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ABSTRACT

The Re-Building Effect of Hurricanes: Evidence from Employment in the US Construction Industry*

We examine the impact of hurricane strikes on the construction industry in US counties. To this end we use a measure of hurricane destruction derived from a wind field model and historical hurricane track data and employ this within a dynamic labour demand framework. Our results show that destruction due to hurricanes causes on average an increase in country level employment in construction of a little over 25 per cent.

JEL Classification: J23, Q54

Keywords: hurricanes, labour demand, construction industry

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Section I: Introduction

Natural Disasters, such as hurricanes, can have devastating effects on local economies, often causing billions of damages in buildings and other physical structures, as well as disrupting normal economic activity. For example, Pielke et al (2008) have estimated that Hurricane Katarina caused over 80 US billion dollars in damages in Louisiana and Missisipi alone, while Strobl (2008) discovered a loss of around 2 percentage points in economic growth rates in US coastal counties for median sized storms. However, as Belasen and Polachek (2008) note:

" .. a county, business or person's wealth is made up of more than just the stock of assets owned by that person. A major portion of the flow of one's wealth comes from earned income. Thus the question is raised, how can the income-specific and employment-specific effects of a hurricane be measured?" (p.3)

Since hurricanes reduce the stock of capital to a suboptimal level, their costs include not only the lost capital but also the loss in output incurred while capital readjusts to its optimal level. By this argument it makes sense to measure the loss in employment and earnings as a result of being at a lower capital stock as an additional cost. Thus, any increase in construction employment from increased economic activity devoted to restoring damaged capital should not be thought of as offsetting the losses associated with the hurricane since this activity reflects resources being utilised to replace the destroyed capital.

In this paper we show that such a `rebuilding' effect of construction employment is large, the implication being that the loss in current output

from being at a lower capital stock as a result of a hurricane may be larger than it appears if one fails to recognise this. To this end we use a proxy of local hurricane destruction derived from a physical wind field model within a dynamic labour demand framework of quarterly county level construction data.

Section II: Data and Summary Statistics

Previous studies of the local impact of hurricane destruction in the US have resorted to using simple measures of hurricane incidence or their maximum observed Saffir-Simpson scale as a proxy of their destruction.[1] Here we, in contrast, employ a measure that takes account of the spatial structure and movement of a hurricane, and hence of actual local wind speeds experienced, and the potentially affected population, and then translate these factors into a proxy local destruction. More precisely, as noted by Emanuel (2005), both the monetary losses in hurricanes as well as the power dissipation of these storms tend to rise roughly as the cube of the maximum observed wind speed experienced rises. Consequently, he proposes a simplified power dissipation index that can serve to measure the potential destructiveness of hurricanes as[2]:

[1] See, for instance, Belasen and Polacheck (2007).

[2] This index is a simplified version of the power dissipation equation $PD = 2\pi \int_0^t \int_0^{r_0} C_{D\rho} |V|^3 \, r \, dr \, dt$ where the surface drag (C_D), surface air density (ρ), and the radius of the storm (r_0) are taken as given since these are generally not provided in historical track data. Emanuel (2005) notes that assuming a fixed radius of a storm is likely to introduce only random errors in the estimation. He similarly argues that surface air density varies over roughly 15%, while the surface drag coefficient levels off at wind speeds in excess of 30m/s, so that assuming that their values are fixed is not unreasonable.

$$\text{PDI} = \int_0^{\tau} V^3 dt \qquad (1)$$

where V is the maximum sustained wind speed, and τ is the lifetime of the storm as accumulated over time intervals t. Here we modify this index to obtain a quarterly index of potential damage due to hurricanes at the county level using census tract level data. More precisely, the total destruction due to the $r=1,...k$ storms that affected county i at time t is assumed to be :

$$\text{HURR}_{i,t} = \sum_{j=1}^{m}\sum_{r=1}^{k} \overline{V}^3_{i,j,r,t} w_{i,j,r,t-1} \qquad (2)$$

where $\overline{V}$ is an estimate of the maximum sustained wind speed of storm r observed in census tract j at time t. *w's* are weights assigned according to characteristics of the affected census track intended to capture geographical differences within countries in terms of the 'potential' damage if a hurricane were to strike. For these weights we use the time varying share of county level population of each individual census tract at *t-1*, where the underlying argument is that, even if severely damaged by hurricane winds, sparsely populated areas are unlikely to play a significant role in the overall destruction of physical structures due to hurricanes in a county in any period *t*.

In order to estimate wind speeds experienced in census tracts within counties we avail of the wind speed estimates that form the basis of the well known HAZUS software, a widely used program developed by the FEMA to enable hurricane damage loss estimation in the US. The wind speeds in

HAZUS are generated by using information from the full historical tracks of hurricanes as given in HURDAT[3], beginning with their initiation over the ocean and ending with their final dissipation, in conjunction with the to date most sophisticated wind field model. In essence the underlying model consists of two main components: (a) a mean flow wind model that describes upper level winds and uses the full nonlinear equations of motion of a translating hurricane to parameterizes these, as developed by Vickery et al (2000); and (b) Vickery et al (2008)'s boundary layer model that allows one to estimate wind speeds at the surface of the earth over a set of rectangular nested grids given the estimated upper level wind speeds and is based on a combination of velocity profiles computed using dropsond data and a linear hurricane boundary layer model. The advantage of the HAZUS model, compared to earlier methods, lies in producing better estimates of the effect of the sea-land interface in reducing wind speeds and a more realistic representation of the wind speeds near the surface.[4, 5] In its most recent release of HAZUS (version MR3), this methodology was implemented to generate wind speeds the census tract level using historical hurricane tracks of

[3] The HURDAT database consists of six-hourly positions and corresponding intensity estimates in terms of maximum wind speed of tropical cyclones in the North Atlantic Basin over the period 1851-2006 and is the most complete and reliable source of North Atlantic hurricanes; see Elsner and Jagger (2004).
[4] Extensive verification through comparison with real hurricane wind speed data showed that this new wind speed model provided a good presentation of hurricane wind fields.
[5] One may also want to note that, in comparison,

Category 3, 4 or 5 storms (at the time of U.S. landfall) from 1900 through 2006.[6]

Our measure of census tract level population share figures used for weights in (2) are derived from the dicennal population census 1980, 1990, and 2000, where the calculated population shares were linearly interpolated to estimate quarterly values for each census tract.

Data that allow us to estimate a dynamic labour demand equation for the construction industry are taken from two sources. Firstly, quarterly wage rates and employment are from the Quarterly Census of Employment and Wages available from 1975. Secondly, since no direct proxy for quarterly output in the construction industry at the county level is available, we use as an indicator the quarterly value of new privately-owned residential housing units authorized by building permits, as derived from the Census Bureau survey, which collects monthly figures for each county collected since 1988.

One should note that, since hurricanes tend to lose substantial power as they make landfall due to surface friction, only areas relatively close to the coast are likely to be affected. To isolate the (potentially) relevant counties in the North Atlantic Basin region for our analysis, we used the historical census tract level wind speeds estimated by the HAZUS model and identified all counties that experienced at least one incidence of hurricane level winds since

[6] We would like to thank Frank Lavelle for provision of the data.

1900.[7,8] The geographical region of this 'potentially affected' area is shown in Figure 1.

Given the availability of the data for the construction industry we limit our actual econometric analysis to cover the period 1988 through to 2005 and the 974 counties for which data on all construction variables was available. Summary statistics of all our variables are given in Table 1. Figure 1 also provides a graphical depiction of the average value of HURR by county for the potentially hazardous area over our sample period. As can be seen, the extent of destruction, as measured by our proxy HURR, differed substantially geographically.

Section III: Econometric Analysis

In order to estimate the effect of hurricane destruction on employment in the construction industry we postulate a standard convex symmetric specification for the cost of adjustment in labour demand, where its empirical equivalent is:[9, 10]

[7] There a few isolated counties that experienced no incidence of hurricane level winds since 1900. If these were at least partially surrounded by other 'affected' areas we nevertheless included this in our potentially affected geographic region.
[8] The data is not complete for all counties, so that our final data sets constitutes an unbalanced panel.
[9] See Hamermesh (1989).
[10] One should note that the proposed empirical equation is based on a micro-level model of profit maximization. Consequently, using more aggregate data may introduce an aggregation bias unless there is micro-level homogeneity or a compositional stability condition. In a study of dynamic labour demand in Portugal comparing sectoral estimates of the coefficients on lagged employment, output, wages to those from sectorally aggregated data Varejao and Portugal (2007) find, however, that these are relatively similar for quarterly data as we employ here.

$$l_{i,t} = a + \pi l_{i,t-1} + \beta w_{i,t} + \delta y_{i,t} + \lambda HURR_{i,t} + \mu_{i,t} \quad (3)$$

where l is employment, w average monthly wages, and y a proxy for output, all in logged values. HURR is our measure of hurricane destruction, while μ constitutes the error term. The possible presence of an (unobserved) county specific effect in μ could induce correlation between the error term and the lagged dependent variable, and hence may lead to biased estimates if not controlled for. We follow the general literature and employ the GMM systems estimator developed by Blundell and Bond (1998) where one simultaneously estimates the equation in levels and first differences, using appropriately lagged differences and lagged levels of the dependent variable as instruments, respectively. Additionally, we allow for the potential endogeneity of wages and output by instrumenting for these as well. A Hansen test is employed to examine the validity of the instruments, as well as a test of second order correlation, the presence of which would render our estimates inconsistent.

The results of estimating (3) for a variety of specifications are given in Table 2. In all specifications the Hansen and second order correlation test statistics provide support for the validity of our empirical equation. In the first column we estimated (3) without including our hurricane damage index. Accordingly, the coefficient on lagged employment turns out to be positive and significant, indicating the presence of adjustment costs in labour in the construction industry. Moreover, the estimated median lag of adjustment,

0.91, is well in line with other studies using quarterly data.[11] Similarly we find that the wage elasticity is within the range found in previous studies.[12]

In the second column we included our main variable of interest, HURR. As can be seen, hurricane destruction significantly increases employment in construction. We next introduced up to t-3 lagged values of HURR in order to allow for a more longer term effect of a hurricane shock.[13] Accordingly, the boom in employment due to hurricane destruction lasts up to two quarters, where the increase in employment is even larger. However, the overall effect becomes significant within half a year (i.e., quarter t-2). Using the coefficients and means of the variables suggests that the average hurricane shock in a county causes an initial direct increase in employment by 318 individuals, and then by a further 496 in the subsequent quarter. For the averaged sized construction industry in a county this translates into a total increase of a little over 25 per cent.

We can use our result to proxy the additional cost in employment that results from the loss in output while capital readjusts to its optimum level due to a hurricane. Say the percentage change in total employment and construction employment resulting from the hurricane are ε and ε_c, respectively, and s_c is construction's share of total employment. If we define ε_n as the percentage change in employment in non-construction activity it is straightforward to see that:

[11] See Hammermesh (1993) for a review of these.
[12] See Hammermesh (1993).
[13] Further lags than this turned out to be insignificant.

$$\varepsilon_n = \varepsilon - \varepsilon_c s_c \tag{4}$$

For example, in a study of Florida counties Belasen and Polachek (2008) find that total employment falls by 2.4% relative to a neighbouring county as a result of a hurricane. Since our results indicate that construction employment rose by about a quarter and in the US construction generally accounts for roughly 5% of total employment, this would suggest that the true loss in employment associated with the falling non-construction activity may be closer to 3.7%.

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Table 1: Summary Statistics

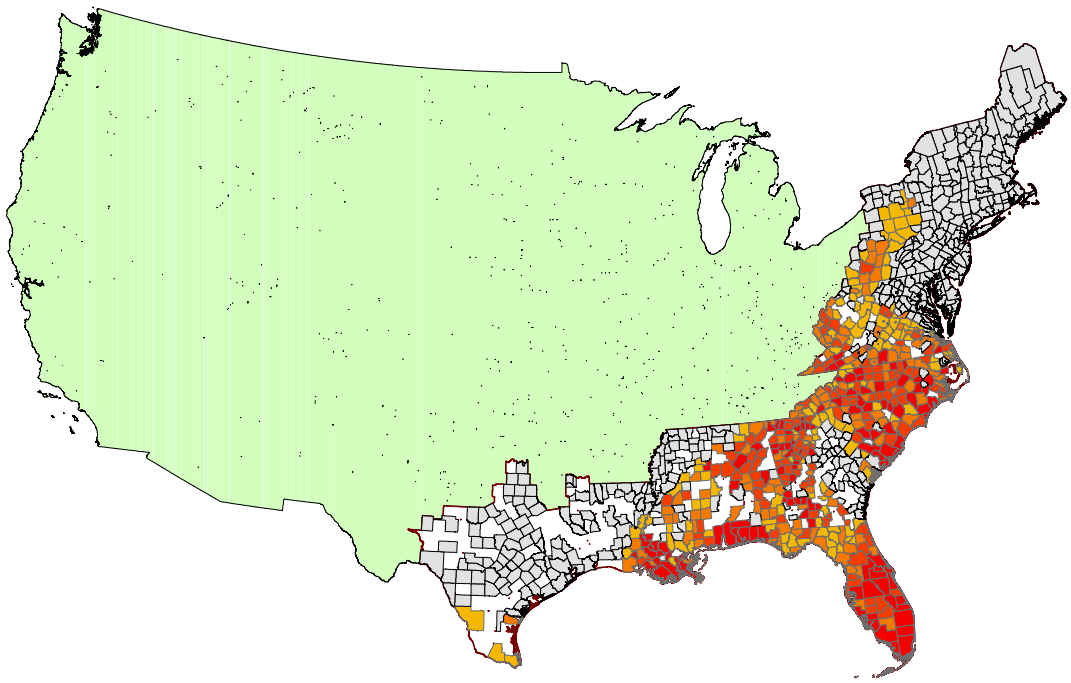
Variable	Mean	Standard Deviation
l	6.73	1.84
w	1.43	1.57
y	13.84	4.27
HURR/100000	0.001	0.021

Table 2: Estimation Results

	(1)	(2)	(3)
$l_{i,t-1}$	0.460***	0.460***	0.461***
	(0.024)	(0.024)	(0.024)
$w_{i,t}$	-0.481***	-0.481***	-0.478***
	(0.027)	(0.027)	(0.027)
$y_{i,t}$	0.057***	0.057***	0.057***
	(0.004)	(0.004)	(0.004)
$HURR_{i,t}$		0.533***	1.223**
		(0.181)	(0.551)
$HURR_{i,t-1}$			1.903***
			(0.732)
$HURR_{i,t-2}$			-0.220
			(0.661)
$HURR_{i,t-3}$			0.743
			(0.674)
Sample Size	54842	54842	54842
Counties	974	974	974
AR(2) test statistic	0.12	0.08	0.12
AR(2) p-value	0.907	0.936	0.901
HANSEN test statistic	963.88	964.34	959.16
HANSEN p-value	0.405	0.401	0.677

Notes: (1) Time dummies included; (2) Robust standard errors in parentheses; (3) Instruments employed: $l_{t-2}...l_{t-5}$, $\Delta l_{t-1}...\Delta l_{t-5}$, w_{t-2}, Δw_{t-2}, y_{t-2}, and Δy_{t-2} are used as instruments. (4) HURR is divided through by 100,000.

Figure 1: Potentially Affected Area and Average County Destruction in Our Sample



Notes: (1)Area NOT in green is 'potentially affected' region; (2) White areas within potentially affected region constitutes areas for which no construction data was available. (3) Grey coloured counties constitute counties within our sample for which there the value of HURR was zero over our sample period. (4) Coloured areas within the potentially affected region constitute counties affected by hurricanes over our sample period, where darker scaled coloring indicates greater average destruction.