Reinsurance // Property CAT

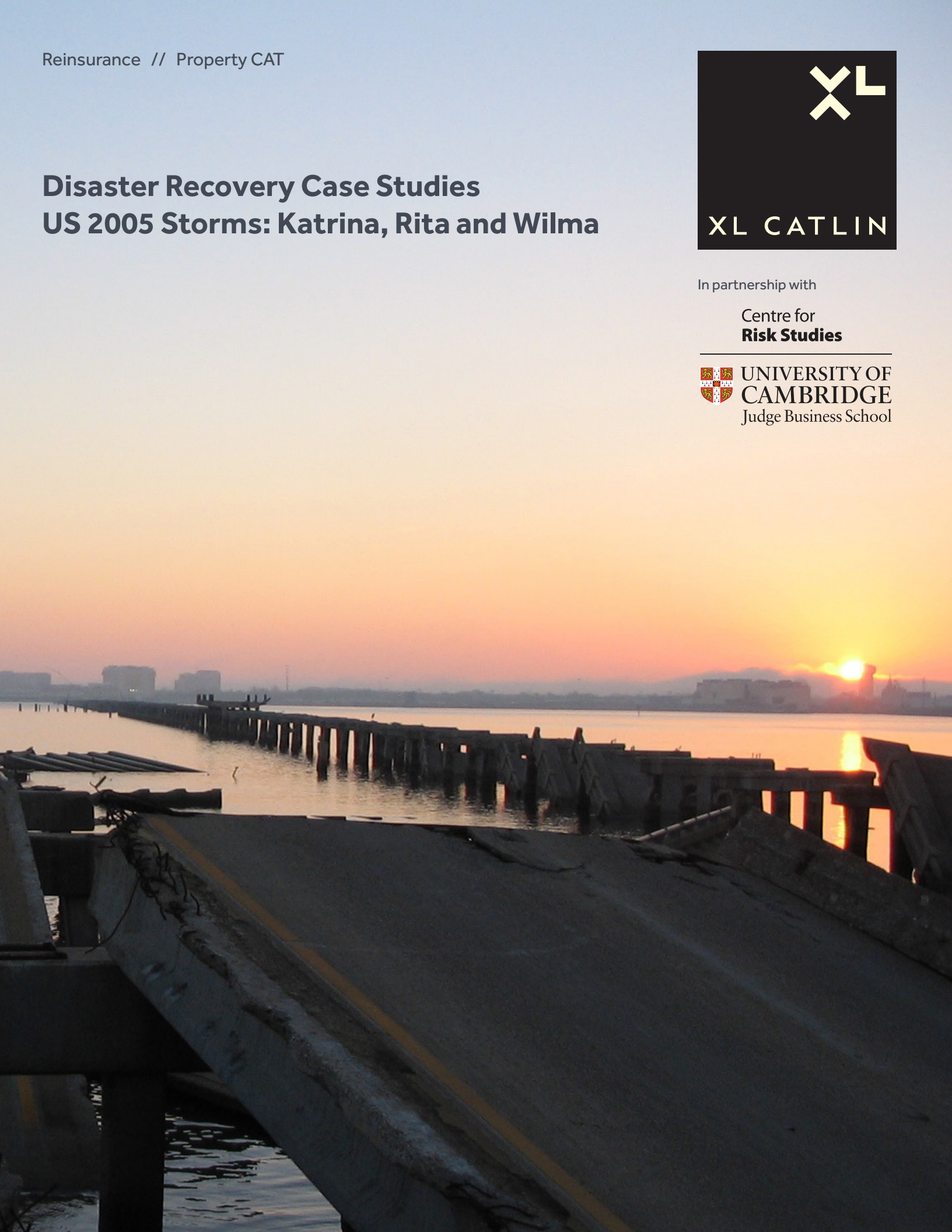
Disaster Recovery Case Studies
US 2005 Storms: Katrina, Rita and Wilma

XL CATLIN

In partnership with

Centre for
Risk Studies

UNIVERSITY OF
CAMBRIDGE
Judge Business School



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Introductory Commentary

Jonathan Gale, Chief Executive, Bermuda Reinsurance, XL Catlin

The important role of (re)insurance in the speed of physical and economic recovery after a major disaster, especially when there is little to no coverage due to unavailability, insufficient capacity or lack of take up (predominantly because of economic reasons), has not really been studied in detail. The (re)insurance industry tends to focus on the potential for future events and events in the immediate past but we at XL Catlin saw the need for a deeper understanding of the aftermath of disasters over a longer time frame, as well as an understanding of the impact that insurance penetration has on the pace of economic recovery.

Working with Cambridge Centre for Risk Studies at the University of Cambridge Judge Business School (CCRS), we have identified 13 catastrophes across the world from 1998 to 2014 to be studied over a three-year timeline to compare and contrast outcomes and establish some conclusions and recommendations. Our original plan was to have one consolidated report released in 2020 but the Case Studies (this one covers Hurricane Katrina) produced by CCRS were so interesting and of such quality we thought it would be beneficial to share these as they became available. CCRS will still issue a consolidated report in April 2020.

Our aim is for this work to be used as a tool by policymakers and governments worldwide when evaluating disaster preparedness and seeking to fully understand, from the lessons learned by others, the impact of displacement of populations; increasing personal debt levels; change in economic mix of industry; political upheaval and overall time to recover, among other things.

We also want to explain the marginal increased cost in relation to the value of rebuilding with resilience – what we call "building back better" – over and above the cost of replacement. The (re)insurance industry needs to provide extra limit and contractual stipulations for "building back better" to minimize the impact of future disasters.

Intuitively, we know the speed and scale of protection the (re)insurance industry provides dramatically reduces the recovery time for communities which have suffered through extreme catastrophes. However, we believe that it is imperative that this be demonstrated in more detail with evidence and placed in front of the right people to effect change.

Almost every event we're focusing on in the 2020 report and associated Case Studies originates from the world's oceans. For the past three decades, XL Catlin has played a leading role in pushing for greater understanding of our oceans, for example, supporting the Bermuda Institute of Ocean Sciences. We have also sponsored independent scientific research into key ocean indicators including extensive work on coral reefs, Arctic sea ice loss and raising awareness of increasing Ocean Risk, i.e., rising sea levels and sea surface temperatures, over-fishing, ocean deoxygenation, pollution and ocean acidity. This work has accelerated in 2018 with the inaugural Ocean Risk Summit held in Bermuda. The Summit, sponsored by XL Catlin and other scientific and Bermuda-based partners, aimed to deepen understanding of Ocean Risk and bring together participants to try to tackle some of these broad ranging consequences.

We are tying increased understanding and awareness of Ocean Risk together with the work by CCRS, making a case for the societal benefit of increased (re)insurance penetration and, in September 2018, will be issuing a special report detailing our own thoughts on the role governments could play in providing cover over and above the (re)insurance industry.

The views, findings and opinions in this Case Study are those of the researchers at CCRS and not necessarily those of XL Catlin. Notwithstanding this, we are proud to be associated with this project and are sure that by gaining a greater level of understanding, we will ultimately develop more catastrophe business and, more importantly, show the world the true value and social benefit of (re)insurance.

Abstract

Hurricane Katrina is considered as one of the most expensive disasters in the history of the insurance industry.

The storms such as Rita and Wilma that ensued made the negative effects pronounced. While at the national level, the impacts on GDP and unemployment were short-lived, their regional and local socioeconomic impacts were found to be very significant. The hurricane trio had a wide-range of effects on the energy sector, housing, infrastructure, construction and, travel and tourism sectors in the Gulf states of the USA. Interestingly, the stock market had barely moved after the storms but the first CAT bond was triggered after Katrina. In addition to the impacts on the economy, several structural issues that were impediments to quick economic recovery were identified. The storms revealed several fundamental flaws in the management of hurricanes characterized by inept disaster response and inefficiencies in administration of aid after Katrina. The over-reliance on ex-post measures like federal disaster aid and the misuse of appropriated funds by aid recipients only slowed the recovery process further. Finally, inadequate risk differentiation of hazard zones, mispricing of risks in coastal areas, lack of enforcement in the purchase of mandatory insurance and lack of incentives for improving private insurance uptake were identified as some of the fundamental problems plaguing the US, those of which warrant immediate attention.

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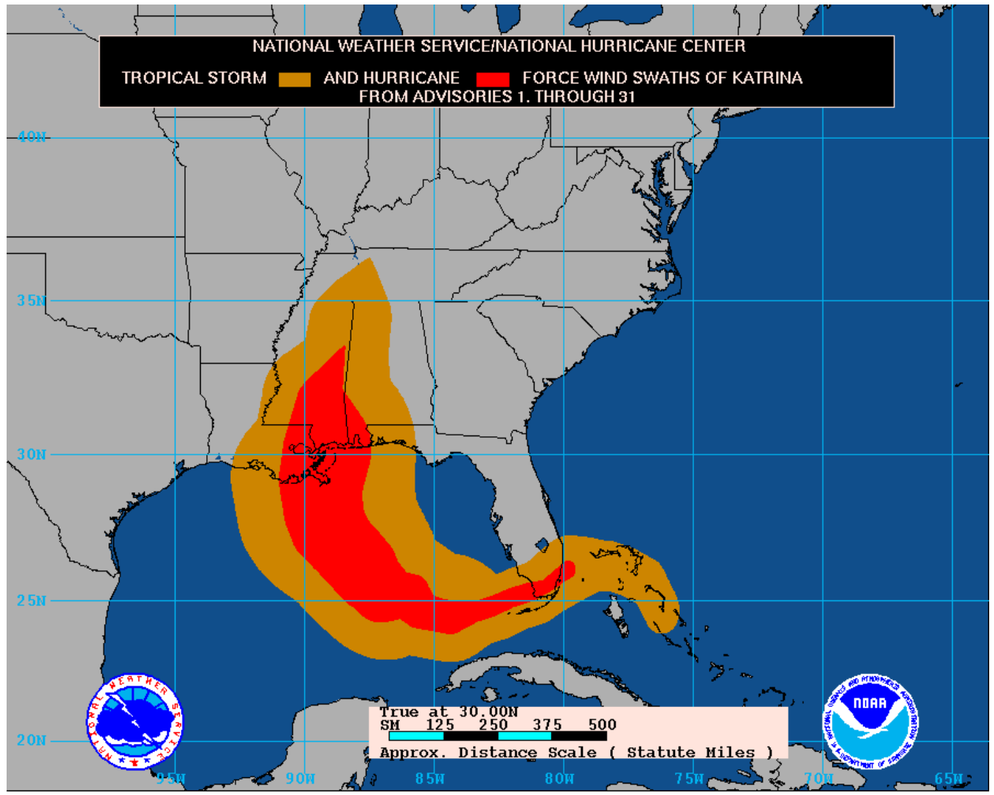
Background

The US Storms trio of 2005, viz., Katrina, Rita and Wilma are the main events of focus in this case study.

Particularly, hurricane Katrina was one of the most devastating hurricanes faced by the US in the last century and is the costliest one ever to be recorded. Katrina made landfall along the Central Gulf Coast in Louisiana on Aug 29, 2005, as a Category-3 hurricane with a windspeed of 125 MPH. It resulted in a storm surge totalling 11 feet in New Orleans and 34 feet in Bay St. Louis and Waveland. In addition to this massive storm surge in these areas, there were 8-15 inches of rainfall that occurred, which exacerbated the situation. These meteorological events led to breaches in three levees in New Orleans, which flooded more than 80% of the total area. In effect, 23 coastal counties in four US states – Louisiana, Mississippi, Alabama and Florida were affected, with a total span of 90,000 sq. miles. Figure 1 shows the trajectory of Hurricane Katrina.

Figure 1. Trajectory of Hurricane Katrina before and after making landfall in Louisiana (Source: NOAA)



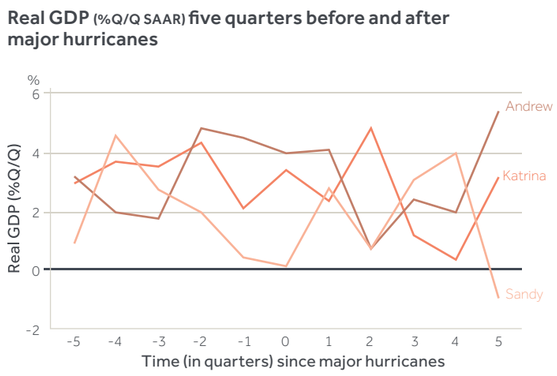
Socioeconomic Impacts

Economic Growth

At the national level, hurricanes (including the major ones) have had very little impacts on economic growth and Katrina was no exception. The forecasters predicted lower GDP growth due to the strength of the hurricane, however, ex-post the disaster there were little change to the actual GDP due to Katrina, Rita and Wilma. Figure 2 shows the graph of major US hurricanes and its impact on national GDP. It is clearfrom the figure that these hurricanes themselves are not severe detractors of economic growth for an economy of this size. It is noteworthy that while the effects of Katrina on economic growth at the national level is not significant, its regional impacts were devastating.

The consensus is that Katrina resulted in economic damages of $108 billion to the US economy, of which about half of which were uninsured according to Swiss Re estimates. (Hallegatte 2008) estimates that in addition to the direct losses report there were indirect losses which added another layer of 28% of the total losses to the total damage estimates. Katrina was one of the most devastating hurricanes in the history of the US, particularly due to the significant damages at the regional levels and the losses incurred by the insurance sector.

Figure 2. Impacts of major hurricanes on country GDP (Source: Rutgers Real Estate)



Labour Market

Local labour markets were the worst hit markets because of the hurricanes. Over 600,000 in the Gulf region lost their jobs due to the storm event and this wiped out 11 years' worth of employment gains in total. The employment sector suffered a massive setback due to the storm and the inundation of the commercial sectors that followed. Of all states that were affected, Louisiana suffered the worst hit. Particularly, 40% of New Orleans workforce were laid off or lost their workplace to the storm. Consequently, the unemployment in the metropolitan region of New Orleans rose from 5.8% to 14.8% within the span of a month (Petterson et al. 2006).

The storms displaced a big fraction of the labour force for a variety of reasons. For instance, after the event, the total population of New Orleans decreased to half of its 2000 levels. Several homes were evacuated and only about half of those displaced returned to their base within three months after the event. Six years after the event, the total population was only 75% of its 2000 levels, which marks a new equilibrium. The returns were slow in comparison to what was expected in a developed country. A key factor that drove the slow recovery of the labour force was the existing (now exacerbated) poverty of the areas in question. Figure 4 shows the recovery trends of the labour market in counties affected by Katrina and provides a comparison across different disasters in the US. It is noteworthy that of all the natural disasters being compared, recovery in terms of employment due to Katrina has been the slowest.

Figure 4. Impacts on the labour market in Katrina affected areas (Source: US Bureau of Labor Statistics)

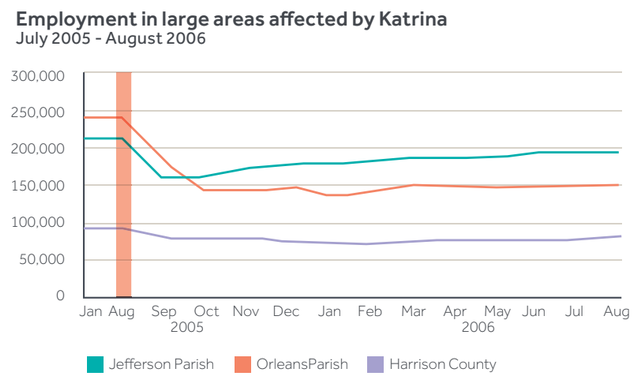
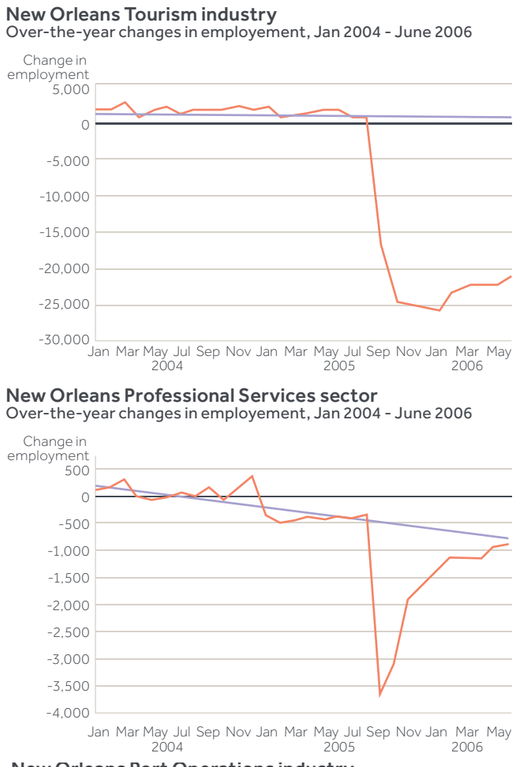


Figure 3. Sectoral breakdown of changes in the employment sector of New Orleans (Source: Dolfman and Bergman (2007))



The chief cause of the labour shortage, apart from migration of workforce to nearby cities, was the lack of housing facilities. In fact, the demand shortages were quite pronounced that prices of houses rose by 10-20%. This includes damaged houses as well. Moreover, it was not uncommon for roofless houses to be sold as-is in the second-hand housing market (Petterson et al. 2006). Due to the reduced supply of the housing materials and increased demand after the disaster, the total cost of building new houses had increased from $80/sq.ft to about $100/sq. ft). All these factors further fuelled the wage increases, particularly in the construction sector. The quintessential feedback dynamics of the macro-economy was at play here. It is to be noted that not all sectors were affected in a similar fashion, which can be seen from Figure 3. All sectors in New Orleans, except the construction sector (which gained from the disaster), were negatively affected. The aggregate change in employment in New Orleans after Katrina is shown in Figure 5 (shown on page 6).

A year after Katrina, the average real wages had increased while the employment prospects were still bleak. During this time, the construction sector got a boost in activity due to the reconstruction and house rebuilding efforts on which New Orleans residents engaged. Job cuts were rampant during this period consistent with the unfavourable macroeconomic situation of the city. Most of the job cuts were at the level of the local government, which were aggressive with their expenditure cuts. As a result, the job losses to the private sector were heavily moderated. Figure 7 (see page 6) shows the distribution of the change in employment a year after Katrina in both private and public sectors. It is clear from the figure that the private

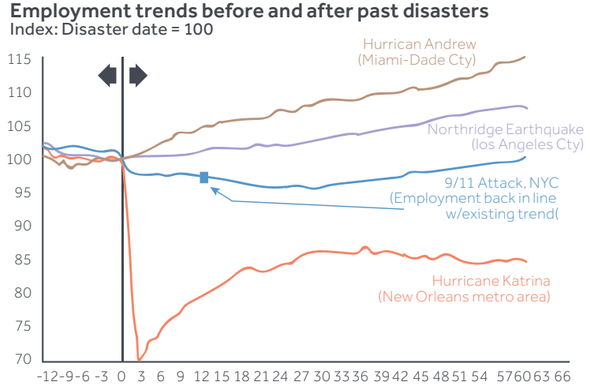
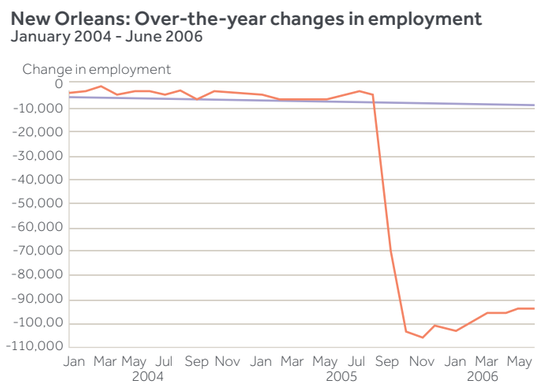


Figure 5. Total changes in the employment sector of New Orleans after Katrina (Source: Dolfman and Bergman (2007))



construction sector was the only beneficiary of the monstrous hurricane, marked by increased year-on-year employment and wage growth. On the other hand, the private accommodation and food services sector of New Orleans had the largest negative percentage change in employment followed by health care and social assistance.

Local unemployment levels had large variations, particularly due to large levels of displacement of residents and relocation by communities to other towns and cities. However, at the national level, the labour market was not affected in the medium-term.

In fact, the unemployment rates of the US dropped back to its projected baseline value within eight months following Katrina. This shows that the smoothing effect of the event across the country as well as the partial success of migrated labourers in finding jobs elsewhere. People displaced did face difficulties in finding jobs elsewhere but eventually adapted. Due to the localized impact of the hurricane, there was a spike in unemployment insurance claims shortly after the event, as shown in Figure 6. However, this appears to be a rather small blip compared to what was to follow in the aftermath of the global financial crisis of 2007.

Figure 6. Trends in unemployment insurance claims (Source: Calculated Risk blog)

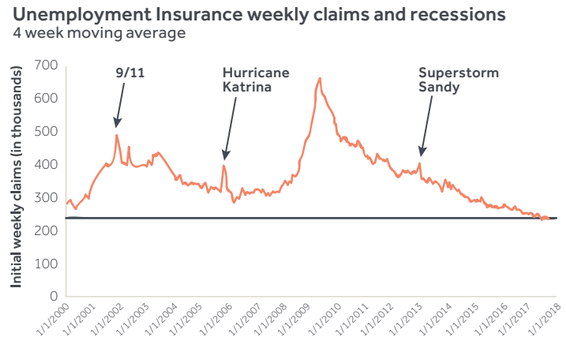


Figure 7. Wage growth and health of the employment sector a year after Katrina (Source: Dolfman and Bergman (2007))

Second-quarter employment and wages, Orleans Parish, 2000

Industry	Average monthly employment (thousands)	Percent of Orleans Parish employment	Percent change in employment, 1990–2000	Total wages (millions)	Percent of Orleans Parish total wages	Average weekly wage
All industries	266.5	100.0	–0.1	$2,088.3	100.0	$603
Private	211.0	79.2	–2.3	1,572.8	75.3	573
Agriculture, forestry, fishing, and hunting	.1	(1)	45.1	.3	(1)	322
Mining	6.5	2.4	–38.3	109.0	5.2	1,298
Utilities	.9	.3	–61.7	13.7	.7	1,217
Construction	7.9	3.0	22.1	62.5	3.0	610
Manufacturing	11.3	4.3	–30.4	107.5	5.1	730
Wholesale trade	8.6	3.2	–17.8	86.3	4.1	770
Retail trade	21.2	8.0	–14.9	103.6	5.0	376
Transportation and warehousing	13.0	4.9	–22.7	116.9	5.6	692
Information	5.4	2.0	–19.3	57.1	2.7	810
Finance and insurance	10.5	3.9	–18.0	117.2	5.6	857
Real estate and rental leasing	4.3	1.6	–8.8	26.5	1.3	475
Professional and technical services	13.4	5.0	–1.2	150.2	7.2	861
Management of companies and enterprises	5.2	2.0	145.1	62.2	3.0	916
Administrative and waste services	17.2	6.4	29.3	75.8	3.6	340
Educational services	7.5	2.8	–15.1	79.9	3.8	818
Health care and social assistance	26.6	10.0	8.1	185.4	8.9	536
Arts, entertainment, and recreation	8.3	3.1	144.0	42.3	2.0	392
Accommodation and food services	34.3	12.9	18.0	134.5	6.4	302
Other services, except public administration	8.7	3.3	–.4	41.7	2.0	368
Port operations	19.5	7.0	–28.7	225.9	11.0	893
Tourism	42.6	16.0	31.2	176.8	8.0	319
Federal government	13.9	5.2	1.1	160.0	7.7	885
State government	18.5	6.9	21.4	153.3	7.3	637
Local government	23.1	8.7	5.4	202.1	9.7	673

[1] Less than 0.1 percent.

Sectoral Impacts

Energy

Most of the areas that were affected were quite key to the US national energy supply system. The location of impact being close to the Gulf of Mexico makes it a prime spot for severe disruptions to oil and gas production. After Katrina, over 50% of crude oil and natural gas production in the Gulf were considered non-productive, referred to as a "shut-in". The recovery was moderate, with only a quarter shut-in by the end of 2005. Furthermore, more than 90% of the oil production were left unusable after Katrina, only to be completely shut down after Rita, a month later. About $38 billion in revenues from production of 153 million oil barrels were missed due to the shut-in process (Petterson et al. 2006). Figure 8 shows the drop in crude oil and natural gas production in the Gulf of Mexico. The only other hurricane in the tens years since Katrina to have made a visible impact was Gustav in 2008.

Due to the shut-in, spot prices of gas rose immediately by 30%. However, it recovered back to its baseline values within a weeks' time, which was faster than Harvey, and traded below baseline later (as shown in Figure 9). On the other hand, the retail gas prices increased by over 35% within the span of a month and recovered over a period of five months after Katrina made landfall. The slower recovery in comparison to spot prices can be partly attributed to the delays in the supply chain. For instance, the disruptions to the downstream gas transmission and distribution adds to the cost of the prices of fuel and this is factored in with the retail prices. Table 1 shows the recovery calculations for retail gas prices in three most affected states.

Figure 8. Gulf of Mexico crude oil and natural gas production trends since 2005 (Source: EIA)

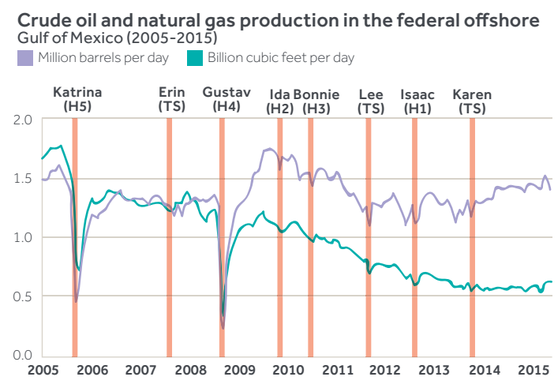
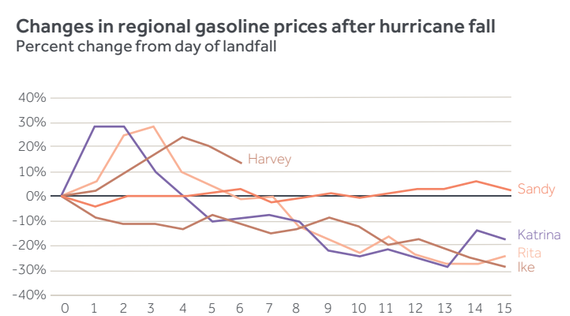


Table 1. Recovery of retail gas prices after Katrina (CCRS calculations using MERIC data)

State	Nov '14	Aug '15	Nov '15	Recovery (5 mos)
Louisiana	$1.87	$2.50	$2.21	11.2%
Mississippi	$1.87	$2.51	$2.13	15.1%
Alabama	$1.88	$2.51	$2.12	15.5%

Figure 9. Changes in regional spot prices of gasoline after hurricanes make landfall (Source: EIA)



Housing

The other important sector apart from Energy to be severely affected by the floods that ensued was the housing sector. The massive surge of displacement of people from their residences to other towns and cities had significant implications for the macroeconomy, particularly in terms of GDP growth of the region as well as the unemployment rates in the labour market.

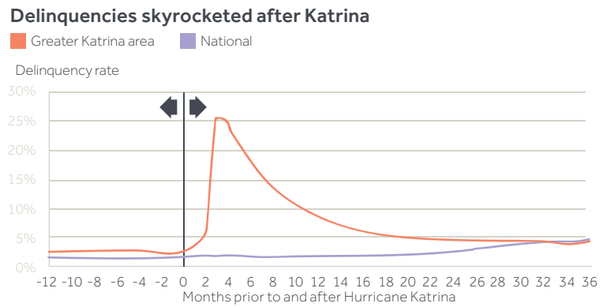
The primary impact on the housing sector is linked to ownership of houses and possession of flood insurance. Between 80,000-100,000 homeowners in New Orleans area alone did not have flood insurance. This resulted in external dependence on federal and state-aid, which was slower to materialize and therefore affected the spee as well as the quality of recovery. Consequently, mortgage payments were affected due to the financial constraints imposed upon by the hurricanes. For instance, 12% of housing loan borrowers in Louisiana were behind their loan repayments by over 90 days, as of December 2005. The delinquencies reported after the hurricanes were the highest since the 1980s in the US (see Figure 10. Delinquency rates and foreclosure rates after Katrina (Source: Urban Institute) Figure 10). Interestingly, the foreclosure rates were still lower than the national average which led prime lenders to allow a 3-month grace period (Petterson et al. 2006). Similarly, Fannie Mae allowed an 18-months grace period. These measures prevented premature liquidation of houses due to foreclosures and therefore averted a market collapse, a year before the actual housing sector collapse in 2007.

The destruction of property, particularly houses led to an increase in demand for houses. This resulted in an increase in average house prices and rents in the greater metropolitan areas. Moreover, there was a marked increase in the number of mortgage originations. The increase in mortgages imply a highly levered housing market, which destabilizes the economy in the long-run. The paucity of ex-ante protection measures only adds to the economic stability concerns. Notably, high leverage in the housing sector was one of the key reasons for the housing market collapse and the subsequent global financial crisis in 2007-08. The specific trends in the housing market are graphically presented in Figure 12.

Contrary to expectations, the total debt balance of New Orleans residents, particularly those who were adversely affected by the floods, were reduced after Katrina. This observation however is consistent with the fact that homeowners used their pay outs to pay off mortgages than opting to rebuild. It also serves as an explanation for the increase in credit card balances after the event, where homeowners chose to pay off their debts on mortgage by raising their credit balances.

Furthermore, flood insurance contributed towards the reduction of mortgage debts after the hurricane, which also is consistent with the timing of the pay outs. See Figure 11 for the change in trends across these balance before and after the hurricane.

Figure 10. Delinquency rates and foreclosure rates after Katrina (Source: Urban Institute)



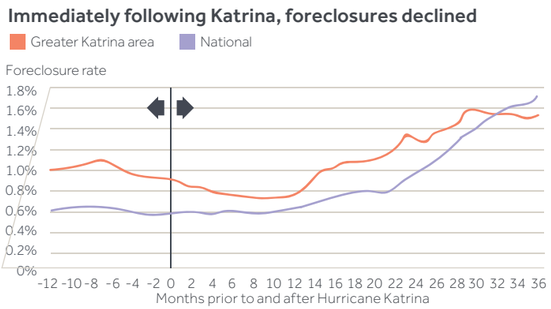
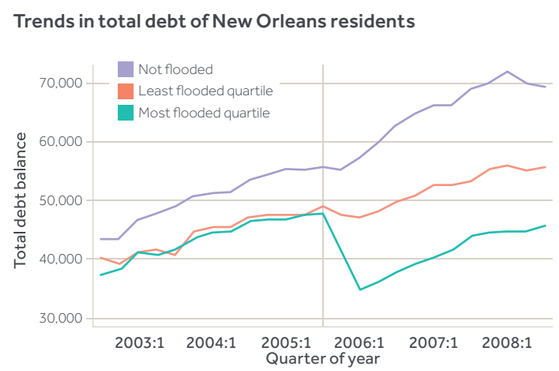
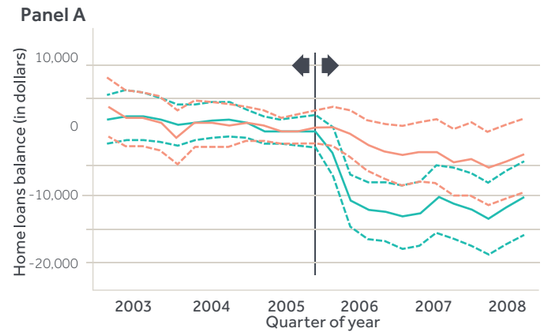


Figure 11. Trends in total debt, home loans and credit card balance of New Orleans residents (Source: Gallagher and Hartley 2017)





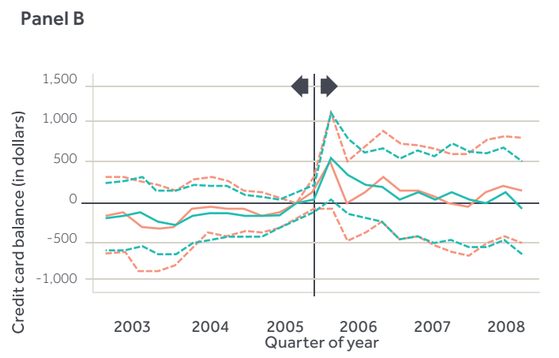
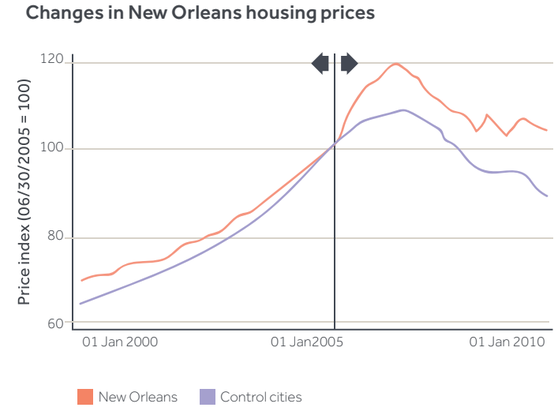
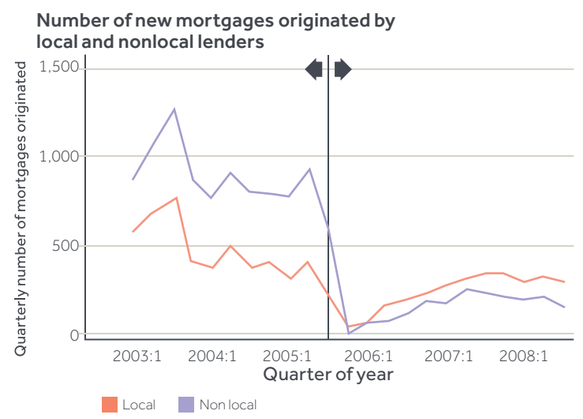


Figure 12. Trends in house prices and new mortgage originated in the New Orleans Area around the time of Katrina (Source: Deryugina, Kawano, and Levitt 2014; Gallagher and Hartley 2017)





Infrastructure

As expected of a hurricane of such magnitude, it caused extensive damage and destruction to infrastructure.. Total infrastructure damage estimates varied by industry:

- Energy: $18-21 billion
- Government structures and equipment: $13-25 billion
- Other industries: $16-32 billion
- Rebuilding costs of damaged infrastructure such as roads, bridges: $3.5 billion

Debris removal alone accounted for 40% of the total costs. In addition to these damages, disruptions due to infrastructure damages also persisted for quite some time. There were quite a few instances where trains were halted for several miles in the US rail systems. In some cases, farm and industrial goods from Midwest suffered temporary access to foreign markets. Furthermore, they also resulted in supply disruptions for basic US food products and certain imports from abroad.

New Orleans is a very important US port, and part of a major commercial waterway in the country. In fact, it is the fourth largest in terms of tonnage. Hurricane Katrina damaged 12 wharfs and affected several transportation barges.

Construction

Manufacturing and construction sectors in the region were severely affected. Sales of single-family houses increased by 13%, a month after the disaster due to the rise in demand after the disaster (Petterson et al. 2006). Residential building permits were 6.7% lower and construction activity (indicating new starts) were lower by 5.6% but completion rates were unaffected, a month later. There were no major changes in prices of construction equipment except transitory price increases to essential building materials (see Table 2 for details on the price changes).

Table 2. Impacts on Katrina on prices of building materials (Source: BLS Producer Price Index series)

Table 1: Changes in prices of building materials

	Seasonally adjusted percent change from:	
	Aug to Sep	Sep to Oct
Intermediate materials less food & feed	2.7	3.0
Plastic construction products	1.6	7.4
Softwood lumber	2.8	-1.2
Plywood	14.1	5.1
Steel mill products	3.7	3.0
Cement	0.7	1.2

Others

Businesses
Businesses took a big hit due to disruptions caused by the floods. For instance, about 80,000 businesses in South West Louisiana were affected, particularly with the restaurants taking a major hit. New Orleans mayor announced permanent layoffs of 50% of non-essential workforce to cut expenses towards achieving an estimated savings of 25%. Furthermore, to boost activity, Louisiana temporarily offered 6-month interest-free loans to the value of $100,000 and helped businesses get back on their feet.

Travel and tourism
Tourism is an important sector for New Orleans and nearby areas. The popularity of the casinos and resorts makes tourism one of the major source of income for the local economy. About 20% of the population in the Gulf states were employed in the tourism-related sectors. New Orleans' tourism sector accounts for $5 billion in revenues annually, which is also the largest industry in terms of employment in the city. Table 3 shows the estimates of average daily losses in the tourism sector, in the four most affect states, resulting from lower revenues and consumption by tourists after Katrina.

Fisheries
Losses in the fishing industry varied by activity across the Gulf region, with seafood industry suffering the biggest blow of $1.3 billion and other losses arising from missed commercial trips. Insurance had notable impact on the fisheries sector after the hurricanes (Petterson et al. 2006). Fish-processing firms were more likely to be insured and hence reconstruction was expected to take place relatively quickly. Similarly, vessels were required to have insurance but on the other hand fishermen were not required to have them. A complication to the recovery process of the fisheries sector was that some companies rejected claims when vessels damaged by Katrina's winds were also damaged by Rita's waters. The wind vs water was a very prominent debate and led to several litigations after the storms subsided.

Table 3. Loss estimates and vital figures on the tourism sector in the Gulf States (Sources: Travel Industry Association of America and Travel Business Roundtable)

Table 3: Estimated impact of Hurricane Katrina on local travel and tourism

	No. of counties affected	Spending on tourism in 2004	Daily spending losses	No. of jobs supported
Total	50	$18.3 B	$50 M	260,000
Alabama	3	$2.0 B	$5.5 M	30,000
Mississippi	15	$2.8 B	$7.7 M	38,000
Louisiana	32	$13.5 B	$37 M	191,000

Social Impacts

In addition to the economic impacts, the social dimension of the problem was also significant. Around 2000 were killed by Katrina's might. The numbers were the largest in Louisiana followed by Mississippi and the other Gulf states. Additionally, 700 were missing and 6000 were injured. As outlined earlier, Katrina succeeded in displacing several residents from their bases. In 6 months, over 43,000 apartments (approximately 24%) were destroyed and over 200,000 were left uninhabitable in the states of Mississippi, Alabama and Louisiana. Following the storm, the demand for rentable houses had risen rapidly and far exceeded availability, which substantiates the massive relocation drive to nearby states (see Figure 13).

The storms led to displacement of 1.5 million people to different parts of the US (Petterson et al. 2006). In some cases, those who were displaced chose to return to their original base. Homecoming after disasters typically depends on several factors such as family and work, scale of event, extent of damage, reconstruction/ housing circumstances and finally, financial constraints. Family and work is one of the chief reasons for the return effect in the US generally after natural disasters. Impacts after Katrina lasted over a year after Katrina and therefore resulted in permanent relocation particularly for some with financial constraints. Importantly, rent increases post-disaster smothered any hope of return to New Orleans for homeowners, who incidentally were mostly uninsured. Figure 15 illustrates the sudden drop in new supply of houses, which in combination with high housing demand led to rapid growth in rents in the New Orleans area.

There was a structural change in population of most of the counties since Katrina, with some counties never achieving the pre-disaster population. Ten years later, only 90% of the pre-storm population achieved in 40 of 72 New Orleans neighbourhoods (Plyer & Mack, 2015). For a selection of the recovery trends in population across major counties, see Figure 14.

Figure 13. Displacement and migration of people after Katrina (Source: US Census Bureau)

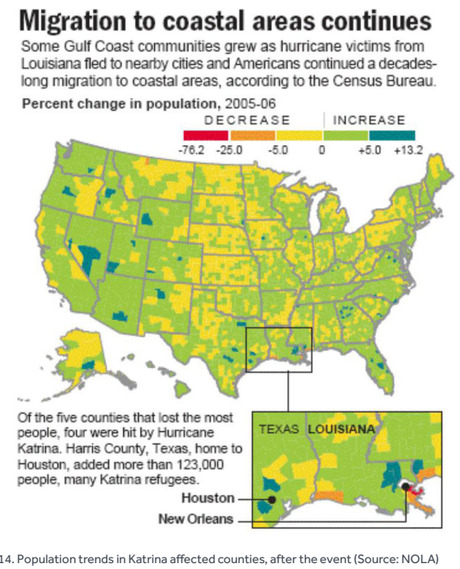


Figure 14. Population trends in Katrina affected counties, after the event (Source: NOLA)

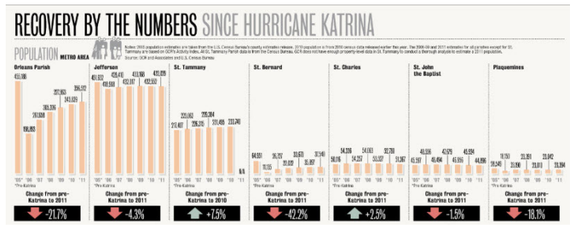
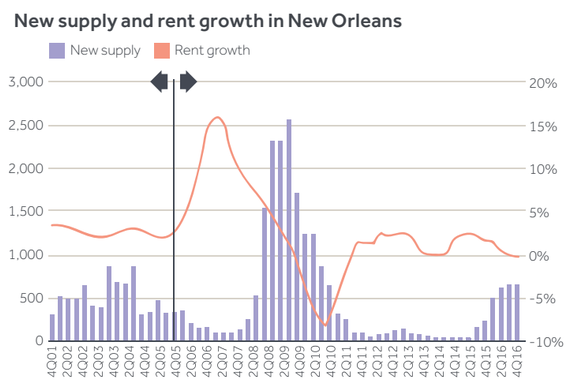


Figure 15. Trends in house supply and rents before and after Katrina (Picture source: Axiometrics)

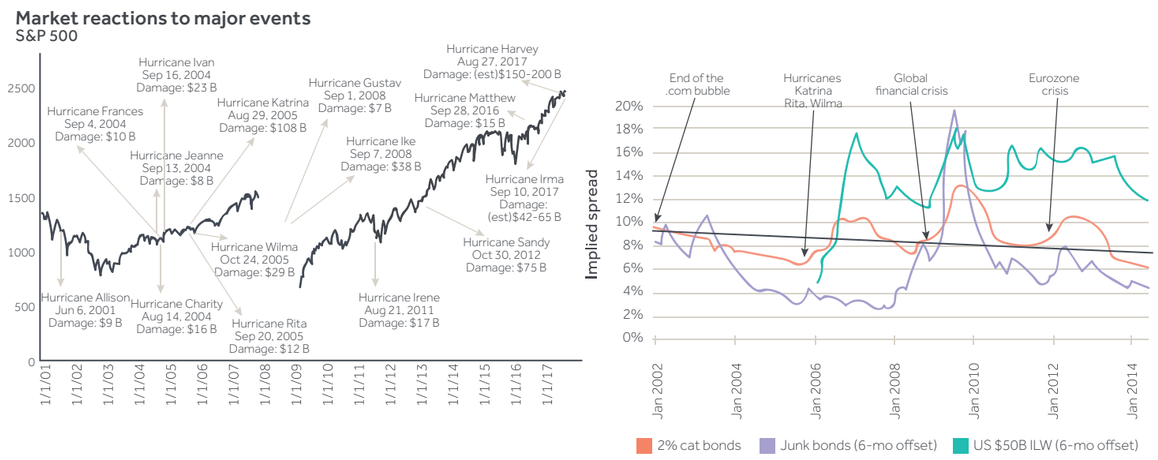


Financial Markets

The impacts of Katrina on the stock markets were transitory and the markets continued to operate as usual very quickly. Therefore, there was only a lukewarm response to Katrina at the US stock market indices, which is evident from Figure 16, where the price decline has not been signficant. Data shows that stock prices of insurance companies decline after hurricanes due to losses from the event. In fact, the decline began before Katrina made landfall in anticipation of future losses to the insurers (Blau, Ness, and Wade 2008). Evidence of short-selling by investors before hurricane Rita but not before Katrina. Investors may have learnt from Katrina and then applied to the forthcoming disasters. P&C insurance firms did not display significant cumulative abnormal returns for stock prices in the 20-day window (10 days each before and after landfall) during Katrina and Sandy; unlike some other hurricanes (Feria-Domínguez, Paneque, and Gil-Hurtado 2017). Due to pricing and availability issues, the event had also resulted in the introduction of new types of insurance products in the ILS markets. There has been an annual growth of 23% of non-life ILS markets since 2000 and Katrina has been partly attributed for this drive in the US, given the losses to the insurance sector.

On the other hand, implied spreads widened for the 2% CAT bonds after these hurricanes due to a sudden reduction in global reinsurance capital, which had implied an increase in the risks of holding CAT bonds (see Figure 16). In effect, the lower capitalization of the insurers due to losses arising from the hurricanes was one of the primary factors of the widening of these bond spreads. Furthermore, the first ever trigger of a CAT bond was also observed after Katrina. It was a $190 million worth security that was tied to the policies by Zurich Financial Services and issued by Swiss Re.

Figure 16. Stock market and CAT bonds market reactions to major events (Source: Wikipedia)

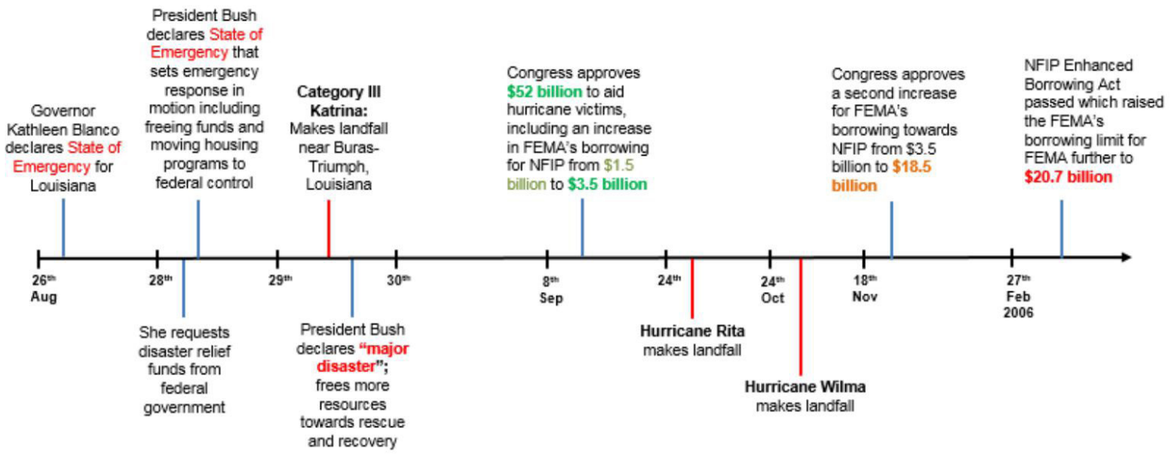


Recovery

Disaster Management Efforts

In the US, the state must first declare emergency and request the President of the country to initiate the relief efforts from the federal government. The President then typically frees the funds allocated for reconstruction, recovery and relief to the state after declaring a state of emergency. In the case of Katrina, these were set in motion a few days before it made landfall because of the pre-storm damages and the severity of the threat posed. On the 29th of August, Katrina made landfall which led to unanticipated damages. A week later Congress approved $52 billion in the form of aid to the victims and increased the borrowing of the Federal Emergency Management Agency (FEMA) for its National Flood Insurance Program (NFIP) from $1.5 billion to $3.5 billion. However, in the span of two months after Katrina, Rita followed by Wilma made landfall thereby exacerbating the damages caused by Katrina. Consequently, in November, the congress approved another increase to the NFIP program to $18.5 billion, which was further increased to $20.7 billion within the next three months to meet the needs. Figure 17 summarizes the timeline of disaster management efforts during these storms.

Figure 17. Disaster management timeline during the US storms of 2005



The major sources of funding after disasters in the US are NFIP, Community Development Block Grant (CDBG), private insurance, charitable donations and humanitarian aid.

The NFIP program was established in 1968 to address lack of flood insurance. NFIP is now the primary source of residential flood insurance in the country. It has over 5 million policies in force in US, representing nearly $1.25 trillion in terms of coverage. Private firms write policies and process claims on NFIP's behalf, but bear none of the risk and they are not responsible for setting premium rates. There is a maximum residential limit of $250,000 for building coverage and $100,000 for contents coverage. Non-residential policyholders can insure both structure and contents up to $500,000 each (only 5% of total policies). On the other hand, CDGB is a very important tool that federal government used to deliver disaster assistance for disaster-affected states and localities. It was the largest source of funding for rebuilding and reconstruction efforts after Katrina (see Table 4 for an overview of all the federal funding sources).

Table 4. Major federal funding sources for recovery after Katrina (Source: Spader and Turnham 2014)

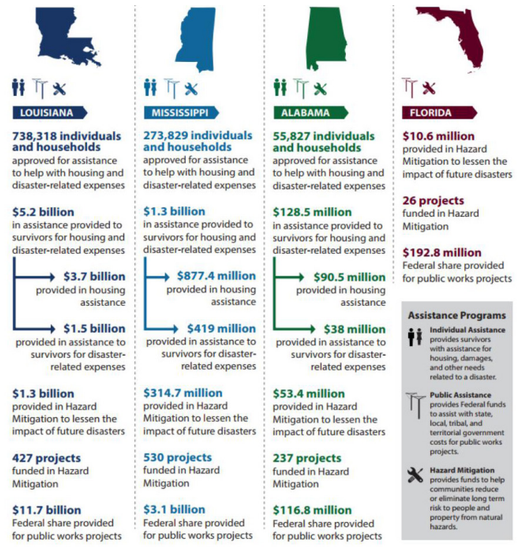
Federal Agency	Program	Appropriations/Allocation Authority ($)
Federal Emergency Management Agency	Hazard Mitigation Grant Program	$1.9 Billion
	Individual and Households Program	$684 Million
	Public Assistance for Permanent Work	$33 Million
U.S. Dept. of Housing and Urban Development	Community Development Block Grant Program	$18.9 Billion
	Capital Fund Emergency/Natural Disaster Funding	$29.8 Million
Small Business Administration	Physical Disaster Business Loan	$270 Million
	Home Disaster Loan	$4 Billion
U.S. Dept of Treasury	GO Zone Low-Income Housing Tax Credits	$276 Million
	GO Zone Tax-Exempt Private Activity	$12.8 Billion
	New Markets Tax Credits (GO Zone)	$1 Billion

The federal assistance programs by FEMA available to the affected states are in the form of Individual Assistance (for housing damages), Public Assistance (Infrastructure and public works) and Hazard Mitigation (reduce vulnerability). Louisiana was one of the major beneficiaries of these programs being the worst affected of the US states after Katrina. See Figure 18 for an overview of funding available to the states under these different schemes.

In the first four months after Katrina, $67 billion was appropriated by the Congress in the form of aid, which included $18 billion in flood insurance. Within six months, the Bush administration had disbursed $11.5 billion in Community Development Block Grants to five affected US states in the Gulf area. The Federal government approved $75 billion in immediate disaster relief and $45 billion in rebuilding funds and emergency aid. They also spent $120 billion in the Gulf region alone, of which $75 billion went to emergency relief operations.

In addition to federal support, over 100 countries contributed to aid to meet humanitarian needs in the US, which was considered to be lacking at that time (Petterson et al. 2006). This included several Islamic nations who sent approximately $1 billion in aid directed towards Katrina affected victims. For instance, Libya sent $100 million to US despite tensions between the nations. Developing nations like Bangladesh also offered monetary aid to victims of the storm. However, in the end, the US government only accepted a fraction of the total aid offered. Furthermore, 13 million citizens made individual donations of aid and $2 billion raised for emergency aid by Red Cross. The chief source of private funding for rebuilding after a disaster in the US has been private been enough to cover the entire losses incurred by such severe natural disasters.

Figure 18. Overview of the assistance programs available to Katrina-affected states (Source: FEMA)



Reconstruction and Recovery

Data shows that the affected counties were slow to recover after the storms. In terms of directly measurable parameters such as population, housing units and business establishments of a region, the recovery has been lethargic. It has taken almost a decade to recover to pre-disaster levels in certain cases (see Figure 19 for examples).

The terms of the CDBG aid for the Katrina-affected victims are as below:

Option 1: Homeowners opting to rebuild on their property could receive a grant equal to 100% of their potential grant amount

Option 2: Homeowners opting to relocate to other areas in Louisiana could receive a grant equal to 100% of the potential grant amount

Option 3: Homeowners opting to relocate outside of Louisiana could receive 60% of the potential grant amount (or 100% of the potential value if the homeowner was 65 or older)

One of the chief reasons for the slow recovery, apart from socioeconomic identity of the region (characterized by the poverty levels) is the mismanagement of funds and/or aid received for rebuilding purposes. Figure 20. The various uses of disaster relief funds from CDGB for non-rebuilding purposes (Source: Spader and Turnham 2014) Figure 20 shows the various uses of CDBG funds. In some cases, it was reported that they were used to buy football tickets or other items of leisure.

In addition to these, several other factors affect recovery from natural disasters.

The key factors that affected recovery from Katrina were identified to be the following:

- FEMA structure: FEMA does not work top-down which implies that the local and state governments bear the initial responsibility of responding to the disaster. In the case of Katrina, the failure at these levels resulted in the slow response after the event, which was also exacerbated by inefficiencies in the management of Katrina at the Federal level (Moreteau 2010)

- Policy weakness: Existing policies during Katrina (and Sandy even) were insufficient to aid quick recovery of infrastructure, houses and commercial business in affected areas (Nejat and Ghosh 2016). It was noted that the mispricing of flood insurance premiums provided wrong incentives to build houses in the coastal areas at a relatively low cost. For instance, the inability to price risks correctly in the case of government pools have also encouraged property development in riskier coastal locations in the US which was a failure of policy (McAneney et al. 2016)
- Socio-economic aspects: such as neighbours' decision to rebuild were found to be crucial to household decisions to rebuild themselves (Financial Services Roundtable, 2006). Furthermore, insurance reimbursement was a key variable that affected post-disaster housing recovery decisions

Figure 19. Examples of recovery after Katrina measured in terms of certain metrics (Source: US Census Bureau)

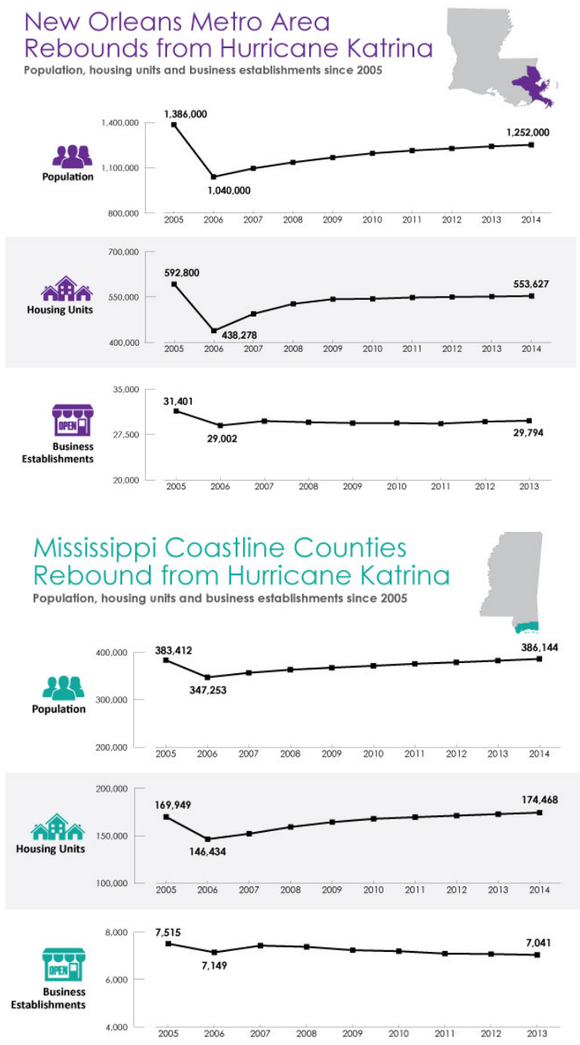


Figure 20. The various uses of disaster relief funds from CDGB for non-rebuilding purposes (Source:Spader and Turnham 2014)

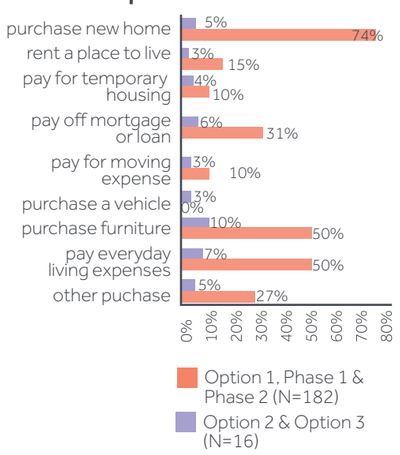


Figure 21. Results from disaster management survey after Katrina (Source: Brodie et al. 2006)

Views of government response to thehurricane and flooding	
Too slow and there is no excuse	76
Reasonable under circumstances	17
Experience made you feel like government cares about people similar to yourself	
No	61
Yes	28
Would government have responded more quickly if more residents had been wealthy and White?	
Yes	68
No	23
Rating of President Bush's handling of situation	
Disapprove	70
Approve	15
Rating of Governor Blanco's handling of situation	
Disapprove	58
Approve	27
Rating of Mayor Ray Nagin's handling of situation	
Disapprove	53
Approve	33

The silver lining in all of this is that the reconstruction efforts after the disaster showed higher productivity of labour force than during previous non-disaster ones (Denhart 2010).

Importantly, the mismanagement and delays associated with the disaster relief efforts highlighted the weakness in emergency response by the administration. These quickly escalated to allegations of inadequate response at the local, state and federal levels and resonated with the public of the affected regions. What started off as a natural disaster also triggered a political crisis of sorts. For instance, approval ratings of top government officials plummeted. This was soon followed by resignation of FEMA director considering the allegations of mismanagement. A survey of 680 randomly sampled respondents conducted in September of 2005, soon after Katrina made landfall, unravelled the political dimension of the disaster. The results show that most of them disapproved of the handling of relief efforts at all levels of governance. It also highlighted the underlying currents of racial tensions in the region affected by Katrina (see Figure 21 for the results).

- Construction costs, insurance premiums: increased by 133% and 400% respectively after the event, particularly in high risk regions. These high costs influenced investment decisions and crippled the reconstruction efforts of housing units therefore affecting economic recovery (Louisiana Housing Finance Agency, 2010)

- Supplementation mindset: The use of federal disaster assistance as a supplement to private property insurance, instead of using them as post-disaster support also considerably affected reconstruction efforts and recovery (Herring and Rosenman 2016)

- Bias: More loans were being approved to wealthy neighbourhoods than others, primarily by lenders to hedge against missed repayments. This affected the speed of recovery at the micro-level

Insurance

2005 was the worst year for the insurance sector, due to the large number of pay outs associated with Katrina (see Figure 22). The total insured losses were twice as large as the next highest. About 63% of flood insurance claims greater than 95% of total insured value between 1978 and 2012 occurred in 2005 (Kousky and Michel-Kerjan 2017). Of the total loss of $125 billion from Katrina, only about $41 billion were insured losses (see Figure 22). The insurance sector took losses to the amount of roughly 47-53% of their market value, whereas the re-insurers' figures were 44-52% in total. The capital markets absorbed rest of the losses. See Figure 23 for an overview of the economic impacts and insured losses by state due to Katrina.

Since 1973, flood coverage has been mandatory for federally insured mortgages in the US, however, only 40% of the victims in Louisiana and Mississippi had insurance to cover losses (Kunreuther 2006). The percentage of homeowners with flood insurance in Louisiana parishes varied from 7% in Tangipahoa to 58% in St. Bernard's. This number was only 60% in Orleans Parish, one of the main parishes in the state. The lack of enforcement of the mandatory flood insurance is one of the reasons for such low levels of flood insurance in the US. The lessons were not learnt in the US, since only 20% of NYC homeowners had flood insurance during Sandy, despite Hurricane Irene the previous year in that region. As a result, US still has a significant protection gap that remains to be filled. The uptake of insurance is determined by several factors, of which poverty levels is one of the main ones. Districts in the US with high poverty were found to have lower flood insurance coverage, as expected (Masozera, Bailey, and Kerchner 2007).

There was a total of 1.7 million different claims for vehicle, houses and business damages were made in the six affected states, of which 1.2 million were personal property claims (Insurance Information Institute, 2010). The volume of claims from these were so high while the premiums collected were low such that the National Flood Insurance Program (NFIP) went into $17-18 billion debt (see Figure 24 for a measure).

Sandy pushed these further to $24 billion, only to be raised to $27 billion after Harvey. There were a total of 168,000 claims paid with a total value of $16.3 billion that resulted in an average amount of $97,000 per claim. This is the highest for any disaster in the US. During Katrina, the average premium shortfalls were approximately $800 million a year. This shortfall had to be borrowed from federal government that had severe economic knock-on effects for the macroeconomic and policymaking (Bingham et al. 2006). Despite the FEMA aid and a massive federal bailout of over $50 billion by 2008, status quo was not reached.

Figure 22. Total insured catastrophic losses for the US by year (Source: American Re)

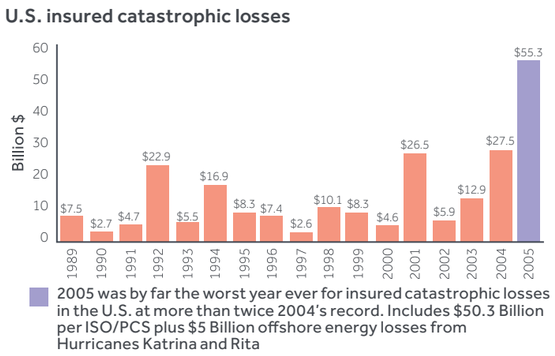


Figure 23. Economic impacts and the insured losses due to Katrina (Source: Insurance Information Institute)

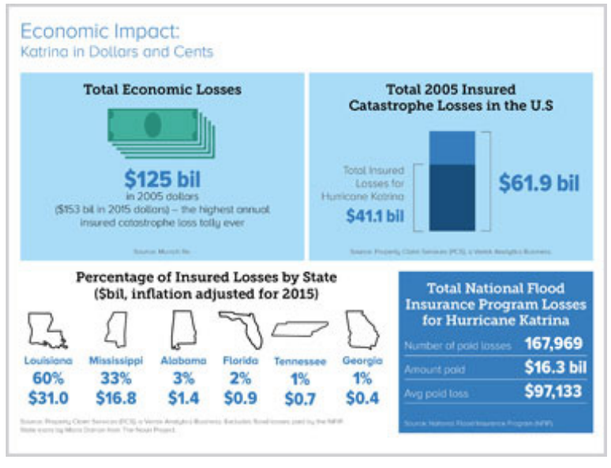
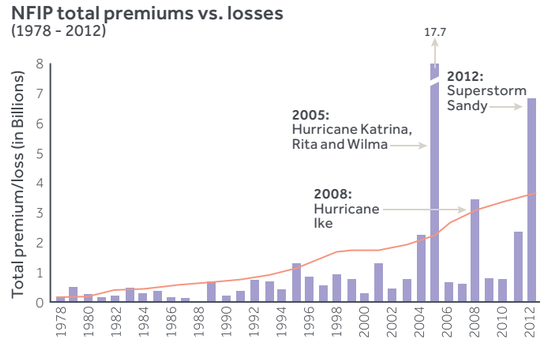


Figure 24. Annual trends in the ratio of NFIP premiums to losses incurred (Source: Harvard Business School)



Some of these were due to the incentives structure in the insurance sector. For instance, a few insurance companies had doubled their rates for certain categories and some refused to issue new property insurance for those along the coast (Smith 2012). The lack of funds to defray the disaster-related expenses also slowed down reconstruction and recovery. Therefore, some states had to step-in to fill the role of providing the necessary funds to enable reconstruction. Mississippi organized a "Wind Pool" (property insurance of last resort) at a very heavy price. They purchased reinsurance from global markets at 398% and 268% premium increases on residential & commercial property policies to meet the demands and promote economic welfare. Such measures proved to be very costly for the States.

Conclusions

Hurricane Katrina was the costliest natural disaster in the history of the insurance industry, which also led to a structural deficit for FEMA due to shortage of funds for its NFIP program. This disaster revealed several issues with the management of catastrophes in the US and the extent of ex-ante protection measures such as insurance. Less than 40% of the total losses were insured, therefore exposing the affected to the repercussions due to a significant protection gap.

At the national level, the impacts on GDP and unemployment were insignificant, and if any were only short lived. However, the regional and local socioeconomic impacts were very significant. The energy sector was particularly affected due to the location of oil and natural gas production units. In addition to incurring losses due to lost income and revenue for businesses, it led to migration and local unemployment in several sectors. The construction sector was largely spared, and in fact it was the only sector to post profits immediately after the storm. The sudden reduction in supply of houses due to the damages triggered an inflationary trend in house prices and rents. This effect led to permanent relocation of residents in some of the areas and therefore was a chief factor in the slower recovery. The financial sector had mixed reactions. Except for stocks of insurance companies, the stock markets were largely unaffected. During this time, the first ever trigger of a CAT bond was witnessed.

The storms, particularly Katrina, revealed several fundamental flaws in the management of hurricanes through the delays and operational mismanagements. Consequently, the inept disaster response and inefficiencies in administration of aid by the government negatively affected the speed of recovery of the economy. The economic recovery was further delayed due to over-reliance on ex-post measures like federal disaster aid (with large lead times), which was exacerbated by the misuse of appropriated funds by recipients.

While it is plausible that the US could benefit from a larger share of insured losses through higher insurance penetration, bigger policy issues need to be first addressed.

Inadequate risk differentiation of hazard zones, mispricing of risks in coastal areas, lack of enforcement in the purchase of mandatory insurance and lack of incentives for improving private insurance uptake are some of the fundamental problems facing the US that warrant attention.

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