DYNAMICS OF URBAN UTILITY AND URBAN CHANGE: A FLOOD CASE OF NEW ORLEANS

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Key words: Urban Utility, Resilience, Urban Growth, Flood

SUMMARY

This study investigated the dynamics of utility affected by urban flooding in New Orleans. Disasters occurring in an urban area affect urban change. However, the impact on urban utility change has been rarely investigated. Utility defined as a net benefit of a resident living in an area is measured with earnings subtracting housing and commuting costs. This study applied regression models to test the relationship between urban flooding and urban utility, simulating multiple scenarios to split the total effect into flood effect and recovery effect. Using American Community Surveys' microdata between 2001 and 2016 collected from IPUMS USA, two hypotheses could be tested: urban utility decreased by urban flooding while increased by recovery activities. With additional in-depth analyses, various policy implications useful for planning are suggested. Firstly, New Orleans becomes a less livable city from utility perspectives. The utility increase is significantly smaller in New Orleans (5.6%) than the rest of Louisiana (10.3%) between 2005 and 2016 mainly because rent price increased relatively high in the city. Secondly, a disaster prevention policy could have not only been cost-effective but also led New Orleans to be a more livable place. Lastly, government support positively affected urban utility. For example, the Katrina Emergency Tax Relief Act of 2005 could contribute to one percent increase in urban utility of New Orleans. Therefore, policy makers and stakeholders will be informed of the change in urban utility associated with disasters by adopting various quantitative approaches provided from this study, which is especially important in the era that global climate change increases disaster risk and vulnerability.

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1. Introduction

New Orleans suffered one of the most damaging flood events in terms of social, economic perspectives in U.S. history. The total economic loss in New Orleans is estimated as $62.1 billion, according to a recent study on the Hurricane Katrina damage (Park et al., 2008). In July 2005, 9,592 people applied for unemployment services and the payroll of metropolitan firms declined by 13.6% between July 2005 and July 2007, indicating an estimated loss of 70,000 jobs (Vigdor, 2008). These impacts are the immediate economic loss after the hurricane. To repair such damages, the Federal Government enacted funds of $114.6 billion, but the actual amount spent was estimated $69.4 billion until August 2007 (Fessler, 2007).

New Orleans steadily increased population since 2007, but it has not yet fully recovered to the status of pre-Katrina equilibrium; it seems to reach about 90 percent level of 2016 according to American Community Surveys (ACS, 2018). This study, hence, investigated the dynamics of urban utility associated with urban flooding referring to the New Orleans experience with various secondary data sources including American Community Surveys (ACS) data. On the individual level, utility is defined as a net benefit of an individual residing in an urban area that affects the individual's location decision (Abdel-Rahman, 2003). On a regional level, utility is one of the most important components determining urban growth, because individuals are likely to locate in the area where their utility can be maximized.

Indeed, urban growth will be affected by a disaster occurrence including urban flooding. It is not surprising that studies dealt with floods' impacts on urban destruction are numerous. However, most of the studies did not investigate urban utility change. Further, it has not been investigated how government support could contribute to the recovery of an urban area as time goes on. This case study of New Orleans demonstrates the dynamic relationship between damages of urban flooding and recovery process by government support, combining the estimates of utility loss and government support with econometric models. This study simulated to provide various policy implications through quantitative analyses. The main test includes three research hypotheses as follows: 1) urban flooding decreases urban utility, 2) recovery activities increases urban utility, and 3) urban flooding and the recovery effort generate the dynamics of urban utility.

2. Definition, Data and Methodology

2.1. Definition

As a net benefit for individuals, urban utility is measured as benefits minus costs (Glaeser, 1999 and Muth, 1969). To determine urban utility, Glaeser uses earnings and commuting cost, while Muth additionally considers housing costs. In this study which examines urban utility of hired workers, benefits only consider the wage and salary income of workers over 16 years or more who live in the selected area regardless of their full-time status, and costs include commuting and housing. Commuting cost is measured by value of time between home and workplace. Housing costs include both rent and owner costs.

Benefit function: f_B (B | Earnings)
Cost function: f_C (C | Rent, Owner Costs, Commuting Cost)

2.2. Data

This study used ACS microdata between 2001 and 2016 collected from IPUMS USA (https://usa.ipums.org/usa/). As data distributor of ACS, IPUMS USA provides decennial censuses from 1790 to 2010, ACS from 2000 to the present and survey data around the world integrated across time and space (IPUMS USA, 2018). In the census, the county boundary of Orleans Parish is equivalent to that of the City of New Orleans. Hereafter, for convenience, this study uses the latter term or simply 'the City', and 'the State' to refer to Louisiana State. Based on these two regions, the study collected 16 time samples (2001-2016) and 12 variables (Appendix A). As microdata, each annual sample represents data density approximately 1% (2005 – 2016) and 0.4% (2001 - 2004).

For empirical tests, four models are developed to investigate RUS, IUS, RUC and IUC (Table 1). The goal is to test the hypotheses. These models involve a pseudo-panel data analysis using a general regression, estimated by intercept, dummy variables and interaction variables. Dummy variable is defined as a historical event known to change urban utility. The function of dummy variables is to separate the years before and after a certain event. Interaction variable is also defined by a historical event. However, the function of interaction variables is to increase a time variable, beginning from a certain event. These dummy and interaction variables are differently adopted by model.

Table 1 Four Urban Utility Concepts

Category	Region (abbreviated terms of urban utility)
Individual Urban Utility	City (IUC)
	State (IUS)
Regional Urban Utility	City (RUC)
	State (RUS)

2.3. Methodology

For RUS and IUS, the models are estimated by intercept, a dummy variable representing the occurrence of Katrina (2005) and four interaction variables: the early 2000s recession recovery (2001), Katrina recovery (2005’), the subprime mortgage economic crisis (2009) and the economic crisis recovery (2011). These models include an adjustment on the subprime mortgage economic crisis. Unlike the national economic downturn due to the subprime mortgage impact started at the end of 2007, the State experienced economic challenges later in 2009. This late impact results from the State’s small portion of the financial or investment service center, which is less likely to impact job losses in those sectors. Most importantly, the infusion of federal recovery support after Katrina is a major reason the state’s economy kept increasing and appeared to be tapering off from the end of 2009 (Scott, 2009). The State holds up better economic indicators than other states between 2008 and 2009. Below is the function of both RUS and IUS.

$$Y_t = I + \beta_1(X_t - X_{2001})D^{2001} + \beta_2 D^{2005} + \beta_3(X_t - X_{2005})D^{2005'} + \beta_4(X_t - X_{2009})D^{2009} + \beta_5(X_t - X_{2011})D^{2011}$$

Where
Y_t = annual urban utility;
I = intercept
D^{2001} = 2001 dummy to execute (1) if year is greater or equal to 2001
D^{2005} = 2005 dummy to execute (1) if year is greater or equal to 2005
$D^{2005'}$ = 2005 dummy to execute (1) if year is greater or equal to 2005
D^{2009} = 2009 dummy to execute (1) if year is greater or equal to 2009
D^{2011} = 2011 dummy to execute (1) if year is greater or equal to 2011
X_{2001} = time variable (1) of 2001
X_{2005} = time variable (5) of 2005
X_{2009} = time variable (9) of 2009
X_{2011} = time variable (11) of 2011
β = coefficient of dummy
X_t = time variable of current year (e.g. return 2 if year is 2002)

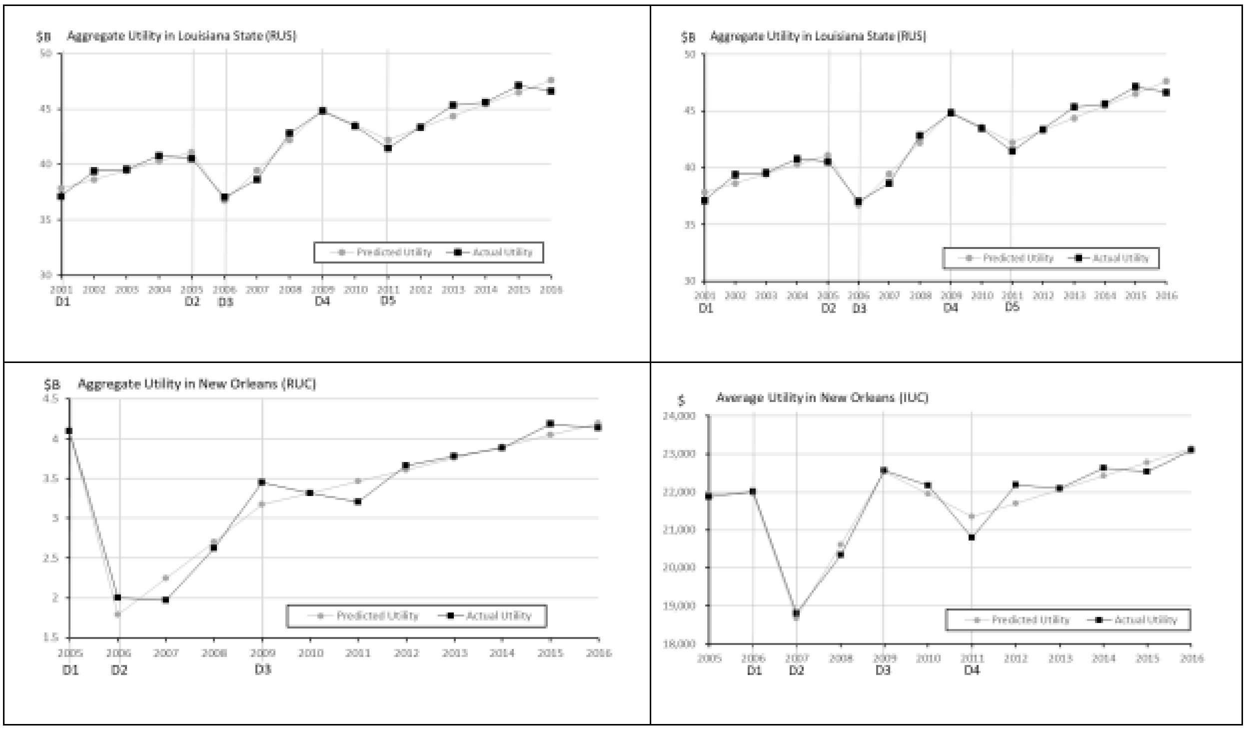
Similarly, the RUC model is estimated by intercept, a dummy variable representing the occurrence of Katrina (2005) and two interaction variables: Katrina recovery (2005’), the subprime mortgage economic crisis (2009). However, the RUC model does not include the economic crisis recovery (2011) due to the insignificant impact.

Unlike other models, the IUC model is estimated by different combination of independent variables despite the same intercept and two interaction variables: the subprime mortgage economic crisis (2009), and the economic crisis recovery (2011). The IUC model involves a delayed impact of the occurrence of Katrina (2006) as a dummy variable, and a delayed impact of Katrina recovery (2006’).

3. Results

Models developed for this study reject the following two null hypotheses: urban flooding does not decline urban utility, and recovery activities do not increase urban utility. The RUS model explains 94.7% (adjusted R square) of the data, including all independent variables significant ($p < .05$), and the IUS model explains 93.7% of the data, including all independent variables significant ($p < .05$) (Figure 1, and Appendices B and C). As both RUS and RUI show similar trends, their models also represent similar trends.

The RUC model explains 93.8% of the data, including all independent variables significant ($p < .05$), and the IUC model explains 92.2% of the data, including all independent variables significant ($p < .05$) (Figure 1, and Appendices D and E). Overall, these four models reject a null hypothesis that urban flooding and the recovery effort do not generate the dynamics of urban utility. The urban flooding immediately declined RUS and IUS by 3 and 6 percent, respectively. While RUC significantly declined by 50 percent due to the population declining by a half. Interestingly, IUC alone experienced one year delay in both urban flooding and the recovery impacts. Therefore, industrial changes should comprehensively be analyzed, because urban utility is highly contingent on wage and salary income, which determines over two thirds of utility value.



Source: Steven Ruggles, Katie Genadek, Ronald Goeken, Josiah Grover, and Matthew Sobek. Integrated Public Use Microdata Series: Version 7.0 [Dataset]. Minneapolis, MN: University of Minnesota, 2017. https://doi.org/10.18128/D010.V7.0

Figure 1 Aggregate Utility (left top) and Average Utility (right top) in Louisiana State between 2001 and 2016; and Aggregate Utility (left bottom) and Average Utility (right bottom) in New Orleans between 2005 and 2016

4. Simulations

4.1. Regional Simulation

To estimate the effects of the flood and recovery, the study simulated two alternative scenarios in the City and the rest of the City (the outer-City) between 2006 and 2009: (1) if the flood did not occur but the recovery activity was provided; and (2) if the flood did not occur and the recovery activity was not provided. This simulation intentionally excluded the years after 2009 due to other historical events - for example, the sub-prime mortgage crisis in 2009 – that would disrupt results.

The majority of the utility loss occurred in the City rather than the outer-City. The utility loss is estimated at $1.2 billion in the outer-City**,** while $8.0 billion in the City (Figure 2 and Table 2). Overall, a utility loss is shown between 2006 and 2009, though a brief utility gain is estimated between 2008 and 2009 in the outer-City.

Table 2 Utility Scenarios and Dummy Effects ($ million) in the outer-City between 2006 and 2009

Year	Actual: Flood(Y), recovery(Y)	Scenario 1: Flood(N), recovery(Y)	Scenario 2: Flood(N), recovery(N)	Total Effect (A): Actual - Scenario 2	Recovery Effect (B)		Flood Effect (C): Actual – Scenario 1
					Scenario 1 – Scenario 2	Percent of actual utility	
2006	35,059	39,131	37,595	-2,536	1,535	4.4	-4,071
2007	36,689	41,357	38,286	-1,597	3,071	8.4	-4,668
2008	40,186	43,583	38,977	1,209	4,606	11.5	-3,397
2009	41,365	45,809	39,668	1,697	6,141	14.8	-4,444
Total	**153,299**	**169,880**	**154,527**	**-1,227**	**15,353**	**10.0**	**-16,580**

Source: Steven Ruggles, Katie Genadek, Ronald Goeken, Josiah Grover, and Matthew Sobek. Integrated Public Use Microdata Series: Version 7.0 [Dataset]. Minneapolis, MN: University of Minnesota, 2017. https://doi.org/10.18128/D010.V7.0

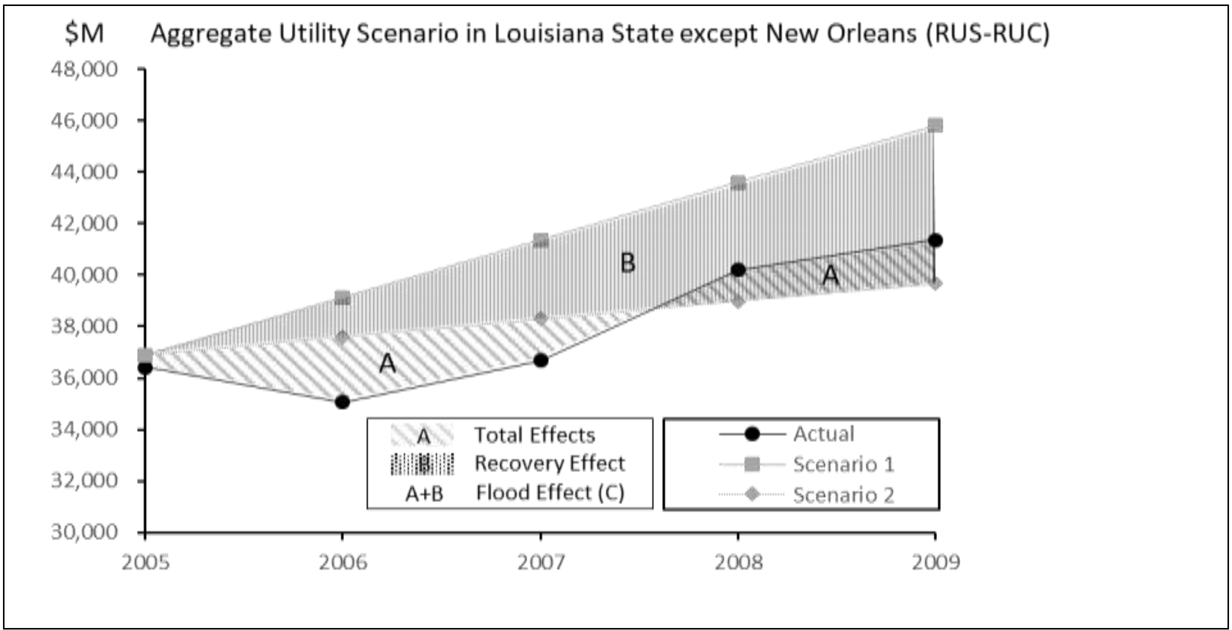
Table 3 Utility Scenarios and Dummy Effects ($ million) in the City between 2006 and 2009

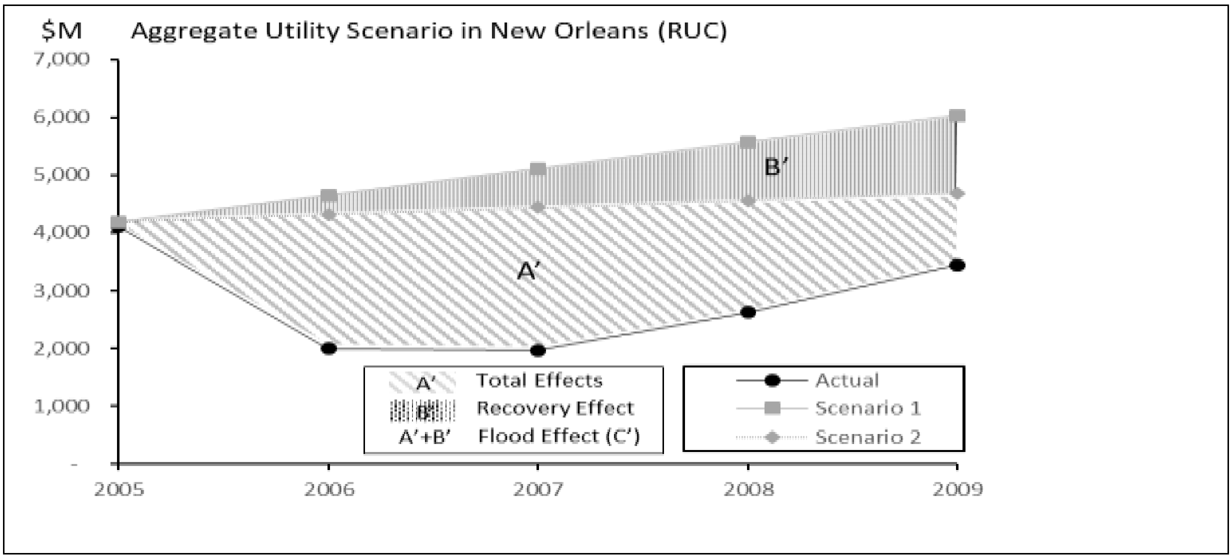
Year	Actual: Flood(Y), recovery(Y)	Scenario 1: Flood(N), recovery(Y)	Scenario 2: Flood(N), recovery(N)	Total Effect (A'): Actual – Scenario 2	Recovery Effect (B')		Flood Effect (C'): Actual – Scenario 1
					Scenario 1 – Scenario 2	Percent of actual utility	
2006	2,000	4,652	4,314	-2,314	338	16.9	-2,652
2007	1,969	5,113	4,438	-2,469	675	34.3	-3,144

2008	2,623	5,574	4,561	-1,938	1,013	38.6	-2,951
2009	3,451	6,035	4,685	-1,233	1,350	39.1	-2,584
Total	**10,044**	**21,373**	**17,998**	**-7,954**	**3,376**	**33.6**	**-11,329**

Source: Steven Ruggles, Katie Genadek, Ronald Goeken, Josiah Grover, and Matthew Sobek. Integrated Public Use Microdata Series: Version 7.0 [Dataset]. Minneapolis, MN: University of Minnesota, 2017. https://doi.org/10.18128/D010.V7.0

This simulation also indicates a large recovery spillover effect in the outer-City. Compared to the City, the outer-City experiences only a 30 percent more flood effect, but its recovery effect is nearly 400 percent more (Figure 2 and Table 3). As a result, the outer-City shows a faster recovery than the City by achieving a positive total effect in 2008, by $1,209 million. This was due to financial flows through the infusion of recovery funds and insurance claims. This unexpected gain is likely to be one of the reasons for the State's late economic recession in 2009, compared to other states.





Source: Steven Ruggles, Katie Genadek, Ronald Goeken, Josiah Grover, and Matthew Sobek. Integrated Public Use Microdata Series: Version 7.0 [Dataset]. Minneapolis, MN: University of Minnesota, 2017. https://doi.org/10.18128/D010.V7.0

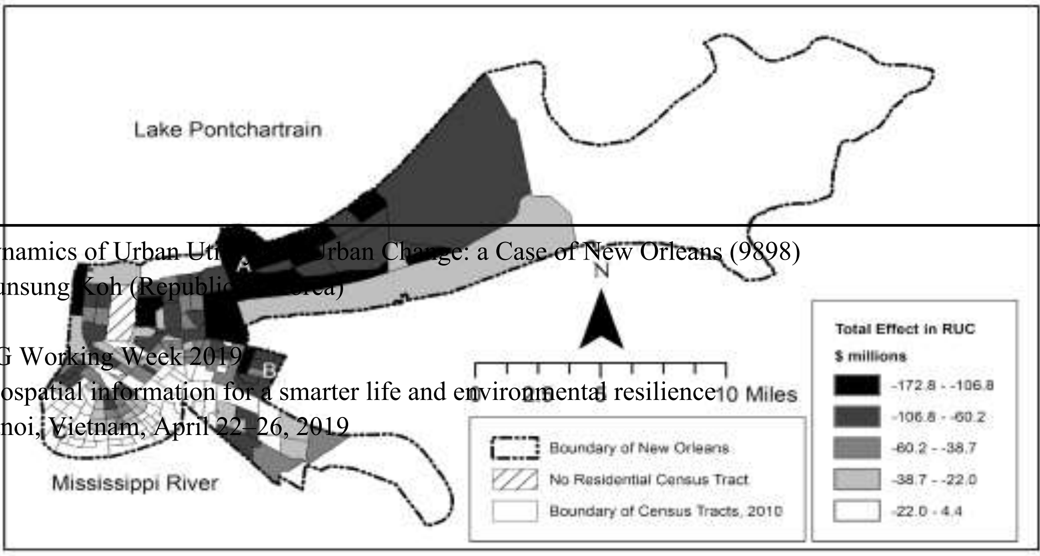
Figure 2 Loss of Aggregate Utility ($ million) due to Katrina in Louisiana State (above) and New Orleans (below) between 2005 and 2009

4.2. Simulation by Census Tract

This simulation analyzed effects of total flood and recovery by census tract. It was based on the Longitudinal Employer-Household Dynamic Original-Destination Employment Statistics (LEHD LODES) data between 2005 and 2009, in New Orleans (https://lehd.ces.census.gov/data/#lodes). As a microdata source, LEHD LODES provides each worker's home location data by census block, between 2002 and 2015. Using 171 census tracts defined in 2010, these effects are represented in each map: total effect map, flood effect map, and recovery effect map (United States Census Bureau, 2017). It excludes uninhabited census tracts 9800, 9801, and 9900.

Based on the estimations in the previous section, this simulation distributed the effects of total, flood and recovery to each census tract, assuming that the flood effect was the main cause of labor change between 2005 and 2006, and the recovery effect caused labor change between 2006 and 2009. For example, more flood effect is given to census tracts that experience larger labor change. Unlike these effects, the total effect by census tract is measured with the flood effect subtracting the recovery effect.

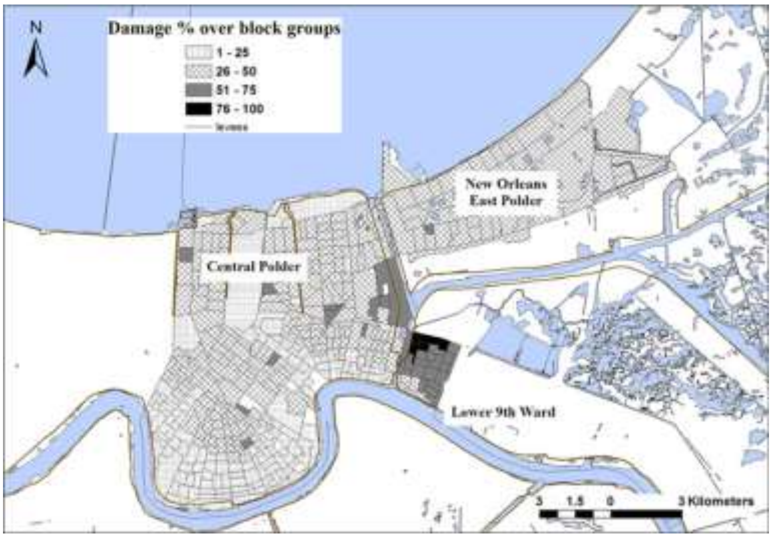
The census tracts that experience higher flood effect also show higher recovery effect, with the exception of a few. In total effect, A and B areas are the most severely affected areas, while C area is the least affected (Figure 3). Such trends are similarly shown in the damaged homes map which indicates home damages by percentage (Figure 4). As one of the



exceptions, B area received relatively low recovery effect despite the severe flood effect (Figures 3 and 6). On the other hand, C area received a higher recovery effect than its flood effect (Figures 5 and 6). Overall, the City experienced fairly balanced utility recovery activities except a few areas, such as B and C, between 2006 and 2009.

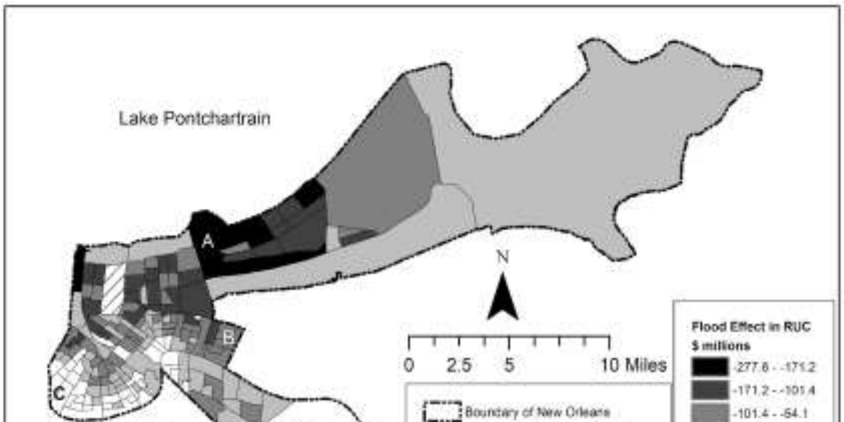
Source: Longitudinal Employer-Household Dynamics, Original-Destination Employment Statistics and United States Census Bureau

Figure 3 Total Effect Map ($ M) by Census Tract in the City between 2006 and 2009



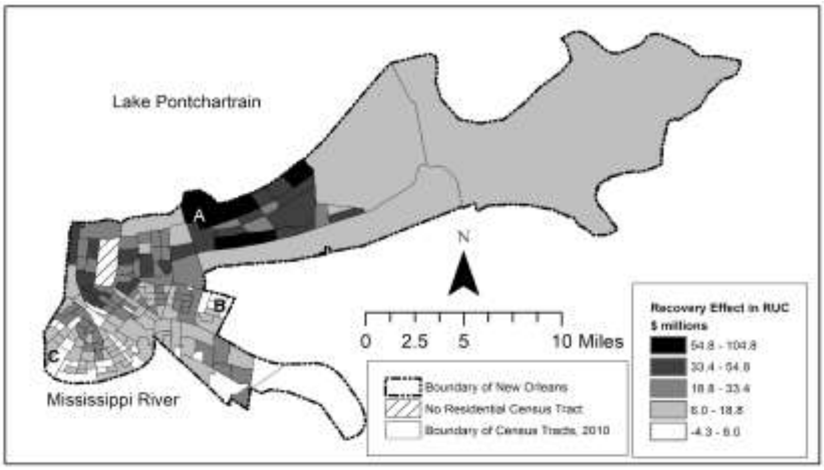
Source: Pistrika, A and Jonkman, S. 2010. Damage to residential buildings due to flooding of New Orleans after hurricane Katrina. Springer. 54:413-434.

Figure 4 Damaged homes in New Orleans



Source: Longitudinal Employer-Household Dynamics, Original-Destination Employment Statistics and United States Census Bureau

Figure 5 Flood Effect Map ($ M) by Census Tract in the City between 2006 and 2009



Source: Longitudinal Employer-Household Dynamics, Original-Destination Employment Statistics and United States Census Bureau

Figure 6 Recovery Effect Map ($ M) by Census Tract in the City between 2006 and 2009

5. Findings

5.1. New Orleans Became a Less Livable City

New Orleans is less likely to recover its equilibrium city size prior to the disaster' occurrence (pre-Katrina equilibrium population) due to a relatively smaller IUC growth than the outer-IUC growth. As in urban utility theory, workers are more likely to settle in cities with a higher utility level. New Orleans has no longer shown a significantly higher utility level since 2007. The average utilities in the City and the outer-City have been equivalent since 2009, this is primarily due to the more significantly increased rent cost in New Orleans (Figure 7). Rent cost shows a 31 percent increase, while the State shows a 14 percent increase between 2005 and 2016. On the other hand, once-soaring owner costs were mitigated by the ‘soft second mortgage program’ in 2011. Therefore, housing policies that mitigate rent cost is highly recommended in New Orleans to recover the pre-Katrina equilibrium population.

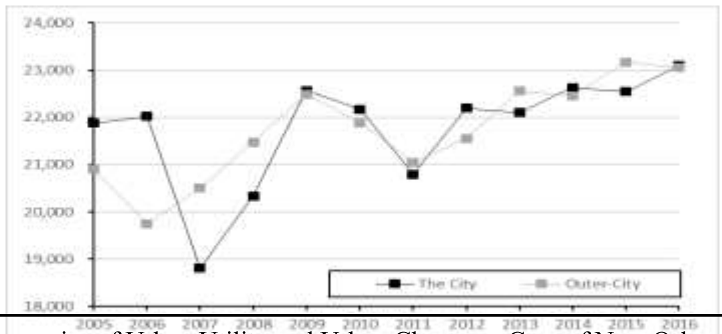


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Figure 7 Average Utility Change in the City and the outer-City between 2005 and 2016

5.2. Government Support in Stabilizing Average Utility

This study also discovered that government support positively affected utility during the decline between 2005 and 2006. As discussed, the negative impact of Katrina was mitigated by the government funds of $69.4 billion, and by policies. These funds quickly created jobs related to recovery activities in the City, which in turn, played a major role in delaying the impact of Katrina on the urban utility decline between 2005 and 2006. The policies were more quantitatively analyzed. On the state level, housing assistance checks totaling $3.6 billion mitigated real housing spending (FEMA, 2006). Although this amount was not included in the data analysis, its impact is estimated at 9.7 percent of IUS 2006, assuming that the total amount was equally divided among workers and all spent in 2006 (Table 4).

Table 4 Impact of Housing Assistance Checks in Louisiana State in 2006

	Housing assistance checks($ billion)	(A) Housing assistance checks per worker ($)	(B) Actual utility per worker ($)	Net utility (A+B)	
				(C) Utility per worker ($)	Percent Increase
2006	3.6	1,927	19,837	21,764	9.7

5.3. The Importance of Disaster Prevention

From utility perspectives, this simulation emphasizes the importance of disaster prevention because the amount of funds spent on recovery, $69.4 billion, would have been nearly 2.5 times greater than the flood effect to RUS of $27.9 billion. Disaster prevention is also expected to generate additional positive impacts on urban utility. As the recovery effect shows, these funds are expected to increase labor and income in disaster prevention industries.

6. Conclusion

This study identified that urban flooding and the recovery effort generate the dynamics of urban utility. Katrina and the subsequent flooding immediately declined IUS in the following year as expected. However, the flood positively affected IUC until negative impacts were shown in 2007. This positive impact is because of the increased average income driven by government funds directed to recovery activities. Then, the recovery effort increased both IUS and IUC. In the multiple scenarios, it is suggested that disaster prevention could have costed less, compared to the funds used in recovery.

This study also identified that urban utility is one of the indicators for a city to recover once-displaced population due to disasters. Policy makers and planners will be informed how to lead a resilient city through the change of urban utility associated with disasters. As individuals are likely to locate in the area where their utility can be maximized, New Orleans showed a significant population recovery when urban utility was greatly increased. To recover pre-Katrina equilibrium population in New Orleans, surging rent is recommended to control. New Orleans between 2005 and 2016 showed a three times higher rent growth, leading lower utility growth.

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Appendix A – Description of Variables and Descriptive Statistics

No.	Name of dataset	Description	Used codes
1	YEAR	Census year	2001 (ACS) – 2016 (ACS)
2	SERIAL	Household serial number	All values
3	STATEFIP	State (FIPS code)	22 Louisiana State
4	COUNTYFIPS	County (FIPS code)	71 Orleans Parish
5	RENTGRS	Monthly gross rent	All values
6	PERWT	Person weight	All values
7	EMPSTAT	Employment status [general version]	1 Employed
8	INCWAGE	Wage and salary income	Except for 999999 (N/A) or 999998 (missing)
9	TRANTIME	Travel time to work	All values
10	OWNERSHPD	Ownership of dwelling (tenure)	Except for 00 N/A (includes 12 Owned free and clear, 13 Owned with mortgage or loan, 21 No cash rent, 22 With cash rent)
11	OWNCOST	Selected monthly owner costs (sum of payments for mortgages, deeds of trust, contracts to purchase, or similar debts on the property)	Except for 99999 Not in Universe
12	INDNAICS	Industry, NAICS classification	All values

Appendix B – Result of Regression Model for RUS

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.982212725
R Square	0.964741836
Adjusted R Square	0.947112754
Standard Error	753016838.1
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	5	1.55153E+20	3.103E+19	54.72445	6.11E-07
Residual	10	5.67034E+18	5.67E+17		
Total	15	1.60824E+20			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	37,837,637,064.6	583,284,334.7	64.87	0.00000	3.65E+10	3.91E+10	3.65E+10	3.91E+10
I2001	814,372,892.6	238,124,832.5	3.42	0.00655	2.84E+08	1.34E+09	2.84E+08	1.34E+09
D2005	-7,091,057,937.4	1,078,719,212.5	-6.57	0.00006	-9.5E+09	-4.7E+09	-9.5E+09	-4.7E+09
I2005*	1,913,482,708.8	400,426,001.5	4.78	0.00075	1.02E+09	2.81E+09	1.02E+09	2.81E+09
I2009	-4,081,129,135.8	663,817,301.6	-6.15	0.00011	-5.6E+09	-2.6E+09	-5.6E+09	-2.6E+09
I2011	2,435,147,984.1	535,319,402.5	4.55	0.00106	1.24E+09	3.63E+09	1.24E+09	3.63E+09

Appendix C – Result of Regression Model for IUS

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.978830819
R Square	0.958109772
Adjusted R Square	0.937164658
Standard Error	266.5169552
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	5	16246216.26	3249243	45.74383166	1.43E-06
Residual	10	710312.8739	71031.29		
Total	15	16956529.14			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	20,074.2	206.4	97.24	0.00000	19614.26	20534.23	19614.26	20534.23
I2001	291.7	84.3	3.46	0.00612	103.8805	479.4559	103.8805	479.4559
D2005	-2,458.7	381.8	-6.44	0.00007	-3309.38	-1608	-3309.38	-1608
I2005*	605.5	141.7	4.27	0.00163	289.6992	921.2592	289.6992	921.2592
I2009	-1,452.6	234.9	-6.18	0.00010	-1976.11	-929.122	-1976.11	-929.122
I2011	971.9	189.5	5.13	0.00044	549.7065	1394.023	549.7065	1394.023

Appendix D – Result of Regression Model for RUC

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.977201673
R Square	0.95492311
Adjusted R Square	0.938019276
Standard Error	194865949.3
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regression	3	6.43541E+18	2.15E+18	56.4915106	9.98E-06
Residual	8	3.03782E+17	3.8E+16		
Total	11	6.73919E+18			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	4,101,750,989.9	194,865,949.3	21.05	0.00000	3.65E+09	4.55E+09	3.65E+09	4.55E+09
D2005	-2,776,751,800.3	297,017,664.0	-9.35	0.00001	-3.5E+09	-2.1E+09	-3.5E+09	-2.1E+09
I2005*	461,132,678.1	71,959,020.7	6.41	0.00021	2.95E+08	6.27E+08	2.95E+08	6.27E+08
I2009	-314,203,128.6	91,036,810.1	-3.45	0.00868	-5.2E+08	-1E+08	-5.2E+08	-1E+08

Appendix E – Result of Regression Model for IUC

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.974741353							
R Square	0.950120705							
Adjusted R Square	0.921618251							
Standard Error	337.9882636							
Observations	12							
ANOVA								
	df	*SS*	*MS*	*F*	*gnificance F*			
Regression	4	15232099.22	3808025	33.3347	0.00012			
Residual	7	799652.4643	114236.1					
Total	11	16031751.68						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	21,949.0	239.0	91.84	0.00000	21383.91	22514.17	21383.91	22514.17
D2006	-5,209.8	560.5	-9.29	0.00003	-6535.27	-3884.39	-6535.27	-3884.39
I2006*	1,935.1	227.6	8.50	0.00006	1396.94	2473.164	1396.94	2473.164
I2009	-2,531.5	379.3	-6.67	0.00028	-3428.4	-1634.69	-3428.4	-1634.69
I2011	954.6	248.2	3.85	0.00633	367.6673	1541.463	367.6673	1541.463

BIOGRAPHICAL NOTES

Munsung KOH holds a master degree in Urban Planning, University at Buffalo (U.S.) as well as another master degree in Geoinformatix, University of Seoul (Korea). He is a cadaster surveyor at LX Korea Land and Geospatial Informatix Corporation. He worked as an organizer for Smart Geospatial Expo in Korea (2015 to 2016). He participated in Land Administration and Management Programme II in Jamaica (2010 to 2012) as a land survey consultant.

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