Impact Assessment of Flood Risk on Residential Property Market in Taipei Metropolis

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ABSTRACT

The excessive developments in hillside areas around Taipei Metropolis have increasingly caused the occurrence of floods in last decade. Research into hazards indicates that there will be adverse consequences to real estate market when hazardous events happen. And we believe that this is due to people's aversion to risk when they confront risky situation. This study aims to assess the impact of flood events and the public's perception of risk on residential property market. To measure the short-term price fluctuation in residential property market resulting from flood events, we compare the quarterly fluctuation rate of market price over time after each event. In order to analyze risk perception, we obtain public collective expressed preference about decision under flood risk through attitude scales surveyed to owner-occupiers and tenants within Taipei Metropolis. Finally, the inference about the impact of the public's response to risk on property market will be drawn from correlation analysis of potential mitigation measures and risk perception.

Keywords: flood risk, risk perception, residential property market

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Introduction

There are many studies about the impact of natural hazard on residential property values. Most results of these studies suggest that hazard events will have some disadvantageous influence on the market value of property. In flood hazard paradigm, a large amount of previous research investigating flood zone valuation effects had implicitly found that properties located in such regions are characterized by lower prices. Furthermore, the negative valuation effect should be equal in magnitude to the cost of eliminating the risk of loss from flooding (Harrison, et al., 2001). Other researchers like Skrantz and Strickland (1987) and MacDonald, et al. (1990) also conducted research on the hazard insurance premiums and the reduced value of properties. Donnelly (1988) used the regression model to explore the property prices influenced by flood risk that people perceived. He suggested that the perceived risk of the buyer differs significantly from the actuarial risks. One important result is that buyers discount the house by almost double the capitalized values of the actuarially determined risk. Tobin and Newton (1986) developed a theoretical structure to explain changes in residential land values following flood events. They suggested that land values would decrease after flood event, while the magnitude of decrease duration depends on the frequency and severity of the flood event. There are similar results in studies about earthquake hazard paradigm. Murdoch, et al. (1993) and Beron, et al. (1997) used the hedonic pricing model to explore the price fluctuations of housing market that was impacted by Loma Prieta Earthquake in California. In Taiwan, a considerable number of researchers explore the impact of the earthquake event on housing prices after Chi-Chi Earthquake. They also found that there were different levels of housing prices decrease (from 0.5% to 30%) in each areas influenced by this earthquake event.

From the perspective of risk perception studies, people seldom use statistical data to estimate risks. In many cases, they must infer risks from the information that had heard or observed to the best of their memory. Therefore, people tend to overestimate the risks resulting from events that occur frequently or may bring catastrophic consequence because of the ease to recall and imagine. Besides, people are confident of their judgment. According to the research of Slovic, et al. (1979), this is one important factor that makes risk perception have biases. However, people still respond to the risk situation relying on their self-perception or public perception. Such belief in risk perception supports our presumption that the behaviors of people’s response to flood hazard are subject to the risk they perceived. The purpose of this study is to explore the impact of flood hazard on residential property market. Since it is the indirect consequence resulting from the behaviors of people to respond flood events, there is theoretical correlativity between risk perception and residential property market. In order to test the above theoretical perspective and understand the practical impact of flood risk to property market, we investigated and analyzed the data about risk perception and housing prices of the peripheral cities in Taipei Metropolis where flood had occurred in last decade.

Characterization of Flood Risk

This study explores 13 peripheral cities in Taipei Metropolis where had experienced flood events since 1987 to 2000. These cities belong to Danshui River Basin including Keelung River, Xindien River and Danshui River, as shown in fig. 1. There are totally 7 flood events occurred since 1987. Using the statistical data made by Water Conservancy Agency, this study integrates these events data and analyzes flood areas and spatial distribution. The result of each city is shown as table 1.

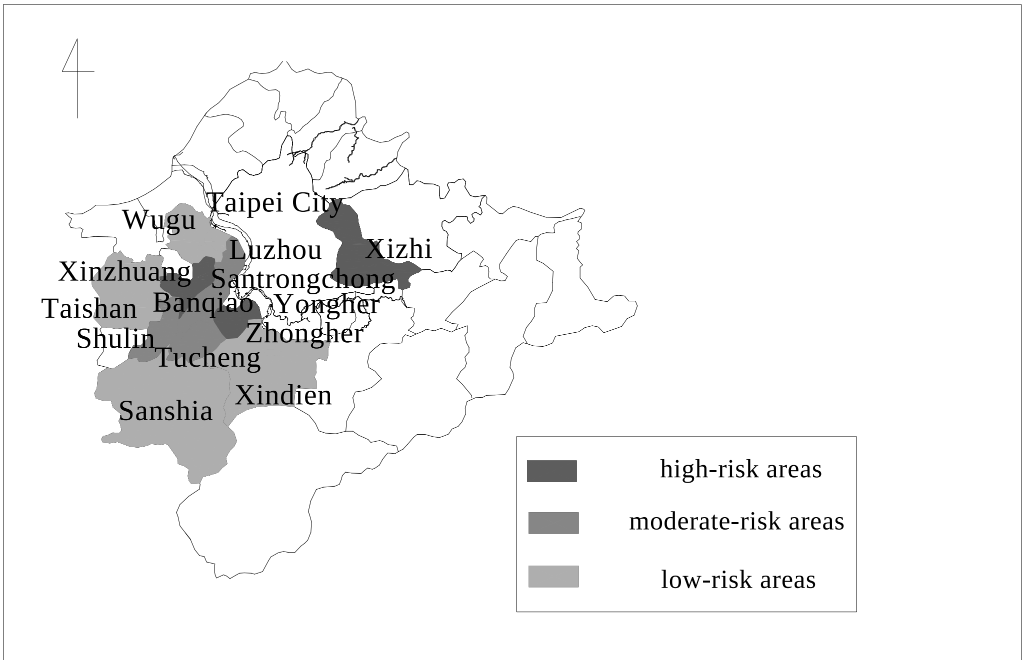

Fig1. Spatial distribution of actuarial flood risk in Taipei Metropolis

Actuarial Flood Risk

In order to understand the risk characteristics of each city where suffered the flood events, we characterized each city's actuarial risks of these flood events with the concept of "risk = frequency * consequence". While to identify risk levels of each city, we used the comparative risk analysis instead of quantified estimation of risk value because lack of detailed data. Each city has its relative position of risk. By comparing the elements that compose risk can identify such position. In the same way, the relative position of actuarial flood risk for each city can be obtained through comparing the statistical data of frequency and submerged areas of flood events. These data can be dotted to a coordinate space to frame a scatter diagram (see fig. 2). Every dot located within this scatter diagram means the simplified risk position of a city. To group all cities into different levels of risk, we partitioned the coordinate space into four quadrants. The horizontal secant is the average of total submerged areas and vertical secant is the average of total numbers of frequency of flood events. Accordingly, those cities locate on the first quadrant are the areas with relative high risk (include Xizhi, Zhongher, Xinzhuan and Yongher) and cities locate on the third quadrant are the areas with relative low risk (include Sanshia, Luzhou, Wugu, Taishan and Xindien). While all other cities locate on the second quadrant and the forth quadrant are the areas with moderate risk.

Table1. Statistics of consequence of flood events in study areas

Impacted City	Flood Events							Frequency (no.)	Submerged Areas (ha/event)
	Lynn Typhoon 1987 (10)	Abe Typhoon 1990 (8)	Herb Typhoon 1996 (8)	Winnie Typhoon 1997 (8)	Zeb Typhoon 1998 (10)	Babs Typhoon 1998 (10)	Xangsane Typhoon 2000 (10)		
Xizhi	609.6			3.49	290	286	356	5	306.15
Santrong		72.8						1	72.8
Xinzhuan		200.0		0.44				2	100.22
Luzhou		8.0						1	8
Taishan		5.7						1	3.7
Wugu		7.0						1	7
Banqiao		100.0	20.8	0.2				3	60.45
Zhongher		250.0	234.0	0.16				3	242.08
Yongher		175.5	1.46	0.12				3	88.48
Shulin		83.5						1	83.5
Tucheng		60.8	0.7	0.03				3	20.49
Xindien				0.1				1	0.12
Sanshia		61.0						1	61

Resource: Statistical data from Water Conservancy Agency.

People's Perception of Risk

This study conducted a questionnaire surveying in the form of attitude scaling to understand the flood risks that residents in 13 cities perceived. There are 351 respondent households are valid within a total of 400 households interviewed. The main respondent person is the key decision-maker of a household. All basic attributes of respondents are as follows:

1. Housing type: there are 281apartments (80.1% of all valid samples), others are

single-family houses.

2. Ownership of building: 257owner-occupiers are the most (with the proportion of 73.2%) and tenants are minor (with 24.5%).
3. Sex: there are 180males and 171 females.
4. Age: the major age group is 21-35, which contains 197 respondents (with 56.1%), group 36-50 is minor (with 112 respondents, 31.9%) and the others exceed 51 years old.
5. Education levels: most respondent persons have college degree or above, totally are 221 persons (with 63%).

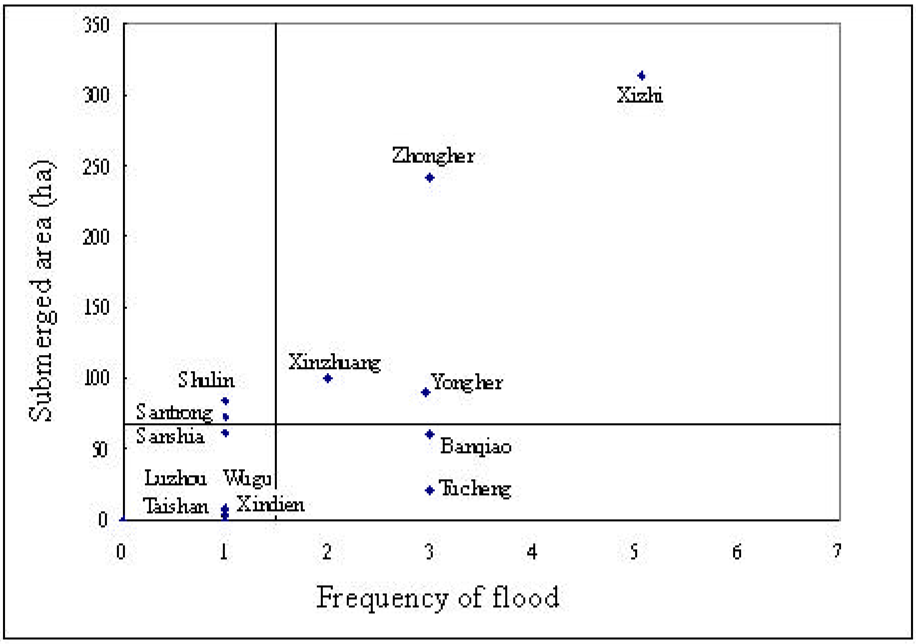

Fig2. The scatter diagram of actuarial risk of each city

There are two questions asking respondents to assign a rating on a scale of 0 to 5 for levels of flood risk perceived where 0 means no risk and 5 means the highest risk. The two questions include "what's the flood risk level do you think where you reside?" and "to compare the flood risk levels of other 12 cities". Such people's attitude to risk can identify both risk perceptions of "self" and "public" for each city through the statistical analysis of those two questions. According to the range of mean rating points for each city, 13 cities are divided into 3 groups including "high-risk areas", "moderate-risk areas" and "low-risk areas". The mean points for 13 cities of two types of risk perception are shown in table 2. Obviously, it exists many differentiae among self-risk perception, public risk perception and actuarial risk. The result of this analysis shows that people's self-risk consciousness is stronger. In the self-risk perception, there are 2 high-risk cities and 6 moderate-risk cities; while in the public risk perception, there is 1 high-risk city and 1 moderate-risk city. Furthermore, most cities obtained the higher points in self-risk perception than in public risk perception.

Table2. The mean points of people's perception of risk evaluated from residents of study areas (n=351)

Risk Position	Point Range	Self-risk Perception		Public's Perception of Risk	
		Mean Points	City	Mean Points	City
High-Risk Areas	3-5	4.06 3.90	Xizhi Yongher	4.33	Xizhi
Moderate-Risk Areas	2-3	2.84 2.81 2.56 2.30 2.24 2.24	Zhongher Bangqiao Tucheng Santrong Luzhou Wugu	2.01	Xinzhuan
Low-Risk Areas	0-2	1.89 1.62 1.29 1.07 0.65	Xinzhuan Taishan Sanshia Shulin Xindien	1.98 1.90 1.83 1.82 1.74 1.68 1.65 1.52 1.24 1.16 1.13	Zhongher Bangqiao Luzhou Yongher Santrong Wugu Xindien Tucheng Shulin Taishan Sanshia

There are some cities obtained the identical position both in people's perceived risk and actuarial risk. They are Xizhi with high flood risk and Sanshia? Taishan and Xindien with low flood risk. In addition, Shulin is the low flood risk city that people perceived yet the actuarial moderate flood risk. While in other cities, there is no common position.

The Impact of Flood Risk

According to the theoretical framework developed by Tobin and Newton (1989), land values will decrease after flooding and then recover in a certain period of time.

Such degree of decrease and recovery of land market will depend on the severity of the event and urban environment. Based on the theoretical framework, this study examines the influences of each flood event to housing property prices in study areas.

To analyze the fluctuations of housing market prices of each city, data were collected on the unit of prices per m^2 of every quarter from "The Statistical Report on Real Estate Prices of Primary Urban Areas in Taiwan". Owing to the limitations of the statistical report, the study length of time merely covers 32 quarters from third quarter of 1992 to second quarter of 2000. It totally occurred three flood events in study areas within the study length. In order to compare the differentiae of prices impact of three types of risk on housing market, we divide study areas into three position of risk space based on its flood risk level. The results of market price fluctuations analysis for actuarial risk areas and perceived risk areas are shown in table 3.

From the examination to the duration of flood events impact to property market prices, we found that the impact duration of first event in 1996 is about 1-3 quarters, second event in 1997 is almost 3 quarters and the following event in 1998 extends to 5-6 quarters. Such phenomenon is consistent with the previous observation of Tobin and Newton: the more frequency of flood events occurred, the longer for it to recover. In the degree of impact, we found that the serious events such as the first event and the third event both produced the maximum quarterly fluctuation rate following the flood event occurred in all influenced areas. For example, in high-risk areas of public risk perception, the third event occurring in 1998(4) produced the decrease proportion of 20% of fluctuation rate in 1999(1) and then the decreasing extent was decaying. Finally, it was recovered to the proportion of 14% in 2000(2). The impact degree of the second flood event occurring in 1997(3) was moderate and the decrease proportion was more little and stable. The observation resulting from above phenomenon show that flood events did decrease the housing prices in study areas, and also exist positive correlativity between severity and frequency of flood events and degree and duration of price fluctuations.

The impact of flood event to each type of risk areas is also different. The mean of quarterly fluctuation rates of market prices per flood event is –2.72% in actuarial risk areas, -5.63% in public risk perception areas and –3.12% in self-risk perception areas. The results are shown in table 4. It shows the discordant impact of people's perceived risk and actuarial risk to fluctuation degrees of housing prices. Obviously, the impact of public risk perception to housing market prices is the most important. It means that the districts where public perceive as high flood risk, their housing prices will have more discount resulting from flood events.

Table3. The quarterly fluctuation rate of housing prices in different risk positions

Unit: NT$10,000/m^2 (%)

Year (Quarter)	Areas of Actuarial Risk			Areas of Public's Perception of Risk			Areas of Self-risk Perception		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
1992(3)	5.36(-)	5.16(-)	4.97(-)	5.23(-)	4.34(-)	5.00(-)	5.86(-)	4.95(-)	4.66(-)
1992(4)	5.28(-2)	5.39(4)	5.70(-23)	4.82(-8)	3.95(-9)	5.25(49)	5.68(-3)	5.29(7)	4.83(4)
1993(1)	6.00(14)	5.28(-2)	5.78(1)	4.78(-1)	4.24(7)	5.78(10)	6.62(16)	5.56(5)	5.01(4)
1993(2)	4.64(-23)	4.88(-8)	7.17(24)	3.13(-35)	4.07(-4)	5.49(-5)	4.59(-31)	5.03(-10)	5.62(12)
1993(3)	4.96(7)	5.42(11)	5.90(-16)	4.92(57)	4.09(1)	5.15(-6)	5.37(17)	5.20(4)	5.00(-11)
1993(4)	5.00(1)	5.58(3)	6.35(7)	4.51(-8)	4.14(1)	5.39(5)	4.96(-8)	5.27(7)	5.24(5)
1994(1)	5.47(9)	5.34(-4)	6.06(-5)	5.25(14)	4.46(7)	5.59(4)	6.37(29)	5.23(-6)	5.26(1)
1994(2)	4.96(-9)	5.31(-1)	7.86(30)	4.63(-12)	4.32(-3)	5.45(-3)	5.20(-18)	5.30(1)	6.09(16)
1994(3)	4.93(-1)	4.73(-11)	5.97(-25)	4.98(8)	3.88(-10)	4.97(-9)	5.37(3)	4.83(-9)	4.92(-19)
1994(4)	4.95(0)	4.84(2)	6.33(7)	4.42(-13)	4.98(22)	5.05(2)	4.82(-10)	4.89(1)	5.66(15)
1995(1)	5.31(7)	5.41(12)	6.38(2)	5.03(12)	5.56(10)	5.29(5)	5.22(8)	5.20(6)	5.97(6)
1995(2)	4.77(-10)	5.69(5)	6.80(6)	4.39(-13)	4.34(-22)	5.49(4)	4.92(-6)	5.23(1)	5.57(-7)
1995(3)	4.63(-3)	4.88(-14)	5.95(-14)	4.15(-5)	4.22(-3)	4.97(-9)	4.72(-4)	4.91(-6)	5.08(-9)
1995(4)	4.82(4)	5.08(4)	6.23(6)	4.32(4)	4.40(4)	5.24(5)	4.92(4)	5.05(3)	5.30(4)
1996(1)	4.71(-2)	4.73(-7)	5.28(-16)	4.68(8)	4.07(-7)	4.83(-8)	5.04(2)	4.76(-6)	4.67(-12)
1996(2)	4.84(2)	4.33(-8)	5.99(13)	4.86(4)	4.18(3)	4.95(2)	5.08(1)	4.89(3)	5.09(9)
1996(3)*	5.48(14)	4.48(3)	5.85(-1)	6.81(40)	3.93(-6)	5.08(3)	6.33(24)	4.83(-1)	4.89(-4)
1996(4)	4.92(-10)	4.14(-8)	5.44(-8)	4.85(-29)	4.19(7)	4.84(-5)	5.36(-15)	4.50(-7)	4.81(-2)
1997(1)	4.95(1)	5.33(29)	5.62(7)	4.48(-8)	4.06(-3)	5.21(8)	5.33(-1)	5.18(15)	4.84(1)
1997(2)	4.78(-4)	5.19(-3)	5.56(-4)	4.42(-1)	4.13(2)	5.14(-1)	5.06(-5)	5.07(-2)	4.85(1)
1997(3)*	5.13(7)	5.03(-3)	5.37(-3)	5.71(29)	4.11(-1)	5.37(4)	5.71(13)	4.88(-4)	4.74(-2)
1997(4)	4.91(-4)	4.93(-2)	5.25(-2)	4.63(-19)	4.14(1)	5.05(-6)	5.15(-1)	4.98(2)	4.70(-1)
1998(1)	4.72(-4)	5.37(9)	5.65(9)	4.71(2)	3.91(-6)	5.03(-1)	5.26(2)	4.93(-1)	4.78(2)
1998(2)	4.32(-8)	5.22 (-3)	5.35(-6)	3.83(-19)	3.71(-5)	4.81(-4)	4.47(-15)	4.87(-1)	4.53(-5)
1998(3)	5.20(20)	6.75 (29)	5.51(6)	6.15(60)	3.93(6)	5.49(14)	6.07(36)	5.74(18)	4.72(4)
1998(4)*	5.06(-3)	4.58(-32)	5.09(-13)	5.34(-13)	4.51(15)	4.69(-14)	5.64(-7)	4.48(-22)	4.80(2)
1999(1)	4.50(-11)	4.73(3)	4.56(-7)	4.29(-20)	3.84(-15)	4.60(-2)	4.89(-13)	4.50(1)	4.20(-12)
1999(2)	4.56(1)	4.68(-1)	4.71(3)	4.01(-7)	3.93(2)	4.61(1)	4.55(-7)	4.71(5)	4.32(3)
1999(3)	4.14(-9)	4.20(-10)	4.44(-7)	3.87(-4)	3.79(-4)	4.20(-9)	4.31(-5)	4.09(-13)	4.11(-5)
1999(4)	4.10(-1)	3.82(-9)	4.30(-3)	3.86(-0)	3.97(5)	4.01(-4)	4.23(-2)	3.88(-5)	4.13(1)
2000(1)	3.89(-3)	4.07(6)	4.23(-0)	3.41(-12)	4.20(6)	4.05(1)	3.93(-7)	3.95(2)	4.22(2)
2000(2)	4.04(2)	3.61(-11)	4.86(13)	3.89(14)	3.95(-6)	4.15(3)	4.11(5)	3.81(-4)	4.41(4)

Note: 1. ” * ” indicates the occurrence of flood event in the quarter somewhere the study areas?

2. ” ” indicates the influenced area and duration of serious flood event;

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Almost every type of risk areas tends to have higher price fluctuation rate when the risk degree is high. Both the data of maximum quarterly fluctuation rate and the mean of quarterly fluctuation per flood event as shown in table 4 account for this result. In the different risk position areas divided by actuarial flood risk, the mean of quarterly fluctuation rate of the three flood events was –4.16% in high-risk areas, -2%

both in moderate-risk areas and low-risk areas. In the different risk position areas divided by public risk perception, the mean of quarterly fluctuation rate of the three flood events in high-risk areas (-9.88%) was about three times of moderate-risk areas (-3.33%) and low-risk areas (-3.67%). Finally, in the different risk position areas divided by self-risk perception, the fluctuation rate was –6.27% in high-risk areas, -1.75% in moderate-risk areas and –1.33% in low-risk areas.

Table4. The comparison of the quarterly fluctuation rates of market prices average in the duration of flood events impact

Unit: %

	Areas of Actuarial Risk			Areas of Public's Perception of Risk			Areas of Self-risk Perception		
	High	Moderate	Low	High	Moderate	Low	High	Moderate	Low
Maximum quarterly fluctuation rate	-11	-8	-6	-20	-6	-6	-15	-7	-5
The mean of quarterly fluctuation per event	-4.16	-2.00	-2.00	-9.88	-3.33	-3.67	-6.27	-1.75	-1.33
	-2.72			-5.63			-3.12		

The Impact of Response to Risk

Many studies about hazard indicate that people have risk aversion tendency when they confront the pure risks situations. According to this point, this study presumes reasonably that people are unwilling to immigrate into the districts with highly flood risk if the risk is an important consideration element before buying a house. So, those districts with highly flood risk perceived by public will confront the pressure of property prices decrease. On the other side, if people perceive risk of the districts they reside are highly, it may urge them to emigrate these districts. And the impact to property market is also negative.

In order to examine this presumption, this study conducted deductions about immigration and emigration. In the part of immigration, we deduced the correlation analysis of "public risk perception" and "the importance of the flood risk consideration before buying a house". In the emigration part, we deduced the correlation analysis of "self-risk perception" and "individual risk response". First of all, the question of the importance of the flood risk consideration before buying a house obtained the average of 3.68 on a five-point scale. This result indicated that flood risk is an important consideration. Second, the results of the correlation analysis between public risk perception and importance of flood risk consideration showed that there was low correlation. While the most important is that the district perceived high-risk by public obtained the positive correlation coefficient 0.178 (with significant at the 99% confident level). The district perceived moderate-risk by public obtained the positive correlation coefficient 0.033 (with no significance). As to other districts perceived low-risk, the correlation coefficient is negative and not significant. Notwithstanding, it clearly shows that many of those considering flood risk into house buying have the same choice while estimating high-risk district.

Third, public measures were thought the most important response of flood risk. It obtained the average of 3.85 on a five-point scale. Relatively, individual measures are much less important. Except for “emigrate flood areas” obtained the average of 3.07, which is at the level of considerable, other measures such as “move in higher floor” (2.17) and “buy flood insurance” (2.06) are both just at the level of under consideration. In the part of the correlation analysis between self-risk perception and individual risk response, it obtained the positive correlation coefficient but without any significance (see table 5). Obviously, though respondents perceived the highly flood risk of districts they resident, they didn’t tend to emigrate. This may be because the moving cost is too high. Furthermore, there is mid-correlativity between “move in higher flood” and “ buy flood insurance”. This may account for the best alternative is the combination of these two low-cost measures instead of the high-cost moving measure. Besides, this result might also explain partly the reason why the impact of self-risk perception to housing prices fluctuation (-3.12%) is less than public risk perception to housing prices fluctuation (-5.63%).

Table5. The correlation analysis of self-risk perception and individual response to risk

	Self-risk perception	Emigrate flood areas	Move in higher floor	Buy flood insurance
Self-risk perception	1.000			
Emigrate flood areas	0.015	1.000		
Move in higher floor	0.065	0.296*	1.000	
Buy flood insurance	0.087	0.235*	0.396*	1.00

Note: “*” significant at the 99% confidence level.

Conclusion

Many researchers have proved that flood events will bring disadvantageous consequences to housing property prices. And the degree of such consequences usually depends on the frequency and severity of flood events. The flood events that had occurred over last decade in Taipei Metropolis were more frequent and sever than before. This study examines the impact of flood risk on housing prices through the practical data collected and investigated in 13 cities of Taipei Metropolis. The results of analysis contain three important findings. First, the degree of impact to housing market prices was not obvious. However, from the observation of change of quarterly market prices, we found that the duration of quarterly market prices decrease following a flood event was longer in the cities where flood occurred more frequently. Similarly, the extent of decrease was larger in the highly risky cities. Secondly, through the combining analysis of practical statistical data and investigated expressed perception of the public, it presented the divergence between actuarial risk and people's perceived risk. After joining up the analysis of market price fluctuations, it showed that the impact degree of risk perception to housing prices was higher than actuarial risk did. Such results revealed the biases that exist in the people's judgment about flood risk. However, risk perception showed the more important influence on the decision of risk response actions. Finally, in order to deduce the impact of risk response behaviors to housing prices, this study investigated the attitude might potentially influence people's immigration and emigration. The finding is unwilling immigrate to highly flood risk areas is the important element to impact housing market.

There are a vast number of factors affecting housing prices, and natural hazard is merely one of them. Moreover, flood event is only one of many kinds of natural hazard. This study examines the impact of flood events on housing price from a risk perspective. This paper attempts to establish the relationship between perception of risk and fluctuation of housing prices through theoretical discussion and empirical correlation analysis. This relationship is proved to account for a certain extent of housing price fluctuation. This relationship, however, cannot explain the entire change of housing price and a more sophisticated analytical model is called for.

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