an unobserved random variable, known as the error or disturbance term.

Second we carried out independent t-tests to examine whether any significant difference exists between the actual and predicted results of number of total house sales (old and new), number of house and land package sales, and number of land sales. Here, the null hypothesis and the alternative hypothesis (termed as \( H_0 \) and \( H_a \) respectively) are as follows:

\( H_0 = \) no significant difference between the actual and predicted mean values of a particular type of sales, and

\( H_a = \) significant difference between the actual and predicted mean values of a particular type of sales.

The decision rule is given by: if \( p \leq \alpha \), then reject \( H_0 \).

Considering all the empirical results, the condition satisfies only for the number of house sales. For the case of number of house sales, \( p \) is 0.000 which is less than \( \alpha \) (0.05). Therefore, it can be stated that there is a significant statistical difference between the actual and predicted values of the number of total house sales. Table 2 shows the t-test results for number of house sales.

Third we used multivariate regression models (MRM) to add flood and mining impacts in different years (between 2000 and 2014) as two more predictors into equation 1 thereby forming equation 2. Our general regression equation for predicting the number of sales is thus:

\[ Y = \beta + \beta_1 X_1 + \beta_2 X_2 + u \]  

Here \( X_1 \) is median price for house sales or house and land package sales or land sales only and \( X_2 \) represents either flood impact or mining impact, and the following six equations predicted the number of sales of each market segment either considering flood or mining impact (Equations 3-8)

Number of land sales, \( Y_L = 1019.5592 \)
- \( 0.004319 \times \) Land price \((x_1)\) + \( 92.143938 \times \) Flood impact \((x_2)\)  

Number of house and land sales, \( Y_{H+L} = 55.070863 \)
- \( 0.000003641 \times \) House & Land price \((x_1)\) - \( 10.32276 \times \) Flood impact \((x_2)\)  

Number of house sales, \( Y_H = 4881.3018 \)
- \( 0.010216 \times \) House price \((x_1)\) - \( 343.1981 \times \) Flood impact \((x_2)\)
Number of land sales, \( Y_L = 327.7733 + 0.0001345 \times \text{Land price} \times x_1 + 212.0616 \times \text{Mining impact} \times x_2 \) (6)

Number of house and land sales, \( Y_{H+L} = 19.053326 + 0.0000706 \times \text{House & Land price} \times x_1 + 8.5870403 \times \text{Mining impact} \times x_2 \) (7)

Number of house sales, \( Y_H = 5672.7597 - 0.013275 \times \text{House price} \times x_1 - 149.1522 \times \text{Mining impact} \times x_2 \) (8)

Table 2: Independent Samples t-Test Results for Number of House Sales

<table>
<thead>
<tr>
<th>Levene’s Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>F</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>1.3</td>
<td>.3</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>4.476</td>
<td>.001</td>
</tr>
</tbody>
</table>

In these cases, our multivariate regression model indicates that the number of sales (i.e. land, house & land, and house) is a linear function of both the price (i.e. land, house & land, and house) and the impact of flood in different years. The same relationship is also applicable for the case of mining impact in different years. The coefficient of each predictor variable is the effect of that variable, for a given value of the other.

Figure 4a: Mining impact on the number of house sales

Figure 4b: Flood impact on the number of house sales

*(0.0 = No impact, 1.0 = Highest impact)
Considering all the associated p-values of different cases it is observed that the p values of house prices are 0.005 and 0.019 for the mining and flood impact respectively (Figures 4a and 4b). Provided the significance level $\alpha = 0.05$, the decision rule is given by: if $p \leq \alpha$, then we rejected the null hypothesis $H_0$ (“there is no significant impact of mining or flood on house prices”). That implies that MRM models observe statistically significant impact of mining and flood on the house prices only.

6. DISCUSSION AND CONCLUSION

Flooding appears to impact on the number of sales of all components of the housing market more significantly than on the house prices in Rockhampton. Even within the “all segments of housing market”, total number of house sales has been affected very significantly by price of sales compared to the other two segments (i.e., house and land packages sales and land sales only). Eves and Wilkinson (2014) investigated short term house price impact of the same flood in Brisbane and they came to similar conclusions in terms of total house sales. 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 characteristics.

It has been further found that flood impacts on housing markets in Rockhampton have been offset by mining impacts which explains why the devastating 2011 flood did not significantly affect house prices. This explains why Rockhampton has behaved differently to some other cases, such as in the USA (Bin and Polasky, 2004).

Lessons we learned from this study are: (1) local development factors can offset any flood or natural disasters impacts on housing markets either partially or significantly at local and sub-regional scale, (2) housing market price revitalisation in regional or rural towns depends on time and geographical scale of inundation as well as ongoing development projects. Therefore the policy makers should emphasise flood recovery infrastructure works immediately after the flood that can help the local economy and help maintain housing markets.

REFERENCES