

# A Storm to Remember

## The Economic Impact of Hurricane Harvey

Joyce E. Jauer, MPSA

Senior Revenue Analyst

Texas Comptroller of Public Accounts

REMI Webinar

February 20, 2019



# The Economic Impact of Hurricane Harvey



- Assumptions
- Productivity Loss
- Rebuilding Gains
- Model
- Results
- Takeaways

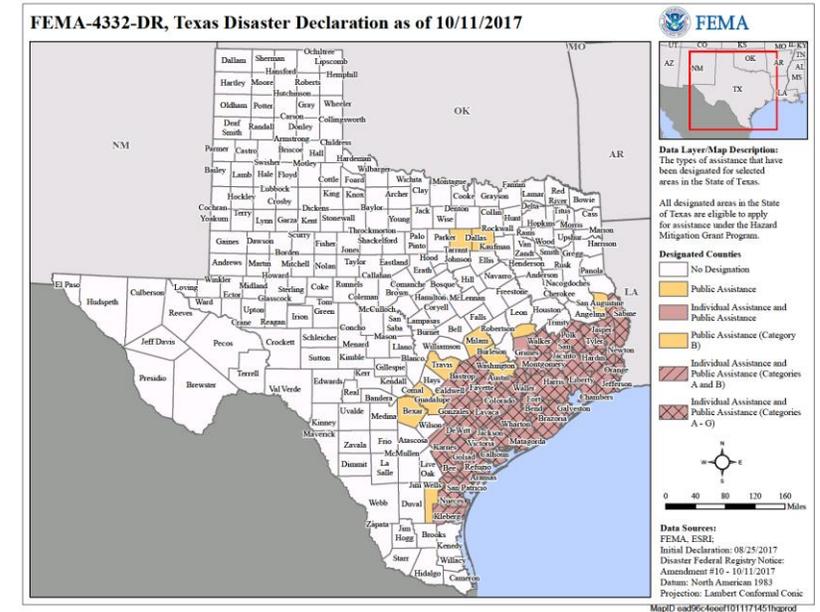
# Harvey by the Numbers

- 178,400 Texas homes damaged
- estimated \$669 million in damage to public property
- 400,000-600,000 cars damaged
- \$200 million in Texas crop and livestock losses
- Winter tourism decreased 50% in coastal areas
- Total costs actuarially estimated \$125-133 billion



# Assumptions

- What geographical areas were affected?
- How long was business disrupted?
- What industries were affected?
- How are supply chains affected?
- How much damage was done?
- How much money is coming in?
- When is it coming?
- On what will it be spent?
- When will it be spent?
- Where will it be spent?



# Assumptions

## Devastating effects for communities:

- Significant damage and replacement costs
- Utilities interrupted
- Businesses offline for a period of time
- Hourly workers unpaid
- Cars and equipment flooded
- Businesses and families displaced
- Infrastructure damaged (roads, ports)



Productivity Loss

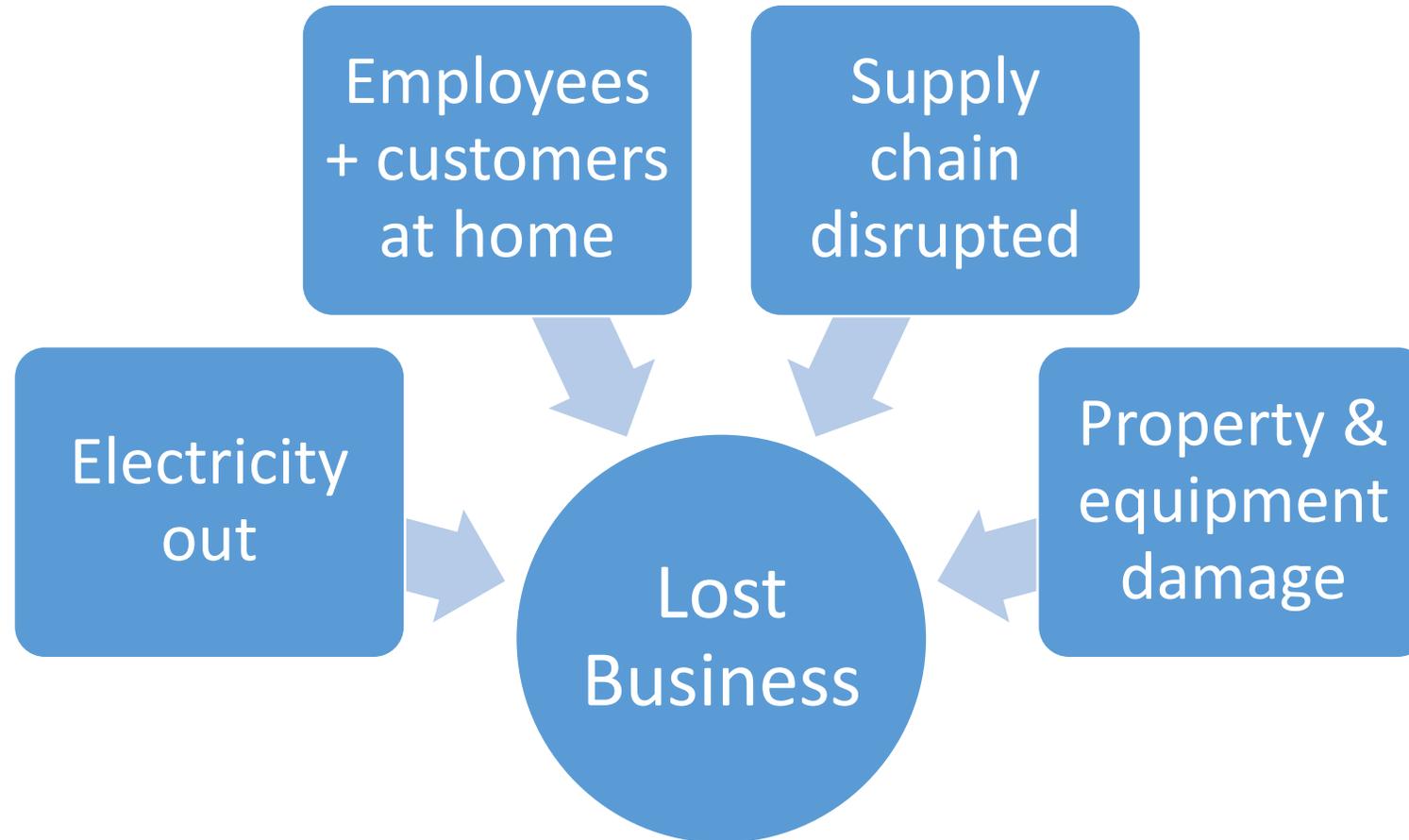
## Economic activity generating effects for the region:

- Increased spending from rebuilding and replacement
- Influx of insurance payments, federal aid
- Increased employment for construction and debris removal
- Increased building materials and replacement equipment purchases
- Increased intermediate effects due to supply for construction
- Increased consumer spending on household items, health care and induced effects



Rebuilding Gains

# Productivity Loss



# Productivity Loss

Industries are discounted differently depending on:

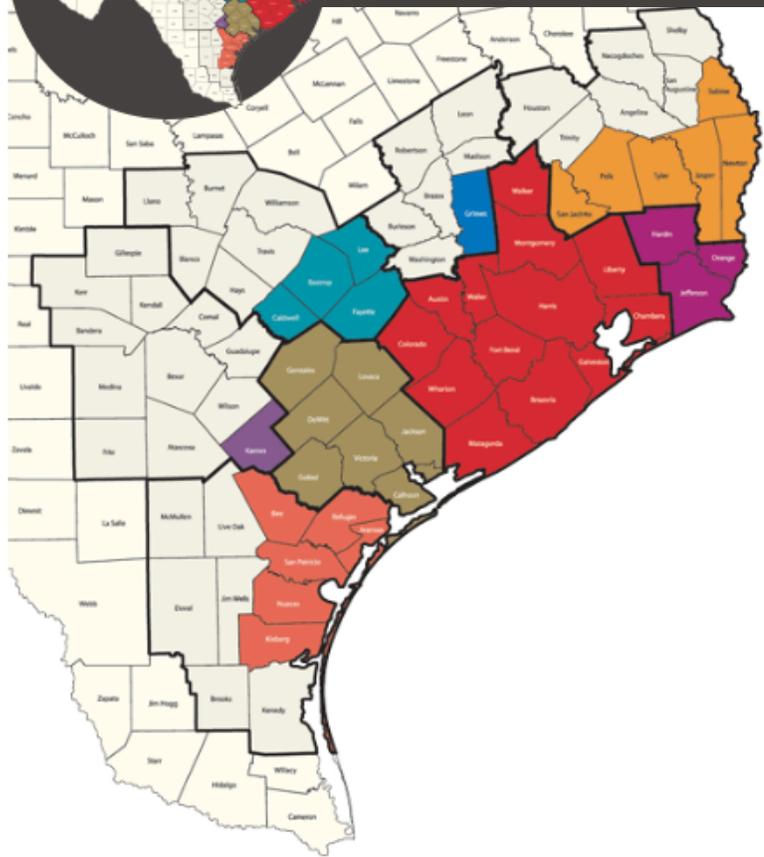
- the amount of time they were estimated to be offline
- their level of competition
- their place in the supply chain

Regions are discounted differently based on disaster area declaration





# Texas Counties Affected by Hurricane Harvey

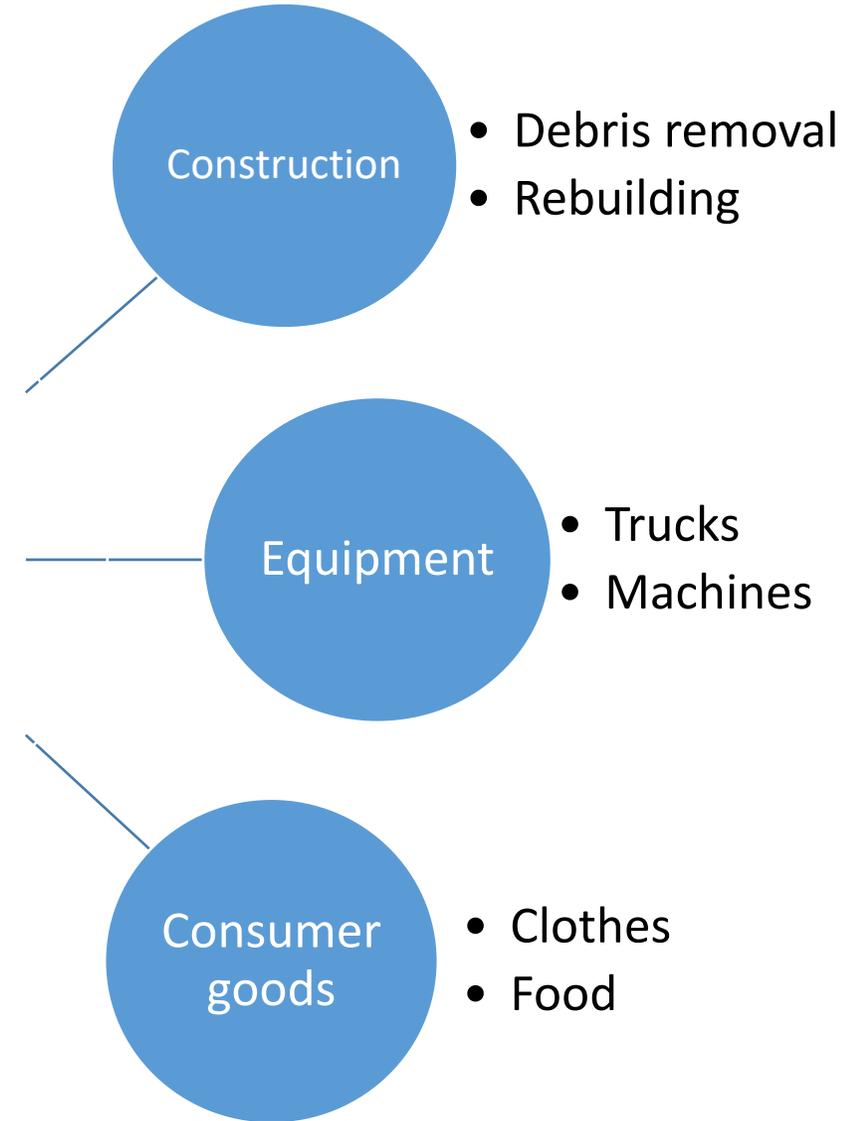
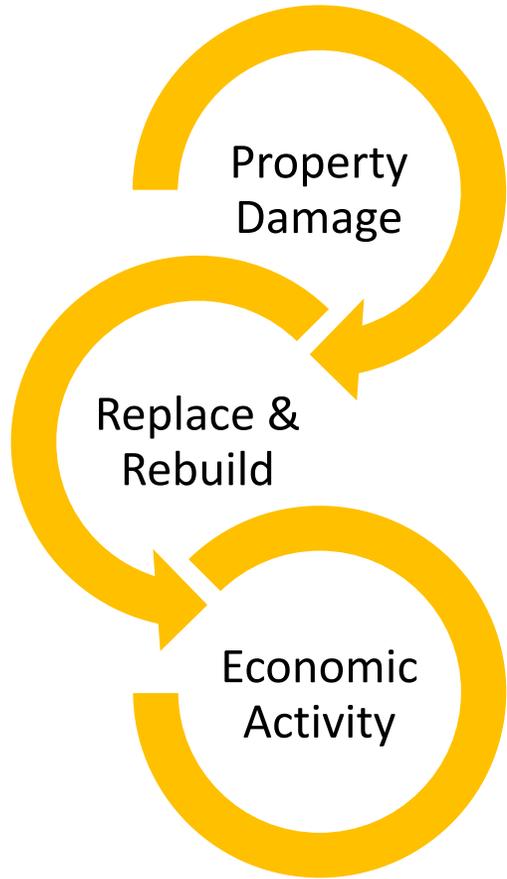


Counties declared by FEMA as disaster areas and boundaries showing the eight councils of governments (COGs) affected.

- DETCOG** **Deep East Texas Council of Governments**  
Jasper, Newton, Polk, Tyler, Sabine, San Jacinto
- SETRPC** **South East Texas Regional Planning Commission**  
Hardin, Jefferson, Orange
- H-GAC** **Houston-Galveston Area Council**  
Austin, Brazoria, Chambers, Colorado, Fort Bend, Galveston, Harris, Liberty, Matagorda, Montgomery, Walker, Waller, Wharton
- BVCOG** **Brazos Valley Council of Governments**  
Grimes
- CAPCOG** **Capital Area Council of Governments**  
Bastrop, Caldwell, Fayette, Lee
- GCRPC** **Golden Crescent Regional Planning Commission**  
Calhoun, DeWitt, Goliad, Gonzales, Jackson, Lavaca, Victoria
- AACOG** **Alamo Area Council of Governments**  
Karnes
- CBCOG** **Coastal Bend Council of Governments**  
Aransas, Bee, Kleberg, Nueces, Refugio, San Patricio

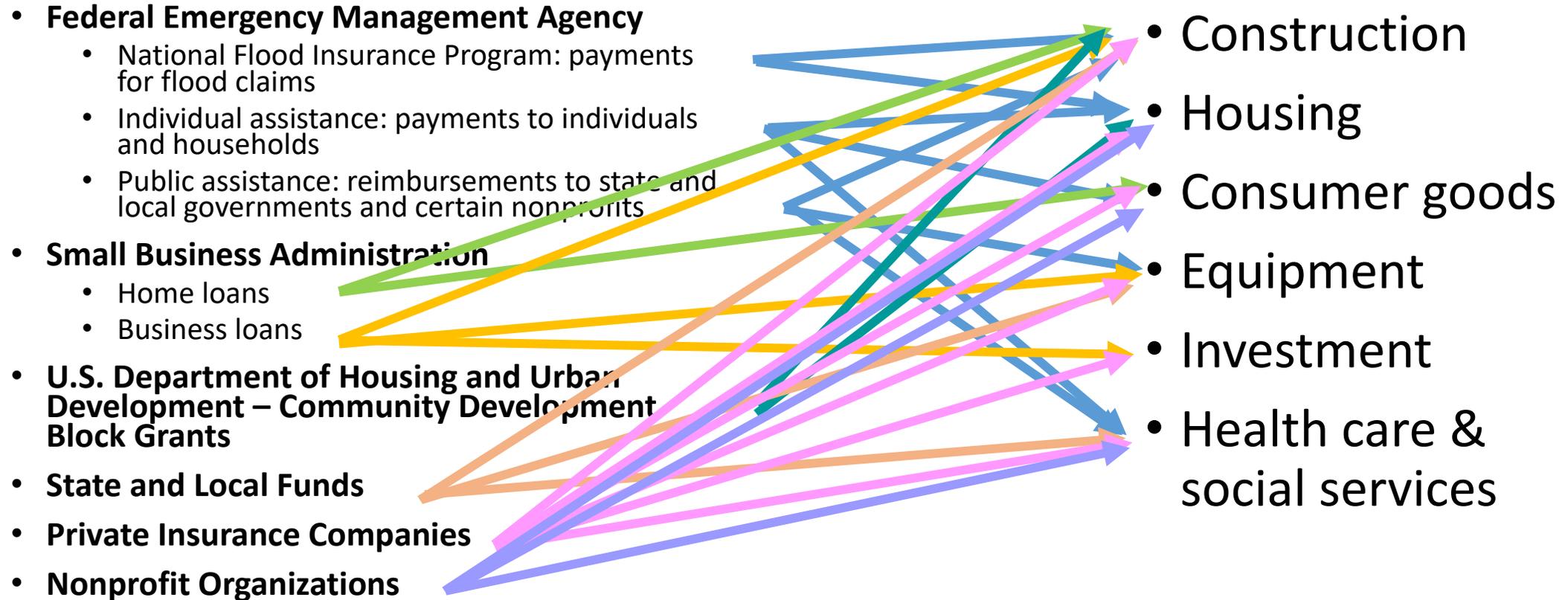
Source: Federal Emergency Management Agency

# Rebuilding Gains

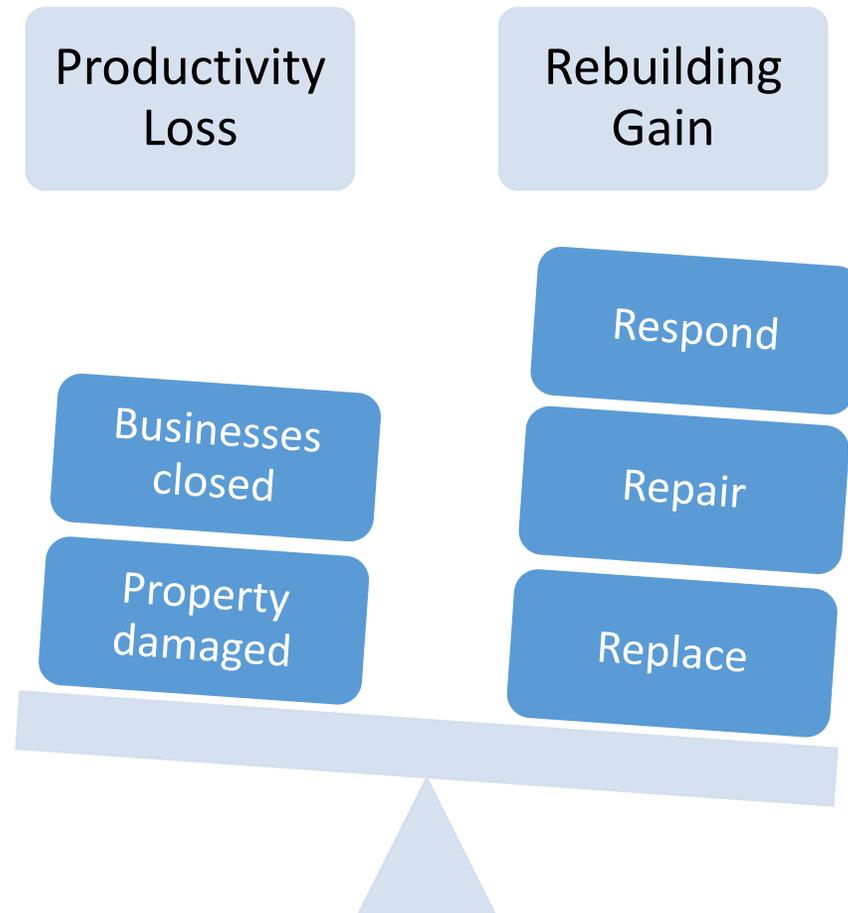


# Rebuilding gains

Funds came into the market from different places and were divided into inputs depending on how they were expected to be spent  
*(involved a lot of spreadsheet tabs)*



# Net result of economic shock

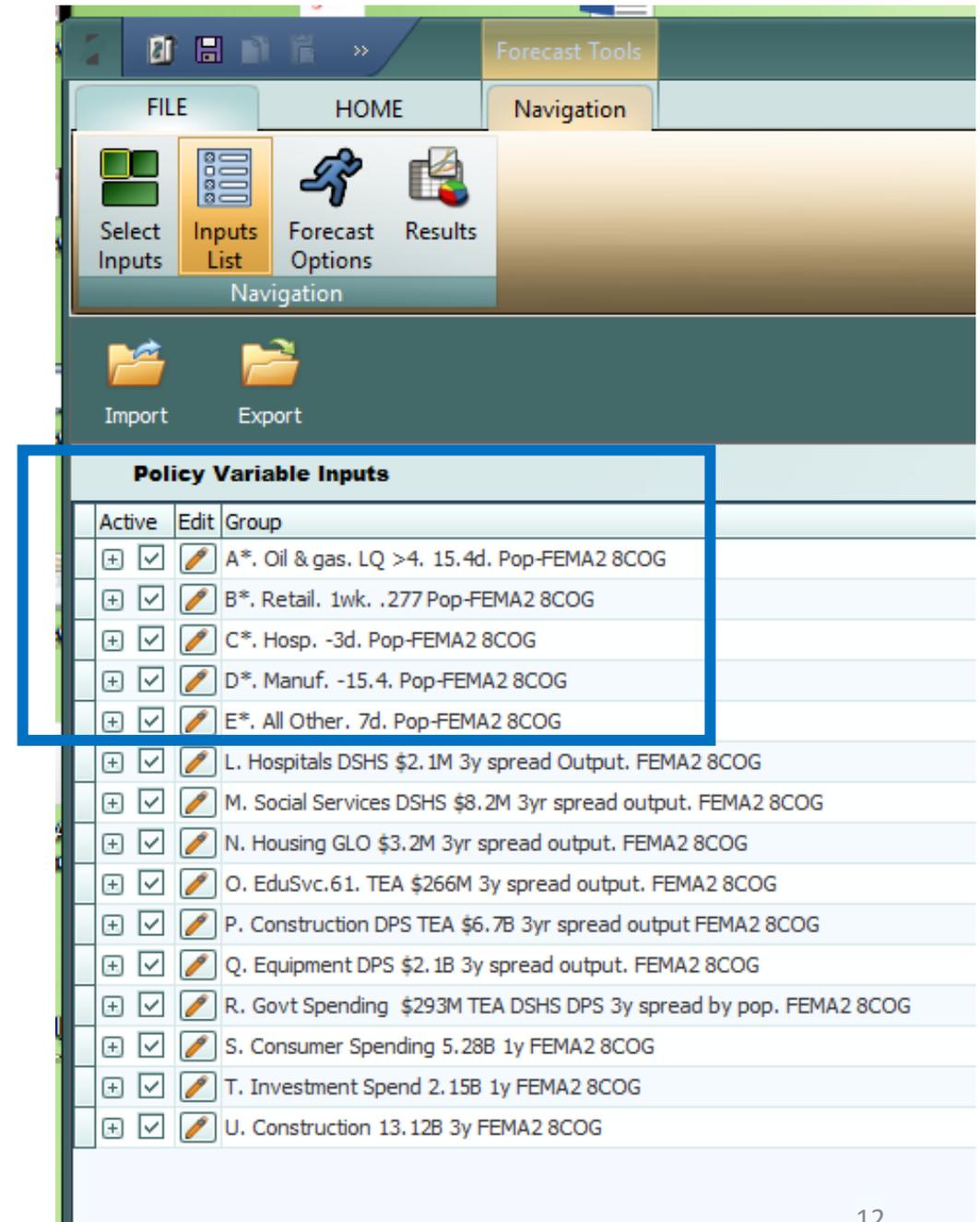


*What is the net impact of these two forces interacting?*

Not included:  
capital stock loss to prevent double counting,  
production cost change difficult to estimate

# Remi Inputs list

- Productivity Loss (A-E)
  - Oil & Gas
  - Retail
  - Health Care
  - Manufacturing
  - All Other
- Rebuilding gains (L-U)



The screenshot displays the 'Forecast Tools' application interface. The 'Inputs List' tab is selected, showing a table of 'Policy Variable Inputs'. The table has columns for 'Active', 'Edit', and 'Group'. The rows are labeled A\* through U\*, representing different input categories. The first five rows (A\* through E\*) are highlighted with a blue box, corresponding to the 'Productivity Loss (A-E)' category mentioned in the text.

Active	Edit	Group
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	A*. Oil & gas. LQ >4. 15.4d. Pop-FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	B*. Retail. 1wk. .277 Pop-FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	C*. Hosp. -3d. Pop-FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	D*. Manuf. -15.4. Pop-FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	E*. All Other. 7d. Pop-FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	L. Hospitals DSHS \$2.1M 3y spread Output. FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	M. Social Services DSHS \$8.2M 3yr spread output. FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	N. Housing GLO \$3.2M 3yr spread output. FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	O. EduSvc.61. TEA \$266M 3y spread output. FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	P. Construction DPS TEA \$6.7B 3yr spread output FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Q. Equipment DPS \$2.1B 3y spread output. FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	R. Govt Spending \$293M TEA DSHS DPS 3y spread by pop. FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	S. Consumer Spending 5.28B 1y FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	T. Investment Spend 2.15B 1y FEMA2 8COG
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	U. Construction 13.12B 3y FEMA2 8COG

# Productivity Loss

- Each of the 5 categories of industry had specific discounts:
  - Time discount – reduced by number of days offline
  - Geography discount – reduced by percentage of the COG affected
  - Industry discount – Retail reduced and Oil&Gas considered exogenous

Policy Variable Inputs									
Active	Edit	Group							
<input checked="" type="checkbox"/>		A*. Oil & gas. LQ >4. 15.4d. Pop-FEMA2 8COG							
Active	View	Category	Detail	Region	Units	2015	2016	2017	
<input checked="" type="checkbox"/>		Output	Industry (Exogenous Production): Details (3)	Capital Area	Percent	0	0	-0.33	
<input checked="" type="checkbox"/>		Output	Industry (Exogenous Production): Details (3)	Brazos Valley	Percent	0	0	-0.33	
<input checked="" type="checkbox"/>		Output	Industry (Exogenous Production): Details (3)	Deep East Texas	Percent	0	0	-1.72	
<input checked="" type="checkbox"/>		Output	Industry (Exogenous Production): Details (3)	Houston-Galveston	Percent	0	0	-4.2	
<input checked="" type="checkbox"/>		Output	Industry (Exogenous Production): Details (3)	Golden Crescent	Percent	0	0	-4.2	
<input checked="" type="checkbox"/>		Output	Industry (Exogenous Production): Details (3)	Alamo Area	Percent	0	0	-0.3	
<input checked="" type="checkbox"/>		Output	Industry (Exogenous Production): Details (3)	Coastal Bend	Percent	0	0	-3.69	
<input checked="" type="checkbox"/>		Output	Industry (Exogenous Production): Details (3)	South East Texas	Percent	0	0	-4.2	

# Productivity Loss (fine print...TL;DR)

- manufacturing and mining were assumed to be offline or experiencing reduced revenue for 15.4 days (Manufacturing Outlook Survey).[49](#)
- hospitals were assumed to be offline or experiencing reduced revenue for four days.[50](#)
- firm-level competition is assumed for all industries except those with a high location quotient (LQ >4) such as oil and gas extraction, which are considered exogenous.[51](#)
- retail and wholesale trade are further discounted to account only for the markup of cost of goods sold, to avoid double-counting.[52](#)
- accommodation is assumed to be unaffected by productivity losses as the decrease in tourism from the storm could be counterbalanced by the increase in hotel occupancy by evacuees.

# Remi Inputs list

- Productivity Loss (A-E)
- Rebuilding gains (L-U)
- Total expected spending divided by category:
  - Hospitals
  - Social Services
  - Housing
  - Education Services
  - Construction (Debris removal)
  - Government Spending
  - Equipment
  - Consumer Spending
  - Investment Spending
  - Construction (Rebuilding)

Forecast Tools

Navigation

Import Export

**Policy Variable Inputs**

Active	Edit	Group	
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	A*. Oil & gas. LQ >4. 15.4d. Pop-FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	B*. Retail. 1wk. .277 Pop-FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	C*. Hosp. -3d. Pop-FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	D*. Manuf. -15.4. Pop-FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	E*. All Other. 7d. Pop-FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	L. Hospitals DSHS \$2.1M 3y spread Output. FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	M. Social Services DSHS \$8.2M 3yr spread output. FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	N. Housing GLO \$3.2M 3yr spread output. FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	O. EduSvc.61. TEA \$266M 3y spread output. FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	P. Construction DPS TEA \$6.7B 3yr spread output FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Q. Equipment DPS \$2.1B 3y spread output. FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	R. Govt Spending \$293M TEA DSHS DPS 3y spread by pop. FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	S. Consumer Spending 5.28B 1y FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	T. Investment Spend 2.15B 1y FEMA2 8COG
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	U. Construction 13.12B 3y FEMA2 8COG

# Rebuilding Gains

- Consider all funding sources entering the market
  - FEMA funding
  - National Flood Insurance Program
  - Private insurance
  - SBA loans
  - State/local governments
  - Nonprofits
  - Personal savings
- How will the funds be spent?
- When will the purchases be made?

	A	B	C	D	E	F
1	U. Payout from flood and private insurance (manna)					
2						
3	<b>Influx of funding</b>					
4	\$11B FEMA Flood Insurance Program					
5	\$8B private insurance					
6	\$1B SBA loans. Not counterbalanced bc assumed pay off over 30yrs					
7	20.543	Billions	spread by consumption			
8						
9	<b>Spending over time</b>					
10	most people rebuild in 18-24 mos					
11	80% accounts closed after year 3 in katrina					
12	2017	2018	2019	out years beyond scope		
13	0.65	0.15	0.1	0.1		
14						
15	<b>Spending categories</b>					
16	proportions of SBA loans for Sandy					
		Total Approved Loan Amount	Approved Amount Real Estate	Approved Amount Content	Approved Amount EIDL	Total by type
17						
18	Biz	20.69%	10.22%	6.84%	3.60%	20.66%
19	Home	79.31%	53.66%	25.68%	0.00%	79.34%
20	Both	100.00%	63.88%	32.53%	3.60%	100.00%

# Rebuilding gains calculation

- Total influx of funding
- Divided by the categories in which we expect people to spend
- Spread over the year we expect them to spend it
- Spread by output, population, and consumption

I	J	K	L	M	N	O	P	Q	R	S
Variables (\$B)	Percentage	Inputs		2017	2018	2019				
<b>Construction</b>	0.64	13.12	real estate: business and home	<b>\$ 8.53</b>	<b>\$ 1.97</b>	<b>\$1.31</b>		spread by output		
<b>Investment</b>	0.10	2.15	content and EIDL	<b>\$ 2.15</b>	assume replace immediately		spread by population			
<b>Consumer spend</b>	0.26	5.28	home content	<b>\$ 5.28</b>	assume replace immediately		spread by consumption			

# Rebuilding Gains

- Time factor – year money spent
- Geography factor – spent in the COGs affected
- Industry factor – spread by output, consumption, or population as appropriate

T. Investment Spend 2.15B 1y FEMA2 8COG												
U. Construction 13.12B 3y FEMA2 8COG												
Active	View	Category	Detail	Region	Units	2015	2016	2017	2018	2019	2020	
<input checked="" type="checkbox"/>		Firm Sales (competes locally)	23 - Construction	Capital Area	Nominal \$ (B)	0	0	1.2296	0.2883	0.1939	0	0
<input checked="" type="checkbox"/>		Firm Sales (competes locally)	23 - Construction	Brazos Valley	Nominal \$ (B)	0	0	0.1645	0.038	0.0254	0	0
<input checked="" type="checkbox"/>		Firm Sales (competes locally)	23 - Construction	Deep East Texas	Nominal \$ (B)	0	0	0.1269	0.0291	0.0194	0	0
<input checked="" type="checkbox"/>		Firm Sales (competes locally)	23 - Construction	South East Texas	Nominal \$ (B)	0	0	0.3651	0.0841	0.0561	0	0
<input checked="" type="checkbox"/>		Firm Sales (competes locally)	23 - Construction	Houston-Galveston	Nominal \$ (B)	0	0	4.8431	1.113	0.7398	0	0
<input checked="" type="checkbox"/>		Firm Sales (competes locally)	23 - Construction	Golden Crescent	Nominal \$ (B)	0	0	0.1245	0.0284	0.0188	0	0
<input checked="" type="checkbox"/>		Firm Sales (competes locally)	23 - Construction	Alamo Area	Nominal \$ (B)	0	0	1.2518	0.29	0.1939	0	0
<input checked="" type="checkbox"/>		Firm Sales (competes locally)	23 - Construction	Coastal Bend	Nominal \$ (B)	0	0	0.4237	0.0974	0.0649	0	0

# Run REMI, Run

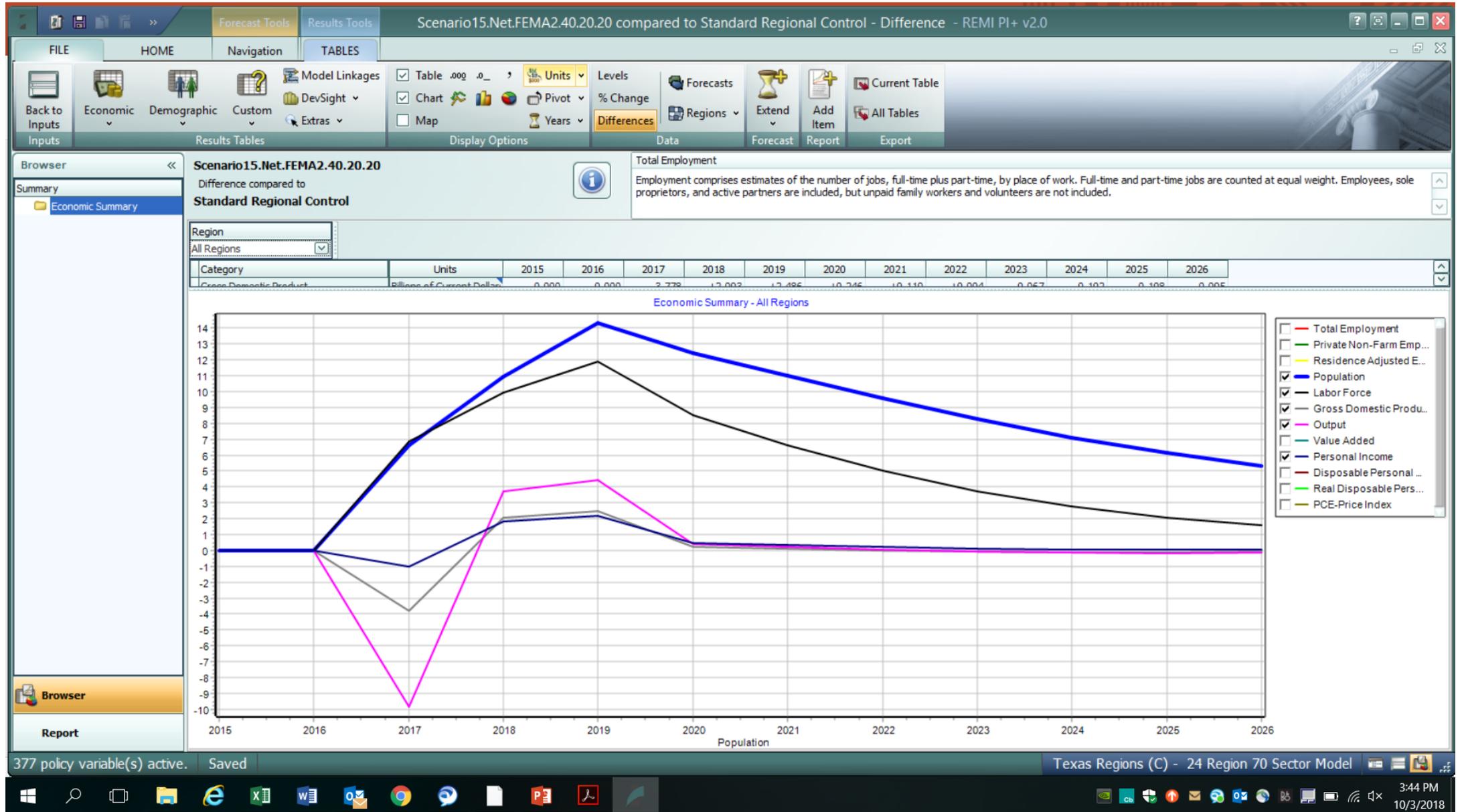
The screenshot displays the 'Forecast Tools' application window. The title bar reads 'Scenario15.Net.FEMA2.40.20.20 - REMI PI+ v2.0'. The interface includes a ribbon with 'FILE', 'HOME', and 'Navigation' tabs. Under 'Navigation', there are buttons for 'Select Inputs', 'Inputs List', 'Forecast Options', and 'Results'. Below the ribbon, the 'Forecast Name' is set to 'Scenario15.Net.FEMA2.40.20.20' with a 'Run Forecast' button. The 'Run Years' section shows a slider from 2015 to 2060, with the current range set to 'Run forecast from 2015 to 2026'. The 'Forecast Information' panel states: 'Running a Regional Simulation (Based on Standard Regional Control) with 24 regions for 12 years. The forecast contains 377 policy variable(s)'. The 'Frequently Asked Questions' section contains two questions: 'How do I use forecast years?' and 'What happens to policy variable changes made in the years prior to the forecast start year?'. A 'Running' dialog box is open in the center, showing a progress bar at 39%, 'Elapsed Time: 0:09', 'Year: 2019', and 'Estimated Time Remaining: 0:10', with a 'Cancel' button. The status bar at the bottom indicates '377 policy variable(s) active. Calculating results... Saved' and 'Texas Regions (C) - 24 Region 70 Sector Model'.

# Productivity Loss + Rebuilding Gains = Net Effects

<b>NET ECONOMIC IMPACT OF HURRICANE HARVEY ON TEXAS GSP (in billions)</b>				
<b>Impact</b>	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Years 1-3</b>
<b>Estimated Losses</b>	(\$16.8)	(\$2.0)	(\$1.0)	(\$19.8)
<b>Estimated Gains</b>	\$13.0	\$4.1	\$3.5	\$20.6
<b>Net Economic Impact</b>	(\$3.8)	\$2.1	\$2.5	\$0.8

The impact of Harvey is certainly substantial, but the robustness of Texas' economy can sustain the economic shock.

A disaster like Harvey is certainly a blow, but the spending required in its wake can buoy the overall economy while families and communities rebuild their lives and their businesses.



# Regional & Industry effects

## Hit hardest:

- First-year losses for the Coastal Bend, South East Texas, and Golden Crescent COGs were projected at \$350 million to \$800 million each
- Industries with the most losses include memberships (to clubs, sports centers, parks, theaters and museums), telecommunication services and entertainment

## Most growth:

- First-year gains in additional economic activity for the Alamo Area, Capital Area, and North Central Texas regions, were estimated \$1 billion to \$2 billion
- Industries with the most gains include health services, food and beverages, rental housing, motor vehicles, furniture, and clothing
- The auto industry in particular should see increased demand as consumers seek to replace the cars and trucks damaged or destroyed by flooding

# Implications

- Federal Reserve Bank of Dallas data showed that Texas bounced back much like we expected, or better
- Some industries recovered much faster than others—small businesses had a harder time
- The more diverse the economy, the quicker the rebound
- Much of the literature shows that OECD countries rebound very quickly while islands or lesser developed countries fair worse.



# Looking forward

Limitations the study did not include (fine print...TL;DR):

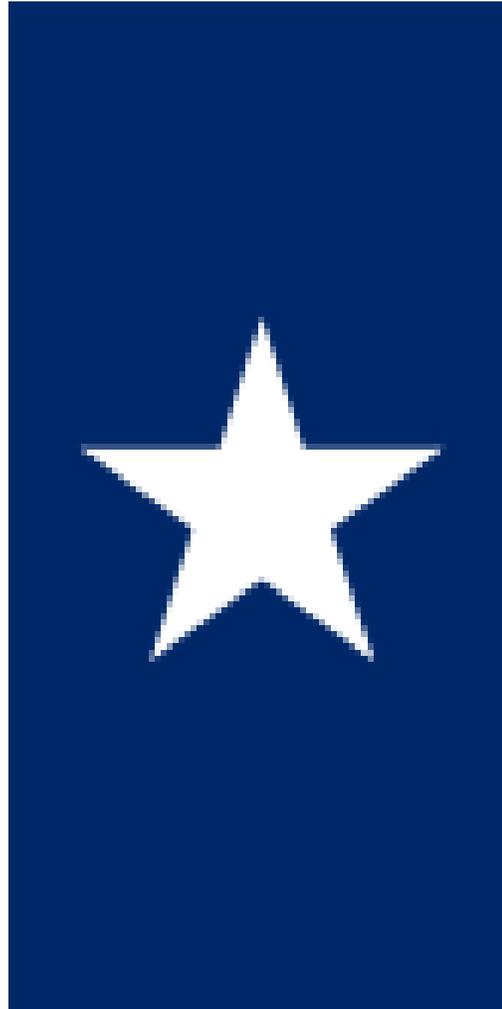
- damage to commercial, government or personal property, including real estate, contents, equipment, vehicles, inventory, etc. Instead, it accounts for the funds likely be spent in the next three years to rebuild and replace these items.
- expenditures from smaller nonprofit organizations.
- change in tax burden on Texans at the local and state levels due to increased costs from Harvey recovery or state budgetary actions that may be taken.
- change in government services provided due to resource reallocation.
- income to insurance companies from deductibles or potential changes in insurance premiums.
- productivity loss and gains from agricultural insurance; this study focused on the nonfarm portion of the economy. The REMI model does not include an agriculture sector.
- non-pecuniary losses due to fatalities or decreased desirability of living in an area. The estimate assumes people who do not receive a buyout will rebuild — especially property owners along the coast in hurricane-prone areas, who are likely to understand the risk of property ownership in their location.
- the long-term costs of flooding, including buyout programs, new reservoirs, bayou dredging or seawall construction. These flood mitigation efforts will cost billions of dollars over a number of years and are beyond the scope of this study.

## Next time:

- Include amenity
- Change production cost
- Expand time horizon
- Increase insurance premiums and property taxes
- Account for cost-shifting in government spending such as drawing 2019 Medicare funds to 2018
- Account for mitigation costs

# Takeaways

- Texas has a diverse economy such that an economic shock to one area can be softened by the other regions and industries
- With a software like REMI, we can pinpoint specific industries and regions that will be most and least affected from an economic shock like Harvey
- Texas' GSP was \$1.6 trillion in 2016 so a \$17 billion loss is significant but not crippling



*"Harvey devastated much of Southeast Texas in August, earning a page in the history books for its overwhelming winds and flooding. The storm brought unprecedented destruction to parts of our coast; dozens died and many more lost homes, automobiles and livelihoods. Many small communities may require years to recover, and some may not recover completely.*

*But Texans are resilient, and so is our state. While the initial impact of Harvey was severe, the Texas economy has already absorbed much of the damage from this record-breaking storm and should avoid long-term losses."*

*--Glenn Hegar,*

*Texas Comptroller of Public Accounts*



Full article in ***Fiscal Notes***  
publication:

[https://comptroller.texas.gov/  
economy/fiscal-notes/2018/special-  
edition/docs/fn.pdf](https://comptroller.texas.gov/economy/fiscal-notes/2018/special-edition/docs/fn.pdf)

Joyce E. Jauer

[Joyce.jauer@cpa.texas.gov](mailto:Joyce.jauer@cpa.texas.gov)

512.936.8495

# References

- National Oceanic and Atmospheric Administration, National Weather Service, [“Hurricane Harvey & Its Impacts on Southeast Texas from August 25th to 29th, 2017.”](#) and National Oceanic and Atmospheric Administration, National Weather Service, [“Hurricane Harvey 2017 – Impacts to South Central Texas.”](#)
- National Oceanic and Atmospheric Administration, [“Reviewing Hurricane Harvey’s Catastrophic Rain and Flooding.”](#)September 18, 2017.
- Texas Division of Emergency Management, [Disaster Summary Outline spreadsheets](#) for November 28, 2017 and November 29, 2017.
- Texas Department of Motor Vehicles, [“TxDMV Informs Owners of Flood-Damaged Vehicles of Duty to Brand Their Title.”](#)October 23, 2017; and *Business Insider*, [“The Auto Industry May Take Longer Than Expected to Recover After Hurricane Harvey.”](#) December 16, 2017.
- Texas A&M Agrilife Extension Service, [“Texas Agricultural Losses from Hurricane Harvey Estimated at More Than \\$200 Million.”](#) October 27, 2017.
- National Oceanic and Atmospheric Administration, [“U.S. Billion-Dollar Weather and Climate Disasters.”](#) 2017; and Kevin Quealy, [“The Cost of Hurricane Harvey: Only One Recent Storm Comes Close.”](#) *The New York Times* (September 1, 2017).
- National Oceanic and Atmospheric Administration, “U.S. Billion-Dollar Weather and Climate Disasters.”
- National Oceanic and Atmospheric Administration, [“Hurricanes in History.”](#); and “U.S. Billion-Dollar Weather and Climate Disasters.”
- [U.S. National Weather Service, National Hurricane Center, Tropical Cyclone Report, Hurricane Katrina \(PDF\)](#), 23-30 August 2005, by Richard D. Knabb *et al.*, Updated September 14, 2011, p. 11,
- National Oceanic and Atmospheric Administration, “U.S. Billion-Dollar Weather and Climate Disasters.”
- National Oceanic and Atmospheric Administration, “Hurricanes in History.”
- National Oceanic and Atmospheric Administration, [“U.S. Billion-Dollar Weather & Climate Disasters, 1980-2017,” \(PDF\)](#) by Adam Smith *et al.*, p. 8; and “Hurricanes in History.”
- National Oceanic and Atmospheric Administration, “U.S. Billion-Dollar Weather & Climate Disasters 1980-2017,” p. 7; and “Hurricanes in History.”
- National Hurricane Center, [Tropical Cyclone Report: Hurricane Sandy \(PDF\)](#), 22 – 29 October 2012, by Eric S. Blake *et al.*(February 2013), pp. 13 and 82.
- National Hurricane Center, [Tropical Cyclone Report: Hurricane Sandy](#), 22 – 29 October 2012, p. 17.
- National Oceanic and Atmospheric Administration, “U.S. Billion-Dollar Weather & Climate Disasters,” p. 4.
- Alana Semuels, [“How a Disaster’s Economic Impacts Are Calculated: Providing an Early Estimate of a Storm’s Costs is Generally a Pretty Rough Science, and Harvey is a Particularly Tough Case.”](#) *The Atlantic* (August 29, 2017).
- Federal Reserve Bank of Dallas, [“Texas Manufacturing Outlook Survey.”](#)
- Federal Reserve Bank of Dallas, [“Texas Businesses Feel Impact of Hurricane Harvey on Revenue, Production.”](#) September 25, 2017.
- Calculated using REMI, reducing capital stock by reported residential and non-residential losses and comparing standard regional control projection, leaving optimal capital stock unchanged.
- U.S. Bureau of Economic Analysis [statistics on GDP by state, current dollars, all industries, for Texas.](#)
- The overall gain is measured in GSP years and calculated by taking the sum of the difference in GSP between the standard regional control and the forecast for each year of the analysis.
- Federal Reserve Bank of Dallas, [“Texas Economy Finishes the Year Firing on All Cylinders.”](#) by Christopher Slijk and Keith Phillips, December 20, 2017.
- [Harris County, All Hazard Mitigation Plan \(PDF\)](#), Section 1, p. 1.
- Ella Nilsen, [“The National Flood Insurance Program was Already \\$24 Billion in Debt before Harvey and Irma.”](#) Vox(September 11, 2017).
- Neena Satija and Kiah Collier, [“Documents Detail Concerns about Houston Dams — Before Harvey.”](#) *Texas Tribune*(September 28, 2017).

- Gulf Coast Community Protection and Recovery District, [Storm Surge Suppression Study Phase 3 Report: Recommended Actions \(PDF\)](#) p. 6.
- Harvey Rice, [“George P. Bush Emerges as Ike Dike Champion,”](#) *Houston Chronicle* (March 20, 2017).
- Neena Satija, Kiah Collier and Al Shaw, [“Boomtown, Flood Town,”](#) *Texas Tribune* (December 7, 2016).
- Dylan Baddour, [“How to Fix the Houston Floods,”](#) *Houston Chronicle* (January 3, 2017).
- David Schaper, [“3 Reasons Houston was a ‘Sitting Duck’ for Harvey Flooding,”](#) National Public Radio, August 31, 2017.
- Neena Satija and Kiah Collier, [“Houston’s ‘Flood Czar’ Says Harvey Has Brought the City to a Decision Point on Flood Control,”](#) *Texas Tribune* (September 13, 2017).
- [“Hurricane Harvey Shows Need to Use More Green Infrastructure,”](#) *Civil + Structural Engineer* (September 21, 2017).
- Natasha Geiling, [“Harvey is an Unprecedented Disaster Made Worse by Poor Planning,”](#) *Think Progress* (August 28, 2017).
- Neena Satija, Kiah Collier and Al Shaw, “Boomtown, Flood Town.”
- Ford Fessenden, Robert Gebeloff, Mary Williams Walsh and Troy Griggs, [“Water Damage From Hurricane Harvey Extended Far Beyond Flood Zones,”](#) *New York Times* (September 1, 2017) .
- Neena Satija, Kiah Collier and Al Shaw, “Boomtown, Flood Town.”
- Ella Nilsen, “The National Flood Insurance Program Was Already \$24 Billion in Debt Before Harvey and Irma.”
- Benjamin Powell and Phil Magness, [“Here’s the Best Way to Limit the Risk of ‘Widespread’ Hurricane Damage,”](#) *CNBC*(September 11, 2017).
- National Weather Service, [The Deadliest, Costliest, and Most Intense United States Tropical Cyclones from 1851 to 2010 \(PDF\)](#), by Eric S Blake *et al.*, (Miami, Florida, August 2011), p. 15.
- National Oceanic and Atmospheric Administration, [“Continental United States Hurricane Impacts/Landfalls 1851-2016.”](#)
- National Oceanic and Atmospheric Administration, [“Tropical Cyclone Climatology.”](#)
- National Oceanic and Atmospheric Administration, [“The Galveston Hurricane of 1900: Remembering the Deadliest Natural Disaster in American History”](#) ; and National Weather Service, [Texas Hurricane History \(PDF\)](#), by David Roth (Camp Springs, Maryland, January 2010), p. 31.
- National Oceanic and Atmospheric Administration, “Continental United States Hurricane Impacts/Landfalls 1851-2016.”
- National Oceanic and Atmospheric Administration, “U.S. Billion-Dollar Weather and Climate Disasters.”

- Productivity loss was calculated with a percent decrease while rebuilding gains were calculated with dollar amounts available at the time of the study.
- Federal Emergency Management Agency, [“Texas Hurricane Harvey \(DR-4332\),”](#) December 4, 2017. Forty-one counties were declared disaster areas: Aransas, Austin, Bastrop, Bee, Brazoria, Caldwell, Calhoun, Chambers, Colorado, DeWitt, Fayette, Fort Bend, Galveston, Goliad, Gonzales, Grimes, Hardin, Harris, Jackson, Jasper, Jefferson, Karnes, Kleberg, Lavaca, Lee, Liberty, Matagorda, Montgomery, Newton, Nueces, Orange, Polk, Refugio, Sabine, San Jacinto, San Patricio, Tyler, Victoria, Walker, Waller and Wharton.
- Texas Department of Public Safety, Texas Division of Emergency Management, [“State Situation Report, Tropical System Harvey,”](#) Report Number 3, August 25, 2017, and Report Number 8, August 30, 2017; and [“Harvey Timeline: See How the Storm Developed and Marched Across Texas and Louisiana,”](#) Corpus Christi Caller-Times (September 7, 2017).
- Federal Reserve Bank of Dallas, [“Texas Manufacturing Outlook Survey,”](#) September 25, 2017. The average number of days businesses were either completely shut down or experienced a reduction in revenue/production is 15.4. Because 59 percent of firms that experienced a reduction in revenue or production reported ongoing reductions, it is assumed that productivity losses continuing beyond the date of the survey are counterbalanced by the 41 percent of firms that did not experience reduced revenue/production.
- Andrea Hsu and Becky Sullivan, [“In Houston, Most Hospitals ‘Up And Fully Functional,’”](#) *All Things Considered*, National Public Radio (August 30, 2017). Although some hospitals were evacuated, many remained operational or entered “ride-out” mode in which outpatient services were postponed while inpatient services continued; only four days are assumed for disruption in service.
- Industries are assumed to compete locally because goods and services could be obtained from neighboring counties that were not affected by the storm; this is thus a more conservative estimate. Some industries, however, were disproportionately affected because of the high number of businesses located in Texas relative to the nation. These categories in the North American Industry Classification System with a high location quotient, a measure of industrial concentration, are treated differently: 211 Oil and Gas Extraction, 213 Support Activities for Mining and 486 Pipeline Transportation had an LQ > 4 for Texas and were considered industry-level (exogenous) production.
- A discount rate of .277 was applied to 42 Wholesale Trade and 44-45 Retail Trade as prescribed by experts at REMI, Inc.
- The amount of funds flowing through the state of Texas are being updated as new costs are incurred and new information is received. The figures presented were determined by the best data available as of Nov. 30, 2017.
- David Hunn, [“FEMA on Track to Pay \\$11 Billion in Hurricane Harvey Insurance Claims,”](#) *Houston Chronicle* (September 13, 2017).
- [“SBA Has Approved \\$1B-Plus in Harvey-related Disaster Loans,”](#) *Houston Chronicle* (October 11, 2017).
- [“ICT Pegs Hurricane Harvey Insured Losses at \\$19B,”](#) *Insurance Journal* (September 15, 2017).
- Morgan Smith, [“How Much Has Been Raised for Harvey Relief — and How’s It Being Spent?”](#) *Texas Tribune* (October 6, 2017).
- Construction is spread by individual industry and output. Equipment is spread by population. Consumer spending is spread by commodity and consumption across these categories: new motor vehicles, net purchase of used motor vehicles, motor vehicle parts and accessories, furniture and furnishings, household appliances, glassware, tableware and household utensils, tools and equipment for house and garden, food and nonalcoholic beverages purchased for off-premises consumption, alcoholic beverages purchased for off-premises consumption, food produced and consumed on farms, men and boys’ clothing, women and girls’ clothing, children and infants’ clothing, other clothing materials and footwear, motor fuels, lubricants and fluids, fuel oil and other fuels, pharmaceutical and other medical products, household supplies, personal care products, rental of tenant-occupied nonfarm housing, group housing, physician services, dental services, paramedical services, hospitals, nursing homes, other motor vehicle services, purchased meals and beverages, accommodations, personal care and clothing services, social services and religious activities and household maintenance.
- For example, on Nov. 17, 2017, the U.S. Department of Housing and Urban Development announced it would award \$5.024 billion in community development block grants for hard-hit areas in Texas; the expenditure timeline was unknown at the time of publication, however, and therefore is not included in this study. See [“HUD Provides \\$5 Billion To Help Texas Recover From Harvey,”](#) Office of the Texas Governor, November 17, 2017.