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Business recovery from Hurricane Harvey

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ABSTRACT

This paper examines factors that affected the progress of post-disaster business recovery in South Texas of the United States using survey and field data collected up to one year after Hurricane Harvey struck the region. Property damage affected the way businesses financed their rebuilding efforts and thus their ability to resume operation after a temporary closure. Local chamber members and women were more likely to reopen their businesses within six months after Harvey, but such demographic effects diminished another six months later. Other than property damage, loss of employees posted a challenge for affected businesses to recover.

1. Introduction

Hurricane Harvey was a Category 4 tropical storm that made landfall in Aransas County on the Texas Gulf Coast of the United States in August 2017. Physical structures across Aransas County sustained storm damage from wind gusts over 130 miles per hour and water damage from tidal surge over 7 feet [28]. Harvey is also regarded as one of the "costliest" natural disasters in U.S. history due largely to widespread flooding across southeastern Texas, particularly areas around the Houston metro area.

In February of the following year, the first pass of debris removal in Aransas County was nearly complete [1]. Meanwhile, more than 40% of its businesses were back in operation, and many homes were being repaired or rebuilt. As post-Harvey recovery was underway along Texas' Gulf Coast, one interesting question concerns factors that might have affected local businesses' operating status and the overall progress of business recovery in the impacted communities.

Business survival following a disaster plays a vital role in long-term community recovery. The presence of open businesses influences residents' return decisions, which in turn affect the likelihood for other businesses to recover [43]. To this end, the objective of this paper is to explore determinants of business recovery from Hurricane Harvey in light of both survey and field data of businesses in the hardest-hit area. The focus is the opening status of individual businesses in a survey sample during six months and one year, respectively, after the storm. We also explore how a business' pre-existing conditions and damage to its establishment affected the way it financed its rebuilding efforts and thus its operating status. In particular, we analyze the demand for federal assistance to mitigate disaster-related economic losses beyond insurance claims.

The business community in Aransas County, where Harvey made first landfall in the United States, represents a unique case study in the literature. Most previous studies look at disaster impacts and recovery outcomes in relatively large areas, such as Los Angeles after the 1994 Northridge earthquake [13,14,33] and New Orleans after Hurricane Katrina of 2005 [10,18,22,25,26,30,32,42]. In contrast to those large metropolitan areas, Aransas County is the sixth smallest county in the state of Texas with a population of roughly 25,000 and mostly small businesses. From this perspective, we contribute to the related literature with findings on firm-level recovery outcomes in a relatively small and less urbanized community. Beyond the geographic scope, our data on impacted businesses' operating status during six months and one year following Harvey shed light on the evolution of short-term business recovery over time.

The reminder of the paper is organized as follows. Following a review of the related literature in Section 2, Section 3 describes the survey and field data in this study, including estimates for property damage. Section 4 presents the results of estimating the demand for government assistance and determinants of business return six months and one year after Harvey. Section 5 contains a summary and concluding remarks.

2. Related literature

In this paper, we investigate Hurricane Harvey's impact on businesses and their subsequent recovery from the storm. There is a large body of empirical literature on economic recovery after a major natural disaster, notably an earthquake or a hurricane. Most studies focus on economic outcomes at the aggregate level, such as overall employment (e.g., [4,5,16,35,41]). However, as discussed below, some industries tend to recover more rapidly than others [14], so a better understanding of disaster recovery would benefit from looking at individual businesses and industries.

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Business return decisions are key to community recovery after a natural disaster [10,25,38,43]. Xiao and Van Zandt [43] also find that returns of impacted households and businesses following Hurricane Katrina were mutually dependent. Local residents are more likely to return to a neighborhood in which more businesses are already open, while the local clientele plays a vital role in many local businesses' survival particularly over the long term. Interactions between households and businesses are especially critical for small communities, which tend to have a relatively small capacity to rebuild infrastructure due to fewer local government resources [3]. For a variety of reasons, small, neighborhood businesses as opposed to large corporations are also particularly vulnerable to economic losses from natural disasters [2,37].

Among studies that do look at recovery at the firm level, the focus is mostly on long-term outcomes years after the disaster event. Corey and Deitch [10] indicate that business survival immediately after a disaster is vital to long-term community-wide recovery. Lam et al. [25] find that business reopening rates became indistinguishable across different industries two years following Hurricane Katrina. These findings imply that it would be fruitful to also look at business survival shortly after a disaster.

The literature identifies a number of determinants of business recovery from disasters. Chang and Rose [8], and Tierney [34] provide reviews of recent studies. The majority of potential factors are related to a business' vulnerability to a disaster and its capability to recover from it. The broad categories of potential factors that affect business recovery outcomes are: (1) direct physical impacts, such as property damage and lifeline disruptions; (2) pre-existing characteristics of the impacted businesses and their owners, such as the sector in which a business operates, firm size, age, financial conditions, and business owner demographics; and (3) different aspects of the impacted community.

2.1. Disaster impacts

Above all, interruptions of lifeline infrastructure, such as power, water supply, roads and telecommunications, are detrimental to business and community recovery [25,37,38]. On the heels of Hurricane Katrina, the entire city of New Orleans was literally "closed" for at least one month due largely to flooding that slowed down restoration of community infrastructure and lifeline services [10]. Sydnor et al. [32] find that physical damage and lifeline disruptions inflicted mostly a short-term effect on businesses' operating status, but a much less effect on their long-term success after Katrina. In the case of Harvey, infrastructure was largely restored within a month among areas where it made landfall in South Texas, but it took much longer time for the southeastern portions of Texas areas near Houston that sustained primarily flood instead of wind damage.

Some businesses are more susceptible to physical damage, including damage to buildings, equipment, furnishings and inventory stocks [44]. As opposed to many service-based businesses, retail stores are inherently vulnerable to damage to inventory stocks. Likewise, structural damage tends to have a greater impact on the operation of hotels and motels than other businesses. Disaster-related property losses also adversely affect businesses' financial conditions.

In addition to property losses, businesses in the affected areas may face operational disruptions due to displacement of their employees with damaged homes [33,43]. Likewise, some businesses, notably retailers and restaurants, rely on their suppliers, so disruptions in supply chains can also hamper their operations. On the contrary, Marshall et al. [26] find that "home-based" businesses were less likely to be closed immediately following Hurricane Katrina, as they tended to be less vulnerable to property damage than their counterparts in a business district.

2.2. Business and owner characteristics

A large number of studies suggest that larger or more established businesses tend to be better equipped to withstand disaster-related economic losses. In particular, Kroll et al. [14,24] and Webb et al. [37,38] indicate that small businesses have limited pre-disaster preparedness and thus less access to insurance and other means of funds to finance property damage and income losses. Sydnor et al. [32] find evidence to support such disadvantages of smaller businesses in the aftermath of Hurricane Katrina. Larger businesses with multiple locations also tend be less vulnerable to a disaster's impact on population dispersion, which in turn affects their customer base as well as workforce availability. Yet Webb et al. [38] argue that smaller firms are likely to be more agile, and thus they adapt to post-disaster economic conditions more easily.

One business attribute related to size is age. Webb et al. [38] find no expected age effect on business recovery from the 1989 Loma Prieta earthquake, but an effect in the opposite direction as expected for businesses in Florida following Hurricane Andrew in 1992. They explain that younger businesses, like smaller ones, can adapt more easily to the changing environment.

The industry in which a business operates affects how well it weathers a natural disaster, especially during the short-term recovery period. Businesses that rely on local market demand, such as retail stores and restaurants, are less likely to survive as temporary population dislocation or permanent population losses reduce their market base [33]. Sales conditions also tend to deteriorate as surviving residents suffer economic losses [9,38]. On the contrary, rebuilding activities across the disaster area is a boon to the local construction and related industries, including real estate and engineering services [24,4–7,10,14].

The literature also relates business recovery to business owners' characteristics. In particular, Morrow and Enarson [27] find that women faced more challenges than men in the areas hit by Hurricane Andrew. However, Webb et al. [38] Wasileski et al. [36] find no evidence to support any gender effect in the long-term performance of businesses impacted by major natural disasters.

In addition to insurance payments, the capability for individual businesses and the broad community to recover from a natural disaster can be enhanced by financial resources from such sources as the Federal Emergency Management Agency (FEMA), Small Business Administration (SBA), and philanthropic organizations, notably the Red Cross. FEMA offers disaster relief to individual residents, but not businesses. Following major disasters, however, FEMA partnered with SBA to offer zero-interest disaster loans to impacted businesses.

Davlasheridze et al. [15] find FEMA grants to be effective in mitigating disaster-related property losses. Haynes et al. [18] also find that following Hurricane Katrina, impacted businesses receiving SBA loans were more likely to survive in the long run. Haynes et al. [17], and Hiramatsu and Marshall [19] find that even though businesses receiving more federal disaster assistance are not more likely to survive than those with less assistance, the former are more likely to realize positive changes in revenues.

Webb et al. [38] report no evidence that government programs help improve long-term business recovery outcomes. They explain that federal disaster programs for businesses, as opposed to residents, are mostly in the form of loans that generate additional indebtedness to business owners. Webb et al. [38] also assert that businesses receiving disaster relief also tend to have suffered more economic losses and thus have been worse off in the first place than otherwise.

According to Josephson and Marshall [22], how a business finances its rebuilding activity is affected by the extent of property damage. Furthermore, women are more likely to apply for SBA loans, and minorities and businesses that are older or in poor financial conditions are less likely to be approved for those loans. Given these findings, financial channels and government aid are not exogenous as assumed in

the standard empirical approach for estimating the impact of these variables on businesses. When the explanatory variables in a regression are not exogenous, regression results become potentially biased.

2.3. Community-wide environment

Other than business-level attributes, community-wide factors can affect business performance. An economy more resilient to natural disasters may reinforce business return along with a more positive overall economic outlook. Disaster resilience commonly refers to the capacity to resist natural disasters or actions that facilitate timely recovery from downturns caused by those shocks. Xiao and Drucker [40] find that a diverse local economy, which is made up of a mix of different industries as opposed to high concentration of a few industries, tends to boost employment and income recovery after a disaster event.

Some studies report that a major natural disaster can exacerbate the ongoing trend of an area's economy [7] or its businesses [14]. For instance, [14] find that businesses that had experienced growth prior to the Northridge earthquake showed better recovery performance than other businesses. Webb et al. [38] find similar evidence on affected businesses in the wake of the Loma Prieta earthquake and Hurricane Andrew. They also find strong association between business owners' assessment of their business recovery outcomes and the overall business climate of their communities.

Other community-level factors are related to social bonds or networks. For instance, [34] find that the attitude of businesses in New Orleans following Hurricane Katrina depended on not only the extent that residents and employees return to the city, but also the opening of other local businesses. Similarly, Islam and Walkerden [21] find spiritual support from neighbors and friends as key factors for community recovery from natural disasters.

3. Data

3.1. Background

Hurricane Harvey made first landfall at San Jose Island of the United States in the late night hours of August 25, 2017. San Jose Island is a barrier island on the Gulf Coast of Texas. Harvey was the first Category 4 tropical storm to strike the Texas coast since Carla in 1961. According to National Oceanic and Atmospheric Administration (NOAA), this storm generated at least $125 billion in economic damage, making it the second "costliest" natural disaster in U.S. history behind Hurricane Katrina [28]. The majority of damage occurred near the Houston and Beaumont metro areas across the southeastern part of Texas as a result of record levels of rainfall that caused massive flooding.

Fig. 1 is a map that shows Harvey's landfall and the area in its path. The eye of Harvey passed directly the northern end of Live Oak Peninsula in Aransas County before hitting Refugio County across Copano Bay. With a total landmass of 252 square miles, Aransas County is one of the smallest counties in Texas. Devastated by sustained winds over 130 miles per hour and storm surge over 7 feet, the county sustained widespread damage to physical properties and infrastructure. Local officials estimated that Harvey damaged 75% of residential and commercial structures, with 35% destroyed or uninhabitable [11]. The average amount of the 7078 windstorm claims from Aransas County was $68,149—the highest among all impacted counties in Texas [39].

According to the U.S. Census, the pre-Harvey population in Aransas County was 25,572. The majority of residents live in the city of Rockport and its neighboring town of Fulton, which together account for 90% of all businesses in the county. In contrast to 38.1 years for the U.S., the median age of the local population is much higher at 50.7 years due to a high percentage of retirees. Like many Gulf Coast

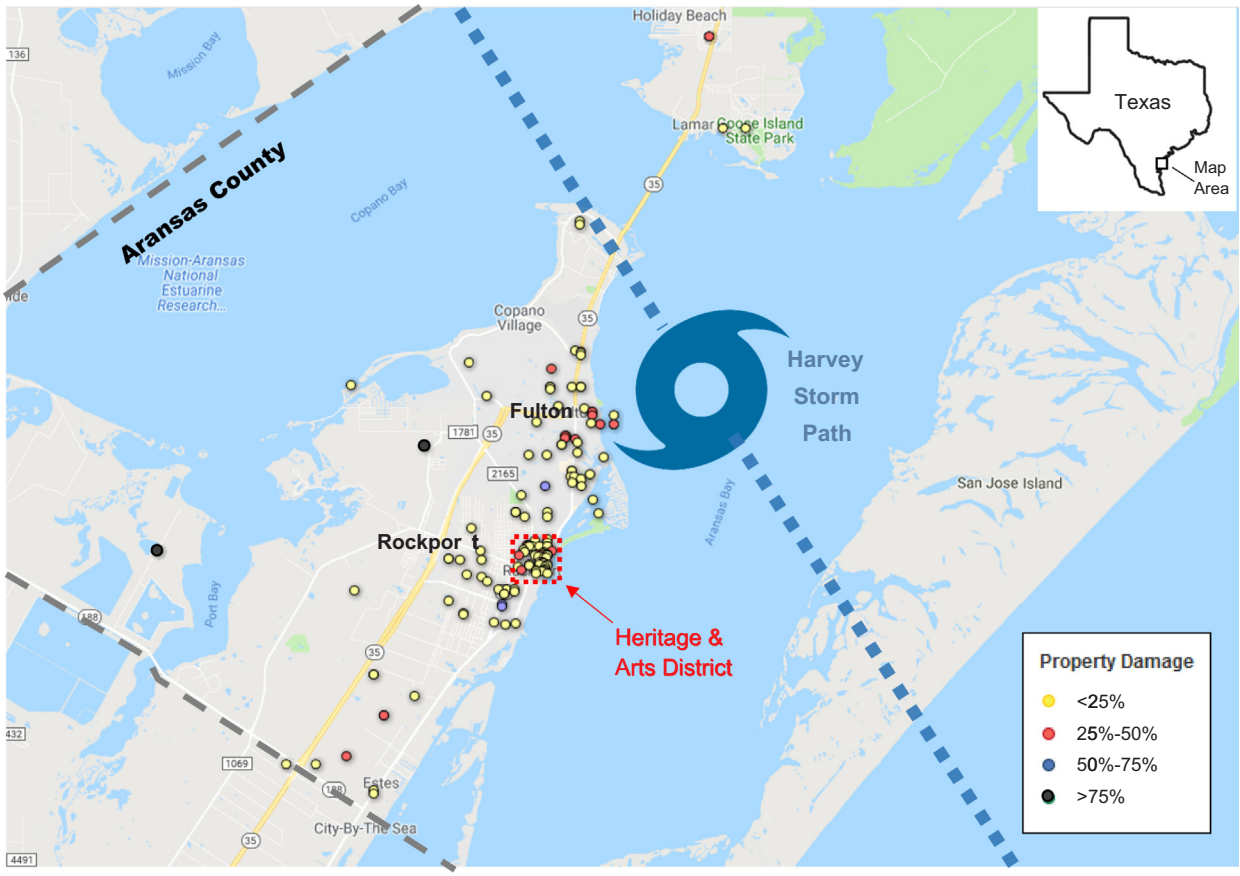

Fig. 1. Business sample in Aransas County.

communities, tourism is a major driver of the local economy. The area is a popular visitor destination for fishing, boating, and birdwatching activities.

Aransas is one of the 41 Texas counties that comprise the Harvey Disaster Region for FEMA's Individual Assistance (IA) program. By the one-year anniversary of Harvey in August 2018, the IA program had provided nearly $30 million to residents in Aransas County for housing damages and disaster related expenses. The SBA had approved over $104 million in disaster loans to a total of 1324 local business owners and residents to mitigate disaster-related property damage and economic injury. Meanwhile, the Rockport-Fulton Chamber of Commerce reported that 84% of local businesses had resumed operation, nearly double the estimate of 46% in February.

3.2. Business survey

In mid-January 2018—about half a year after Harvey struck the area—the Rockport-Fulton Chamber of Commerce conducted a survey of local businesses. This survey concerns the immediate impact of the storm on individual businesses, how they had recovered, and any assistance they had received.

The survey instrument contains 27 questions. The appendix displays details of the questionnaire. To maximize the number of responses, the survey was announced through various town-hall meetings, local organizations, such as the Rotary Club, and emails and social media. Survey responses were collected online at Constant Contact. A total of 152 respondents filled out the survey completely. According to the Dun & Bradstreet database, there were 1469 private businesses in Aransas County pre-Harvey. This means that the survey sample represents slightly more than 10% of the local business population. Among the various distribution channels, 89% of respondents received the survey through the Rockport-Fulton Chamber's announcements, and most of the rest responded through social media.

As discussed below, a number of questions deal with individual businesses' demographics. Although the survey sample was not stratified by industry or economic sector, the composition of respondents' businesses is representative of the area's business population. In particular, 25% of respondents belong to the retail trade sector, and another 21% of them represent businesses in the accommodation and food services sector. Similarly, 31% of the survey sample represents female-owned businesses, which is comparable to the local business population. By contrast, only 4% of respondents in the sample are Hispanics—the dominant minority population. According to the 2016 Census data, Hispanics make up 28% of all businesses in Aransas County. Underrepresentation of Hispanic-owned businesses may be due to the fact that the survey was conducted only in English, while Spanish is also spoken among many Hispanics in South Texas.

In response to the question about businesses' operating status, 46% of the respondents indicated that their businesses had reopened. This closely matched the percentage of all open businesses (49%) in the area at the end of February, according to the field survey of local businesses by the Rockport-Fulton Chamber (see Section 4.1 below). From this perspective, empirical findings seem to be robust to the potential survivorship or sample selection bias, which arises from a non-randomized sample that is likely to include mostly surviving businesses [25]. Nevertheless, we have dealt with possible bias in the sample by replicating the results with the weighted endogenous sample maximum likelihood estimator, as outlined in Greene [20]. The estimation results deviate little from those reported below and thus are not reported here to save space.

3.3. Direct losses

According to the Rockport-Fulton Chamber survey, the vast majority (90%) of businesses in Aransas County sustained property damage, either to building structure or contents that include equipment, furnishings and inventory stocks. Most of respondents who reopened their businesses within 15 days after Harvey experienced minimal or no property damage. Other than damage to business property, one survey question concerns the share of staff that was negatively impacted by Harvey. While 42% of respondents indicated a workforce loss of more than 90%, 27% of them indicated no more than 10% due in part to the fact that many of these businesses were non-employer firms.

Given the importance of disaster-related losses to business survival, we supplemented the survey data with direct estimates of property damage. Following Xiao and Van Zandt [43], we obtained damage assessment data from the Aransas County Appraisal District (ACAD). The Appraisal District's appraisers inspected all home and business properties within the county between late 2017 and early 2018. A business' property loss due to Harvey is measured as the difference in its appraised values between 2018 and 2017. These two estimates are ACAD certified property values as of the beginning of the years. For each business establishment, the total appraised values include estimates for both "real" (land and building) and "personal" (movable property such as vehicles and boats) properties.

Based on appraised property values of businesses in the survey sample, 10 businesses registered no property loss. On the contrary, two establishments were nearly destroyed ($> 75\%$ loss) and thus was recorded as being closed permanently. The business with the most structural damage ($> 95\%$ loss) also sustained the largest amount of property damage over $12 million. The average amount of reduction in appraised values between 2017 and 2018 was $213,565, which included $189,308 in "real" property and $24,257 in "personal" property. This measure of property damage at 15% for the business sample matches closely the 16% average reduction in appraised values among all real and personal properties in Aransas County.

Table 1 lists the distribution of four levels of property damage (from minor damage to complete loss) against various closure lengths (from within one month to longer than one year). Information on the operating status within one month following Harvey was obtained from survey respondents, and the operating status beginning November 2017 drew from continuous field survey updates of the Rockport-Fulton Chamber of Commerce. Data of individual businesses' opening status at the six-month and one-year benchmarks will be used for regressions below.

Clearly, Table 1 shows that the delay in business reopening (temporary closure) was directly related to the extent of property damage. The vast majority of businesses that resumed operation within one month after Harvey experienced "minor" damage ($< 25\%$) to their properties. One outlier was a retail business, which ceased operation despite minimal property damage. On the contrary, most businesses that were open within half a year despite "major" property damage ($> 50\%$) belonged to the construction sector. The two businesses that sustained more than 75% damage ("complete loss") were closed permanently. By the end of the first year, 89% of the business sample had returned. This was comparable to the 84% reopening rate for the local business population, although about half of hotel and motel rooms were still under repair [39].

In Fig. 1 above, each dot on the map indicates the geographic location of a business in the sample along with its property damage level. Reflecting the distribution of the local business population, the majority of those businesses cluster within the more populated areas of Rockport and Fulton, and 26% of which are within the downtown area of Rockport called the Heritage and Arts District. It is evident that those closer to Harvey's path sustained relatively more damage.

3.4. Federal assistance

Most business insurance policies do not cover property losses resulting from windstorm or flood events. Windstorm insurance is available from private insurers, but in most Texas coastal counties, including Aransas, business and home owners purchase a policy from the Texas

Table 1
Business property damage and closure length.

	Minor Damage(< 25%)	Moderate Damage(25–50%)	Major Damage(50–75%)	Complete Loss(> 75%)	Total
Closure Length:					
< 1 Month	44%	1%	0%	0%	**45%**
1–6 Months	21%	4%	6%	0%	**30%**
6 Months to 1 Year	7%	4%	3%	0%	**14%**
> 1 Year	4%	1%	0%	0%	**5%**
Closed Permanently	1%	3%	0%	1%	**5%**
Total[a]	**78%**	**12%**	**10%**	**1%**	**100%**

[a] Individual numbers may not sum to total due to rounding. The total number of observations is 152.

Windstorm Insurance Association (TWIA), which is an organization overseen by the Texas Department of Insurance. In addition to private insurers, flood insurance is available from the federal government's National Flood Insurance Program (NFIP).

In the Rockport-Fulton business survey, 66% of respondents indicated that they had business insurance as a source to rebuild their business. Out of those respondents that had business insurance coverage, 45% carried both flood and wind insurance, and 46% of them indicated that their insurance also covered income losses. The next popular (43%) source to fund property damage was windstorm insurance. Another 23% of them indicated retained earnings or business savings. While 49% of respondents registered with FEMA for assistance, only 7% received FEMA's disaster aid and 16% received SBA's Disaster Assistance Loans. Another 10% of business owners received private donations, such as the Rebuild Texas Fund, Red Cross and chambers of commerce in the South Texas region.

Josephson and Marshall [22] find that business owners' demand for government financial assistance following Hurricane Katrina was affected not only by the amount of property damage, but also their gender and whether they had insurance. They also find minority business owners, older businesses and those with cash-flow problems to be less likely to be approved for SBA disaster loans. Accordingly, the way businesses covered their post-disaster economic losses was affected by their own pre-existing characteristics. This would affect our analysis of the impacts of alternative funding sources on business recovery with conventional regression methods, which assume those funding channels to be exogenous variables. To overcome this drawback, our empirical analysis below incorporates data of property damage as the primary factor that affects business owners' decisions to finance their rebuilding efforts.

Overall, the local business data allow us to address two broad questions: (1) How does property damage affect the way a business finances its rebuilding activity on the road to recovery? (2) Controlling for the extent of property damage, what explains a business owner's ability or decision to reopen a business or close it permanently? We address these questions by applying two empirical models. The first model explores factors that influenced how business owners covered disaster-related property losses. Following Josephson and Marshall [22], we focus on federal aid as one financing alternative or supplement to insurance payments. Estimation results will help us better understand whether a business' pre-existing conditions affect its post-disaster financial decisions and thus its ability to recover over time. The second model deals with the operating status of those businesses six months and one year respectively following Harvey.

4. Empirical analysis

4.1. Descriptive statistics

Table 2 lists the means of variables included in the empirical models and the numbers of non-zero observations. The Rockport-Fulton business survey generated 152 completed returns and so all variables have 152 data observations. The first (left) panel of the table lists the means of dependent variables. These five variables equal one for an entry checked by a respondent and zero otherwise. For binary variables, the means represent the shares of responses in the survey.

Table 2
Summary statistics of variables in regressions.

Dependent variables:	Mean	N	Explanatory variables:	Mean	N
FEMA Registration	0.56	85	Location - Heritage & Arts District	0.26	40
Finance - Insurance	0.47	71	Location - Other Rockport Areas	0.45	68
Finance - Government Aid	0.20	30	Sector - Construction	0.07	11
Open Within 6 Months after Harvey	0.46	70	Sector - Retail	0.25	38
Open Within One Year after Harvey	0.89	135	Sector - Real Estate, Finance & Insurance	0.15	23
			Sector - Education	0.07	11
			Sector - Healthcare	0.07	11
			Sector - Accommodation & Food Services	0.21	32
			Sector - Arts & Recreation	0.10	15
			Age (Years in Local Area)	15.57	152
			Size (Employees)	5.39	72
			Employee Loss (%)	0.14	107
			Chamber Member	0.78	119
			Woman Owner	0.31	47
			Property Damage	0.15	142

Notes: N represents the number of non-zero observations.

According to the survey, 56% of respondents applied for FEMA's Individual Assistance program, but only 20% of them in fact received aid in the form of FEMA grants or SBA loans. The most popular reason for not receiving federal assistance was that their applications were denied. Likewise, although 71% of business owners carried insurance coverage, 47% of them rebuilt their businesses with payments from insurance claims for windstorm, flood, or business damage.

The bottom two rows of the first panel in Table 2 are the respective reopening rates of businesses as of six months and one year after Harvey. As discussed in Section 3.3 above, the opening status of businesses in the sample drew from field surveys conducted by the Rockport-Fulton Chamber of Commerce, which continuously monitored reopened businesses in Aransas County beginning November 2017. By February 2018, 46% of businesses in the sample were open. Another six months later, 89% of the same business sample had resumed operation.

The second (right) panel of Table 2 lists the means of explanatory variables in our regression models. Age is the number of years in business within Aransas County; business size is measured by the number of employees; employment impact is measured by the share of lost employees after Harvey; and the extent of property damage is measured by the percentage of reduction in a business' total appraised property value from 2017 to 2018 (as discussed in Section 3.3 above). Data entries of all other variables are binary numbers (0 or 1) coded the same way as the dependent variables.

Overall, our sample resembles the composition of the local business population in most aspects. Data for the two location variables draw on

Table 3
Probit regression of financing sources.

	FEMA Registration				Insurance				Government Aid			
	Coefficient			Slope	Coefficient			Slope	Coefficient			Slope
Constant	−0.86	(1.76)	**	−0.34	−2.05	(3.57)	***	−0.81	−1.44	(2.90)	***	−0.23
Location:												
Heritage & Arts District	0.07	(0.16)		0.03	0.15	(0.35)		0.06	0.85	(1.67)	*	0.14
Other Rockport Areas	0.32	(0.97)		0.13	0.61	(1.75)	*	0.24	0.62	(1.44)		0.10
Sector:												
Construction	0.47	(0.74)		0.19	0.80	(1.24)		0.32	−0.14	(0.18)		−0.02
Retail	0.34	(0.91)		0.13	0.22	(0.55)		0.09	0.09	(0.21)		0.01
Real Estate, Finance & Insurance	−0.37	(0.92)		−0.15	0.07	(0.17)		0.03	0.10	(0.21)		0.02
Education	−0.07	(0.12)		−0.03	0.04	(0.12)		0.02	−0.39	(0.50)		−0.06
Healthcare	−0.04	(0.07)		−0.02	0.57	(0.87)		0.23	−7.50	(0.11)		−1.19
Accommodation & Food Services	0.80	(2.32)	**	0.32	0.90	(2.42)	***	0.36	−0.14	(0.31)		−0.02
Arts & Recreation	0.98	(1.96)	**	0.39	0.42	(0.87)		0.17	0.64	(1.29)		0.10
Other Attributes:												
Age	0.21	(1.79)	**	0.08	0.36	(2.75)	***	0.14	0.03	(0.05)		0.01
Employment Size	−0.09	(0.82)		−0.04	0.21	(1.69)	*	0.08	0.20	(1.33)		0.03
Chamber Member	−0.08	(0.26)		−0.04	−0.29	(0.79)		−0.11	−0.75	(1.97)	**	−0.12
Woman Owner	−0.06	(0.11)		0.02	0.02	(0.07)		0.01	−0.10	(0.26)		−0.02
Property Damage	0.28	(0.27)		0.11	0.18	(0.21)		0.07	2.08	(2.30)	**	0.36
Observations	152				152				152			
Psuedo-R^2	0.14				0.24				0.17			
LR Test for Coefficients	18.75	*			27.14	**			20.15	*		

Notes: Absolute t-statistics are in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10%, respectively.

the first two questions in the business survey. Reflecting the local business population, 71% of businesses in the sample were located in Rockport, and 26% were located in the city's Heritage and Arts District downtown. The rest of the sample were largely located in Fulton.

The second set of variables represents different economic sectors. To achieve parsimony, data for the 23 industries in the survey are grouped into NAICS 2-digit, broad economic sectors. Respondents' entries were verified against the Dun & Bradstreet database to ensure accuracy. Sectoral distribution of the sample is overall representative of the local business population. Retail trade is the largest sector that makes up 25% of the sample, followed by accommodation and food services (21%), and real estate, finance and insurance (15%). The construction, education, and healthcare sectors each makes up 7% of the sample. The arts and recreation sector, which includes fishing guides, accounts for 10% of the business sample. These sectoral variables will be estimated against sectors not on the list, including agricultural, manufacturing, wholesale trade and transportation. Each of those sectors has only few observations.

Several survey questions concern the characteristics of individual businesses. The time that respondents' businesses had been in operation locally, or age, ranges from less than one year to 95 years, with an average of slightly less than 16 years. The vast majority of businesses in Aransas County are small businesses with fewer than 50 employees. In this survey sample, the average size of employment before Harvey was 5.39, and the largest employer hired 45 workers. On average, respondents reported a loss of 14% of their staff after Harvey. The entries for two businesses are in fact negative as the respondents reported the hiring of more employees since Harvey.

Among the survey respondents, 78% are members of the Rockport-Fulton Chamber of Commerce and 31% are female business owners. While women-owned businesses in Aransas County are well represented by this sample, the share of chamber members in the sample is higher than the share of 55% in the local business population. The latter observation might be the outcome of the higher tendency for chamber members to participate in the survey than for non-members.

The last explanatory variable in Table 2 is the relative size of property damage. The data are derived from the difference in Aransas County District's appraised values of the business properties between 2017 and 2018. Section 3.3 above describes the data construction in detail. The average damage due to Harvey amounted to 15% of pre-disaster property values. Only 10 businesses in the sample sustained no property damage (0%). Other measures of property damage, such as the levels of reduction in appraised values instead of percentages, do not alter the qualitative results presented below and thus are not reported here to save space.

4.2. Financing sources

We address the questions about Harvey's impact and business return by estimating two empirical models. The first model concerns how business owners covered damage to their establishments. We focus on the application for federal government assistance and subsequent receipt of FEMA/SBA funds. Government aid affects a business' ability to recover from a disaster. The second model concerns the operating status of businesses six months and one year respectively after Harvey. To overcome potential heteroscedasticity in cross-sectional data, we have followed Greene [20] and computed robust covariance matrixes that produce heteroscedasticity-consistent standard errors.

As all dependent variables take on the value of either zero or one (i.e., binary response), we estimate such binary data with the probit maximum likelihood estimator [20]. Other than discrete or dummy variables, a number of explanatory variables are continuous variables. In particular, the age and employment size reflect the age of a structure and the size of the business, respectively. Their data are skewed by a few relatively old (> 60 years) and large (> 40 employees) businesses, leading to non-linearity in regression results. For this reason, natural logarithmic transformation was applied to the age data before estimation. For the number of employees, which contains zero entries, the inverse hyperbolic-sine function is applied to the data instead. This transformation is similar to natural logarithm but has the advantage of preserving observations with zero or negative values.

Table 3 presents estimation results for different channels to finance rebuilding efforts. As opposed to parameters in linear regressions, estimated coefficients of a probit model do not directly quantify the effect of the explanatory variables on the probability that the dependent variable takes on the value of one. In Table 3, next to each probit coefficient estimate is a measure of the slope coefficient, which is the average of individual marginal effects. In the case of a dummy variable, the slope coefficient estimate indicates the percentage points of change in the probability that the dependent variable takes on the value of one

when the dummy variable changes from zero to one, given that all other variables are constant.

The first regression is aimed at exploring factors that determine the demand for government assistance following Harvey. The dependent variable represents a business owner's decision to register with FEMA's Individual Assistance program. According to the estimation results, businesses in tourism-related industries, including those in accommodation and food services, and arts and recreation, were more likely to apply for government assistance. According to the slope coefficient estimates, the probability of FEMA registration was at least 30% points higher in those industries than in industries not included in the regression. Other than different industries, an older business tended to be more likely to apply for FEMA assistance, controlling for property damage.

The other two panels in Table 3 compare two main funding sources to cover post-disaster economic losses. Because approval for federal assistance in the form of FEMA grants or SBA loans depends on whether a business owner applies for FEMA assistance in the first place, we followed Josephson and Marshall [22] and applied a two-stage estimator also known as Heckit. In this modeling framework, FEMA registration serves as the first stage and the receipt of government aid or insurance payments as the second stage.

According to the estimation results, businesses in the Heritage and Arts District of downtown Rockport were more likely to obtain government aid, other things being equal. By contrast, businesses in other Rockport areas were more likely to finance their rebuilding activity with insurance claims. The findings on locational effects are in line with Josephson and Marshall [22], who study the demand for SBA loans among impacted businesses following Hurricane Katrina.

In the regression for businesses utilizing insurance payments to cover economic losses, the dummy variable that represents the accommodation and food service sector is statistically significant, even controlling for the effects of property damage. The estimate for this economic sector is also statistically meaningful in the regression for FEMA registration but not in the regression for receipt of government aid. Instead, the property damage variable is statistically significant in the latter regression. The estimated coefficient suggests that a 10% increase in property damage raises the probability of receiving government aid by 3.6%.

According to the likelihood ratio (LR) tests, the coefficient estimates are together statistically significant in all three regressions. Given the McFadden pseudo-R^2 statistics analogous to the R^2 statistics in conventional regressions, the explanatory variables together explain between 14% and 24% of the dependent variables. The overall explanatory power for FEMA registration and government aid appears weaker than that for insurance payments.

4.3. Business return

Next, we examine factors that affected the recovery of local businesses after Harvey hit the area. Table 4 shows the probit regression results for the operating status of businesses in the sample as of February 2018 and August 2018, respectively. The slope coefficient estimates represent the marginal effects of individual explanatory variables on the probability of reopening a business. The pseudo-R^2 statistics suggest that the explanatory variables together explain 34% of variations in businesses' operating status as of six months after Harvey and 27% another six months later.

The first panel shows the probit estimation results for business return within six months after Harvey. According to the coefficient estimates, businesses in the Heritage and Arts District as well as retail stores were 20% more likely to be open than other businesses, while healthcare facilities were less likely to open their doors. There is also strong evidence to support that membership to the local chamber of commerce affected business owners' decision or ability to reopen their businesses despite property damage.

The estimates for both employee loss and property damage are statistically significant. Their negative entries confirm that Harvey's impact on a business' establishment and its employees adversely affected its decision or ability to resume operation following a disaster. In particular, a 10% increase in property damage reduced the probability of opening in February 2018 by 1.6%.

The second panel shows the corresponding probit estimation results for businesses' operating status as of August 2018. According to estimates for the geographic variables, Rockport businesses located outside the downtown area were less likely to be open than those in the downtown or other areas. Estimates for the sectoral variables indicate that businesses were more likely to be open if they were in construction, real estate, finance and insurance, and arts and recreation. On the contrary, those in accommodation and food services, and healthcare were more likely to remain closed.

The two variables capturing the direct impacts on employees and business property are also statistically meaningful. The absolute sizes of their slope coefficients are three times as large as their counterparts in the previous regression, highlighting the relative importance of physical capital and labor in the business recovery process over time.

The effects of business owners' different attributes seemed to diminish by the end of the first year after Harvey. In contrast to the results in the previous regression, neither the estimate for chamber membership nor the gender effect is statistically meaningful. The summary statistics, such as the pseudo-R^2 and likelihood ratio test, also suggest that the predictive power of all explanatory variables together reduces noticeably from six months to one year after Harvey.

4.4. Discussion

Despite a relatively small sample, our survey data on post-Harvey business reopening reaffirm several findings in the existing literature. First, property damage is a key factor for the probability of business closure up to one year after the disaster [33], Wasileski et al., [36]. As in Josephson and Marshall [22], the extent of physical damage also affects the way small businesses finance their rebuilding activity particularly through federal disaster assistance, which may in turn affect their performance in the long run [17,19].

The influence of physical damage on FEMA registration and the subsequent receipt of federal assistance explains the mixed findings in the literature about the efficacy of government disaster relief programs in promoting community recovery. In particular, the dilemma of finding a *negative* relationship between government assistance and business recovery (e.g., [38] may arise from the fact that a hidden factor, particularly property damage, influences both variables. Moreover, Kousky et al. [23] find that federal disaster assistance crowds out the impact of insurance payments. Failing to control for the extent of disaster-related damage would therefore result in biased results for evaluating the impacts of different financing channels on business success.

Controlling for property damage, we have found that the construction industry tended to recover from Harvey more rapidly than other industries. As widely documented in the literature [14,24,4,5,7,10], local rebuilding activities after a disaster benefit construction firms the most. On the contrary, hotels and motels were less likely to be open after Harvey because their business was more vulnerable to structural damage [44]. Likewise, damage to contents, particularly inventory stocks, affected retail stores' ability to resume operation. The prospect of tourism in the wake of a major disaster might also have influenced the decision to resume operation in those industries relying on out-of-town visitors. Displaced residents, who adversely affect the local market base, might have also affected the sustainability of retail businesses.

Our estimated models yield no statistically meaningful results for the size or age effect as found in the existing literature [24,14,37,38]. This might be the outcome of our sample that consists of mostly very

Table 4
Probit regression of reopened businesses.

	6 Months after Harvey				1 Year after Harvey			
	Coefficient			Slope	Coefficient			Slope
Constant	0.32	(0.52)		0.06	2.00	(2.45)	***	0.38
Location:								
Heritage & Arts District	1.04	(1.72)	**	0.20	−0.30	(0.51)		−0.06
Other Rockport Areas	−0.64	(1.44)		−0.12	−0.93	(1.77)	**	−0.18
Sector:								
Construction	−0.45	(0.70)		−0.09	6.09	(10.16)	***	1.17
Retail	1.05	(1.81)	**	0.20	−0.63	(1.19)		−0.12
Real Estate, Finance & Insurance	−0.23	(0.51)		−0.04	8.78	(6.21)	***	1.68
Education	0.97	(1.34)		0.19	8.79	(9.63)	***	1.68
Healthcare	−1.96	(3.10)	***	−0.38	−2.17	(3.03)	***	−0.42
Accommodation & Food Services	0.59	(1.11)		0.11	−1.21	(2.11)	**	−0.23
Arts & Recreation	0.67	(1.10)		0.13	7.26	(12.36)	***	1.39
Other Attributes:								
Age	−0.10	(0.77)		−0.02	0.26	(1.57)		0.05
Employment Size	0.07	(0.36)		0.01	0.34	(1.33)		0.07
Employee Loss	−0.37	(1.87)	*	−0.07	−1.50	(1.71)	*	−0.29
Chamber Member	1.56	(3.73)	***	0.30	0.55	(0.96)		0.11
Woman Owner	0.62	(1.92)	*	0.12	0.30	(0.79)		0.06
Property Damage	0.82	(2.06)	**	0.16	4.39	(3.82)	***	0.65
Observations	152				152			
Psuedo-R^2	0.34				0.27			
LR Test for Coefficients	37.33	*			25.51	**		

Notes: Absolute t-statistics are in parentheses. ***, **, and * represent statistical significance at the 1%, 5%, and 10%, respectively.

small businesses, including single owner-operators with no employees. For businesses with employees, however, Harvey's impact on their staff affected their ability to resume operation up to one year following the event. This finding aligns with previous studies [33,43] that highlight the role of operational disruptions on business survival.

Regarding business-owner attributes, we have found a strong gender effect among businesses within six months after Harvey. In contrast to the finding in some studies (e.g., [27]), the positive estimate for female business owners indicates that women tend to be back in business after a disaster more rapidly than their male counterparts. This finding is also in line with [12] observation that federal disaster assistance helps raise the post-disaster resilience of female-owned businesses while lowering the resilience of male-owned businesses.

Members of the local chamber of commerce also tended to resume operation sooner than non-members. This finding is consistent with the emphasis on the role of social bonds or networks in business recovery [21,33]. Likewise, Norris et al. [29] emphasize the importance of organizational linkages and social supports for promoting community resilience.

A comparison of empirical results between six months and one year after Harvey corroborates [25] assertion that it is more difficult to discern a disaster's impacts when observations are taken later after the event. The collective explanatory power of the same set of explanatory variables is weaker for the opening status as of August 2018 relative to six month earlier. Nonetheless, damage to physical properties continued to be a major determinant of business survival over time.

The business reopening rate of Aransas County above 80% one year after Harvey was remarkably high, especially relative to the aftermaths of Hurricane Katrina. Lam et al. [25] find that 39% of businesses in New Orleans returned 10 months after Katrina, and the rate increased only to 66% another year later. Other than being much smaller in comparison with most disaster-hit areas in previous research, the seemingly more "resilient" Rockport-Fulton business community relative to New Orleans could be explained by differences in mitigation activities and other community services.

Among alternative measures of disaster resilience, the Baseline Resilience Indicators for Communities (BRIC) capture each U.S. county's vulnerability to natural disasters and its capacity to recover [31]. Aransas County, in particular, receives a relatively high score for the "institutional" category, although its scores for other aspects, such as economic, social, and infrastructure are lower than the U.S. average as well as New Orleans. Our finding regarding the particular effect of local chamber membership in the operating status of businesses also highlights the role of social networks in community resilience to natural disasters.

Our findings on one year following Harvey are limited to the early stage of business recovery. Schrank et al. [30] find that a large number of small businesses in New Orleans failed to recover in the long run even though they survived immediately following Katrina. Marshall et al. [26] and Sydnor et al. [32] find that certain businesses (e.g., younger, smaller) and their owners (e.g., women, minorities) in that area were more likely to be closed by 2013 after reopening their doors. From these perspectives, a better understanding of business success in the long run would benefit from observing the changing performance of different businesses over time.

5. Concluding remarks

We have looked narrowly at business reopening after disruptions caused by Hurricane Harvey. Local survey and field data shed light on Harvey's impact on businesses and determinants of business survival. The survey sample is representative of the local business population in most aspects, except for minority-owned businesses.

Property damage not only causes disruptions in business operation, but also the way a business finances its rebuilding activity, including the decision to apply for federal assistance. In addition to physical losses, model estimation results underscore the challenge of rebuilding a business community in the face of a tight local labor market that often follows a major disaster. Other than the direct impact on labor and capital, economic prospects of different businesses and their owners' characteristics affect business return after a natural disaster. In particular, local chamber members and women were more likely to reopen their business soon after a disaster.

The business survey was conducted in early 2018, so the data reflect business recovery shortly after the event. To provide insight into post-disaster economic recovery over a longer term, we also analyzed the opening status of those businesses in the survey sample as of one year after Harvey. Schrank et al. [30] and Sydnor et al. [32] find that a large

number of businesses that were reopened soon after Katrina did not survive years later. To better understand sustainable success of impacted businesses, an exploration of their performance over longer periods of time is warranted. This line of research will also benefit from longitudinal data on alternative measures of long-term business performance, such as revenues. Other than pre-existing conditions, such as industry and firm age, it would also be fruitful to examine the efficacy of disaster relief programs and businesses' post-disaster behavioral characteristics, such as adaptive capability [18].

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Declarations of interest

None.

Appendix A

Rockport-Fulton Chamber of Commerce Business Assessment 2018 Survey

1. What is the name of your company and street address?
2. Where is your company located?
   - City of Rockport
   - Town of Fulton
   - Lamar/Holiday Beach
   - Aransas County
   - Other
3. Is your company located in the Rockport Cultural Arts, Heritage District/Downtown Rockport or Downtown Fulton?
   - Yes, Rockport Heritage District/Downtown Rockport/Cultural Arts
   - Yes, Downtown Fulton
   - No
   - Not sure
4. How long has your company been in operation in Aransas County?
5. What is your company's primary type of industry/affiliation? Select all that apply.
   - Accommodation
   - Food Service
   - Real Estate/Rental/Leasing
   - Finance and Insurance
   - Retail Trade
   - Health Care and Social Assistance
   - Educational Services
   - Construction
   - IT Services
   - Manufacturing
   - Transportation and Warehousing
   - Media/Printing
   - Management of Companies and Enterprises
   - Guide Services
   - Arts and Entertainment
   - Staffing/recruiting
   - Wholesale Trade
   - Waste Management and/or Remediation Services
   - Energy Services (Oil & Gas)
   - Childcare
   - Services (car detail and maintenance)
   - Storage Facility
   - Other industry
   - Woman Owned
   - Minority Owned
6. Please provide the number of employees your company employs (currently) post Hurricane Harvey. If you are an Owner/Manager with no employees please indicate such.
7. Please provide the number of employees your company employed prior to Hurricane Harvey. If you are the Owner/Manager with no employees please indicate such:
8. What were your current hours of operation Pre-Hurricane Harvey?
9. What are your current hours of operation Post Hurricane Harvey?
10. How long was your business closed immediately after Hurricane Harvey? Select all that apply.
    - It did not close
    - 1–15 days
    - 16–30 days
    - 31 or more days
    - It was permanently closed
    - Other
11. What happened to your business during Hurricane Harvey and immediately afterward?
    - Stayed open; physical damage to structure
    - Stayed open; damage to contents or customer area
    - Closed; physical damage to structure
    - Closed; damage to contents or customer area
    - Nothing significant occurred
    - Other
12. Please estimate the total damage in dollars to your physical business location:
13. Please provide an estimated dollar amount of direct damages to your Inventory/Product and Equipment/Office/Assets:
14. Of the damages to your business, how are you financing recovery? Select all that apply.
    - Line of Credit
    - Flood insurance
    - Windstorm insurance
    - Property or Business interruption insurance
    - FEMA Program
    - SBA Disaster Assistance Loan
    - Loan(s) from family or friends
    - Bank loan(s)
    - Business savings (retained earnings)
    - Personal savings
    - Community Donations
    - Self-insured
    - I do not have damages
    - Other
15. What percentage of your workforce has been negatively impacted by Hurricane Harvey?
    - 0–10%
    - 11–20%
    - 21–30%
    - 31–40%
    - 41–50%
    - 51–60%
    - 61–70%
    - 71–80%
    - 81–90%
    - 91–100%
16. After Hurricane Harvey, what assistance have you received? Select all that apply.
    - Assessing my options
    - Determining financial needs
    - Operating expenses under $10,000
    - Operating expenses between $10,000 and $25,000
    - Operating expenses over $25,000

- Working capital or building repairs under $10,000
- Working capital or building repairs between $10,000 and $25,000
- Working capital or building repairs over $25,000
- Deciding how to rebuild my business
- Physical help to repair my business
- Finding a new location for my business
- Workforce Issues
- Expanding business
- Prospecting new home seller/buyers
- New Marketing Plan
- Reaching Client Base
- None
- Other

17. What additional assistance do you need help with? Select all that apply.
    - Assessing my options
    - Determining financial needs
    - Operating expenses under $10,000
    - Operating expenses between $10,000 and $25,000
    - Operating expenses over $25,000
    - Working capital or building repairs under $10,000
    - Working capital or building repairs between $10,000 and $25,000
    - Working capital or building repairs over $25,000
    - Deciding how to rebuild my business
    - Physical help to repair my business
    - Finding a new location for my business
    - Workforce Issues
    - Expanding business
    - Prospecting new home seller/buyers
    - New Marketing Plan
    - Reaching Client Base
    - None
    - Other
18. Do you have business insurance?
    - Yes
    - No
19. If you have insurance, does your business insurance cover flood or wind losses?
    - Yes, flood losses
    - Yes, wind losses
    - Both flood and wind
    - No
    - Unknown
    - Not applicable
20. If you have insurance, does your business insurance cover loss of income?
    - Yes
    - No
    - Unknown
    - Not applicable
21. Have you been able to receive materials, supplies, and services adequately since Hurricane Harvey?
    - Yes
    - No
    - Not Applicable
22. Did you register with FEMA for assistance and receive a case number?
    - Yes
    - No
    - Not applicable
23. Are you planning to seek or in the process of seeking a SBA disaster recovery loan or loan deferment?
    - Yes
    - No
    - Not applicable
24. If your company is interested in providing services/products to help with Harvey recovery, what are your company's capabilities/qualifications/certifications? Select all that apply.
    - Financial assistance
    - Free respite services
    - Long term/short term housing
    - Healthcare services
    - Business/Flood/Wind Insurance advising
    - Volunteer (Manual Labor)
    - Donation Services (Supplies, and other services)
    - Business and/or Transactional Law Firm
    - Communication services/IT Services
    - Commercial and/or Residential Construction
    - Meal services
    - I am not interested
    - Other
25. Name of the organization which you received this survey from:
    - Rockport-Fulton Chamber of Commerce (Membership)
    - City of Rockport (Community Planner)
    - Town of Fulton (City Secretary)
    - Aransas County (Judges Office)
    - Social Media Platforms
    - Rockport Yacht Club
    - American Legion
    - American GI Forum
    - VFW (Candy Fletcher)
    - Rotary Club
    - Lions Club
    - Rockport Area Board of Realtors
    - Coastal Bend Guides Association
    - Other
    - Comment:
26. Please share any comments or concerns regarding Hurricane Harvey which you believe would be helpful:

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