Taken by Storm: Business Financing, Survival, and Contagion in the Aftermath of Hurricane Katrina*

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Abstract

We use hurricane Katrina’s damage to the Mississippi coast in 2005 as a natural experiment to study business survival in the aftermath of a capital-destruction shock. We find very high exit rates for businesses that incurred physical damage, particularly for small firms and less-productive establishments. Auxiliary evidence from the Survey of Business Owners suggests that the differential size effect is tied to the presence of financial constraints. In the long run, the cumulative effect of the storm was even larger, compounded by local demand externalities due to the proximity of surviving businesses to damaged businesses that had exited. These forces explain why the most heavily damaged coastal areas of Mississippi had not recovered within five years despite significant help from both federal and state sources.

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1 Introduction

Hurricane Katrina’s landfall in the fall of 2005 famously breached levees, flooding New Orleans. It also unleashed wind gusts and a storm surge that destroyed hundreds of buildings along the Mississippi Gulf Coast. In this paper, we study the effect of direct storm-inflicted damage on business exits, focusing on the Mississippi coast. We explore the characteristics of businesses that exited in response to this capital-destruction shock, their productivity and access to financing. Why did some businesses exit while others rebuilt? What are the dynamics for businesses in the area following the initial shock? What can we learn about the propagation mechanism and the pace of recovery?

We use data from the Census Bureau’s Longitudinal Business Database (LBD) on approximately 10,000 business establishments in Mississippi, including nearly 1,500 businesses in four counties with significant storm damage, combined with precise information on the location and extent of storm damage from the Federal Emergency Management Administration (FEMA). These data allow us to pinpoint which establishments were damaged or destroyed and which were left intact in the same area. We focus on establishments in the retail, restaurant, and hotel sectors, whose locations are non-fungible. Our identification comes from the randomness of actual damage within a limited geographic area.

We find that the storm generated significant excess exits of physically damaged establishments in the short run, creating a 30-point wedge between the survival rate of damaged and undamaged businesses in Mississippi by 2006. This suggests that short-term distress caused businesses that would otherwise have survived to cease operation.

We test two competing hypotheses regarding the return of damaged businesses in the immediate aftermath of the storm. Under the first hypothesis, capital markets operate efficiently. In this case, there is some threshold of future expected producer surplus above which a business chooses to return to operation, and below which it shuts down. Alternatively, credit markets may be inefficient, so that credit is rationed or interest rates do not reflect the true cost of funds. Under this alternative hypothesis, smaller businesses face higher
costs of financing and return to operation at lower rates, even controlling for expected future profitability.

We find evidence for both efficient and inefficient sorting in the short run. Across the board, exiting establishments are, on average, less productive than continuers, and this productivity wedge approximately doubles for businesses whose physical structures were destroyed by Katrina. At the same time, even controlling for productivity we find that the brunt of the effect of storm damage on short-run survival fell on smaller firms. Larger firms have lower exit rates even in undamaged areas, but having been hit by storm damage triples or quadruples the advantage that these firms have over their smaller counterparts.

These results are consistent with a number of explanations including differences in market power, differential levels of risk aversion, managerial talent, and insurance take-up rates. In an auxiliary analysis we find direct evidence of the importance of financial constraints to business survival. Businesses that had previously relied on credit-card debt to finance expansion or capital improvements, demonstrating a very high cost of financing, also experienced much higher post-shock exit rates than similar businesses that relied on other forms of financing, including bank loans, for capital projects.

The observation that small firms have higher exit rates and are more financially constrained than large firms is not new.\(^1\) Our contribution is to show how firm size interacts with a well-defined capital-destruction shock while controlling for other environmental factors using a group of unaffected businesses and to explore the propagation of the shock geographically over time.

We examine the effect of the shock over a five-horizon. By 2007 the area started feeling the effects of a local demand shock that may have been exacerbated by the Great Recession. As a result, the largest businesses, having survived the initial shock at higher rates, were more likely to exit in subsequent years than smaller ones. This is consistent with the interpretation

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\(^1\)See, e.g., Mishkin (2008); Calomiris and Hubbard (1990); Fazzari, Hubbard, and Petersen (1988).
that there was excess culling of small but productive business in the short run and that only “superstar” small businesses survived. We also find evidence of a local contagion effect, whereby businesses that rebuilt immediately after Katrina had a higher likelihood of exit the more of their nearest neighbors had previously shut down.

Considerable government resources were invested to ensure the recovery of businesses along the Mississippi coast; the evidence we find for financing constraints suggests small businesses remained vulnerable. Furthermore, our results indicate that it is important when considering such policies that the long-run outcomes of short-run surviving (for the most part large) businesses are tightly linked to the earlier fortunes of their neighboring (small and large) businesses.

Our paper is related to a broad literature exploring the impact of exogenous shocks on real economic activity, and to a small but growing literature on the effects of natural disasters on businesses and labor markets.

A number of papers assess how exogenous macroeconomic shocks, including monetary shocks, demand shocks, energy shocks, and technology shocks, affect the real economy. Within this literature, the papers most closely related to ours examine the differential effect of these shocks on firms of different size and age. For example, Gertler and Gilchrist (1994) and Sharpe (1994) show that small firms are more sensitive to monetary and business cycle shocks than large ones; Mian and Sufi (2010) explore the impact of housing prices on local economic outcomes, highlighting the consumption channel; and Adelino, Schoar, and Severino (forthcoming) and Fort, Haltiwanger, Jarmin, and Miranda (2013), using similar data to ours, find that small firms are more sensitive to housing-price shocks, underscoring the potential importance of less-traditional forms of financing for these firms and the real economy.²

²In a similar vein, Davis and Haltiwanger (2001) examine employment effects of oil-price and credit-market shocks on manufacturing establishments of different sizes and ages, and Chevalier and Scharfstein (1996) find that local and highly leveraged supermarket chains raised their prices relative to national and less-leveraged supermarket chains during the oil-price contraction in 1986 and the 1990–1991 recession.
We differ from these papers in that we focus on a highly localized capital-destruction shock and its associated rebuilding costs. One advantage in our setting is that we can cleanly isolate the impact of the shock. A common difficulty with this literature is disentangling cost shocks associated with business cycles, for example as a result of an increase in the cost of financing due to an increase in interest rates or the collapse of collateral values, from demand shocks associated with the same cycles. Mississippi’s post-Katrina experience allows us to plausibly circumvent this problem because of the initially limited demand shock. Damage was extremely localized, infrastructure was largely unaffected (and where infrastructure was damaged, repair times were fairly short), and there was no significant population outflow from the affected areas.\(^3\)

Most of the disaster literature focuses on assessing the impact of natural shocks on employment and growth outcomes. Many of these papers use aggregate data focusing on overall impacts and cannot isolate the heterogeneity in firm specific responses (e.g., Strobl, 2011; Belasen and Polachek, 2009; Ewing and Kruse, 2005; Hsiang and Jina, 2014; Leiter, Oberhofer, and Raschky, 2009). Siodla (2013) uses micro data to study the effect of the 1906 San Francisco fire on businesses, but he focuses on relocation rather than survival.

A few papers, like ours, straddle the literatures on disasters and financing. Hosono, Miyakawa, Uchino, Hazama, Ono, Uchida, and Uesugi (2012), use detailed firm-level data to estimate the impact of the 1995 Kobe earthquake on the supply of loans. They find that firms whose headquarters were located outside the damaged area but which had borrowing relationships with banks located inside the damaged area fared worse than undamaged firms borrowing from undamaged banks. A similar finding for the 2011 Great Tohoku earthquake is reported in Uchida, Miyakawa, Hosono, Ono, Uchino, and Uesugi (2013). These papers underscore the importance of lending relationships for firm performance and complement

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\(^3\)This contrast dramatically with the situation in Louisiana, where population shifts were large, infrastructure damage was widespread and long-lasting, and even businesses that were not directly damaged by wind and flooding were affected by shifts in demand and disruptions to the supply chain.
our findings regarding the selection effect of storm damage, its disproportionate impact on small businesses in the short run, and local contagion effects in the long run.

2 Katrina’s Effect on the Mississippi Coast

Hurricane Katrina was the most damaging hurricane of a particularly active 2005 hurricane season. Katrina struck several locations in Florida before veering into the Gulf of Mexico and making landfall again in New Orleans on August 29, 2005 as a Category 3 hurricane. Katrina caused damage in several states, including Alabama and Florida, but the most severe damage to businesses was in Louisiana (primarily due to flooding) and along the Mississippi coast (primarily due to high winds and storm surge). In Louisiana, flood waters did not completely recede for several weeks.

Katrina’s damage in Louisiana was widespread and caused large-scale population relocations and destruction of infrastructure. The population relocation created significant and persistent demand shocks; population in many of the parishes has yet to recover. In the hospitality industry, which is a major focus of our paper, infrastructure damage also reduced tourism, exacerbating the demand shock. Because it is difficult if not impossible to compare the consumption patterns of the displaced and remaining populations it is not possible to separately identify demand and cost shocks in Louisiana.4

To alleviate these problems the present study focuses on Mississippi. Infrastructure damage in Mississippi was for the most part limited, localized, and short-lived, and population loss was also limited and short-lived. Because of the localization and short life of most infrastructure damage, we minimize confounding short-run demand and infrastructure shocks that might otherwise bias estimates of the effects of damage to specific businesses.

4 There are several recent studies of the effects of Katrina on population and labor-market outcomes. Among them, Deryugina, Kawano, and Levitt (2013) study the effects of Katrina on Louisiana residents, and Groen, Kutzbach, and Polivka (2013) study Katrina survivors from a broader geographic area.
Figure 1 shows a map of Mississippi, highlighting the four counties that were most affected by hurricane Katrina.

The quick recovery of the Mississippi coast depended heavily on two sectors, military and casinos. Keesler Air Force Base in Biloxi, just a few blocks from the water, was heavily damaged by the storm. Uncertainty about whether it would be rebuilt was resolved within three weeks of the hurricane, when Air Force Secretary Pete Geren visited the base and promised to spend a billion dollars to fully restore it. The casinos, which had been barred from land and operated on floating barges, presented a bigger challenge when they threatened not to rebuild unless they were allowed on land. Their threat was heeded: a month after the storm, on September 30, 2005, a controversial land-based casino bill made it through the Mississippi legislature (Smith, 2012, pp. 218-231). These combination of the Federal government’s explicit commitment to rebuilding Keesler and the casino bill seemed to seal the return of the Mississippi gulf coast.

Business recovery was also aided by a web of government programs that provided post-storm support to residents and business owners affected by the storm. The most substantial program directed at business owners was a loan program administered by the Small Business Administration (SBA). Access to this program was not restricted to small business and it offered lower interest rates and longer terms than conventional loans. In addition, Mississippi offered small businesses in the worst-hit areas a 180-day, no-interest loan program; by the end of 2005, 392 small businesses had taken loans totaling over $9 million under this program (Kast, 2005).

While Mississippi as a whole, and the coastal counties in particular, were set on a path to recovery early on, the short run did see a shift of economic activity from the damaged zone to

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5The SBA approved over 13,400 disaster loans for businesses of all sizes affected by the hurricanes from fiscal years 2005 through 2009, and more than 10,700 of these loans were identified as having assisted small businesses. 2,362 of these small business loans went to Mississippi. Most of these loans were specifically directed to small businesses that were not able to obtain credit elsewhere (Small Business Administration, 2008).
nearby undamaged areas. Gagnon and López-Salido (2014), using high-frequency store-level data from Information Resources Inc. (IRI) to study the effect of demand shocks on retail pricing, note that five of the nine Mississippi stores in their sample did not report data for a period of one to two weeks around Katrina’s landfall. When they resumed operation, their sales volume had spiked by 20% (p. 15). Although they do not observe the exact locations of the stores in their sample, Gagnon and López-Salido infer that the IRI supermarkets had not been damaged (or perhaps damaged only to a very limited degree), but some of their competitors, not in the IRI sample, suffered more serious damage, resulting in a shift of shopping activity by consumers.

Recovery appeared imminent. Smith (2012) reports that “by January 2006, three of the 13 destroyed casinos were back in business [...]. Seven more casinos were scheduled to reopen by the end of 2006” (p. 231). The large investments these casinos made clearly signals that they, like the rest of Mississippi, expected a swift return to pre-Katrina conditions.

The reality on the ground turned out to be more complicated. On the one hand, Mississippi’s population remained largely in place in the aftermath of Katrina. Table 1 lists the 2000 and 2010 population in the affected counties and the rest of the state. Population changes between 2000 and 2010 were generally modest in Mississippi. The only exception is for one of the damaged counties, Stone County, which saw a population gain of nearly 27%. Stone County is very small, however, and accounts for little economic activity; less than 0.5% of our observations. In addition, the local unemployment rate, which rose in Hancock, Harrison, and Jackson counties in 2005 and 2006, had returned to its pre-storm levels by 2007 (Sayre and Butler, 2011).

However, the recovery was uneven. Although the area maintained its population level and overall economic activity, even as casinos recovered, “membership in the Gulf Coast 6

6Contrast this with the experience in Louisiana. Census data show that St. Bernard, Cameron, and Orleans parishes, the most affected parishes in Louisiana, each lost more than a third of its population between 2000 and 2010, while other Louisiana parishes experienced large population gains due to the relocation of evacuees.
Chapter of the Mississippi Hospitality and Restaurant Association stood at only 70 percent of its pre-Katrina strength [and] few of the mom-and-pop motels and eateries that once dotted Highway 90 [along the coast] had rebuilt” (Smith, 2012, p. 232). In addition, Keesler’s recovery took much longer than originally expected. A report issued in July 2006 noted that Keesler plans “call for only 1,067 military housing units (MHU) to be rebuilt, less than half the pre-Katrina inventory” (Reviving the Renaissance Steering Committee, 2006, p. 63). A pre-storm estimate of Keesler’s economic impact on the Biloxi economy was $1.5 billion; by 2009, that estimate fell to $1.1 billion, a 30% drop. Only in 2010, five years after Katrina’s landfall, did the base report completing its construction project (81st Training Wing History Office, 2011, p. 24).

Finally, the Great Recession hit the area, and particularly the tourism industry, hard. Rebuilding along the coast slowed to a halt by 2008 (Smith, 2012, p. 233). While entry rates were suppressed nationwide during the Great Recession (causing what Siemer, 2014, calls a “missing generation” of entrants), the effect of suppressed entry was particularly hard-hitting along the Mississippi coast due to the recent high exit rates.

In short, although residents and businesses in the area had hoped and expected to escape a negative demand shock in the aftermath of Katrina, one did take place. However, it was separated in time from the shock to the capital stock, a fact that we use in our empirical analysis in the coming sections.

3 Data

The primary building block in our analysis is the Census Bureau’s Longitudinal Business Database (LBD). The LBD is a longitudinal database covering all employer establishments

7 The first estimate is from Reviving the Renaissance Steering Committee (2006, p. 63); the second from a Keesler press release at http://newpreview.afnews.af.mil/shared/media/document/AFD-100310-061.pdf, accessed August 24, 2014. We do not take a position on the level of these estimates, but the decline over just a three-year period is striking.
and firms in the U.S. non-farm private economy. We use data from the LBD to track the activity and outcomes of all retail stores, restaurants, and hotels operating in Mississippi between 2002 and 2010.

The LBD identifies the six-digit NAICS code that represents the primary activity of each business establishment.\(^8\) We limit our analysis to retail and restaurant businesses and hotels and other accommodation facilities (including casinos) for several reasons.\(^9\) First, they represent a very large share of the local economies in the affected counties, approximately ten times as large as manufacturing. This is important since affected areas are small and we need sectors with enough data to conduct the analysis. Second, unlike many other service industries and some non-service industries (e.g., construction), the location of the business is non-fungible. Whereas a lawyer may continue to provide legal services and a janitorial firm may continue to provide cleaning services even if the main office is destroyed, stores, restaurants, and hotels provide their services at the business address and cease operations when that location is destroyed. Finally, these sectors serve local (and tourist) demand. Demand for products in other sectors such as manufacturing may extend beyond the local area differentially depending on the size of the business and in ways that we do not observe, making it hard to determine the relative effect of demand and cost shocks for these businesses.

A few aspects about the construction of the LBD are relevant for our purpose. The LBD is constructed by combining administrative business filings with Census collections.\(^10\) These filings are processed by the Census Bureau on a flow basis as they are received. Establishments in the LBD are defined to be “active” if they report positive payroll in their

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\(^8\)This is an extremely fine classification. For example, among car dealerships this classification distinguishes between new- and used-car dealerships and between both of those and motorcycle dealerships; in the home-furnishings sector, it distinguishes between stores specializing in floor coverings, window treatments, and other home furnishings; and in the apparel sector, it distinguishes between men’s-, women’s-, children’s- and family-clothing stores.

\(^9\)These business establishments correspond to NAICS 44-45 and 721-722. We exclude from the analysis non-store retailers such as catalog companies and vending-machine operators, NAICS 454, as well as caterers and mobile food-service providers, NAICS 72232 and 72233.

\(^10\)Administrative records are enhanced with Census collections to identify meaningful economic units of interest such as establishments and firms. For more information on the LBD, see Jarmin and Miranda (2002).
filings for any part of the year. Following Katrina, the IRS postponed tax filing deadlines several times, including waiving penalties and late fees, for individuals and businesses in affected areas. The original relief order, IRS News Release IR-2005-84, extended the filing deadlines by 45 days to taxpayers in 31 Louisiana parishes, 15 Mississippi counties, and three Alabama counties; later revisions increased the number of counties and parishes relieved and ultimately extended the deadline by another full year. Further extensions to April 2007 were also available. These filing extensions naturally cause disruptions in the flow of transactions recorded by the Census in a given year and could lead us to attribute an establishment exit when none exists. However, late filings are recorded by the Census Bureau as amendments to prior year records when they are reported by the IRS. These amendments are recorded up to two years after the original filing year. We rely on late filings and amendments to fill in reporting gaps and to identify late filers. However, because some businesses filed even later (or perhaps not at all), we expect some reporting gaps for establishments that were otherwise active for at least part of 2005, particularly for smaller firms. To ensure that we correctly measure exits against the true population of businesses, we use 2004 data as our baseline, and compare 2004 to 2006 for our short-run analysis, and 2006 to 2010 for the long-run analysis.

The LBD does not include establishment-level revenue. We use revenue information from the 2002 Census of Retail Trade (CRT) and the 2002 Census of Accommodation and Food Services (CFS) to construct a measure of labor productivity at the establishment level. In the absence of information on other inputs, such as cost of materials and capital, we calculate labor productivity as the log of the ratio of the establishment’s annual revenue to employment.11 Because this productivity measure is from 2002, we limit our analysis to

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11 Establishment revenue is not available in annual data sets, but only in the quinquennial (five-year) Economic Censuses. Employment is measured as of the week of March 12, 2002. We drop the top and bottom 1% of our productivity measures to remove the influence of outliers. Our ratio measure is also used in Foster, Haltiwanger, and Krizan (2002) and Doms, Jarmin, and Klimek (2004). Basker (2012) uses the ratio of revenue to payroll as an alternative measure of productivity. See Foster, Haltiwanger, and Krizan (2002), Haskel and Sadun (2009), and Betancourt (2005) for further discussion.
continuers that had existed in 2002.

We supplement the LBD/CRT/CFS with data from the Integrated LBD (ILBD), which provides data on businesses with revenues but no payroll. Non-employer businesses have firm identifiers but no establishment identifiers since an establishment is defined by the Census Bureau as the location of employment.\(^{12}\) If a firm disappears from the LBD, having laid off or lost all its employees in a given year, we search for that firm in the following year’s ILBD to determine whether it has continued to earn revenue. Approximately 7% of businesses that lose their employees retain a non-employer status two years later. A small number of those return to employer status in later years.

The resulting enhanced LBD is an establishment-level dataset that includes establishment and firm characteristics as well as transitions into non-employment. Establishments that belong to the same firm are linked in the data via a firm identifier. A firm is defined as the legal entity with operational control (over 50% ownership). The LBD tracks the activity of these firms over time, including the opening and closing of establishments and acquisitions and divestitures of pre-existing establishments. Our data thus allows us to identify exits in the form of shutdowns (the establishment never reopens), but also exits as transitions into the non-employer universe, and exits in the form of ownership changes. In most of the analysis below, we define an establishment as a continuer from year \(t\) (the “base year,” generally 2004) to year \(t' > t\) if the establishment had positive payroll in both years or had positive payroll in year \(t\) and again in some later year \(t'' > t'\), and as an exiter if it had positive payroll in year \(t\) and no payroll in year \(t'\) or thereafter. This definition of exit is conservative in that periods of temporary inactivity are not considered exits. The sample for our analysis of exits includes all establishments with payroll in both 2002 (for productivity calculations) and the base year.

The firm identifier helps us determine the age and size of the entity that owns the

\(^{12}\) The ILBD is described in detail in Davis, Haltiwanger, Jarmin, Krizan, Miranda, Nucci, and Sandusky (2009).
establishment. Firm age is defined as the age of the oldest establishment in the firm when a new firm identifier first shows up in the database. The firm then ages naturally regardless of merger and acquisition activity as long as the firm continues to exist as such.\textsuperscript{13} Firm age is censored from above because we do not know the exact age of firms that existed in 1976, the LBD’s first year. Our measure of firm size is the number of establishments the firm operates nationwide; it is one for single-unit firms and exceeds 1,000 for others.

For robustness checks, we have both expanded and narrowed the definition of exit. First, in some robustness checks we have expanded the definition of exit to include establishments whose payroll fell by more than 90\% between years $t$ and $t'$ and establishments that continued to operate in $t'$ but under new ownership. Conversely, we have also restricted the definition of exit to exclude cases of establishments that cease to report payroll but report revenue as non-employers in year $t'$ or thereafter.

In our sample approximately 18\% of establishments that had payroll in 2004 are no longer in business in 2006, and 22\% of establishments still active in 2006 are no longer in business by 2010. These exit rates increase (decrease) by 1–3 percentage points when we expand (restrict) the definition of exit, depending on the year.

We geocode establishments using Geographic Information System (GIS) tools to assign latitude and longitude based on the business’s address. The Census Bureau spends considerable resources ensuring that the business address on file corresponds to the physical address. It requires businesses responding to a census or a survey form to provide the physical address of all their establishments. Establishments never covered by a census or a survey are assigned their mailing address as identified by their administrative filing forms. Beginning in 2007, the Census Bureau’s Geography Division has provided geocoding for all business establishments. For establishments still in operation in 2007 we use the Geography Division’s

\textsuperscript{13}For a full discussion of this methodology see Haltiwanger, Jarmin, and Miranda (2013). This methodology is also used in the construction of the Business Dynamics Statistics (BDS); see http://www.census.gov/ces/dataproducts/bds/.
geocodes. For establishments that exited prior to 2007 we use ArcGIS’s “address locator” geocoding tool to attach latitude and longitude information to business addresses. In a small number of cases the business address may represent the address of an accountant or other hired provider who assists the business with those forms. To minimize this problem, we drop 230 businesses whose addresses were identical to addresses provided by accounting or bookkeeping firms.

Not all addresses are of the necessary quality to be able to geocode down to latitude and longitude successfully. ArcGIS provides a normalized score, out of 100, to indicate the quality of the geocoding; we keep only geocodes scored 60 or above. Incomplete addresses and non-standard addresses (e.g., rural routes or POBox addresses) are the main reasons for failures. Rural areas are known to be particularly problematic in this regard. For 2004, in each of the four Mississippi counties that experienced significant direct damage from Katrina — Hancock, Harrison, Jackson, and Stone Counties — we were able to geocode more than 85% of establishments. Table 2 lists the number of geocoded establishments in each of the four affected counties in comparison with the rest of the state.\textsuperscript{14,15} Geocoding rates are typically higher in the damaged counties close to the Gulf than in the more rural inland areas in the rest of the state. Table 3 compares summary statistics of establishment and firm characteristics for geocoded and non-geocoded establishments in the four affected counties in 2004. Compared to non-geocoded establishments, geocoded establishments are on average about one year younger and more likely to belong to single-unit firms. In all cases geocoded establishments are not statistically distinguishable from the overall population in the state.

Damage information comes from FEMA and is described in detail in Jarmin and Miranda (2009). Using remote-sensing technology, FEMA classified damaged areas over the period August 30 to September 10 using a four-tier damage scale: limited, moderate, extensive, and

\textsuperscript{14}These geocoding rates are similar to those obtained by the Geography Division in 2007.
\textsuperscript{15}All establishment counts throughout the paper are rounded to the nearest hundred.
catastrophic.\textsuperscript{16} We reduce this to a two-tier scale, combining “extensive” and “catastrophic” into one category (“severe” damage) and “limited” and “moderate” into a second category (“mild” damage). In practice, there was very little extensive damage so almost all of the damage we classify as severe is catastrophic. Critically, damage designations are not based on insurance claims. However, because FEMA’s remote-sensing maps focus primarily on developed areas, we may under-estimate the damage in less-developed areas.

Following Jarmin and Miranda (2009), we add the FEMA damage information to the enhanced LBD to obtain, for each geocoded establishment, the FEMA classification of the location containing that establishment. Figure 2 shows an area on the border of Harrison and Hancock counties in Mississippi in which storm damage was widespread and highly variable. Each gray dot on the map represents a single business establishment.\textsuperscript{17} Establishments in red (diagonally cross-hatched) areas were severely damaged, while those in green (horizontal and vertical cross-hatched) areas were mildly damaged. Establishments in the white areas were physically undamaged. In addition, a handful of business establishments were located in areas in Mississippi that still had standing water one week after the storm. These areas are indicated in the figure in blue (diagonally lined) but are excluded from our analysis due to the very small number of establishments impacted by flooding; none of our results are sensitive to this exclusion.

Table 2 provides 2004 summary statistics for the four affected counties and an aggregated “rest of state” category. Approximately 350 establishments were in areas later designated

\textsuperscript{16}FEMA’s damage classification defines damage categories as follows. “Limited Damage: Generally superficial damage to solid structures (e.g., loss of tiles or roof shingles); some mobile homes and light structures are damaged or displaced. Moderate Damage: Solid structures sustain exterior damage (e.g., missing roofs or roof segments); some mobile homes and light structures are destroyed, many are damaged or displaced. Extensive Damage: Some solid structures are destroyed; most sustain exterior and interior damage (roofs missing, interior walls exposed); most mobile homes and light structures are destroyed. Catastrophic Damage: Most solid and all light or mobile home structures destroyed.” FEMA reports that, of the 150,000 homes it classified using this scale in Katrina’s immediate aftermath, fewer than 10\% were mis-classified (http://www.geoplatform.gov/geoconops/best-practices/fema-damage-polygons).

\textsuperscript{17}These dots were “jittered” in compliance with Census Bureau disclosure procedures to prevent identification of particular establishments.
by FEMA as having endured severe damage, and 350 more were in areas later designated as having suffered mild damage. We refer to all of these establishments as “damaged.” The last two columns in Table 2 provide the approximate percentage of establishments in each of the counties with a damage designation. Very small cells are suppressed to comply with Census Bureau disclosure requirements.

Table 4 shows pre-storm summary statistics for the 2004 cross-section of geocoded establishments. The first column, showing the average value of the variable for all geocoded establishments, reproduces column (3) of Table 3. We then show the average value for establishments located in areas that were later damaged and those located in areas that were undamaged. For almost all the variables listed — firm size (number of establishments in firm as well as a single-unit firm indicator), firm age, establishment size (employment), and establishment age — the differences between the damaged and undamaged areas are both small and statistically insignificant. The only statistically significant difference between damaged and undamaged establishments is that damaged establishments have slightly lower measured pre-storm labor productivity. We control for labor productivity in all the reported regressions in the paper.

Finally, we supplement our analysis with data from the 2002 Survey of Business Owners (SBO). The SBO is conducted in Economic Census years and elicits more detailed information about firm operation than what is available in the Economic Census. The questions on the SBO form change somewhat from year to year. In 2002, a direct measure of capital access comes from the question: “During 2002, were any of the following sources used to finance expansion or capital improvements for this business? Mark all that apply.” The list includes personal or family savings and other assets; credit-card debt; bank loans; government and government-guaranteed loans; and financing from an outside investor. In addition, a check box for “no financing needed” was also provided. Of the approximately 6,300 businesses we were able to match to our geocoded Mississippi LBD sample in 2002, about 3,500 reported they needed and obtained some form of financing for capital improvements in the previous
year, and nearly 3,000 of those survived to 2004 to be included in our exit regressions. We treat the use of credit-card debt to finance expansion or capital improvements as a strong signal of a high cost of financing. Table 5 provides summary statistics for the sample that matches the SBO data. These establishments are quite large, with 29 employees on average, but they are younger than the full sample, 13 years old on average. Establishment and firm characteristics do not differ statistically for damaged and undamaged establishments within this sample.\footnote{We also obtained a list of Mississippi businesses that received Katrina-related physical-disaster loans from the Small Business Administration (SBA). There are approximately 4,000 loans on this list, many of them given to schools, churches, and other not-for-profit institutions that are not part of our analysis. Fewer than 600 of the loans were given to establishments with NAICS codes matching the ones we include in our analysis (restaurants, retailers, and hotels). Even among those, some are not among the set of businesses in our sample (e.g., businesses without employees or ones that started operating after 2002). Moreover, as many of the recipient businesses were severely damaged, the address of the loan recipient often does not match the address of the business; only about two thirds of the loan zip codes are in the affected counties, and 5% have an address outside Mississippi, though the loan was targeted to a Mississippi business. Similarly, the name of the recipient need not match the business name, as in many cases the loans were given in the owner’s name. As a result, despite our best efforts, we were unable to match enough of the loans to the enhanced LBD to enable us to use this information in our analysis.}

\section{Stylized Facts}

We start by taking the universe of retail, restaurant, and hotel establishments in Mississippi with positive payroll and a geocoded address. We partition these establishments into two subsets: those located in Hancock, Harrison, Jackson, and Stone counties (the counties in which FEMA designated most damaged areas); and those located elsewhere in Mississippi. Figure 3(a) shows the log level of the number of restaurants, stores, and hotels that had positive payroll in these two parts of the state from 2005 to 2010, relative to the 2004 level in each region. Unlike the rest of the state, the four counties in which Katrina damage was concentrated saw declining business activity between 2005 and 2006. Consistent with observations reported in Section 2, the 2006 dip was only halfway reversed in 2007 and 2008, after which the local economy seems to have stagnated. In 2010, while the rest of the state
had approximately 5% fewer businesses in the retail, restaurant, and hotel sectors relative to pre-storm levels, the affected counties were down approximately 10% from their pre-storm level.

Damage within these counties varied considerably with distance to the coast. Figure 3(b) restricts the analysis to the four damaged counties and partitions those further into areas that were designated by FEMA as: (a) undamaged, (b) mildly damaged, or (c) severely damaged. It shows the log level of the number of restaurants, stores, and hotels with positive payroll activity in each of these areas since 2005, again relative to the 2004 baseline. This finer partition shows that activity in the undamaged areas of the four counties more than fully recovered by 2007, overtaking the growth rate upstate. By contrast, even areas that had experienced only mild damage had not fully recovered by 2007 and suffered a significant decline in the Great Recession years. Areas classified as severely damaged experienced an even greater decline: the number of active establishments decreased between 2005 and 2006 by approximately 35%, then declined by a further 10% by 2007, and still had not stabilized by the end of our frame in 2010, at which point the decrease exceeded 50%.

Our main analysis explores the outcomes of establishments that were directly impacted by the storms. Figures 4(a) and 4(b) restricts the analysis to the cohort of establishments that were active in 2004 and also had positive revenue in 2002 (therefore they were at least two year old in 2004).\textsuperscript{19} The difference between these figures and the previous ones is that we now exclude entrants into the market. The solid line in Figure 4(a) shows establishments in undamaged counties exit at a rate of roughly 9% per year. By 2010, approximately 40% of these establishments had exited. The dashed line shows exit rates for establishments in the four counties with significant damage. The trends are similar prior to the storm, but the count of continuing establishments in the damaged counties drops by 15 percentage points between 2005 and 2006, when the hurricane hit, before settling back to similar trends.

\textsuperscript{19}we need them to have revenue in 2002 so we can control for productivity later on.
Focusing on the damaged counties only, we again find large differences in outcomes by degree of damage. Figure 4(b) shows undamaged areas experienced exit rates very similar to those upstate, whereas establishments located in storm-hit areas saw cumulative exit rate of 80 log points (55%) by 2010.

5  Exits and Firm Characteristics

5.1  Short-Run Analysis

5.1.1  Firm Size and Productivity

In the absence of frictions in financial markets we expect to find a socially efficient response to the shock: firms return to operation if and only if the present discounted value (PDV) of future profits exceeds the lump-sum cost of rebuilding structures, buying new equipment, and replenishing inventories. On the other hand, if financial markets are inefficient so that the cost of financing is higher for small firms than large ones even for a given profit level, we expect larger firms to return to operation at higher rates than smaller firms.

Formally, we estimate a linear probability model of exit, including pre-storm labor productivity as a proxy for future profitability, which we cannot observe directly, as well as a measure of firm size:

\[
\text{Exit}_i = \alpha_j(i) + \gamma_n(i) + \sigma \ln(\text{FirmSize})_i + \delta \text{Damage}_i + \beta \ln(\text{FirmSize})_i \cdot \text{Damage}_i \\
+ \pi \cdot \text{Prod}_i + \phi \cdot \text{Prod}_i \cdot \text{Damage}_i + \eta \ln(\text{FirmAge})_i + \eta_T \mathbb{I}(\text{FirmAge}_i = T) + \epsilon_i, \quad (1)
\]

where \text{Exit} is an indicator that equals 1 if the establishment permanently exited the employer universe by 2006. The sample includes all geocoded Mississippi retail, restaurant, and hotel establishments with positive payroll in 2004 and labor productivity estimates from the 2002 Economic Census. These are the same establishments whose survival is plotted in Figure 4.
Larger and older firms are selected for better management, access to resources, and other correlates of survival, so we explicitly control for both firm size and firm age. **FirmSize** is measured as the number of U.S.-based establishments owned by the firm that operates establishment $i$, and **FirmAge** is the age of the firm operating establishment $i$. The coefficient on $I(\text{FirmAge} = T)$ captures the differential exit probability of an establishment belonging to a firm that existed in 1976 and whose measured age is therefore right-censored, relative to an establishment in a firm whose oldest establishment entered in 1977. **Prod**, the log ratio of revenue to employment in 2002, is our measure of business performance.

**Damage** is a vector of two damage indicators: mild damage and severe damage. Regardless of the efficiency of the market, we do not expect all establishments damaged by the storm to return to operation. In some cases, although the business was previously viable, the cost of restoring structures, equipment, and inventories cannot be justified by expected future profits. As a result we expect exits in severely hit areas to be much higher than in the undamaged control areas, and exits in the areas hit by mild damage to be slightly higher as well.

We interact the damage vector with both productivity and firm size. The first interaction captures the notion that more productive establishments can withstand a shock that less-productive ones cannot. Under the efficient-markets hypothesis, we expect the coefficient on this interaction term, particularly for the severe damage indicator, to be negative. The interaction between firm size and damage captures the differential exit rates for establishments in damaged areas by firm size, after controlling for differences in productivity. Under the hypothesis that financial markets are inefficient, and the cost of capital is higher for small firms, we expect the coefficient $\beta$ to be negative.  

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20 An alternative to interacting firm size and damage is to interact firm age and damage, or include both interactions. Despite recent evidence that firm age may be a better indicator of a firm’s ability to withstand a serious shock (Haltiwanger, Jarmin, and Miranda, 2013), we prefer using firm size in this setting with a limited sample size for two reasons. First, firm size has a technical advantage over firm age, in that it is never censored and can take on any integer value. Firm age is right-censored for about a third of the establishments in our sample, dramatically limiting the explanatory variable of the continuous variable.
The county fixed effect $\alpha$ is intended to capture different area-wide exit probabilities due to overall demand and infrastructure shocks. The six-digit NAICS fixed effect $\gamma$ captures differences in exit rates across 110 types of businesses due to different growth and churn rates across sectors. The error term $\varepsilon$ is clustered at the county level. Clustering accounts for the fact that business survival is interdependent across the county.

We include all establishments in Mississippi in the retail, restaurant, and hotel sectors as controls. However, because we have county fixed effects, the coefficients on the two damage variables are identified within county: they represent the differential exit rates of damaged establishments relative to the average exit rate of undamaged establishments in the same county. Establishments in other counties are used to identify control variables, including the 110 NAICS fixed effects and firm and establishment characteristics. The coefficients on the interaction terms are identified within county, but their magnitude is also affected by the control variables, which depend in part on the control group.

The identifying assumption in this regression is that, within the counties affected by Katrina, the precise path of the storm and therefore the damage inflicted was random. While businesses were clearly not damaged due to any underlying characteristics such as size, productivity, profitability, etc. (the hypothesis of God’s wrath notwithstanding), it could still be that damage was assigned non-randomly, that is, in a way that is correlated with underlying characteristics (both observable and unobservable). Table 4 in Section 3, however, provides reassurance that observables are distributed similarly in the treated (damaged) and control (undamaged) samples. The only exception is labor productivity, which is slightly lower on average for establishments located in damaged areas, and for which we control directly.

Finally, we assume that county and detailed-industry fixed effects fully capture demand shocks following the storm. The remaining differences between damaged and undamaged

$\ln(FirmAge)$. Second, on a conceptual level, since the shock we consider here is destruction of capital stock, the total number of establishments the firm operates provides a measure of the fraction of the capital stock actually destroyed; all single-establishment firms, whether young or old, experienced a 100% capital-stock destruction if Katrina’s winds and storm surge destroyed their one establishment.
establishments can then be attributed to their differential recovery costs.

Estimates are presented in the first column of Table 6. All coefficients are interpreted as exit rates relative to the average exit rate of a hypothetical one-year-old undamaged establishment in a single-establishment firm, whose labor productivity is equal to the average level within its six-digit NAICS sector.

The main short-run effect of the storm is an increase in exit probability in areas that experienced severe (primarily catastrophic) damage. Ceteris paribus, establishments in these areas had a 40 percentage-point increase higher exit probability between 2004 and 2006 than undamaged establishments in the same counties. The effect of mild damage is smaller, about 15 percentage points, and less precisely estimated.

As expected, higher-productivity establishments are less likely to exit. The standard deviation of productivity within a six-digit NAICS industry is approximately 0.6, so a one-standard-deviation increase in productivity is associated with a 2.7 percentage point decrease in the exit probability of an undamaged establishment. At the same time, firm age and firm size are both negatively correlated with exit for undamaged establishments: for example, doubling an owning firm’s size is associated with a 0.8 percentage point decrease in an undamaged establishment’s probability of exit. Since establishment productivity is known to be correlated with firm size and age, these estimates represent the partialed-out effects of productivity, age, and size.

Size and productivity both act to diminish the negative effect of storm damage. The same one-standard-deviation increase in an establishment’s productivity reduces exit rates for the most damaged establishment by an additional 2.3 percentage points, nearly doubling the impact relative to an undamaged establishment. Similarly, a doubling of a firm’s size decreases the exit probability of severely damaged establishments by an additional 2.1 percentage points beyond the effect in the undamaged areas, almost tripling the effect of size on exit. Put differently, all establishments located in damaged areas exit at higher rates but small businesses are particularly sensitive to damage. The firm-size distribution is quite
wide, with some firms in our data having in excess of 1,000 establishments while many others operate just one establishment. In the severely damaged areas, our estimates imply that an establishment belonging to a 1,000-establishment firm is 21 percentage points less likely to exit than a single-establishment firm; by contrast in the undamaged area, the difference is only 6 percentage points.

The negative coefficient on the interaction of productivity and severe damage is consistent with the efficient-market hypothesis: the most productive businesses find it worthwhile to rebuild and return to operation, while less-productive ones rationally exit. The negative coefficient on the interaction term of firm size and damage, however, suggests additional factors are at work when firms make these decisions. Even after controlling for productivity establishments belonging to larger firms are more likely to return to operation.

The presence of size effects is consistent with financial constraints, but it could also arise purely for measurement reasons. We consider two types of cases. First, larger businesses may have reduced their employment dramatically in preparation for exit, but retained or even hired a few key employees to facilitate an orderly shut-down. These establishments would be coded as continuers in the LBD, when in fact they have begun the process of shutting down. Such cases not only cause attenuation bias in the estimated effect of damage but, to the extent that this approach is more common among larger chains, may also bias the estimated coefficient on the interaction term of size and damage. To address this concern we recode any establishment that reduced its payroll by 90% or more in 2006 relative to 2004, and that exited by 2010, as an exit in 2006. Similarly, some productive and profitable businesses may not shut down but rather change ownership if the current owner is unable to handle the costs of rebuilding and recovery. This may also be particularly common among small businesses. In this case exit by an owner does not mean the establishment stops operating. To address this concern we also recode ownership changes as exits. Note that both of these changes have the effect of mechanically increasing the number of establishments coded as exits in 2006, particularly in the areas that were severely damaged. The inclusive exit variable is
approximately three percentage points higher in undamaged areas and five percentage points higher in severely damaged areas.

Results from this more inclusive exit specification are shown in column (2) of Table 6. As expected, the direct effect of damage is estimated to be larger in this specification — over ten percentage points larger in the case of severe damage. The coefficient on the interaction between productivity and severe damage increases in absolute value, from \(-0.0388\) to \(-0.0633\) — suggesting that less-productive establishments are more likely to shut down slowly or to change ownership. At the same time, the coefficient on the interaction between size and severe damage hardly changes, indicating that delayed shut-down activities do not drive the size effect in our results.\(^{21}\)

Second, we consider the possibility that some — perhaps particularly small — businesses do not necessarily cease economic activity when they exit the LBD. Instead, they may become non-employer businesses. Consider, for example, the owner of a badly damaged bed-and-breakfast hotel or small shop that returns to operation after spending significant resources on rebuilding and repairing the business. Such an owner may rationally decide to lay off her one or two employees, and take on more work herself and/or scale back hours or services. If such responses are common, exit rates of small businesses damaged by the storm may appear to be higher than those of larger businesses. To address this concern we restrict, rather than expand, our definition of exit, recoding non-employers that had positive revenue in 2006 as continuers. This recoding has the effect of mechanically reducing the overall exit rate — by about one percentage point in undamaged areas and by one and a half percentage points in severely damaged areas. Estimates from this specification appear in column (3) of Table 6. The coefficient on severe damage is slightly smaller, but all coefficients retain their signs, magnitudes, and significance levels.

In addition, it is possible that exit rates of small firms are generally higher in the area

\(^{21}\)The 90% threshold on payroll reduction is arbitrary. We have checked the robustness of our results using various alternative thresholds, as low as 50%, and continue to find qualitatively similar results.
damaged by Katrina, not because of Katrina, but because the damaged areas somehow favor large chains. If that were the case, exit rates in these areas would also have been higher for small businesses prior to the storm. To test this possibility we re-estimate Equation (1) but, on the left-hand side, we replace exit between 2004 and 2006 with exit between 2002 and 2004. This regression functions as a falsification exercise. The only difference between the 2002 sample and the 2004 sample is the age distribution of firms. By 2004, all establishments with labor productivity measures from the 2002 Census belong to firms that are at least two years old, but in 2002 some establishments belong to new firms. Because we do not want to lose establishments belonging to new firms when we take the log of firm age, we arbitrarily set $\ln(0) = 0$ and add an indicator for establishments with age zero; the coefficient on $\mathbb{I}(\text{FirmAge} = 0)$ captures the differential exit probability of an establishment belonging to a brand-new firm (thus the establishment is new itself) relative to an establishment belonging to a one-year-old firm.\footnote{We have also estimated this regression limiting the sample to establishments ages two and higher in 2002; the results are not sensitive to this age restriction.}

Results from this specification using the baseline exit variable are shown in column (4) of Table 6. Although we find excess exit by less-productive establishments in the damaged area prior to Katrina’s landfall, we see no evidence that smaller firms fare worse in these areas than large firms.

We have checked the robustness of these results in several unreported regressions. Changing the sample of controls to include only counties immediately adjacent to the damaged counties (Pearl River, Forrest, Perry, and George), or to omit those same counties, does not change the results in any meaningful way, although standard errors on some coefficients increase. Similarly, adding establishment age and employment to the regressions has no impact on the qualitative patterns of coefficients. Finally, we have estimated the regression nonlinearly using a probit model; the results are again qualitatively unchanged.
5.1.2 Access to Credit

Credit constraints are not the only explanation for small firms’ greater sensitivity to the cost shock in the short run. For example, small-business owners may be more risk averse than larger businesses and may have responded more cautiously to uncertainty about the local economy’s rebounding.\textsuperscript{23} The decision to rebuild and reopen may have included considerations other than the success of a particular business establishment, such as public relations or media attention. Although we cannot directly test for these and other alternative explanations, we can test for the importance of credit constraints.

Most Census data sets do not contain any direct information about business balance sheets, banking and credit relationships, or access to financial markets. The one exception is the Survey of Business Owners. We link the SBO data to our sample of establishments in Mississippi to explore the role of financing on exit in the aftermath of the storm.

We use the 2002 SBO, which covers the cohort of establishments in our data, to explore the extent to which access to credit can explain the differential effects of severe damage by firm size. The SBO does not collect balance-sheet information or any direct measure of assets, but it does include a question about funding sources for capital improvements and expansions undertaken during 2002. We omit from our analysis businesses that report they did not “need” any such funding, not being able to distinguish whether they did not want to make capital improvements or they made no capital improvements because funding was unavailable or too costly.

We are agnostic about most sources of financing due to problems with interpretation. For example, a business may have obtained a government or government-guaranteed loan because it is not sufficiently viable to obtain a private loan, or because its owner is savvy and able to exploit any available resources; the former implies a negative relationship between such loans and survival whereas the latter may lead to a positive relationship. Likewise, using

\textsuperscript{23}In this context, it is interesting to note that Dessaint and Matray (2013), using data from large publicly traded firms, find evidence that managers tend to over-react to hurricane risks.
personal savings may indicate that a business cannot attract loans or outside investors, or it may be a signal that the owner has the resources to invest in her business and the confidence that it will do well.

One source of financing, credit-card debt, stands out as particularly useful for our purposes. Credit cards charge high interest rates. A business that uses credit-card debt to finance expansion or capital improvements is signaling a lack of other viable sources of funds. While a business owner is unlikely to incur such an unsecured expense without reasonable expectation that the investment will justify itself, a surprise on the order of the demolition of the business by storm surge could prove particularly fatal to a credit-card financed business.

We estimate a model with interactions of damage with past use of credit cards as follows:

\[
\text{Exit}_i = \alpha_j + \gamma_n + \sigma \ln(\text{FirmSize})_i + \delta \text{Damage}_i + \beta \ln(\text{FirmSize})_i \cdot \text{Damage}_i
\]

\[
+ \lambda \text{CreditCard}_i + \mu \text{CreditCard}_i \cdot \text{Damage}_i + \pi \cdot \text{Prod}_i + \phi \cdot \text{Prod}_i \cdot \text{Damage}_i
\]

\[
+ \eta \ln(\text{FirmAge})_i + \eta_I \mathbb{I}(\text{FirmAge}_i = T) + \varepsilon_i, \quad (2)
\]

The results are reported in Table 7.

The first column of Table 7 reports the results of a regression with the SBO sample but without the credit-card variables. As with the full sample in the previous section, we find size and productivity predict survival in the undamaged areas. The estimated effects are of similar magnitude. The coefficient on the interaction of productivity and severe damage is negative and large as before. We also find the interaction between firm size and severe damage is statistically significant, though its magnitude is only about \(1/3\) of the size in Table 6 (\(-0.007\) vs. \(-0.021\)). This may be a result of the fact that the SBO sample has fewer single-unit firms relative to the sample in the earlier regressions.\(^{24}\)

In the second column, we add the credit-card variable and its interaction with the damage

\(^{24}\)Only 30% of SBO establishments, compared to 60% of establishments in the full LBD sample, are single-units. As our previous results show, larger firms were less affected by severe damage in the short run.
vector. The third and fourth columns repeat this analysis using the inclusive and restrictive exit variables.

Across specifications, the coefficient on the credit-card variable is negative, but small and statistically insignificant. On its face, this may seem puzzling, given our contention that credit-card debt is a strong signal of a financially weak business. However, the credit-card financing question refers to 2002, and our sample conditions on the business having survived to 2004. Credit-card reliant businesses that survived two years may be a selected sample, no weaker than its counterparts which relied on other sources of financing, at least absent any additional shocks. Partly this is due to the fact that the SBO questionnaire does not allow us to distinguish between businesses that went into significant credit-card debt and those that used their cards more prudently. In addition, some credit-card users may have had excellent business ideas but faced moral-hazard problems or were unable to credibly signal the quality of their ideas to potential investors. Finally, the SBO does not ask businesses to rank the relative or absolutely importance of their various financing sources. Most businesses that used credit cards relied on other sources of financing as well: approximately half also reported using personal savings, and others also received bank loans.

Although credit-card usage in 2002 does not predict exit for undamaged businesses, businesses that relied on this expensive form of financing and were hit by severe storm damage were unable to recover from this shock. The coefficient on the interaction of credit-card usage and damage is very strong and statistically significant: conditional on severe storm damage, an establishment whose owner reports having used a credit card for expansion or capital improvements in 2002, is 70 percentage points more likely to exit between 2004 and 2006 than one that did not use a credit card for these purposes. In other words, while businesses that had previously signaled a high marginal cost of financial capital are able to continue operating as long as no major cost shocks arise, they cannot respond to a major shock. Interestingly, the direct effect of size is unchanged in this specification, but the interaction effect of size and damage disappears entirely.
5.2 Long-Run Analysis

We return to the full sample of stores, restaurants, and hotels to estimate the probability that a business that did not exit between 2004 and 2006, nevertheless exited later, between 2006 and 2010. As before we contrast damaged and undamaged establishments. However, we can no longer treat the coefficients as causal under the assumptions we applied in the short-run analysis because the selection criterion for inclusion in the sample is having survived to 2006, an endogenous outcome. We take this selection into account when interpreting the coefficients. We estimate the same model as in Equation (1), but replacing the LHS variable with an indicator for exit between 2006 and 2010. The results are reported in the first column of Table 8.

As noted earlier, by late 2007 the effects of the Great Recession started to be noticed in Mississippi, reducing tourism, and Keesler AFB was nowhere near back to its original staffing level, suppressing local demand. However, even among businesses in the area that operated continuously (if undamaged) or returned to operation by 2006 (following rebuilding and repair, if damaged), those in severely damaged areas were substantially more likely to exit by 2010. This long-run effect of the storm, seen in the coefficient on severe damage, is striking in part because of the massive federal, state, local, and private funds that poured into the area for rebuilding efforts. We find exit rates in these areas exceeded those in undamaged areas by 22 percentage points during this period.

The interaction effects now tell a different story. On the one hand, the interaction of productivity and severe damage continues to be negative, implying that the most productive stores, restaurants, and hotels continue to be partially shielded from the effects of the storm. As the damaged establishments are already selected to be more productive than their undamaged counterparts due to the higher exit rates between 2004 and 2006, this effect increases the productivity differential between the storm survivors and their physically undamaged competitors even further.

The second interaction effect, that of size and damage, reverses sign: controlling for
productivity, larger firms located in severely damaged areas were more likely than small firms to exit between 2006 and 2010. These establishments experienced severe damage in 2005, invested considerable resources rebuilding and were active again by 2006. Why would these larger establishments exit now?

Delayed exit by large businesses is consistent with differential access to credit in the aftermath of the storm. Differential access to credit based on the size of the business would induce a stronger selection of the smaller businesses. Under this scenario only “superstar” small businesses were able to return to operation. Large firms, having had relatively easier access to internal resources, collateral, or established banking relations, experienced less selection based on expected future performance. If this is the case, surviving establishments belonging to small firms would be more profitable, on average, than surviving unconstrained establishments. Consequently, they are also less vulnerable to a continued shock.

What accounts for the continued effect of the storm up to five years after the storm hit? We do not believe that large businesses systematically misjudged the expected recovery trajectory of the Mississippi coast relative to small businesses. Rather, the impact of the demand shock and the Great Recession may have come as a surprise to all. Businesses with the resources to rebuild may have also been surprised by the endogenous demand shock induced by the destruction and consequent closure of many neighboring businesses. The failure of so many businesses may have reduced customer traffic to their surviving neighbors, in turn increasing their failure rate. This explanation is consistent with evidence on the importance of externalities in shopping malls (see, e.g. Pashigian and Gould, 1998; Gould, Pashigian, and Prendergast, 2005). The recession also suppressed entry rates, which otherwise would be expected to offset exits. (See Figure 3 for the trends in the overall count of establishments by area damage status.)

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25 The idea is similar to the contagion effect of home foreclosures (Towe and Lawley, 2013; Harding, Rosenblatt, and Yao, 2009), which may create additional externalities, like higher crime rates (Cui and Walsh, 2014). For a general discussion of agglomeration externalities, see Rosenthal and Strange (2003).
To test this hypothesis, we calculate the number of establishments within a 0.2-mile radius around each establishment in 2004; the average number of neighbors for each establishment is about ten in undamaged areas and 25 in areas that experienced severe storm damage. For establishments that survived to 2006, we also calculate the fraction of their 2004 neighbors that exited before 2006. The average fraction of 2004 neighbors that exited by 2006 is about 14% in undamaged and 34% in damaged areas. We add this variable to the regression equation.

Because the added variable is undefined for the 15% or so of survivors to 2006 that had no close neighbors in 2004, we first re-estimate the 2006–2010 exit regression using only the sample of establishments that had neighbors in 2004. In this smaller sample, the direct effect of severe damage is somewhat smaller than in the full sample, with an estimated coefficient of 0.15 as compared to 0.22 in the full sample. This reflects a lower exit rate among establishments in the damaged areas that are located near other establishments. For this sample, although the standard error is slightly smaller, the coefficient is not significant at conventional levels.

In the third column of Table 8, we add the fraction of 2004 neighbors that exited between 2004 and 2006. The coefficient on this variable is 0.14 and highly significant: an establishment that had lost all of its neighbors by 2006 is 14 percentage points more likely to exit between 2006 and 2010 than a similar establishment that had lost none of its neighbors. The direct effect of severe damage falls from 0.15 to approximately 0.10 with the addition of this explanatory variable, consistent with at least some of the late exits from this area being due to contagion effects.

The last column of Table 8 repeats the analysis, but further limits the sample to establishments with at least five neighbors within 0.2 miles in 2004. This restriction effectively limits the sample to establishments in high-traffic areas. For this sample, the coefficient on neighbor exits doubles and the coefficient on severe damage shrinks to near zero.

Together, these results suggest the presence of long-lasting demand externalities. Even
years after the shock, the outcomes of surviving businesses continue to be tied to those of their less-fortunate neighbors. Establishments that invested considerable funds in rebuilding, rehiring and retraining workers, refurbishing equipment and restocking inventory, but lost neighboring businesses, were effectively hit twice: first by storm surge, and then, after rebuilding, by a less-hospitable demand environment. In this sense, the social cost of storm damage compounded over time.

6 Discussion

Our results show that small businesses have higher exit rates following a capital-destruction shock than their similarly affected larger counterparts. This differential response to the shock cannot be explained by productivity differentials, speed of exit, transitions to non-employer status, or differential demand shocks. These patterns are consistent with empirical studies that show there is considerable variation in establishment exit by size and age even after controlling for productivity differences. The relationship between firm age and size and survival, even conditional on productivity, has been variously attributed to market power, product differentiation, managerial talent, or financing (see, e.g., Foster, Haltiwanger, and Syverson, 2008; Braguinsky, Ohyama, Okazaki, and Syverson, 2014; Katayama, Lu, and Tybout, 2003; Bloom and Van Reenen, 2007).

Differential access to financing explains at least some of these short-run size differences. The measure of financing constraints that we observe is a business using credit-card debt, with its notoriously high interest rate, to finance expenditures associated with an expansion or capital improvements. Other financing constraints, such as differential insurance coverage and debt overhang may play a role as well.\footnote{Although we do not have insurance take-up rates for Mississippi, a recent report by the RAND Corporation on the aftermath of Superstorm Sandy in the New York City area (Dixon et al., 2013) notes that flood insurance take-up among large commercial firms was very high, estimated at 80–90 percent, whereas small businesses had only a 5–10\% take-up rate, with medium-sized businesses somewhere in between.}
These financial constraints serve as a selection mechanism for small businesses and suggest the excess exit rates we observe are privately inefficient. Some small firms are unable to rebuild otherwise-profitable operations, leading to inefficient liquidation of valuable production units. By contrast, larger businesses with easy access to capital may not be as profitable, but have been able to survive and continue operation. This explanation is particularly compelling in our setting, in which the establishment’s capital stock — including structure, equipment, inventory, and possibly software and data — is destroyed, but is also applicable to other situations in which businesses are hit by any unexpected cost shock.

Consistent with this interpretation, a General Accounting Office (GAO) report concluded that small businesses experienced credit and funding-related difficulties recovering from the disaster. Among the explanations provided were the loss of financial documents, which limited businesses’ ability to apply for SBA and other loans, as well as increased costs of doing business due to insurance payments and the need to repay recovery-related debts (General Accounting Office, 2010).27

This result is also consistent with research on the importance of financing in other contexts. For example, Adelino, Schoar, and Severino (forthcoming) document the important of housing collateral to small-business formation and expansion, and Adelino, Ma, and Robinson (2014) show that young firms are more responsive to local investment opportunities in areas with better access to small-business finance. Specifically with regard to the Great Recession, Siemer (2014) finds strong evidence that financial constraints disproportionately impacted small firms. The result is also consistent with broader evidence that policy interventions providing credit and know-how have a disproportionate effect on small firms (e.g., Jarmin, 1999; Brown and Earle, 2013).

Several theories attempt to explain the presence of frictions in financial markets. For example, in Clementi and Hopenhayn (2006), firms face borrowing constraints due to asym-

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27In other cases, business owners simply declined to take out loans even with low or no interest (Smith, 2012, p. 229).
metric information regarding their profitability. The constraints are endogenously relaxed for firms that experience positive shocks and grow; that is, older and larger business. Caballero and Hammour (2005) develop a model in which financial constraints can lead to excess scrapping of otherwise-profitable projects in response to a negative shock.\textsuperscript{28} Both models imply higher exit rates for constrained businesses that would otherwise be profitable.\textsuperscript{29}

Other, non-financial, factors may also contribute to the differential sensitivity of small businesses to severe damage. Small businesses may have different attitudes towards risk than larger businesses: some businesses may have exited voluntarily because returning to operation would have been profit maximizing in expectation but risky (e.g., due to uncertainty about the local economy’s rebounding), or entailing higher non-pecuniary costs.\textsuperscript{30} Small-business owners’ risk-averse behavior may be further explained by the need to provide personal property as collateral for commercial loans.

In addition, the decision to rebuild and reopen may have included considerations other than the success of a particular business establishment. Investments made by large, multi-state operations, may not have immediate local returns and instead respond to broader considerations. There is anecdotal evidence that larger firms used the Katrina rebuilding effort in their public-relations efforts. For example, a Wal-Mart press release announcing the reopening of its Waveland, Mississippi, store in August 2006 read in part: “After its building was damaged by Katrina … the Waveland Wal-Mart quickly erected a 16,000-square foot tent on its lot to ensure people could buy food and basic items. As power across the county remained down for weeks, it was crucial for residents of this hurricane-ravaged community to replace lost items, buy food, cleaning supplies, refill prescriptions, process film and get cellular telephones connected in the storm’s aftermath” (Newswires,\textsuperscript{31})

\textsuperscript{28}Caballero and Hammour model cyclical demand shocks, but their insights extend to other shocks.
\textsuperscript{29}The reverse is also possible: unconstrained businesses that should otherwise exit may remain in operation, as in Caballero, Hoshi, and Kashyap (2008).
\textsuperscript{30}These costs could include mental and emotional costs. In this context, it is interesting to note that Dessaint and Matray (2013), using data from large publicly traded firms, find evidence that managers tend to over-react to hurricane risks.
Other large enterprises also garnered considerable media attention with their quick reopening. The return of the casino hotel “Beau Rivage” in October 2006, for example, generated considerable media attention (see, e.g., Ball, 2006).

At the same time, however, the differential size effect may be under-measured, masking to some degree the financial constraints of small firms. One reason for this is that the lump-sum cost of recovery varies with the physical size of the business establishment. Across sectors, the largest establishments in our dataset, hotels, tend to belong to the largest chains; and even within retail, establishment size and firm size are known to be correlated (Basker, Klimek, and Van, 2012). This implies that the cost shock was itself heterogeneous, and higher for establishments in larger firms. The fact that establishments in larger firms returned at higher rates in the short run implies that they weathered a larger capital-destruction shock more easily than establishments in small firms weathered a smaller shock.

A second reason is that, because our productivity measure uses revenue as a measure of output, it is likely to be artificially higher for businesses with market power, whose prices are higher (Foster, Haltiwanger, and Syverson, 2008). To the extent that market power is correlated with firm size, for example due to national branding, the productivity variable may be picking up some of the size effect. Conversely, if larger firms charge lower prices due to lower input costs, as in Basker, Klimek, and Van (2012), or are more efficiently run, as in Braguinsky, Ohyama, Okazaki, and Syverson (2014), larger businesses may more profitable even controlling for productivity.

The result that more productive establishments are less affected by damage is reminiscent of the cleansing models in Caballero and Hammour (1994, 1996). Establishments that exit are those whose rebuilding costs exceed their lifetime PDV of profits. Variation in the cost of rebuilding is due to a combination of damage level and cost of funds, while variation in the expected PDV of profits is due to differential productivity levels. The least productive
units are scrapped and factors released to alternative uses.\footnote{The role of the financial sector in facilitating a sort of Schumpeterian exit is also explored in Bertrand, Schoar, and Thesmar (2007).}

In the long run, both efficient and inefficient exits are compounded by the endogenous demand shock. The predictive power of both size and productivity diminishes for businesses that survived to 2006. But, while the most productive businesses remain somewhat protected from the consequences of severe damage in the long run, large businesses do not. The reversal in the size effect suggests that only “superstar” small business were able to survive. Selection was not as binding for the larger firms and these became relatively more vulnerable in the long run.

7 Concluding Remarks

Our analysis uses Hurricane Katrina as a natural experiment to examine the impact of an external cost shock due to capital destruction on business activity. We document several facts. First, consistent with a “cleansing” hypothesis we find the less productive establishments were disproportionately more likely to exit in response to the initial shock. Second, even after controlling for productivity, establishments belonging to small firms were more likely to exit in the short run.

To distinguish between financial constraints and other explanations for these findings, we supplement the analysis with estimates showing that business owners who reported relying, at least in part, on credit-card debt to finance capital projects such as business expansion, were particularly vulnerable to exit following severe damage.

The short-run results suggest that binding constraints other than those presented by a firm’s productivity serve as a selection mechanism for small businesses following a cost shock. We are agnostic about the particular mechanism at work. Whether due to difficulties accessing credit from financial institutions, limited collateral, or risk aversion on the part
of business owners with limited personal resources, only a small subset of these businesses survive the initial shock. As businesses age and grow, this selection mechanism diminishes in importance. But small businesses that face a major cost shock early in their development cannot reach this later phase.

In the long run, we find evidence of long-run contagion effects that are a function of the depth of the initial shock. In the retail and hospitality sectors, agglomeration creates demand externalities: the success of a business depends, in part, on the success of its neighbors. As a result, we find that later business failures are predicted by the failure rate of the business’s initial cluster of neighbors. This points to the need to consider social cost, in addition to private costs, when evaluating the policy response to an initial shock.

Finally, the area most affected by storm damage did not recover in the five years after Katrina’s landfall, despite enormous resources spent by federal and state government agencies. This finding is particularly striking in that it is a very small geographic area, there was massive support for rebuilding at all levels of government, and nearby areas in the same counties continued to grow.

Put together, these findings demonstrate the heterogeneous response of businesses following an initial shock. Small firms disproportionately respond to a shock because they tend to be less productive, generating efficient selection, but also because they are more resource constrained, generating inefficient exits. These dual selection mechanisms are relevant not only for capital-destruction shocks such as the one we analyze, but more broadly for any shock that imposes an unforeseen one-time cost on business. Our findings also shed light on the dynamics following the initial shock: the recovery may be delayed and the damage deepened as initial exits propagate to remaining businesses.
References


Figure 1. Mississippi (Shaded Counties Most Affected by Katrina)

Figure 2. Damage Area Closeup: Harrison and Hancock Counties, MS
(a) All Mississippi

(b) Damaged Counties

Figure 3. Log Number of Mississippi Stores, Restaurants, and Hotels by Area Damage Status, Relative to 2004

(a) All Mississippi

(b) Damaged Counties

Figure 4. Log Number of Mississippi Stores, Restaurants, and Hotels that Existed in 2002 by Area Damage Status, Relative to 2004

43
Table 1. Population of Selected Mississippi Counties 2000–2010

<table>
<thead>
<tr>
<th>County</th>
<th>2000 Population</th>
<th>2010 Population</th>
<th>Log Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hancock</td>
<td>42,967</td>
<td>43,929</td>
<td>+ 2.2%</td>
</tr>
<tr>
<td>Harrison</td>
<td>189,601</td>
<td>187,105</td>
<td>− 1.3%</td>
</tr>
<tr>
<td>Jackson</td>
<td>131,420</td>
<td>139,668</td>
<td>+ 6.1%</td>
</tr>
<tr>
<td>Stone</td>
<td>13,622</td>
<td>17,786</td>
<td>+26.7%</td>
</tr>
<tr>
<td>Rest of State</td>
<td>2,467,048</td>
<td>2,578,809</td>
<td>+ 4.4%</td>
</tr>
</tbody>
</table>

Source: Authors’ Calculations from Population Census, 2000 and 2010

Table 2. County Summary Statistics, 2004

<table>
<thead>
<tr>
<th>State</th>
<th>County</th>
<th>Estabs&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Geo-Coded&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Severe Damage</th>
<th>Mild Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS</td>
<td>Hancock</td>
<td>200</td>
<td>200</td>
<td>10.7%</td>
<td>68.0%</td>
</tr>
<tr>
<td>MS</td>
<td>Harrison</td>
<td>1,000</td>
<td>900</td>
<td>35.2%</td>
<td>16.9%</td>
</tr>
<tr>
<td>MS</td>
<td>Jackson</td>
<td>500</td>
<td>400</td>
<td>6.9%</td>
<td>18.1%</td>
</tr>
<tr>
<td>MS</td>
<td>Stone</td>
<td>100</td>
<td>&lt;100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS</td>
<td>Rest of State</td>
<td>10,600</td>
<td>8,500</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>Total&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12,300</td>
<td>10,000</td>
<td>3.5%</td>
<td>3.5%</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Establishment counts represent the retail, restaurant, and hotel sectors, rounded to the nearest hundred
<sup>b</sup> May not match sum due to rounding
Damage counts are percentages of geo-coded establishments.
Blank cells indicate fewer than ten establishments in damage zone.

Table 3. Establishment Summary Statistics: All Establishments, 2004

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs&lt;sup&gt;a&lt;/sup&gt;</th>
<th>All</th>
<th>Non-Geocoded</th>
<th>Geocoded</th>
<th>T-test&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-unit firms (%)</td>
<td>12,300</td>
<td>59.4</td>
<td>55.4</td>
<td>60.3</td>
<td>0.000</td>
</tr>
<tr>
<td>Establishments in firm</td>
<td>12,300</td>
<td>460.3</td>
<td>479.1</td>
<td>456.0</td>
<td>0.451</td>
</tr>
<tr>
<td>Firm age&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12,300</td>
<td>18.1</td>
<td>18.8</td>
<td>17.9</td>
<td>0.000</td>
</tr>
<tr>
<td>Establishment employment</td>
<td>12,300</td>
<td>17.6</td>
<td>16.2</td>
<td>17.9</td>
<td>0.270</td>
</tr>
<tr>
<td>Establishment age&lt;sup&gt;d&lt;/sup&gt;</td>
<td>12,300</td>
<td>12.8</td>
<td>12.6</td>
<td>12.9</td>
<td>0.146</td>
</tr>
<tr>
<td>Productivity&lt;sup&gt;e&lt;/sup&gt;</td>
<td>12,300</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>0.576</td>
</tr>
</tbody>
</table>

<sup>a</sup> Rounded to the nearest hundred
<sup>b</sup> p-value from t-test for equality of the mean
<sup>c</sup> Right-censored age of 29 used for 4000 observations
<sup>d</sup> Right-censored age of 29 used for 1200 observations
<sup>e</sup> Log ratio of revenue to employment in 2002 for establishments that survived to 2004
### Table 4. Establishment Summary Statistics: All Establishments, 2004

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs&lt;sup&gt;a&lt;/sup&gt;</th>
<th>All</th>
<th>Undamaged</th>
<th>Damaged</th>
<th>T-test&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-unit firms (%)</td>
<td>10,000</td>
<td>60.3</td>
<td>60.2</td>
<td>60.9</td>
<td>0.727</td>
</tr>
<tr>
<td>Establishments in firm</td>
<td>10,000</td>
<td>456.0</td>
<td>451.2</td>
<td>519.1</td>
<td>0.188</td>
</tr>
<tr>
<td>Firm age&lt;sup&gt;c&lt;/sup&gt;</td>
<td>10,000</td>
<td>17.9</td>
<td>17.9</td>
<td>17.4</td>
<td>0.153</td>
</tr>
<tr>
<td>Establishment employment</td>
<td>10,000</td>
<td>17.9</td>
<td>18.6</td>
<td></td>
<td>0.788</td>
</tr>
<tr>
<td>Establishment age&lt;sup&gt;d&lt;/sup&gt;</td>
<td>10,000</td>
<td>12.9</td>
<td>12.4</td>
<td></td>
<td>0.115</td>
</tr>
<tr>
<td>Productivity&lt;sup&gt;e&lt;/sup&gt;</td>
<td>10,000</td>
<td>4.5</td>
<td>4.4</td>
<td></td>
<td>0.000</td>
</tr>
</tbody>
</table>

<sup>a</sup> Rounded to the nearest hundred  
<sup>b</sup> p-value from t-test for equality of the means  
<sup>c</sup> Right-censored age of 29 used for 3200 observations  
<sup>d</sup> Right-censored age of 29 used for 1000 Observations  
<sup>e</sup> Log ratio of revenue to employment in 2002 for establishments that survived to 2004

### Table 5. Establishment Summary Statistics: Survey of Business Owners, 2004

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs&lt;sup&gt;a&lt;/sup&gt;</th>
<th>All</th>
<th>Undamaged</th>
<th>Damaged</th>
<th>T-test&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-unit firms (%)</td>
<td>2,900</td>
<td>31.4</td>
<td>31.3</td>
<td>32.2</td>
<td>0.801</td>
</tr>
<tr>
<td>Establishments in firm</td>
<td>2,900</td>
<td>583.9</td>
<td>569.9</td>
<td>818.8</td>
<td>0.160</td>
</tr>
<tr>
<td>Firm age&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2,900</td>
<td>21.0</td>
<td>21.0</td>
<td>20.3</td>
<td>0.370</td>
</tr>
<tr>
<td>Establishment employment</td>
<td>2,900</td>
<td>29.1</td>
<td>28.7</td>
<td>36.8</td>
<td>0.362</td>
</tr>
<tr>
<td>Establishment age&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2,900</td>
<td>13.1</td>
<td>13.2</td>
<td>13.0</td>
<td>0.856</td>
</tr>
<tr>
<td>Productivity&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2,900</td>
<td>4.5</td>
<td>4.5</td>
<td>4.4</td>
<td>0.490</td>
</tr>
<tr>
<td>Credit-card expansion financing (%)</td>
<td>2,900</td>
<td>3.5</td>
<td>3.4</td>
<td>4.3</td>
<td>0.539</td>
</tr>
</tbody>
</table>

<sup>a</sup> Rounded to the nearest hundred  
<sup>b</sup> p-value from t-test for equality of the means  
<sup>c</sup> Right-censored age of 29 used for 1300 observations  
<sup>d</sup> Right-censored age of 29 used for 200 observations  
<sup>e</sup> Log ratio of revenue to employment in 2002 for establishments that survived to 2004
Table 6. Difference-in-Difference Exit Regressions: Productivity vs. Firm Size

<table>
<thead>
<tr>
<th></th>
<th>2004–06</th>
<th></th>
<th></th>
<th>2002–04</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Inclusive</td>
<td>Restrictive</td>
<td>Baseline</td>
</tr>
<tr>
<td>Severe Damage</td>
<td>0.3956***</td>
<td>0.5211***</td>
<td>0.3841***</td>
<td>0.0304</td>
</tr>
<tr>
<td>Mild Damage</td>
<td>0.1339</td>
<td>0.2382**</td>
<td>0.0794</td>
<td>0.0309</td>
</tr>
<tr>
<td>ln(Firm Size)</td>
<td>-0.0084***</td>
<td>-0.0067***</td>
<td>-0.0069***</td>
<td>-0.0088***</td>
</tr>
<tr>
<td>I(Firm Age = 0)(^a)</td>
<td></td>
<td></td>
<td></td>
<td>0.0612**</td>
</tr>
<tr>
<td>ln(Firm Age)</td>
<td>-0.0387***</td>
<td>-0.0316***</td>
<td>-0.0349***</td>
<td>-0.0353***</td>
</tr>
<tr>
<td>I(Firm Age = T)(^b)</td>
<td>0.0158</td>
<td>0.0107</td>
<td>0.0141</td>
<td>-0.0010</td>
</tr>
<tr>
<td>Productivity</td>
<td>-0.0449***</td>
<td>-0.0393***</td>
<td>-0.0432***</td>
<td>-0.0837***</td>
</tr>
<tr>
<td>Severe Damage × ln(Size)</td>
<td>-0.0215***</td>
<td>-0.0211***</td>
<td>-0.0197***</td>
<td>0.0025</td>
</tr>
<tr>
<td>Mild Damage × ln(Size)</td>
<td>-0.0081</td>
<td>-0.0064</td>
<td>-0.0053</td>
<td>0.0029</td>
</tr>
<tr>
<td>Severe Damage × Prod</td>
<td>-0.0388***</td>
<td>-0.0633***</td>
<td>-0.0392***</td>
<td>-0.0120*</td>
</tr>
<tr>
<td>Mild Damage × Prod</td>
<td>-0.0228</td>
<td>-0.0448**</td>
<td>-0.0147</td>
<td>-0.0068</td>
</tr>
<tr>
<td>County FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NAICS FE (6 digit)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Observations(^d)</td>
<td>10,000</td>
<td>10,000</td>
<td>10,000</td>
<td>11,300</td>
</tr>
<tr>
<td>Percent predicted outside [0,1](^c)</td>
<td>2%</td>
<td>1%</td>
<td>2%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses, clustered by county.
* significant at 10%; ** significant at 5%; *** significant at 1%
\(^a\) Age of zero occurs only in 2002 sample; later samples are continuers from 2002
\(^b\) Age ofature indicates the firm or one of its original establishments was in operation in 1976
\(^c\) Rounded to the nearest percentage point
\(^d\) Rounded to the nearest hundred
<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Baseline</th>
<th>Inclusive</th>
<th>Restrictive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe Damage</td>
<td>0.3387***</td>
<td>0.3360***</td>
<td>0.4494***</td>
<td>0.3497***</td>
</tr>
<tr>
<td></td>
<td>(0.0340)</td>
<td>(0.0339)</td>
<td>(0.0803)</td>
<td>(0.0297)</td>
</tr>
<tr>
<td>Mild Damage</td>
<td>0.2895***</td>
<td>0.2753***</td>
<td>0.3425***</td>
<td>0.2851***</td>
</tr>
<tr>
<td></td>
<td>(0.0646)</td>
<td>(0.0458)</td>
<td>(0.0963)</td>
<td>(0.0448)</td>
</tr>
<tr>
<td>ln(Firm Size)</td>
<td>-0.0076**</td>
<td>-0.0078**</td>
<td>-0.0073*</td>
<td>-0.0074**</td>
</tr>
<tr>
<td></td>
<td>(0.0038)</td>
<td>(0.0036)</td>
<td>(0.0040)</td>
<td>(0.0036)</td>
</tr>
<tr>
<td>ln(Firm Age)</td>
<td>-0.0457***</td>
<td>-0.0461***</td>
<td>-0.0199</td>
<td>-0.0439***</td>
</tr>
<tr>
<td></td>
<td>(0.0152)</td>
<td>(0.0151)</td>
<td>(0.0170)</td>
<td>(0.0148)</td>
</tr>
<tr>
<td>I(Firm Age = T)^a</td>
<td>0.0234</td>
<td>0.0226</td>
<td>0.0007</td>
<td>0.0213</td>
</tr>
<tr>
<td></td>
<td>(0.0257)</td>
<td>(0.0261)</td>
<td>(0.0294)</td>
<td>(0.0259)</td>
</tr>
<tr>
<td>Productivity</td>
<td>-0.0258*</td>
<td>-0.0272*</td>
<td>-0.0296*</td>
<td>-0.0229</td>
</tr>
<tr>
<td></td>
<td>(0.0152)</td>
<td>(0.0148)</td>
<td>(0.0153)</td>
<td>(0.0144)</td>
</tr>
<tr>
<td>Credit Card^b</td>
<td>-0.0077</td>
<td>-0.0173</td>
<td>0.0029</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0374)</td>
<td>(0.0366)</td>
<td>(0.0388)</td>
<td></td>
</tr>
<tr>
<td>Severe Damage × ln(Size)</td>
<td>-0.0072***</td>
<td>0.0052</td>
<td>0.0062</td>
<td>0.0037</td>
</tr>
<tr>
<td></td>
<td>(0.0025)</td>
<td>(0.0034)</td>
<td>(0.0105)</td>
<td>(0.0038)</td>
</tr>
<tr>
<td>Mild Damage × ln(Size)</td>
<td>0.0004</td>
<td>0.0013</td>
<td>0.0102</td>
<td>0.0004</td>
</tr>
<tr>
<td></td>
<td>(0.0094)</td>
<td>(0.0113)</td>
<td>(0.0128)</td>
<td>(0.0111)</td>
</tr>
<tr>
<td>Severe Damage × Prod</td>
<td>-0.0315*</td>
<td>-0.0493***</td>
<td>-0.0705***</td>
<td>-0.0506***</td>
</tr>
<tr>
<td></td>
<td>(0.0163)</td>
<td>(0.0143)</td>
<td>(0.0199)</td>
<td>(0.0121)</td>
</tr>
<tr>
<td>Mild Damage × Prod</td>
<td>-0.0729***</td>
<td>-0.0713***</td>
<td>-0.0813***</td>
<td>-0.0728***</td>
</tr>
<tr>
<td></td>
<td>(0.0179)</td>
<td>(0.0149)</td>
<td>(0.0226)</td>
<td>(0.0148)</td>
</tr>
<tr>
<td>Severe Damage × Credit Card</td>
<td>0.7397***</td>
<td>0.7057***</td>
<td>0.7197***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0552)</td>
<td>(0.0466)</td>
<td>(0.0533)</td>
<td></td>
</tr>
<tr>
<td>Mild Damage × Credit Card</td>
<td>0.0547</td>
<td>0.0138</td>
<td>0.0418</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.2595)</td>
<td>(0.2818)</td>
<td>(0.2584)</td>
<td></td>
</tr>
<tr>
<td>County FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NAICS FE (6 digit)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Observations^d</td>
<td>2,900</td>
<td>2,900</td>
<td>2,900</td>
<td>2,900</td>
</tr>
<tr>
<td>Percent predicted outside [0,1]^c</td>
<td>8%</td>
<td>8%</td>
<td>3%</td>
<td>8%</td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses, clustered by county.

* significant at 10%; ** significant at 5%; *** significant at 1%

^a Age of T indicates the firm or one of its original establishments was in operation in 1976

^b Used a credit card to finance capital improvements or expansion in 2002

^c Rounded to the nearest percentage point

^d Rounded to the nearest hundred
Table 8. Difference-in-Difference Exit Regressions, 2006–2010

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>Neighbors≥ 1</th>
<th>Neighbors≥ 1</th>
<th>Neighbors≥ 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe Damage</td>
<td>0.2212***</td>
<td>0.1552</td>
<td>0.1056</td>
<td>0.0085</td>
</tr>
<tr>
<td></td>
<td>(0.1111)</td>
<td>(0.1042)</td>
<td>(0.0972)</td>
<td>(0.0760)</td>
</tr>
<tr>
<td>Mild Damage</td>
<td>-0.0626</td>
<td>-0.0434</td>
<td>-0.0546</td>
<td>-0.0825</td>
</tr>
<tr>
<td></td>
<td>(0.1191)</td>
<td>(0.1249)</td>
<td>(0.1228)</td>
<td>(0.1052)</td>
</tr>
<tr>
<td>ln(Firm Size)</td>
<td>-0.0145***</td>
<td>-0.0140***</td>
<td>-0.0136***</td>
<td>-0.0109**</td>
</tr>
<tr>
<td></td>
<td>(0.0033)</td>
<td>(0.0032)</td>
<td>(0.0031)</td>
<td>(0.0042)</td>
</tr>
<tr>
<td>ln(Firm Age)</td>
<td>-0.0663***</td>
<td>-0.0668***</td>
<td>-0.0676***</td>
<td>-0.0530***</td>
</tr>
<tr>
<td></td>
<td>(0.0116)</td>
<td>(0.0127)</td>
<td>(0.0126)</td>
<td>(0.0170)</td>
</tr>
<tr>
<td>I(Firm Age = T)^a</td>
<td>0.0207</td>
<td>0.0314*</td>
<td>0.0309*</td>
<td>0.0195</td>
</tr>
<tr>
<td></td>
<td>(0.0158)</td>
<td>(0.0168)</td>
<td>(0.0166)</td>
<td>(0.0182)</td>
</tr>
<tr>
<td>ln(Productivity)</td>
<td>-0.0366***</td>
<td>-0.0424***</td>
<td>-0.0416***</td>
<td>-0.0522***</td>
</tr>
<tr>
<td></td>
<td>(0.0076)</td>
<td>(0.0090)</td>
<td>(0.0090)</td>
<td>(0.0116)</td>
</tr>
<tr>
<td>Severe Damage × ln(Size)</td>
<td>0.0140***</td>
<td>0.0113***</td>
<td>0.0125***</td>
<td>0.0120***</td>
</tr>
<tr>
<td></td>
<td>(0.0036)</td>
<td>(0.0032)</td>
<td>(0.0034)</td>
<td>(0.0038)</td>
</tr>
<tr>
<td>Mild Damage × ln(Size)</td>
<td>0.0020</td>
<td>-0.0007</td>
<td>-0.0011</td>
<td>0.0006</td>
</tr>
<tr>
<td></td>
<td>(0.0116)</td>
<td>(0.0115)</td>
<td>(0.0113)</td>
<td>(0.0102)</td>
</tr>
<tr>
<td>Severe Damage × Prod</td>
<td>-0.0382**</td>
<td>-0.0249</td>
<td>-0.0210</td>
<td>-0.0133</td>
</tr>
<tr>
<td></td>
<td>(0.0172)</td>
<td>(0.0158)</td>
<td>(0.0156)</td>
<td>(0.0132)</td>
</tr>
<tr>
<td>Mild Damage × Prod</td>
<td>0.0193</td>
<td>0.0140</td>
<td>0.0156</td>
<td>0.0068</td>
</tr>
<tr>
<td></td>
<td>(0.0346)</td>
<td>(0.0372)</td>
<td>(0.0367)</td>
<td>(0.0328)</td>
</tr>
<tr>
<td>Neighbor Exits/Neighbors^b</td>
<td>0.1406***</td>
<td>0.2780***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0248)</td>
<td>(0.0456)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Robust standard errors in parentheses, clustered by county.

* significant at 10%; ** significant at 5%; *** significant at 1%

<table>
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</tr>
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<tr>
<td>County FE</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NAICS FE (6 digit)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Observations^d</td>
<td>8.600</td>
<td>7.300</td>
<td>7.300</td>
<td>4.800</td>
</tr>
<tr>
<td>Percent predicted outside [0, 1]^c</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
</tr>
</tbody>
</table>

a Age of T indicates the firm or one of its original establishments was in operation in 1976
b Fraction of establishments within 0.2 mile in 2004 that exited by 2006
c Rounded to the nearest percentage point
d Rounded to the nearest hundred