



Hurricane Harvey and Resilience in Houston's Economy

Robert W. Gilmer, Ph.D.
C.T. Bauer College of Business
January 2019

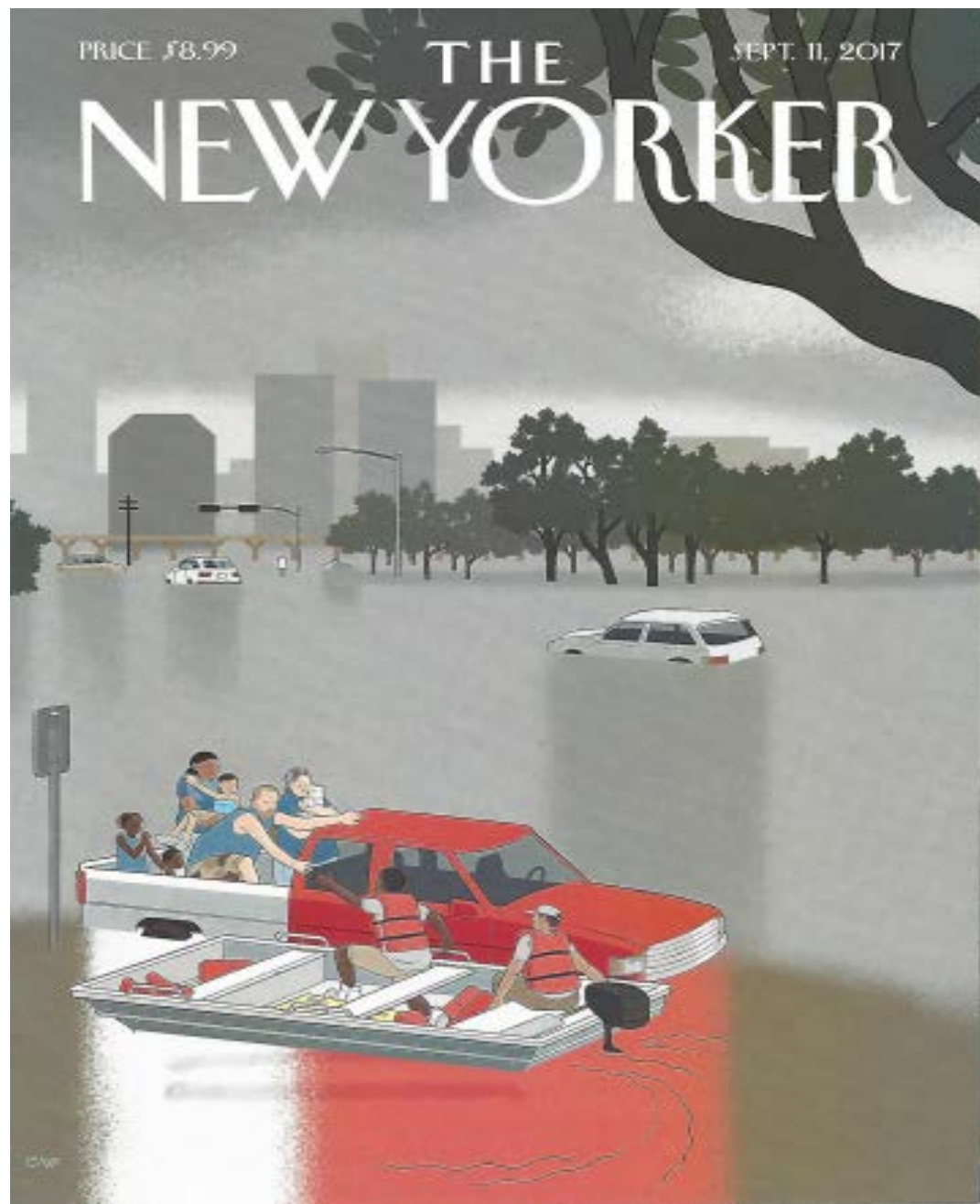
Natural Disasters Take Many Forms: In Houston It Is Floods and Tropical Storms

- *Natural Disasters*
 - *Climatological* – Drought, extreme temperatures, wildfires
 - *Geophysical* – Volcanoes, earthquakes, and tsunamis
 - *Hydrological* – Floods, landslides
 - *Meteorological* – tropical cyclones, tornados
- *Houston and the Gulf Coast?*
 - *Floods* – 1994 Southeast Texas, Memorial Day, Tax Day
 - *Tropical Storms/Hurricanes* – Alicia, Allison, Rita, Ike, Harvey
 - *Tornados* -- are mostly incidental to bigger storms

PRICE \$8.99

SEPT. 11, 2017

THE NEW YORKER



© 2017

Harvey: One More Tropical Storm?

- This was another tropical storm – just less wind, more water. MUCH more water. It was a 1000-year flood event with no known precedent in North America according to the University of Wisconsin’s Space Science and Engineering Center.
 - These storms do enormous property damage. Harvey shrank collective balance sheets across Texas and Louisiana by \$125.0 billion. In Houston, about 41,400 Houston homes were left with major damage or destroyed, and 300,000 vehicles totaled. Insurance can only partly recoup these losses, and losses are written off the balance sheet
 - Tropical storms are usually neutral or good for most current economic measures like employment, income, or output. These are flows on the income statement, not property losses
 - For a hurricane, we lose worktime as we shelter, but we come out to meet an intense mini-economic boom that quickly gets underway – and then fades just as quickly
 - The recovery boom is led by spending and construction. Spending is for new carpet, furniture, wallboard, cleaning supplies, etc. Construction is for clean-up and repair of damaged structures. This surge usually offsets losses to the shelter period
- We are poorer because of property losses, but six months later the effect on employment, income and production is usually near neutral. Continuing economic effects are too small to register in an economy of 6.7 million people

Why Would Economists Think This?

Because Many Studies Support it

- Based on the 1964 Alaska earthquake, Dacy and Kunreuther (1969) concluded the region's inflow of capital from rebuilding produced net benefits for the economy; Friesema and others (1979) found this true for the Yuba City floods, Hurricane Carla, and tornados in Conway, Arkansas and Topeka, Kansas
- Guimaraes, Hefner, and Woodward (1973) examine gains and losses from Hurricane Hugo in South Carolina. Changes in regional income were neutral after a year, despite a surge in activity in specific sectors
- Sarmiento (2007) uses a panel of U.S. floods to show how they disrupt local employment, but recovery comes within a year. Belasen and Polachek (2009) show income levels rise following a disaster

Goals for the Day

- How could a natural disaster be a small plus or minus for local employment or income? After all the damage?
- Storm damages have been rising rapidly in recent years. Why? What factors might figure into these growing damages?
- Do the little-economic-impact rules apply to flood-prone Houston? Even to Harvey? We look at the short-term impact of eight major storms that have affected Houston since 1983: Alicia, the 1994 floods, Allison, ... ,etc.
- We will take a deep dive into Harvey impacts: oil and gas, the service sector, commercial real estate, apartments and single-family housing
- We at least give some thought to public policy from our findings: infrastructure needs, planning for disaster, use of police powers during and after the storm, land-use restrictions, and flood insurance

**More Storms? Bigger Storms?
Or Just Bigger Cities?**

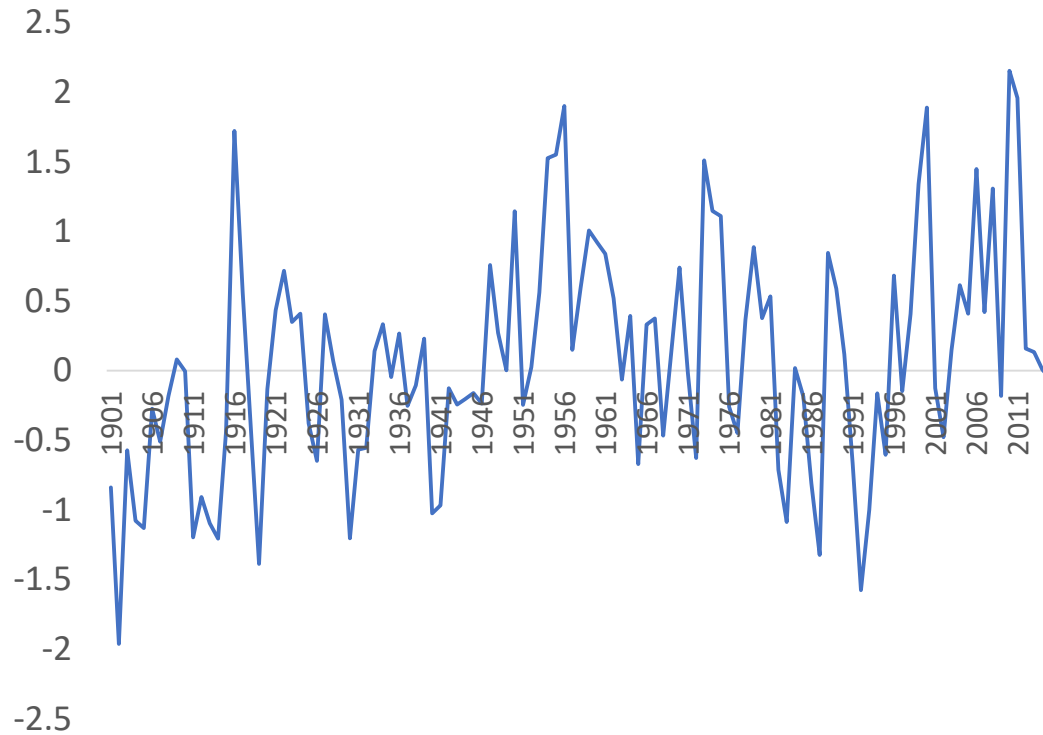
Storm	Year	Damages		Peak Category	Comments
		Const \$2017	Current \$		
Katrina	2005	171.23	125	5	infrastructure failure
Harvey	2017	125.00	125	4	storm stalls, infrastructure failure?
Maria	2017	91.60	91.6	5	infrastructure failure
Sandy	2012	81.79	68.7	3	hits large east coast metro areas
Andrew	1992	65.00	27.3	5	powerful cat 5
Irma	2017	64.80	64.8	5	powerful cat 5
Ike	2008	46.34	38	4	infrastructure failure in Galveston?
Ivan	2004	38.96	26.1	5	powerful cat 5
Wilma	2005	37.53	27.4	5	powerful cat 5
Rita	2005	25.34	18.5	5	powerful cat 5, evacuation issues
Charley	2004	25.22	16.9	4	
Michael	2018	24.39	25	4	
Hugo	1989	23.10	9.47	4	
Georges	1998	18.37	9.37	4	
Irene	2011	17.32	14.2	3	
Florence	2018	16.29	16.7	4	
Matthew	2016	15.73	15.1	5	
Frances	2004	15.07	10.1	4	
Allison	2001	14.66	8.5	Trop Storm	Small storm stalls over Houston
Agnes	1972	13.13	2.1	1	
Camille	1969	13.00	1.43	5	
Betsy	1965	13.00	1.43	4	
Floyd	1999	12.26	6.5	4	
Mitch	1998	11.92	6.08	5	
Jeanne	2004	11.85	7.94	3	
Fran	1996	10.42	5	3	
Gustav	2008	10.13	8.31	4	
Opal	1995	10.00	4.7	4	
Fifi	1974	10.00	1.8	2	
Alicia	1983	9.09	3	3	Houston 120% bigger at time of Harvey

What Drives Rapidly Rising Storm Damages?

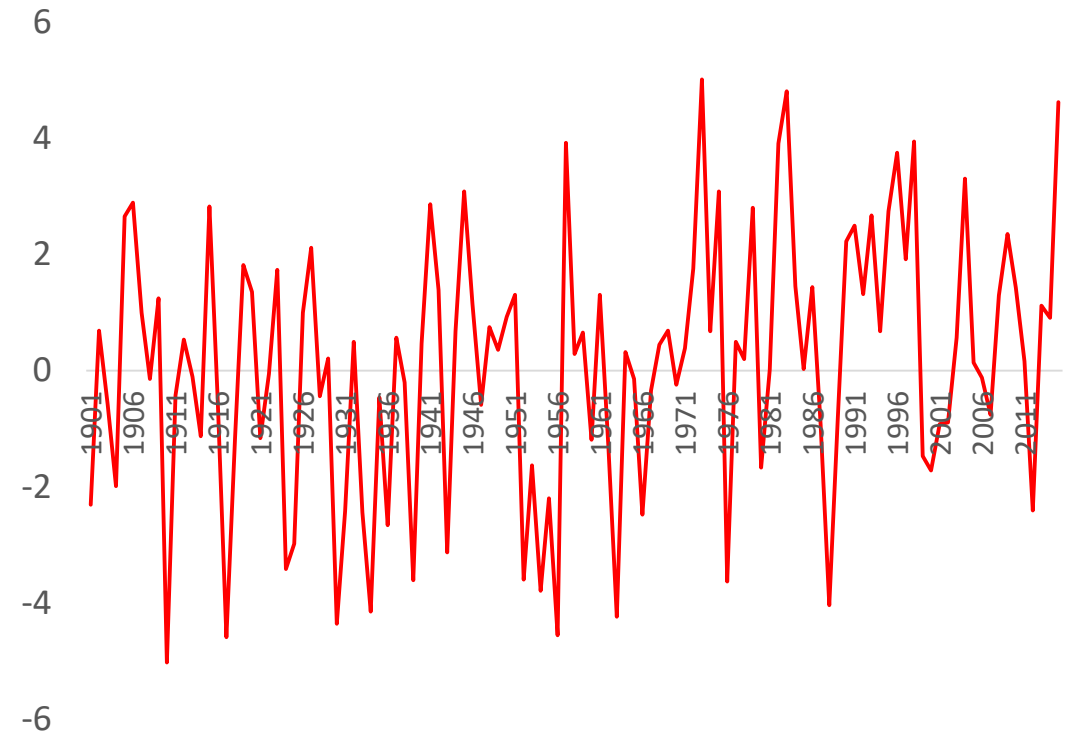
- Some of the most expensive storms were the result of storms that overcame infrastructure in New Orleans, Puerto Rico, and perhaps Houston in both Ike and Harvey
- Damage increases are mostly to structures. Deaths see less frequent spikes over time, but decline in number
- Structural damages continue to grow
 - The previous table was adjusted for cost of rebuilding over time
 - We must allow for the rising growth of the population/economic value of region that is hit
 - Storm damages are not usually specific to one location, but often spread over many cities and states
- The power of the storm
 - A list of major damages is dominated by Category 4 and 5 storms
 - Is the number and power of storms increasing over time?

Differences from Normal Precipitation: Global and U.S., 1901 to 2015

Global Annual Difference From Normal
Precipitation, Inches



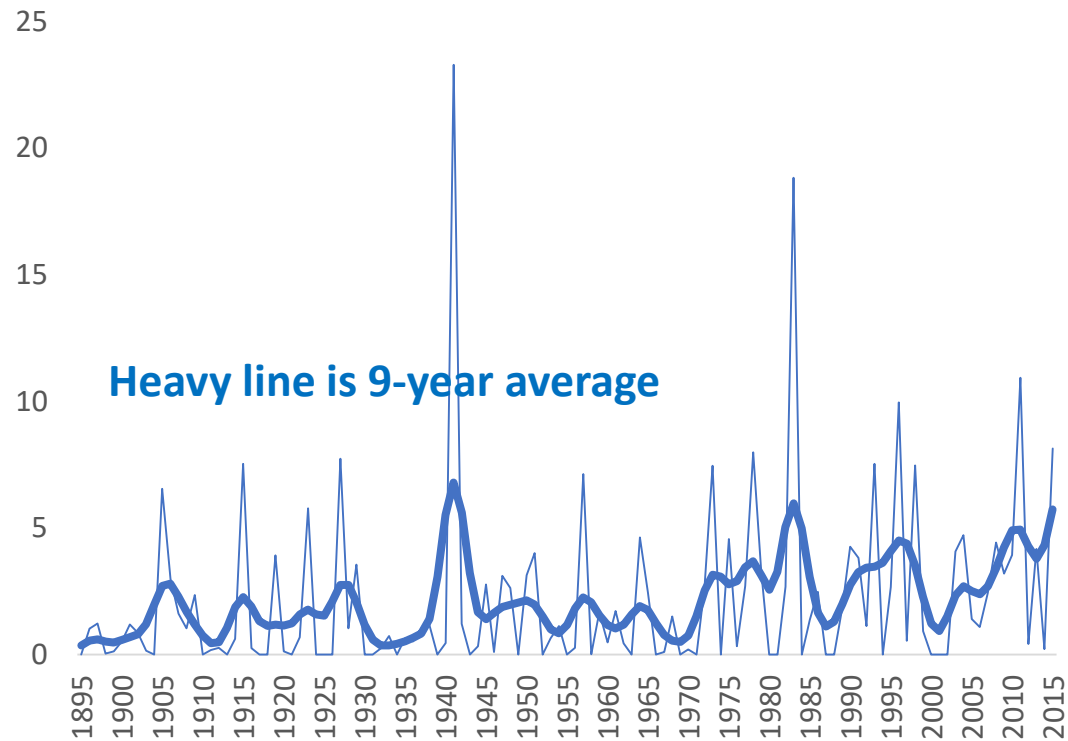
U.S. Annual Difference From Normal
Precipitation, Inches



NOAA via EPA

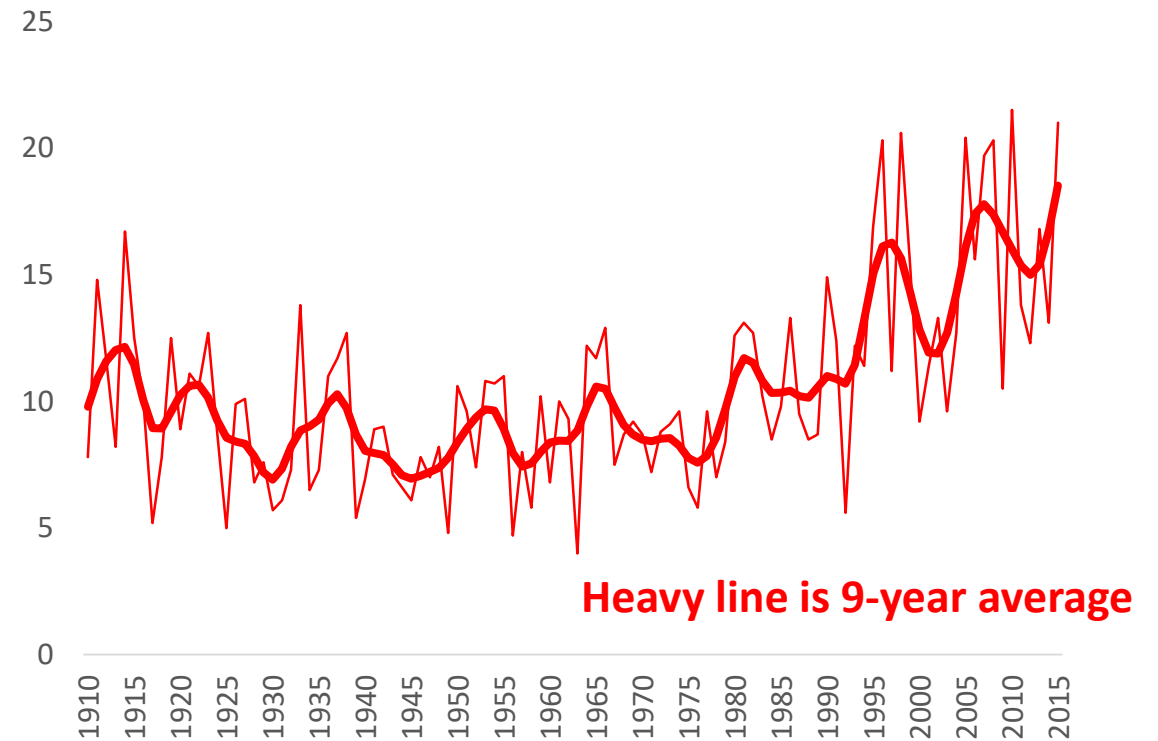
Evidence That Extreme Precipitation Events Are Spreading Into More of the U.S. Since 1980s

Unusually High U.S. Precipitation
% Land Area Affected



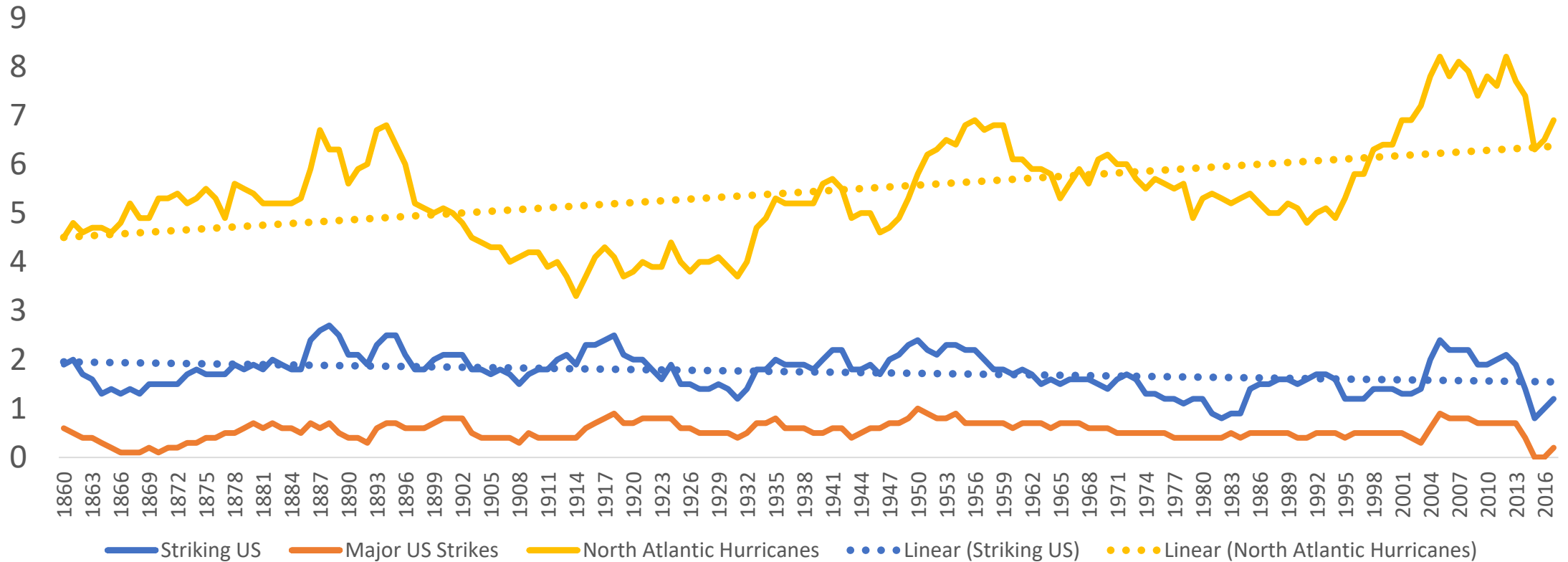
NOAA via EPA

Extreme U.S. Precipitation
% Land Area Affected



North Atlantic Hurricanes Striking the U.S. Have Averaged About Two Per Year for Decades

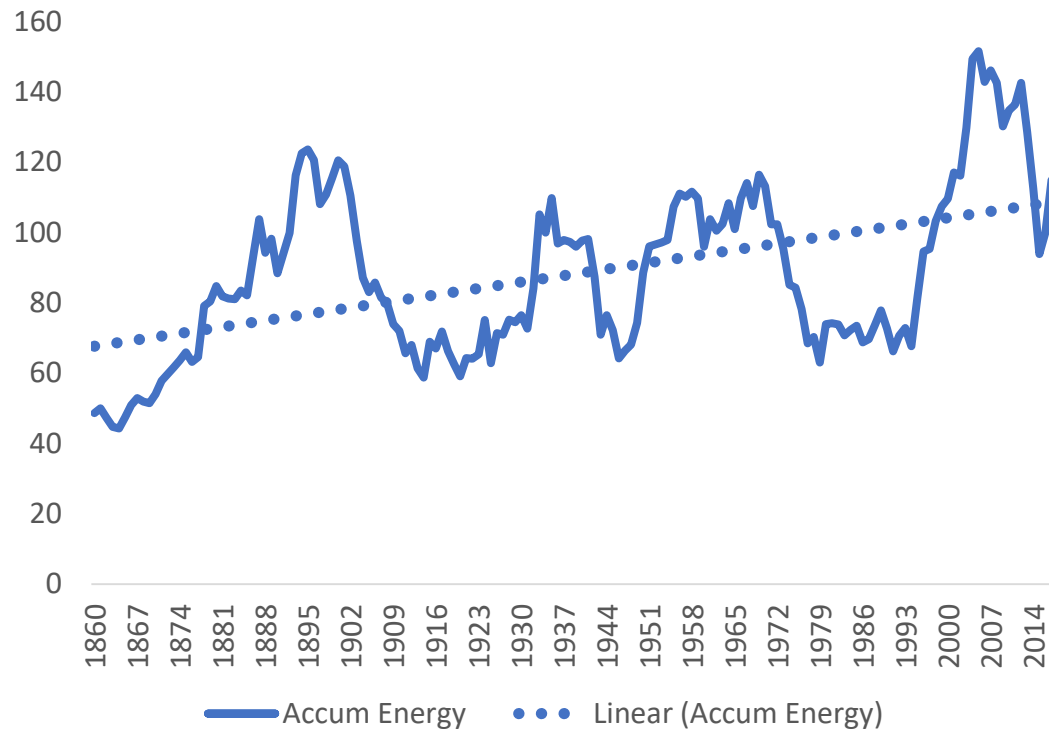
North Atlantic Hurricanes 10-year average, 1860 to present



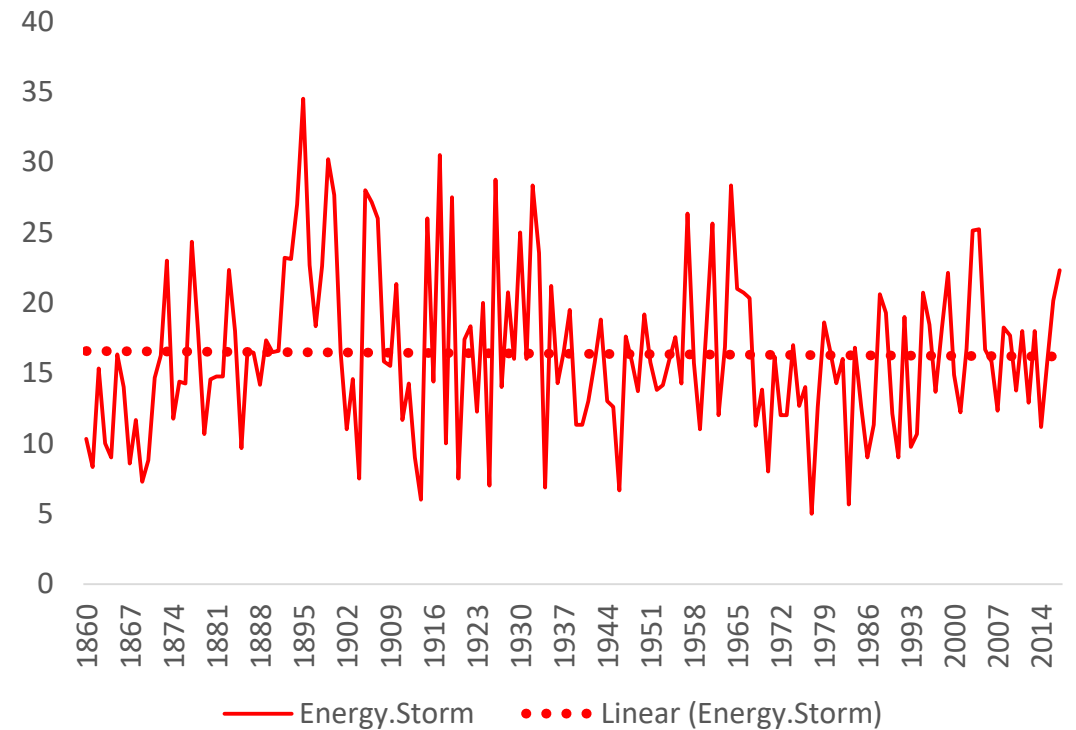
Hurricane Data Base, NOAA

Atlantic Storms Getting More Powerful? Not If You Allow for the Number of Storms

Accumulated Energy,
1860-2016, 10-yr averages



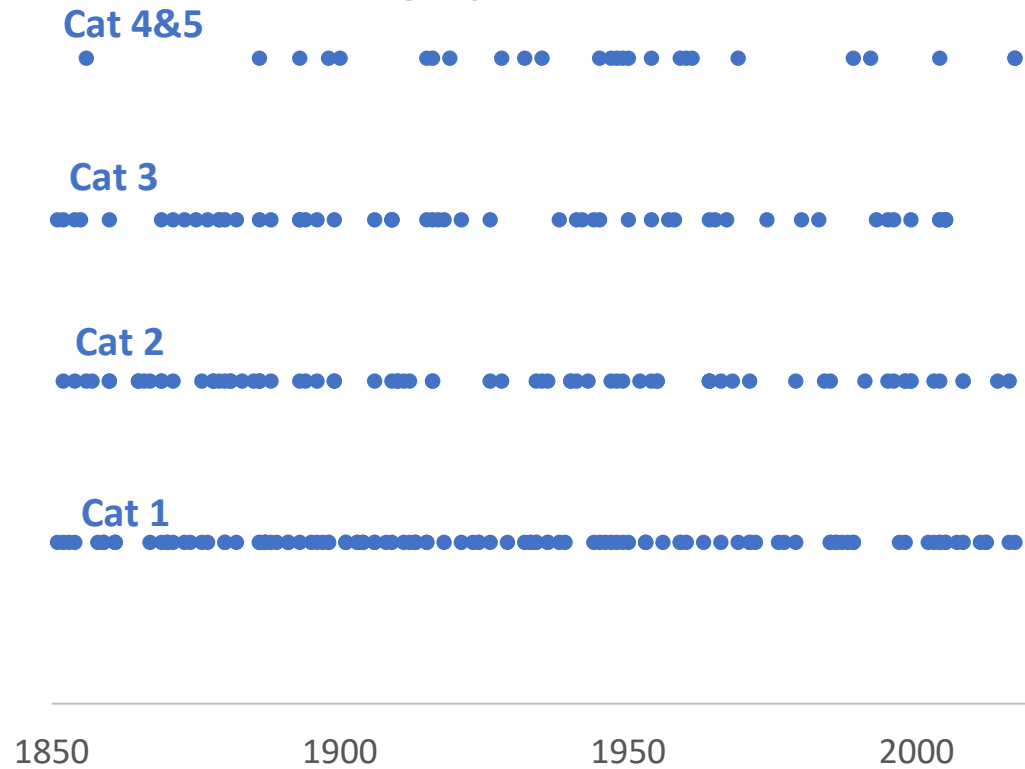
Energy per Storm, 1850-2014
10-yr averages



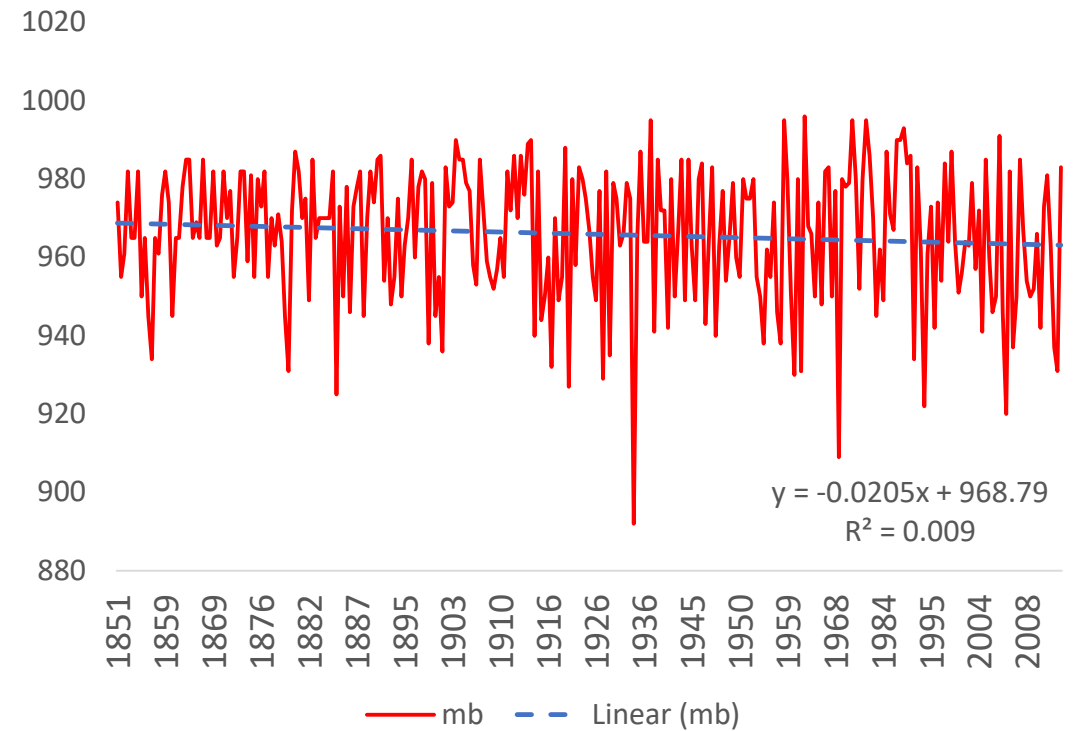
Hurricane Data Base, NOAA

Are U.S. Hurricane Landings Getting More Powerful Over Time?

Date of Storms by Saffir-Simpson Category, 1851 to 2017



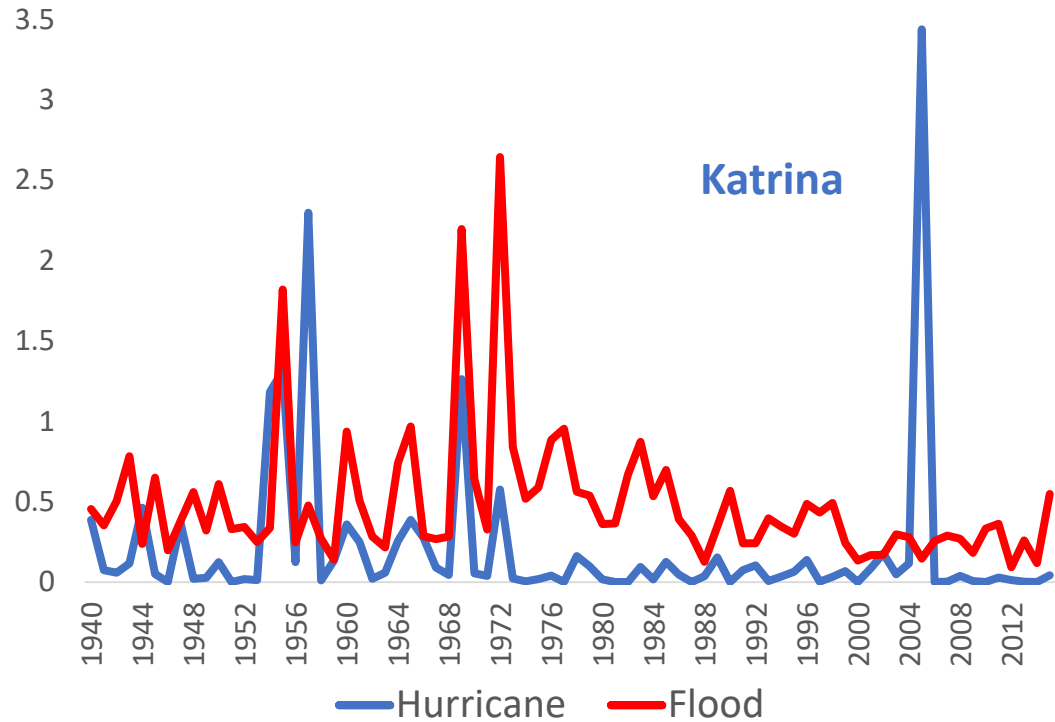
Storms by Dates and Central Pressure (mb), 1850-2017



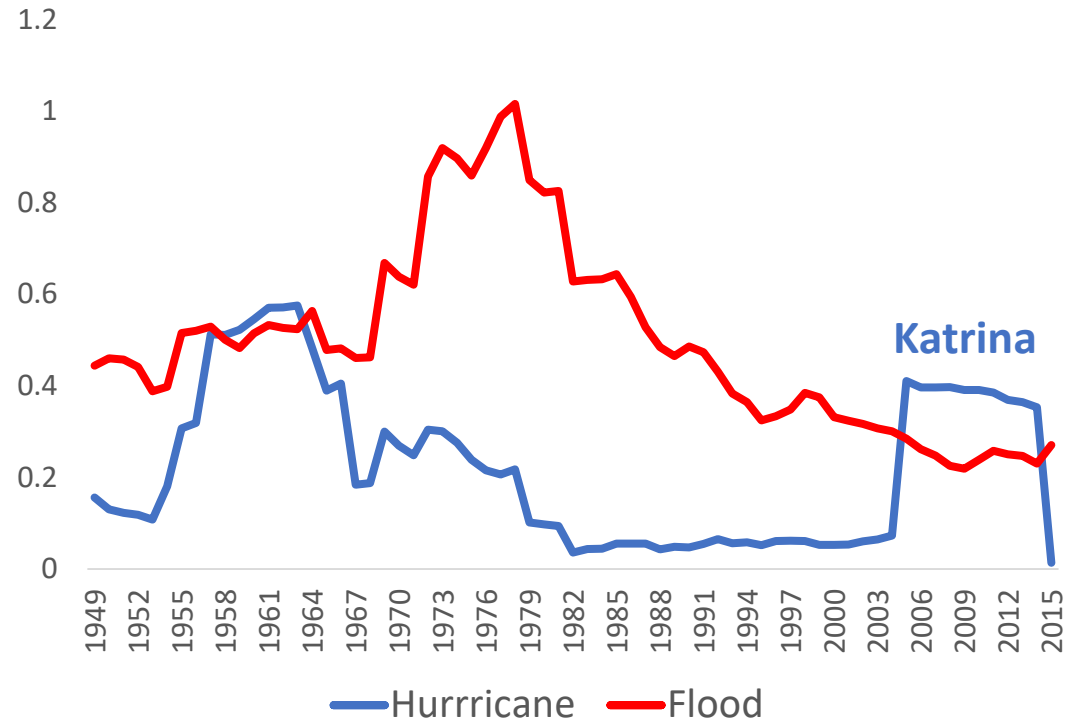
Big Factor in Growing Storm Damage? A Rapidly Growing Economy

Large Numbers of Deaths Due to Flood and Hurricane Are Less Frequent in U.S., Trend Down Since the 1980s

Number of Deaths per million,
By Year, 1940-2015

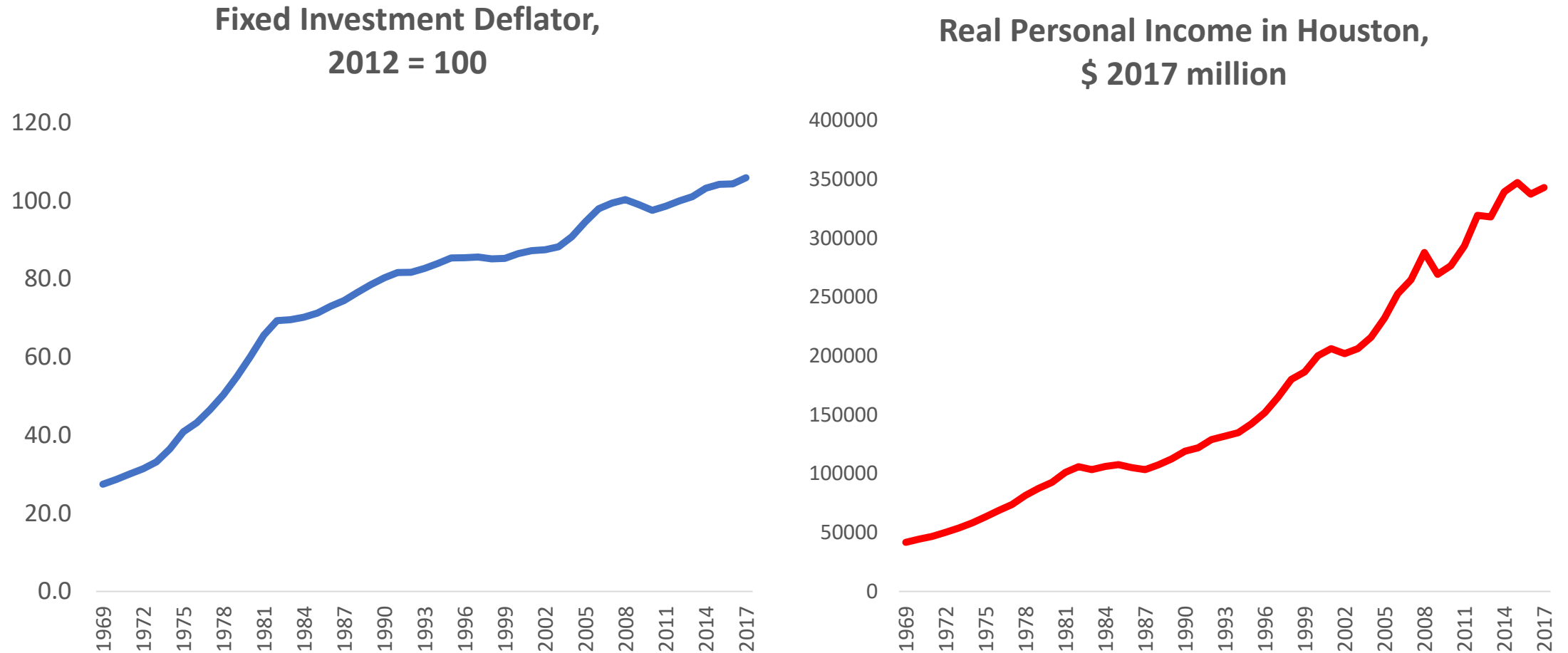


Number of Deaths per Million,
10-yr Average



NOAA, annual population data

Since 1969, Replacing Plant and Equipment Has Grown 3.9 Times, Real Personal Income in Houston Is Up 8.2 Times



Note: Real personal income is the major component of gross product, and its growth rate should be roughly proportional to wealth, including fixed structures (residential and nonresidential) and equipment

Storms and the Economy?

- The impact of Atlantic hurricanes and floods on the U.S. might be rising – by number or strength -- but very recently, with perhaps more ahead
- The growth of Houston has been at work longer and far faster than storms – so far. Personal income is a good proxy for GDP and for the amount of the community's wealth that is put at risk by storms. Up by a factor of 8.1 since 1969
- This rapid economic growth is a Sun Belt phenomenon, shared by coastal regions from the Carolinas, to Florida, Mississippi, Louisiana, Texas, and beyond
- Even if the growth of weather-related impacts were slow or non-existent, as long as Houston's economy grows fast, total storm damages will rise quickly. However, Houston's current large size (6.8 million people) should make it more resilient to a storm like Alicia in 1983, when the population was 3.7 million. Proportional damages should fall over time

Houston and Its Storms

Eight Billion Dollar Storms in Houston (I)

- *1983*: Hurricane Alicia forms in the Gulf of Mexico off Mississippi and Alabama, and lands 25 miles southwest of Galveston. It was a short-lived Category 3 hurricane that brought 11 inches of rain. Wind and storm surge account for most of the damages
- *1994*: Southeast Texas Floods from remnants of Pacific Hurricane Rosa mixed with humidity from the Gulf of Mexico to form widespread thunderstorms. The front stalls and remains stationary over the San Jacinto River basin, bringing 30 inches of rain to parts of Harris County
- *2001*: Tropical Storm Allison brings only 60 mph winds and little surge, but its rains stall over Houston. Torrential rainfall peaks at 40 inches in some areas.

Eight Billion Dollar Storms in Houston (II)

- *2005*: Hurricane Rita was the most intense hurricane ever recorded in the Gulf, and it triggered a massive evacuation of 2.5 million people from coastal areas. The storm missed Houston and hit east Texas, but the resulting gridlock from evacuations affected the city for days.
- *2008*: Hurricane Ike made landfall in Houston after weakening to a Category 2 storm. Wind caused electrical outages that often took ten or more days to repair in many areas. The massive size of the storm meant that its surge outflanked the Galveston Seawall; Galveston Island was declared uninhabitable in the wake of the storm
- *2015*: The Memorial Day Floods originated from an outbreak of spring thunderstorms that swept across Texas and Oklahoma, then parts of it stalled over Houston. Rainfall totaled 12 inches in about 10 hours.

Eight Billion Dollar Storms in Houston (III)

- *2016*: The Tax Day Floods were a rerun of the Memorial Day Floods. Widespread spring thunderstorms brings Houston 15 inches of rain over 10 hours
- *2017*: Hurricane Harvey makes a last-minute turn to the west, striking Rockport as a Category 3 hurricane. Houston is spared wind and storm surge. However, the storm stalls then slowly drifts west, bringing torrential rains all along the Gulf Coast, including Houston.

Houston's Severe Weather Events Follow Different Patterns

	Date	Damage	Deaths	Conditions			Pattern	
	mo./yr.	Billion \$ 2017	No.	Wind	Surge	Floods	Shelter	Recovery
Hurricane Alicia	8/83	\$7.7	21	x	x	x	x	x
SE Texas Floods	10/94	\$1.7	19			x		x
Tropical Storm Allison	6/01	\$12.3	43			x		x
Rita	9/05	\$24.4	119				x	
Ike	9/08	\$35.7	112	x	x	x	x	x
Memorial Day	5/15	\$2.7	31			x		x
Tax Day	4/16	\$2.8	6			x		x
Harvey	8/17	\$127.5	89			x	x	x

Note: National Centers for Environmental Information, NOAA, damage estimates and deaths are specific to the storm, and not to the Houston metro area. Conditions/Pattern defined by the author.

Storm Impacts on Houston's Economy: Must Adjust for the Business Cycle

Six of Houston's Eight Most Recent Major Storms Overlap With Its Business Cycle

Modern Business Cycle Events in Houston

- *Local Recession*
 - Mar '82–Aug '83 Oil Bust I (Alicia)
 - Nov '84–Dec '86 Oil Bust II
 - May '01–July '03 Tech Bust (Allison)
 - Aug '08–Dec '09 U.S. Fin Crisis (Ike)
- *Big Slowdowns*
 - July '90–Sep '92 U.S. Recession
 - Dec '98–May '99 Asian Fin Crisis
 - Jan '15–Dec '16 Fracking Bust (Memorial Day, Tax Day, Harvey)

Dallas Fed Business Cycle Index Tracks Houston Economy Since 1978

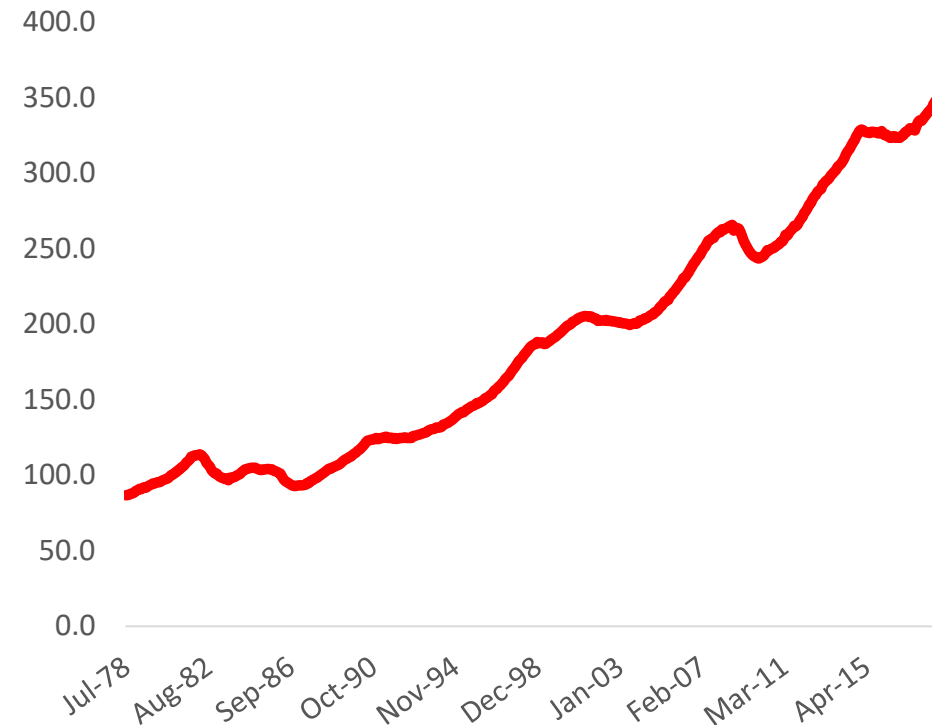
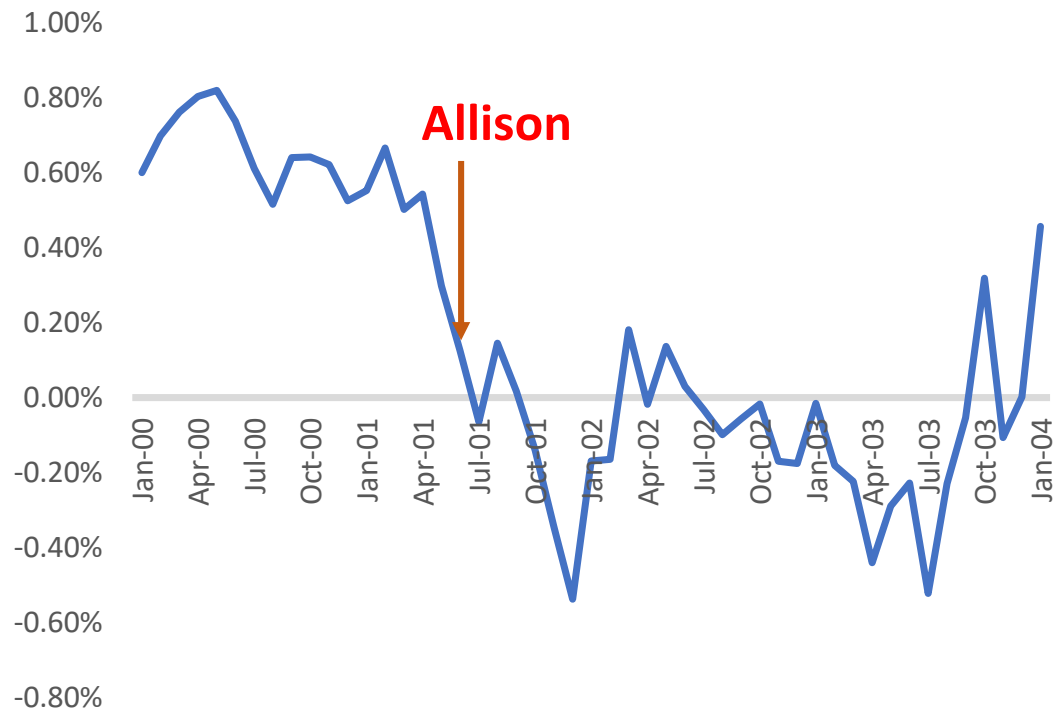


Figure 1. Houston's Storms Have Often Been Intertwined with the Business Cycle

Allison Timing and Tech Bust

3-Month % Change in Payrolls



Ike Arrives with the Great Recession

3-Month % Change in Payrolls



As We Measure the Effect of Storms, Adjustments for the Economy Must Be Made

	Houston Employment		Houston Business Cycle Index		Houston ISM Index
Period	1990-2018	1979-1999	1990-2018	1970-1999	1997-2018
Indep Variables	- Local Oil Jobs - U.S. Employment	- Local Oil Jobs - U.S. Employment	- Local Oil Jobs - U.S. Employment	- Local Oil Jobs - U.S. Employment	% Change Jobs
Method	Error Correction	Error Correction	Error Correction	Error Correction	Ordinary LS
R-Squared	0.703	0.772	0.668	0.652	0.901
Autocorrelation?	pass	pass	pass	pass	pass
Bounds t-test significance	> 95.0%	> 99.0%	> 99.0%	> 99.0%	NA
Bounds F-test significance	> 97.5%	> 99.0%	> 99.0%	> 99.0%	NA
Storm Dummies	yes	yes	yes	yes	yes
Other Dummies	yes	yes	yes	yes	yes

More Adjustments: Some Sectors Can Be Affected by Other Specific Events (Impact on City of Houston Sales Tax Revenue)

Event	% Impact	Time Period
<i>Y2k</i>	28.60%	Oct/Dec
<i>Final Four</i>		
2011	5.80%	Mar/Apr
2012	NS	Mar/Apr
2016	NS	Mar/Apr
<i>Super Bowl</i>		
2004	15.90%	Jan/Feb
2007	12.60%	Jan/Feb
<i>NCAA Regionals</i>		
2008	NS	
2010	7.50%	
2015	NS	
<i>World Series</i>		
2005	conflict with Rita/Katrina Relocation	
2017	conflict with Harvey recovery	

Note: NS = Not statistically different from zero; revenues measured in constant 2017 dollars

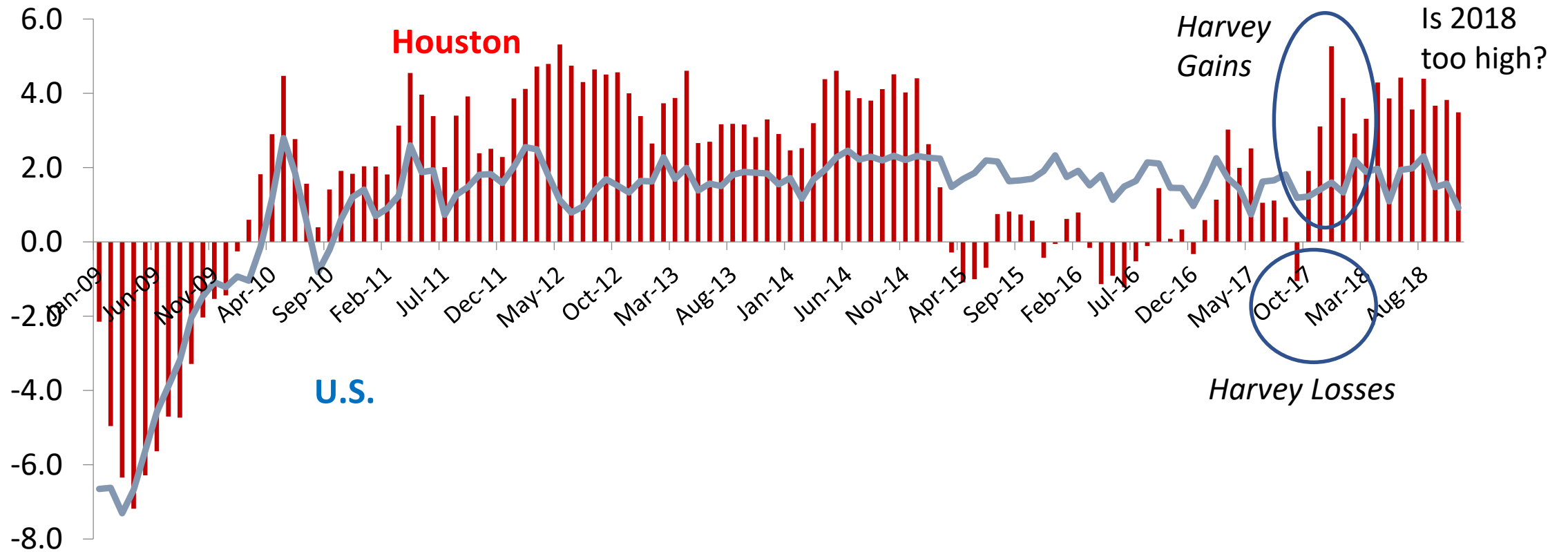
The Impact of Eight Storms on the Short-Term Growth of Houston

Look at Houston Storm Impacts in Various Ways

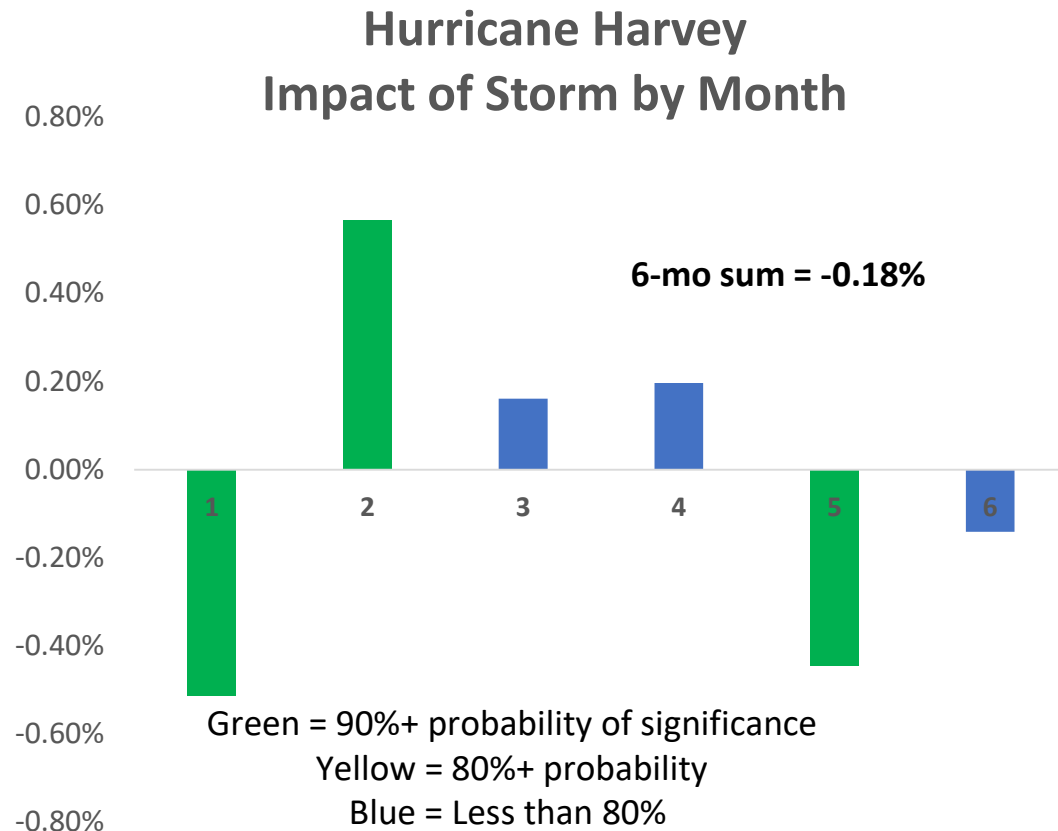
- Three economy-wide measures
 - Payroll employment
 - Dallas Fed's business cycle index
 - Houston NAPM Index
- Sector gains and losses
 - Spending (Sales Tax Revenues)
 - Contract Construction
- Basic/Non-basic
 - Oil and gas and other basic activity
 - Service sector and other non-basic activity

Payroll Employment Is Houston's Best and Most Detailed Measure of the Business Activity

(3-month percent change at annual rates, s.a.)



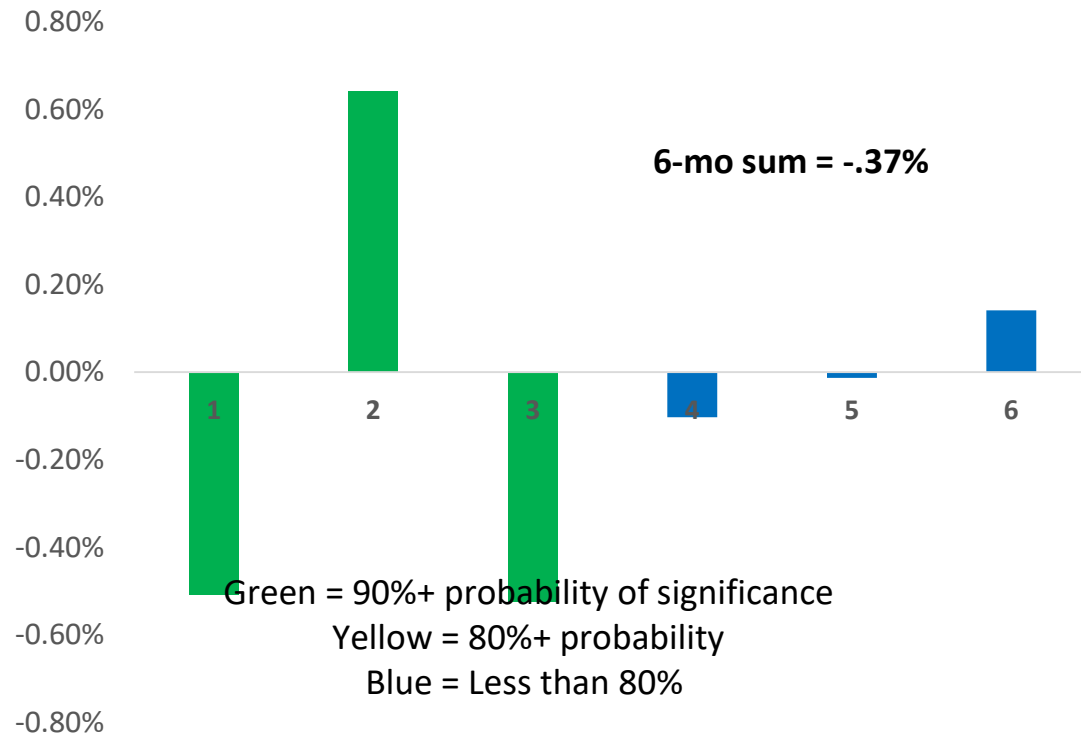
Short-Run Impacts of Hurricane Harvey on Houston's Payroll Employment Net Out to Zero



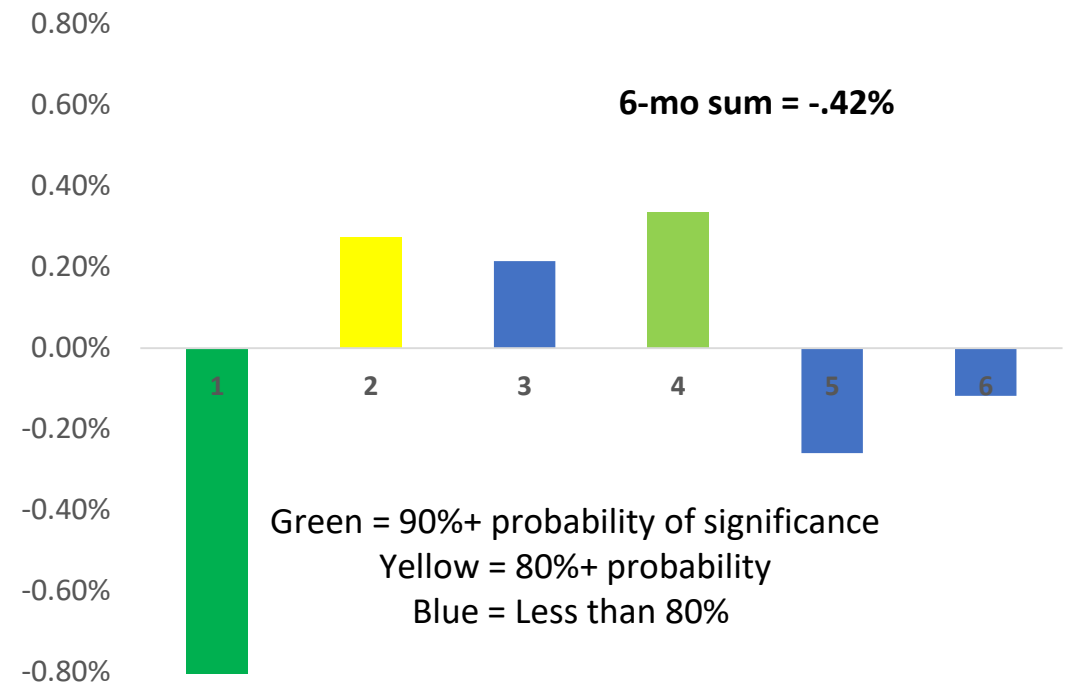
- The chart shows the impact of Hurricane Harvey for each of six months following the storm
- The first month is the negative shelter period or a loss of 0.51% of employment
- The second month every one goes back to work, plus clean-up after the storm, adding 0.57%
- Months three and four add small numbers of additional clean-up jobs, a combined 0.36%
- Months five and six mark the point where clean-up is ending, subtracting or -0.59%
- ***The net change over six months is -0.18% which is not different from zero.***

Alicia and Ike Show Same Shelter/Recovery Pattern and No Six-Mo Impact on Economy

Hurricane Alicia
Impact of Storm by Month

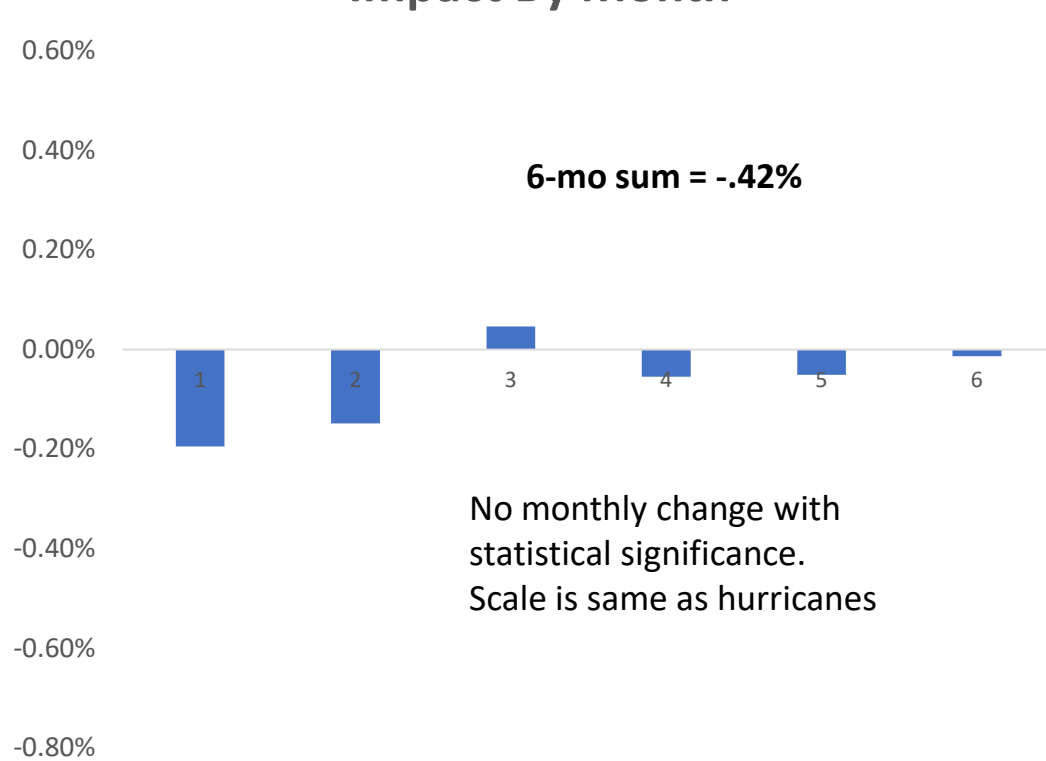


Hurricane Ike
Impact of Storm by Month

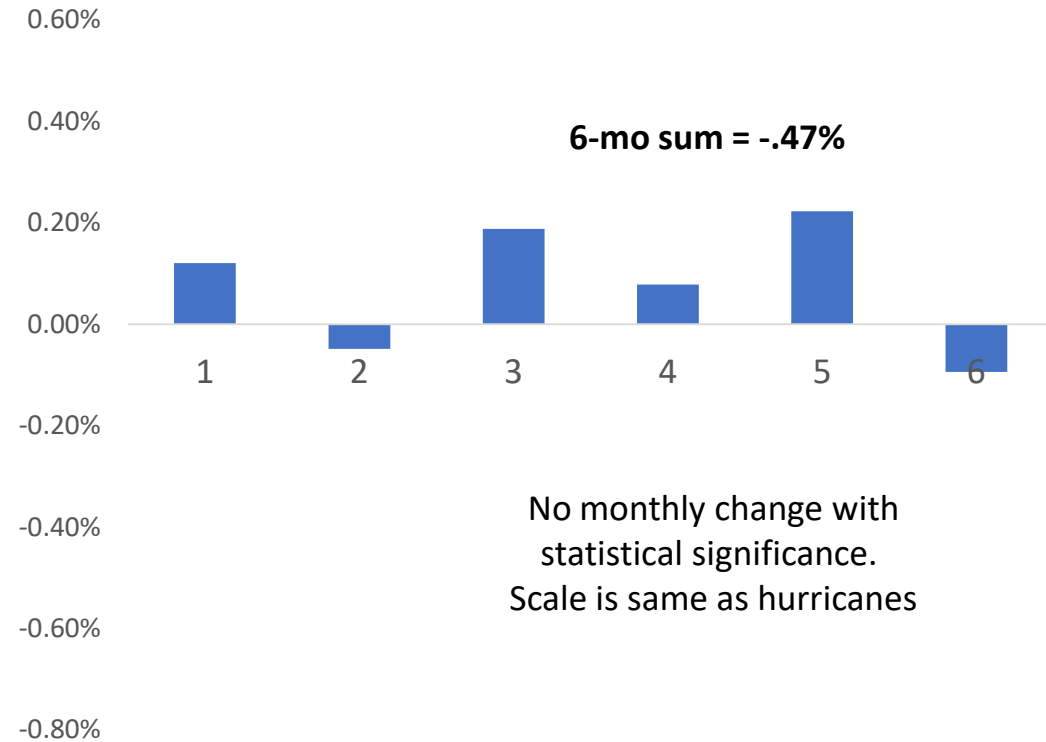


Flood Events and Impact on Houston's Payroll Employment

Tropical Storm Allison Impact By Month



Tax Day Floods Impact By Month



Short-Run Payroll Employment Impact of Three Hurricanes on Houston

Number of Payroll Jobs

Month	Harvey		Alicia		Ike	
	Monthly	Cumulative	Monthly	Cumulative	Monthly	Cumulative
1	-15,000		-7,300		-22,800	
2	17,200	2,200	9,200	1,900	7,200	-15,600
3	4,900	7,100	-7,500	-5,600	5,700	-9,900
4	6,000	13,100	-1,500	-7,100	8,800	-1,100
5	-13,500	-400	-200	-7,300	-6,800	-7,900
6	-4,300	-4,700	2,000	-5,300	-3,100	-11,000

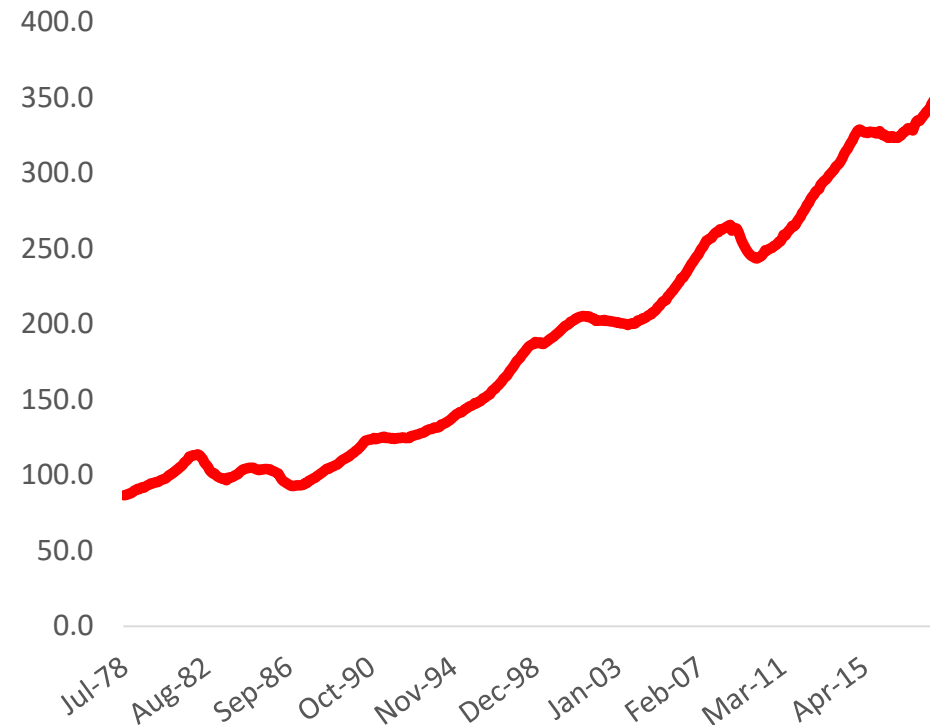
Note: Calculations of author. At the time of Harvey in 2017, Houston employment was 15% bigger than when Ike hit in 2008 and 105% bigger than when Alicia landed in 1983. Green is 90% significance level, and yellow is 80%.

Use the Dallas BCI to Measure Storm Impacts

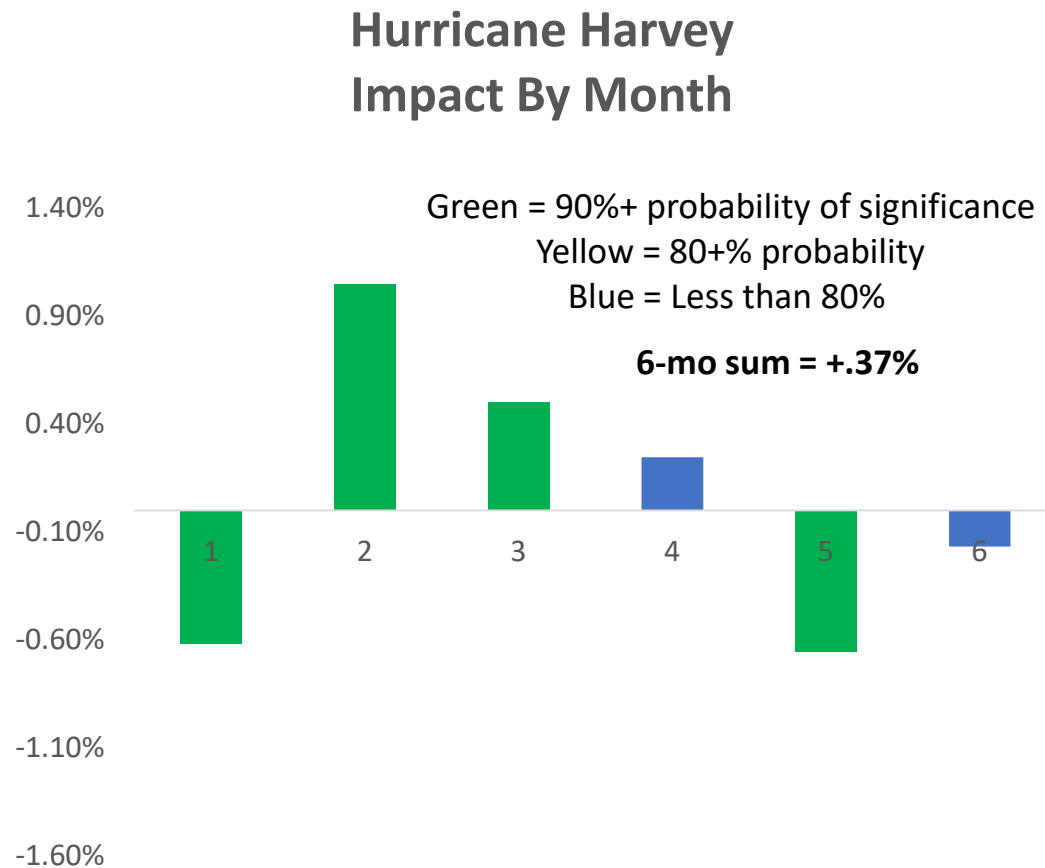
The BCI is a Broader Measure of the Houston Economy than Payroll Employment

- The BCI includes payroll employment as a component, but it also includes the unemployment rate, real wages, and real retail sales
- The Houston BCI covers all the years of our eight storms
- The results of using the BCI look much like those of employment, with only one storm with impacts that reach to six months duration

Dallas Fed Business Cycle Index Tracks Houston Economy Since 1978



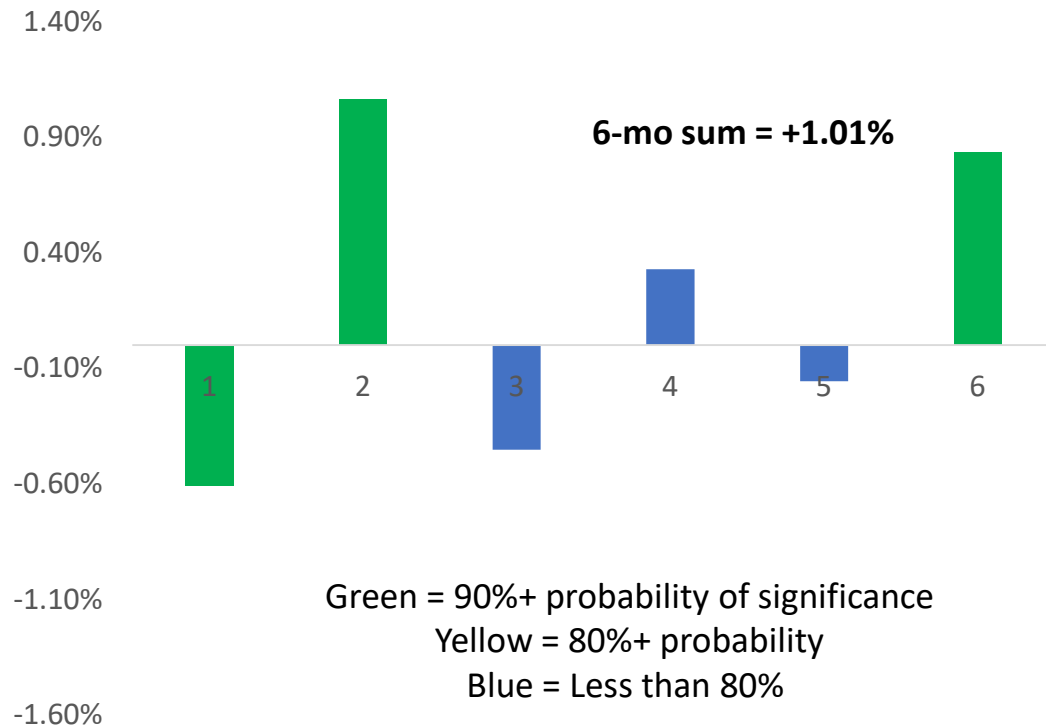
Short-Run Impacts of Hurricane Harvey on Houston's BCI Nets Out to Zero at 6-Months



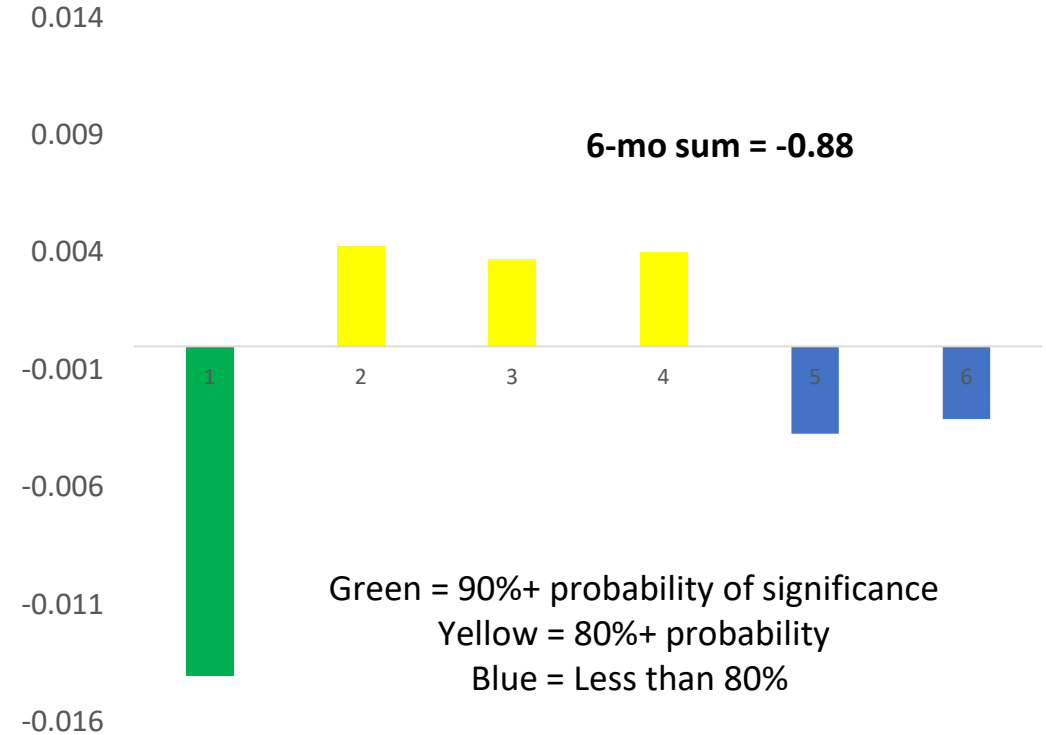
- The chart shows the impact of Hurricane Harvey for each of six months following the storm
- The first month is the negative shelter period or a loss of 0.61% of BCI value
- The second and third months are strong recovery, with the end of the shelter period and clean-up adding 1.55%
- Months five and six mark the point where clean-up is ending, subtracting -0.82%
- ***The net change over six months is +0.37% which is not statistically different from zero***

Alicia and Ike Again Show Same Shelter/Recovery Pattern with BCI

Hurricane Alicia
Impact of Storm By Month

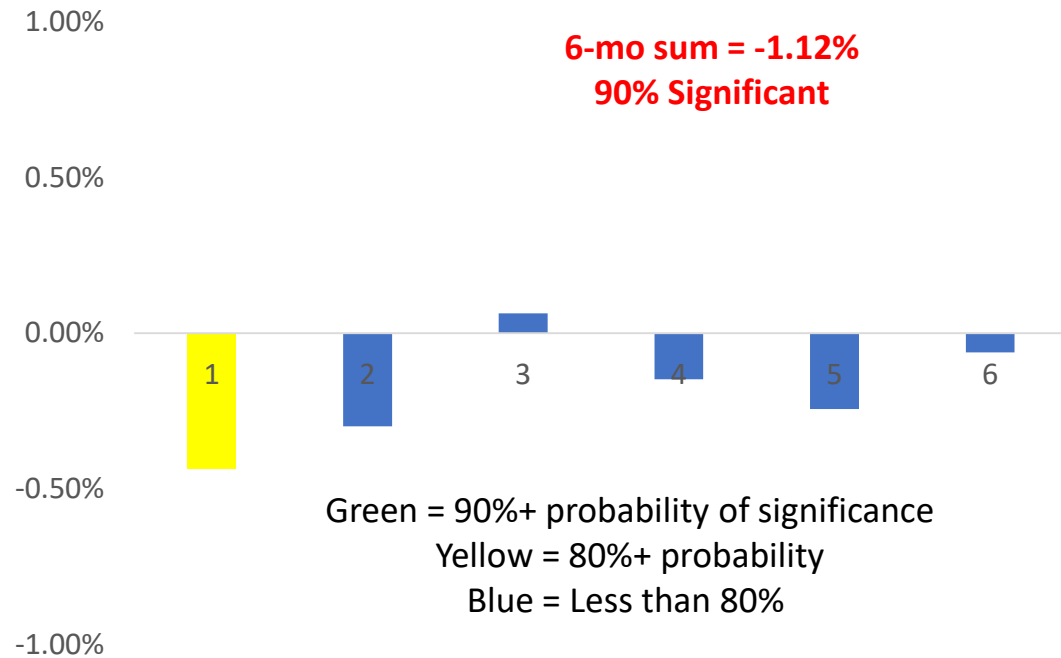


Hurricane Ike
Impact of Storm By Month

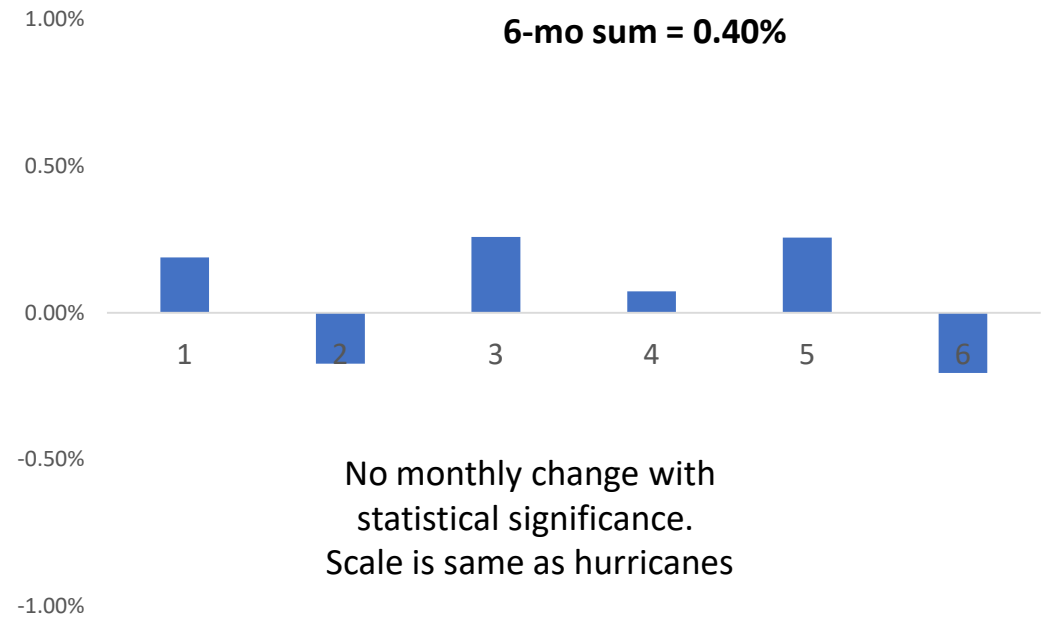


Flood Events and Impact on Houston's Business Cycle Index

Tropical Storm Allison Impact by Month

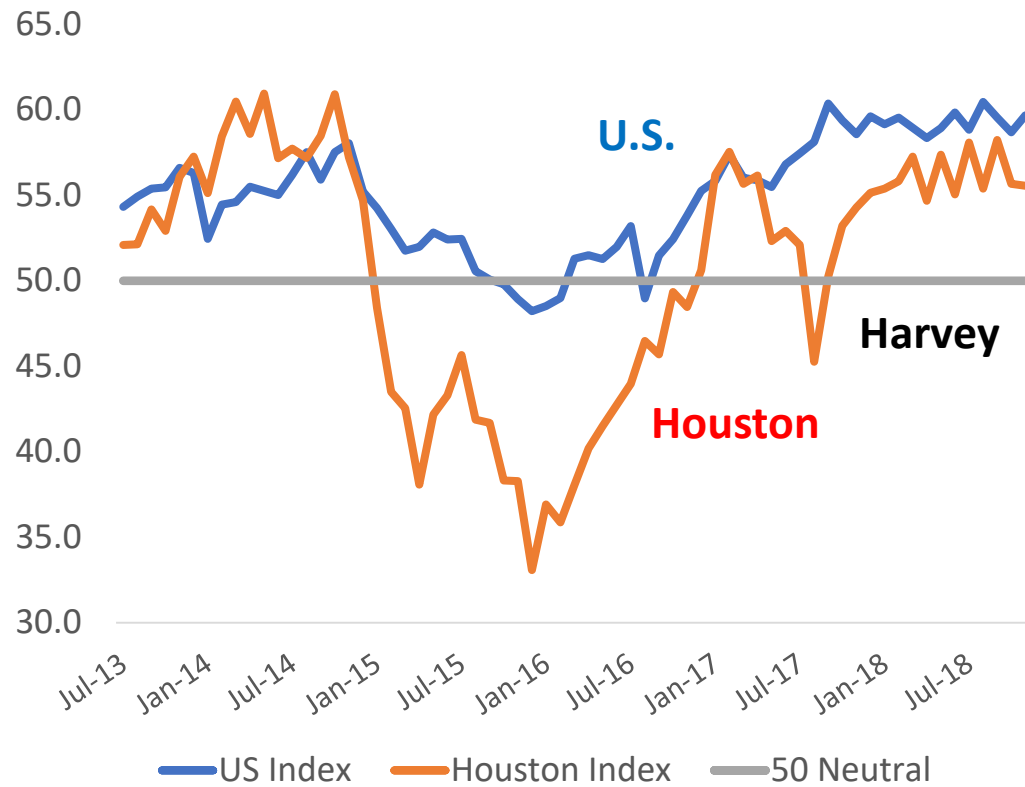


Tax Day Floods Impact by Month



All the Basics of Houston's Current Economy Are Also Told by the Houston PMI

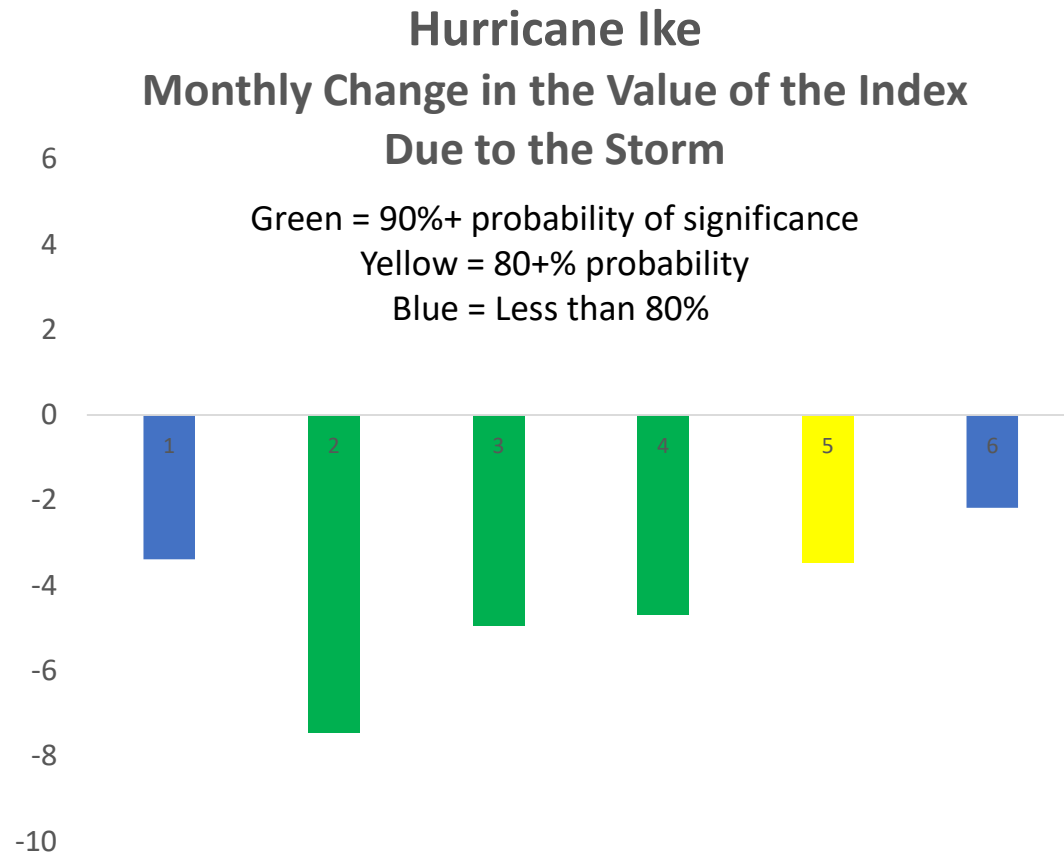
U.S. and Houston PMI



Houston PMI and Local Job Growth

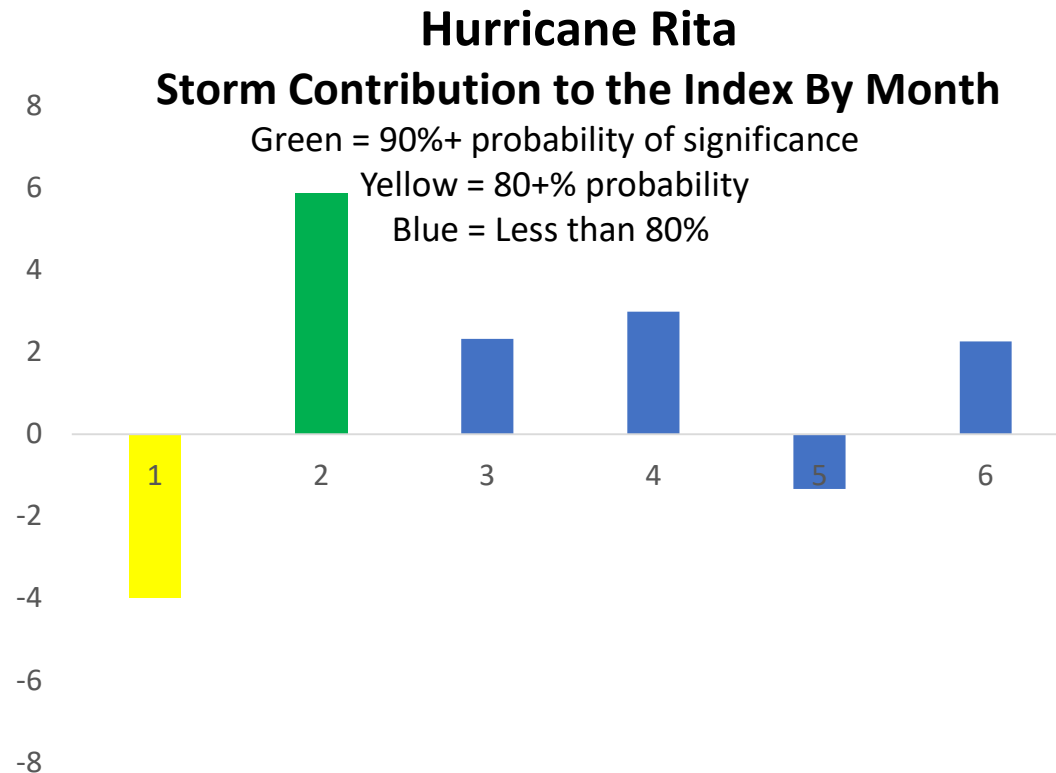


The Houston ISM for Hurricane Ike Shows Economywide Disruption Through Five Months



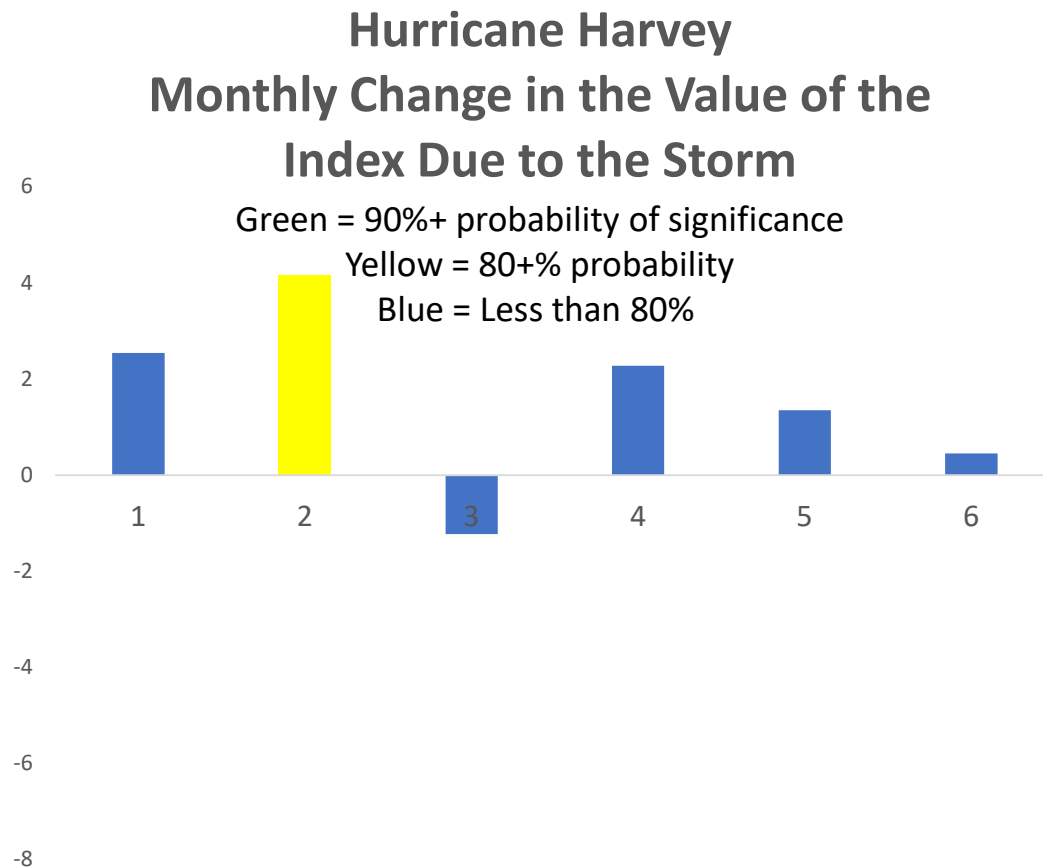
- The Houston PMI results look different from previous results. This is not the classic shelter and return pattern
- Unlike Harvey, Hurricane Ike greatly disrupted logistics on the ship channel, for example, causing headaches for purchasing managers
- The data series starts in 1997 and begins after Hurricane Alicia and the 1994 floods
- The value in the chart is the change in the monthly value of the index. They are 90% significant if the change is +/-4.4 points, and 80% significant at +/-3.4 points
- If the value of the index in the sixth month is not significant, the impact of the storm has likely passed. The sixth month is not significant for any of these six storms

The Houston ISM for Hurricane Rita Is Evacuation and Recovery ... But No Storm



- This is the only economy-wide measure to show impact from Hurricane Rita
- Rita struck Beaumont-Port Arthur, and largely missed Houston, but caused a massive evacuation of 2.5 million people, resulting in gridlock
- This shows the shelter and recovery period for local business – with no storm to follow
- When we look at sales tax figures below, they will reflect the arrival of Katrina evacuees in Houston during this same time period

The Houston ISM for Hurricane Ike Shows Economywide Disruption Through Five Months



- Like Ike, Hurricane Harvey does not show the shelter/recovery pattern
- Unlike Ike, if we abstract from the economy Harvey was a positive for the business cycle
- The overall ISM index for Houston was falling hard during August. The price of oil had reverted to \$45 and the rig count fell by 60 rigs or 6.3 percent from August to November
- We will look more closely at Harvey below

Houston and Eight Billion-Dollar Storms

Cumulative Impact Six Months After Storm

	Date	Employment	BCI	Houston ISM
Alicia	8/83	-0.37%	1.01%	NA
SE Texas Floods	10/94	-0.08%	0.44%	NA
Allison	6/01	-0.42%	-1.12%	-1.5
Rita	9/05	-0.78%	-0.11%	2.3
Ike	9/08	-0.42%	-0.88%	-2.2
Memorial Day	5/15	0.29%	0.20%	-2.0
Tax Day	4/16	0.47%	0.40%	-2.3
Harvey	8/17	0.30%	0.36%	0.4

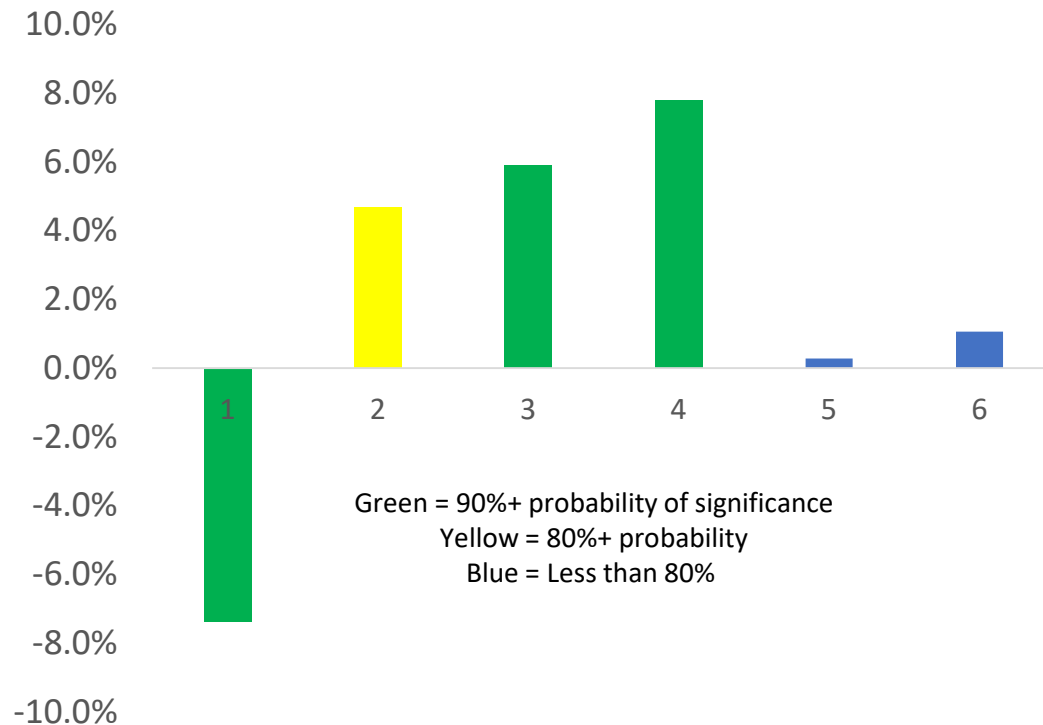
Note: For payroll employment and the BCI the numbers shown are the percent increase in values six months after the storm. The ISM shows the number of points added or subtracted from the index six months after the storm. Green indicates that the storm has a significance levels of 90% or higher and yellow implies 80% or higher

**Retail Sales and Construction: These Two Sectors
Have A Large and Positive Response to Storms**

City of Houston Taxable Sales

A Large Impact from Four Big Storms

Taxable Sales Impact of Harvey
Gone After Six Months



- Taxable sales data are based on City of Houston sales tax collections since 1981, deflated by the consumer price index and converted to 2017 dollars
- The City used a penny sales tax throughout, so taxable sales are 100 times collections
- Storm impacts are corrected for business cycle conditions, Y2K, and sporting events
- Hurricane Harvey had the smallest spending increase of the four major storms that significantly affected Houston
- Rita evacuation/Katrina relocation might have had an impact as high as \$280 million, but the combined 1994 , Tax Day and Memorial Day floods did not register any positive effect on City of Houston sales tax collections

Short-Run Taxable Sales Impact of Four Storms in Houston

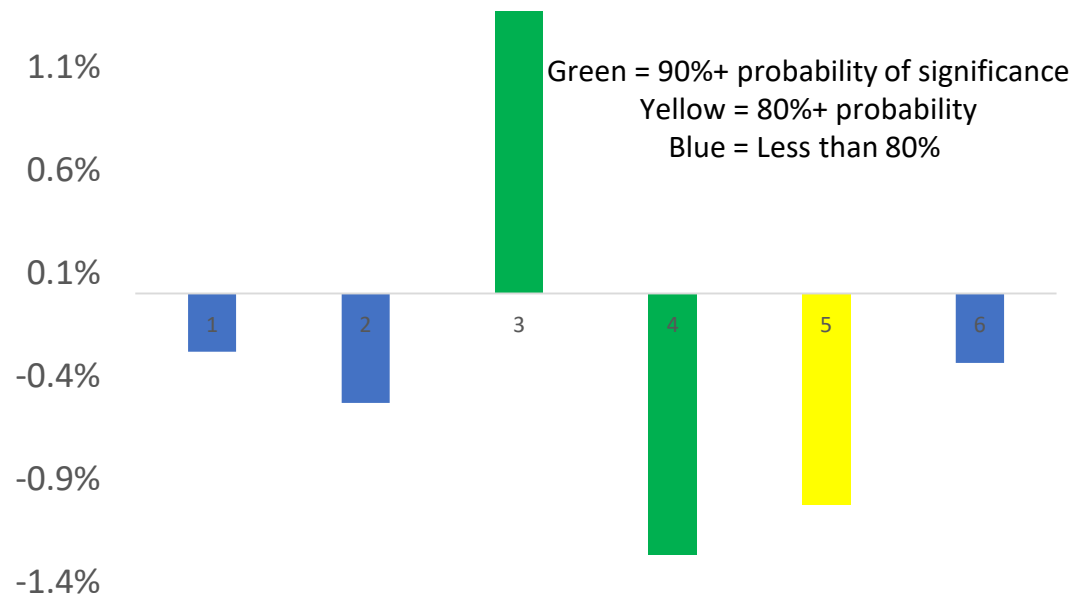
Monthly and Total After Six Months for City of Houston

Month	Alicia		Ike		Allison		Harvey	
	%	\$million	%	\$million	%	\$million	%	\$million
1	-6.9	-\$155.5	-2.7	-\$123.8	1.0	\$38.7	-7.4	-\$320.2
2	4.4	\$98.8	7.4	\$340.6	4.1	\$157.5	4.7	\$235.2
3	14.5	\$327.0	11.8	\$547.4	1.7	\$65.5	5.9	\$296.0
4	12.4	\$280.5	5.2	\$242.9	7.6	\$289.6	7.8	\$391.7
5	-7.7	-\$175.8	1.2	\$54.1	3.2	\$123.5	0.3	\$14.2
6	8.2	\$184.6	1.5	\$69.7	0.7	\$27.8	1.1	\$53.5
<i>Six Month</i>	<i>24.8</i>	<i>\$560.6</i>	<i>24.4</i>	<i>\$1,130.80</i>	<i>18.5</i>	<i>\$702.5</i>	<i>12.4</i>	<i>\$620.5</i>

Note: Calculations of author. Constant 2017 dollars. At the time of Harvey in 2017, City of Houston tax collections were 102 percent bigger than when Alicia hit in 1983, 32 percent bigger than when Allison struck in 2001, and 8.5 percent bigger than Ike in 2008.

Contract Construction and Storms in Houston

Hurricane Ike and Negative Impact on Construction?



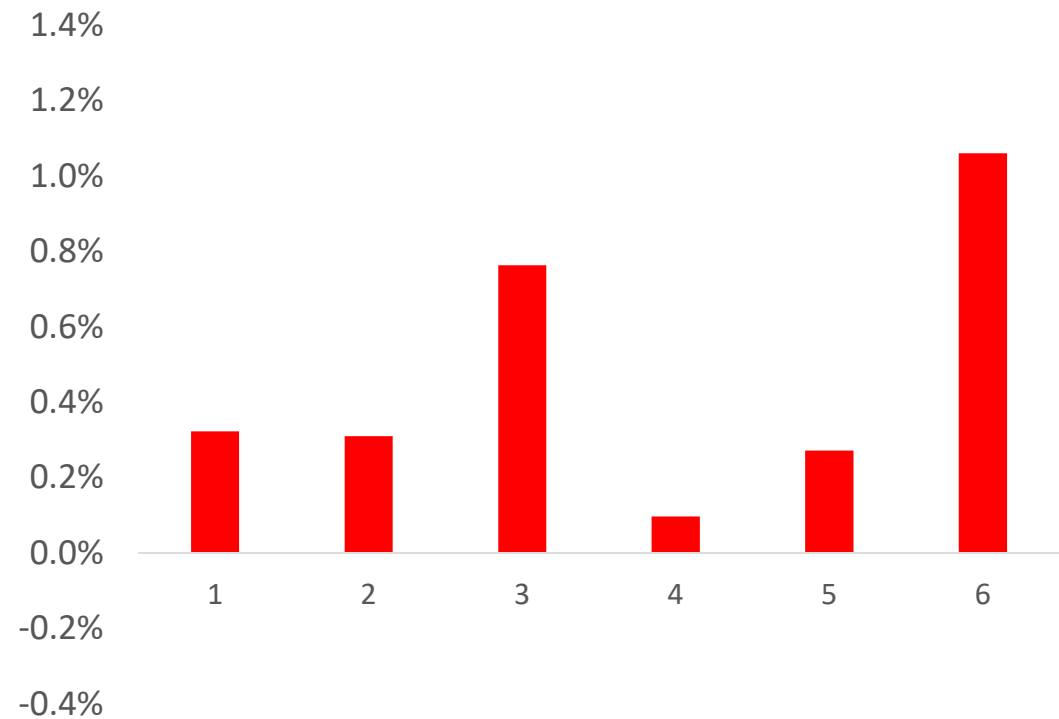
- Contract construction includes on-site contractors for everything from foundations to flooring to roofing. Excludes heavy construction and any building where trades are not involved
- These sectors are obviously affected by storms, but much of the immediate recovery work is day labor – pulling carpet, mucking out buildings, cutting drywall, etc. This won't be counted by BLS site surveys
- Data from BLS is limited to 2005 and after, beginning with Rita
- Ike at left did show significant increases after 6 months? It should have! Raises concern about the correction for the Great Recession and the credit crunch underway in 2009-09

The Most Recent Three Storms All Show Construction Gains

Memorial Day and Tax Day Floods See Big Gains End After Six Months



Harvey Also Was Significant But Over After Six Months



Focus on Harvey: Why Weren't Things as Bad for the Economy as Widely Believed?

Any Harvey Setback to the Big Drivers of the Houston Economy Last Only Days

- Upstream oil and gas?
 - We don't drill for oil and gas in Houston. Most upstream oil production and oil services is office-based, white-collar engineering activity. There was mostly disruption to an employee base found in high-rise structures
 - Houston's upstream machinery and fabricated metals industry supports a global drilling industry. The world's rigs are engineered and built here. But according to JLL, "today's industrial developments are designed with on-site water detention or retention systems, large lots, and two to four feet above grade." Business parks avoid building in the bayou system.
 - Beyond the big three – Schlumberger, Halliburton, Baker Hughes – in late 2017, oil services was a depressed industry in late 2017. Even if there was damage, there was surplus capacity in the industry
- Refining, chemical and plastics?
 - Most ship channel facilities were still operating as Harvey hit Rockport and Corpus Christi, and plants shutdown only when they realized employees and first responders were at risk from flooding
 - The damage done to Katrina refineries was months of repair due to water reaching electric motors or control systems due to storm surge. There was no surge from Harvey. This was a shut-down and restart on the Ship Channel that has been seen many times before

Any Harvey Setback to the Big Drivers of the Houston Economy Last Only Days

- Medical?
 - Most medical in Houston is service to local residents. We don't steer the economy by taking each others' blood pressure
 - However, key parts of the economic base are at the Texas Medical Center. About 10 percent of their patient care, billions in research, and a major educational role. No big problems: *Learned their lessons well from Allison, as new flood gates worked well*
- NASA and its contractors?
 - Mission control worked through the storm. The space station is still up there. They found a safe place to store the replacement for the Hubble
- The Port of Houston?
 - Closed on August 25 due to Harvey, and reopened partially by September 1. It took several days more to get up to speed by allowing larger vessels, operating night hours, etc.
 - Some parts of the Ship Channel remained closed for several months, but there were no major impediments.

Commercial Real Estate

- *Office Buildings* –
 - JLL says 57 of 1200 local office buildings were “affected” by Harvey in some way, but only a small number of those had flooding of lobbies, building systems, or parking garages.
 - Flooded buildings total about 1.5 million square feet of space. If needed there was 10 million square feet of *sublease* space that was immediately available in late 2017
- *Retail* – CBRE, JLL say significant damage was limited to neighborhood retail and strip centers in hard-hit areas like Kingwood, Cypress, and West Houston
- *Apartments* --
 - Apartment Data Services surveyed of 98.4% of 638,000 units in Houston, and found 215 properties damaged with 15,662 units, or 2.4 percent of the market. Ultimately, only 2,000 units were removed from inventory until repairs could be completed.
 - This is half the damage compared to Ike? Why? (1) A different kind of storm, with water moving in narrow and more predictable channels compared to wind or storm surge; and (2) Many lessons were well learned from recent floods
- *Industrial* – Limited impact was discussed earlier

Harvey Mostly Brought Single-Family Housing Problems in Existing Neighborhoods

- *New Home Construction*

- Limited damage to homes or infrastructure in active developments. Shortages of labor and materials cost posed major problems in rebuilding, and extended schedules substantially.
- According to both Meyers Research and MetroStudy, suburban homes built after post-Allison land-use regulations went into place in 2001 were largely unscathed by Harvey

- *Existing homes*

- About 101,500 homes were *affected*: 60,187 affected but quickly habitable with repair (2.5% of housing stock); 37,757 homes had major damage (1.6%), but habitable with repair; 3,638 homes were destroyed (0.1%)
- Reconstruction was slowed by labor shortages and sharply rising costs of building materials
- About half the flooded area was outside the 500-year floodplain, and 83% of Houstonians had no flood insurance. Even if you had insurance, there were big deductibles and limited total coverage.
- What happens to the value of homes in affected neighborhoods? Single-family REITS and other investors were actively acquiring damaged single-family units.

Could the Tail Wag the Dog? Could Damage to Neighborhood Businesses Hurt the Economy?

- The one place we can point to damage in Houston is its neighborhoods
- The kinds of businesses affected are shown at right, often scattered through neighborhoods and found in strip malls
- Combined, they make up about 44 percent of Houston's total employment base or 1.4 million jobs
- In the first six months after Harvey, there were 40,000 local disaster loans approved by the Small Business Administration, worth \$3.1 billion

Nine Big Service Sectors in Houston

Sector	Employees	Examples
Accommodation	28,000	hotel, motel
Arts & Entertainment	35,100	movie theater, museum
Private Education	61,400	schools
Finance	164,900	bank branches
Food Service	258,300	bars, restaurants
Health care	335,100	doctors, dentists
Local Education	212,500	schools, colleges
Retail	324,000	groceries, dry cleaner
sum	1,419,300	

No Evidence Here That Tails Wag Dogs: Nine Secondary Sectors

- Use a test similar to those employed earlier to see if storms have ever affected these nine combined secondary sectors
- There is no sign that any of these storms have affected these industries on a month-to-month basis, apart from the usual shelter and recovery pattern in the first few months
- Measured across a six month period, none of the storms – including Harvey – have a statistically significant impact on the secondary sectors

Probability Combined Service Sectors Affected By a Major Storm

Storm	Probability (%)
1994 Floods	46.9
Allison	64.9
Rita	12.2
Ike	8.3
Memorial Day	35.6
Tax Day	61.2
Harvey	26.7

Conclusions

- Don't confuse the balance sheet with the income statement, or stocks with flows
 - Flows of employment, income and production were largely unaffected by Harvey and other Houston storms, with only small net gains or losses after a few months
 - While the economy rolled on, uncompensated personal and property losses for damages were not made up. We were left poorer by the storms
- For Harvey in particular, Houston's economic base was left virtually unscathed by the storm. There were many positive lessons learned from previous storms by the Texas Medical Center, commercial real estate, apartments, and recent home construction
- Harvey was mostly about damage to homes and businesses in our neighborhoods, and posed little threat to our near-term growth prospects. The worst damage was northeast of downtown in older and smaller homes in disadvantaged neighborhoods
- Both Ike and Harvey posed important challenges to flood control infrastructure, both in managing the bayou system and from potential storm surge.

The empirical evidence ... indicates that a community may benefit economically from a disaster ... [T]ypical are the comments appearing six months to a year after the disaster, expressing surprise at the speed with which the community has recovered and the prosperity that now reigns.

Douglas C. Dacy and Howard Kunreuther,
The Economics of Natural Disasters, 1969

Public Policy and Natural Disaster: Mitigating the Damage

- Providing basic infrastructure for flood and surge protection is fundamental
- Planning for the next disaster
- Implementing public safety/police powers before, during, and after the storm
- Floodplain regulations to mitigate damage storm damages come with a trade-off in their high cost and effect on housing affordability
- Is flood insurance as a market failure requiring public intervention?

Rules About Resilience Can Go Out the Window with Major Infrastructure Failure

- Katrina in New Orleans and its levees fail; Maria hits Puerto Rico and the electrical system collapses; Galveston's Great Storm of 1900 left city unprotected on a barrier island; Galveston in 2008 with Sea Wall overcome by Ike; Indianola in 1886 leaves city unprotected after public/private dispute over paying for better storm infrastructure
- Houston has had recent warnings about the adequacy of infrastructure to protect the bayou system and the coastal regions from storm surge
- Harvey seems to have delivered the message. But much work to be done.
 - Harris County has approved a \$2.5 billion bond issue for drainage improvements, warning systems, infrastructure improvements, and more retention ponds
 - There is another \$5.5 billion in immediate, targeted disaster relief for Texans, with \$2.3 billion for Houston/Harris County
 - In October 2017, two federal bills provide \$126 billion in disaster relief and infrastructure to be divided among Texas, California, Florida, Puerto Rico and Louisiana

Planning for Hurricane Carla in 1953: Advance Warning to the Gulf Coast

- Dacy and Kunreuther describe the first detailed Civil Defense survival plans put into place before Hurricane Carla in 1961. Weather Bureau personnel toured the Texas Coast before Carla alerting county judges, Civil Defense personnel, and first responders to implement the plan
- There is early evacuation of low-lying areas, followed by the eventual evacuation of 350,000 people off the Gulf Coast as the storm approaches
- The storm lands as a Cat 4 at Port Lavaca with 122 mph winds and a 22 foot storm surge. There were only 42 deaths reported
- The plan breaks down after the storm with uncontrolled movements of people back into the area (evacuees and sightseers), jammed messages by telephone and telegraph, and the influx of emergency supplies to start rebuilding. Results in a severe traffic jam on the Gulf Freeway in Houston

Planning for Storms with No Warning: The Waco and San Angelo Tornadoes of 1953

- May 11, 1953 a major multi-state outbreak of tornadoes resulted in large tornadoes hitting both Waco and San Angelo
- Waco was totally unprepared, believing an old Indian myth that Waco could not be hit by a storm. San Angelo had detailed plans in place – after having previously been struck
- Everything broke down in Waco: There was no warning before; no radio or telephone communications after; no electricity; the closest hospital is swamped while others nearby were available; first responders were scattered; arrival and distribution of outside help and supplies is completely unorganized
- San Angelo has police officers follow the storm's path into town; the officers report constantly to the local radio station and newspapers; schools are evacuated ahead of the storm; downtown brick buildings are used for storm shelters; convergence of people and supplies from outside the city was properly anticipated
- Waco has 114 dead 600 injured. San Angelo sees 13 die and 159 injured. The cost to the public of these contingency plans is relatively low

Higher Elevations for the City/County Floodplain Ordinances

- The City of Houston's new floodplain ordinance requires new home construction at the 500-year floodplain plus two feet; previously it was at 100-foot level plus one foot. Harris County's change is similar.
- *This creates a trade-off*: The new ordinance and its additional protections will lower the future cost of flooding incurred by homeowners; it will also substantially and immediately increase the cost of new home construction
- Concerns largely center on the immediate loss of affordability:
 - Raising the slab on a new home by one foot increases its construction cost by \$35,000, and add \$10,000 for each additional foot
 - Builders are struggling to keep entry-level housing in Houston below \$300-350,000, as costs of land, labor, and materials have soared in recent years. This also will force new home construction into surrounding counties
 - New homes built after Allison saw minimal damage. The existing homes most seriously damaged by Harvey were older, smaller, and in disadvantaged neighborhoods. The ordinance adds to the shortage of low-income housing
 - It strikes at the heart of the Texas growth formula: low regulation, low taxes, and low housing costs. The ordinance implies slower growth

Properly-Priced Flood Insurance Could Eliminate the Need For a Floodplain Ordinance

- In principle, a good floodplain map and properly-priced flood insurance would eliminate the need for a floodplain ordinance. Like an ordinance, insurance would raise costs to high-risk areas, and correct over-building in the most flood-prone areas; unlike the ordinance, the housing market sets the rules on cost/pricing
- The National Flood Insurance Program (NFIP) offers insurance up to \$250,000 for structures and \$100,000 for personal possessions. It handles 98% of U.S. flood insurance
- Why a federal program? Floods are rare, unpredictable, and catastrophic, creating huge tail-risks that private insurance companies won't accept. Floods are concentrated geographically, and there is adverse selection of insurance by flood-prone areas
- The NFIP underprices this insurance. The CBO saying that NFIP loses \$1.7 billion per year and still owes the Treasury \$20.5 billion even after years of write-offs
- If we accept that Gulf Coast over-building in the floodplain results from cheap federal insurance, the floodplain restrictions may be necessary as second-best corrective. Sometimes it takes two wrongs to make a right



Hurricane Harvey and Resilience in Houston's Economy

Robert W. Gilmer, Ph.D.
C.T. Bauer College of Business
January 2019