The Labor Market Impact of Hurricanes: Evidence from Florida Counties

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Abstract

This study investigates the impacted of hurricanes on wage and employment growth in Florida. I utilized a model of wind intensity which accounts not only for locations through which the eye of a hurricane travels but also the wider impact caused through wind dispersion. By accounting for variation in hurricane intensity, the results reveal a less severe effect on both wage and employment growth than previously reported. Additionally, I identify an absence of labor force spillovers due to hurricanes which speaks to labor force mobility and location choice following hurricanes.

Keywords: Labor Markets, Natural Disasters, Hurricanes.
JEL Classification: J0, J2, Q5, R0

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1 Introduction

The south eastern coast of the United States on a yearly basis is threatened by multiple hurricanes. More recent hurricanes such as Harvey and Irma in 2017 resulted in combined damages totalling $175 Billion (Smith, 2018). Hurricane Katrina in 2005 caused damages estimated at $160 Billion, which is to date the most devastating hurricane to affect the United States, while simultaneously causing an estimated 1,833 deaths (Knabb et al., 2005). As the southernmost state, Florida is vulnerable to hurricanes traveling towards the Atlantic Ocean as well as those entering through the Gulf of Mexico. This places Florida in the path of most hurricanes that approach the southern coast of the US. Though the hurricanes that affect Florida do not always make landfall in the state, the effects of these hurricanes are still experienced through wind, rain and storm surges in areas within proximity of the reach of the hurricanes.

As capital and other economic factors are destroyed due to the effects of hurricanes (Lee, 2019; Zhang et al., 2009), the prospects for employment and by extension opportunities for earning higher wages are significantly affected. Labor markets in affected areas are further impacted by the migration of labor out of the area (Strobl, 2011; Belasen and Polachek, 2009; McIntosh, 2008) or other short term population changes due to death or illness (Zhang et al., 2009). As hurricanes become stronger and more prevalent due to global warming, labor markets in the coastal regions of the country are at increased risk. Therefore, it is important that researchers and policy makers understand the impact of hurricanes on local labor markets.

In this paper I build on the literature which explores the economic effects of natural disasters, specifically the impact of hurricanes on labor markets. I build upon the work of Belasen and Polachek (2009) by applying a model that estimates the wind speed (known in the literature as the wind field model) developed by Boose et al. (2004) to estimate the effect of Atlantic hurricanes on Florida's local labor markets. Additionally, I apply a Hurricane destruction proxy (Strobl, 2009) to deviate from the static classification used in the previous literature which classifies an area using a binary measure of whether an community was hit or not by a hurricane (known as a land fall model). This destruction proxy gives a continuous measure of the impact of the hurricane versus treating all areas that experience hurricane winds the same. In addition, I include both hurricane specific as well as location specific characteristics to measure hurricane damage.

The results of the analysis demonstrate how land fall[1] or hurricane paths as a measure

[1]Land fall as an identification strategy uses the phenomenon of a tropical cyclone's eye crossing onto land as a means of indicating the areas that should be classified as affected by the storm

of impacted areas can bias estimates of the economic impact of hurricanes. Specifically, the results indicate that these measurements fail to capture the wind speed dynamics of hurricanes as their effects are not simply confined to geographical classifications. Failing to account for the varying intensity of hurricanes as they travel along their paths, potentially paints a picture of an impact that may be more devastating than reality. Additionally, land fall models can incorrectly classify areas that experienced hurricane force winds as unaffected due to there being no formal way of estimating the extent of the hurricane's effect in relation to the physical location of the hurricane.

Given that the previous literature has relied primarily on the land fall model to estimate the impact of the hurricane, I revisit the effect of hurricanes on labor markets using the wind field model. This model will allow me to more accurately classify areas as treated and control areas using the information on the actual wind speeds experienced. These improved estimates can assist in the formation of policy prescriptions to properly aid labor markets that struggle after experiencing a hurricane.

I find that on average hurricanes do indeed have a negative impact on employment growth in directly hit counties while having a statistically insignificant effect on earning growth. When dis-aggregated into different intensities, the results indicate that severe hurricanes cause employment growth to fall while resulting in a statistically significant increase in wage growth in affected counties. Weaker hurricane effects lead to reductions in employment growth but have no statistically significant impact on wage growth. Where statistical significance was identified, the estimates were small relative to those estimated in the previous literature using the land fall model. Additionally, I do not find evidence of labor market spillovers from affected counties to geographical neighbors. The results also show that the effect of hurricanes are primarily felt through employment changes with little to no impact on wages.

2 Conceptual Framework For Labor Market Outcomes

In the wake of a natural disaster with significant destructive potential such as a hurricane, the literature has shown that the impact on the labor market can take many forms. In a standard labor supply model, in areas affected by disasters, the displacement of labor is a common result (temporarily or permanently). Displacement tends to shift the labor supply curve to the left leading to decrease in the number of individuals employed and an increase in the wages paid to those workers who remain in the affected area (Brown, 2006; Zhang et al., 2009; Belasen and Polachek, 2009). Zhang et al. (2009) also highlight another means through which the labor market in affected areas react to the effect of hurricanes. The study notes that these affected areas face the risk of reduced labor demand as well due to a shift in consumer preferences for goods and services. Luxury goods and services and vacation services are examples of industries in which employees may be temporarily or permanently laid off conditional on the severity of the storm and its impact. In this scenario, the labor demand curve may also shift to the left as some entities may close down or require less labor due to losing a portion of their customer base.

Groen et al. (2020) expound on the change in the labor demand that arises in the wake of hurricanes due to industries relevant for redevelopment and recovery desiring additional labor to meet the present need created by the disaster. The study highlights the fact that the effect of a hurricane, though negative in many contexts, can spur growth in certain industries such as construction, wholesale building material, and furniture providers which then causes the demand curve for labor in these industries to shift to the right. Zhang et al. (2009) also notes that there may be an influx of construction crews from other areas into the affected areas, which will stimulate demand for hotels and restaurants and thereby workers in the hospitality industry. With the urgency to meet the new wave of demand, additional positions and hours of work become available. In light of the downward pressure on labor supply coupled with the ambiguous effect on labor demand, the true effect of hurricanes on income and employment is ambiguous a priori.

Studies such as Belasen and Polachek (2009), Strobl (2009), Brown (2006) and Groen and Polivka (2008) have noted that another factor that plays a significant role]regarding the impact of hurricanes on labor markets is population displacement. Population displacement creates an increase in labor supply in locations outside the affected areas as labor migrates. Due to this migration, by standard economic theory, one would anticipate a reduction in the average wage in the new locations that the workers move into. With no real disturbance to the previous structure of the labor market in the new areas, the labor demand should remain similar to what existed prior to the influx. Therefore, we should see a shift of the labor supply curve to the right with no change in labor demand resulting in an increase in employment but a decrease in the average wage in these areas. For the directly affected areas, the labor supply curve is expected to shift to the left while labor demand as mentioned before could go either direction, making the overall impact uncertain.

With the evidence from the cited work above, we observe that the effect of hurricanes is ambiguous a priori. In some cases, the effect of a hurricane can result in increased employment propelled by sectors which are needed in order to assist in recovery from hurricane damage.

In other cases the outcome is negative on average as businesses are destroyed, supply chains disturbed, and customer bases dissolved. Earnings are expected to fall in the affected area if the sector that labor is concentrated in is vulnerable to the effects of hurricanes. Where labor can migrate from place to place or sector to sector, there is an increase in earnings for those who remain in the affected area after the hurricane. For the migrating population, either due to the difficulty of assimilating or the over saturation of the new labor market, earnings tend to be lower for movers in their new location. Overall, for both earnings and employment, from the evidence presented above we see that there is room for further exploration of the effect of hurricanes on earnings growth and employment growth.

3 Data

The data utilized in the study is a combination of the data set compiled by Belasen and Polachek (2009) from the Quarterly Census of Employment and Wages (QCEW) and the best track HURDAT2 database provided by the National Oceanic and Atmospheric Administration (NOAA). The QCEW data covers the period between quarter one of 1988 and quarter four 2005. The selection of this period of study is primarily motivated by the need to produce results comparable to previous literature and emphasize the differences identified with the application of the measurement strategy employed in this paper. The HURDAT2 database provides spatially relevant and updated data to measure wind speeds of each storm that has maneuvered the Atlantic basin beginning in 1851. The database provides information on each tropical cyclone whether the cyclone maintained tropical storm status or transitioned into a hurricane. Each tropical cyclone is monitored in six hour intervals. As noted by Strobl (2009) tropical cyclones can move considerable distances over a short period of time. Therefore, I chose to linearly interpolate the location and wind speeds of each hurricane from six hourly intervals to three hourly intervals. This is consistent with extant literature (Strobl, 2009; Jagger and Elsner, 2006).

Geographical data in the form of shape files was gathered from the United States Census Bureau. The study period spans the first quarter of 1988 to the last quarter of 2005. This time period was selected in order to remain consistent with the time period utilized in prior research as I seek to observe how the estimates are altered given the application of a different hurricane measure. Our primary variables of interest are the deviations in the growth rate in employment and the deviations in the growth rate in earning (average wage per worker) from the average Florida county.

4 Empirical Strategy

4.1 Wind Field Model

Unlike other studies in the literature detailing the impact of hurricanes on labor markets, Belasen and Polachek (2009) combined the effects of hurricanes over an extended time period to capture an average effect of all hurricanes rather than the impact of an individual hurricane. In that study, the authors utilized land fall as the measure of a hurricane's impact. A problem that arises with this measurement is that the intensity of a hurricane changes as the storm progresses. This is due to many factors which range from sea surface temperatures to the position of the storm relative to land. Thus, the category of the storm may, and many times does change as the storm makes land fall.

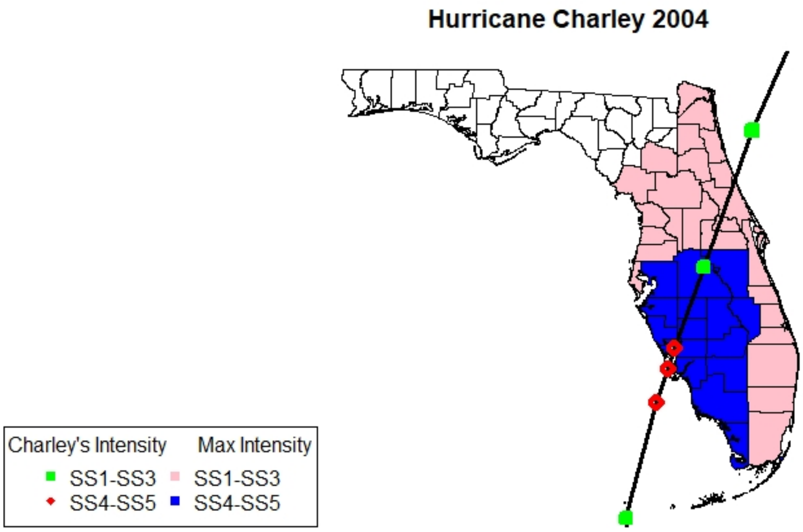

Figure 1

A prime example of such a storm is hurricane Charley in 2004. Hurricane Charley entered Florida as a category 4 hurricane and later, before completely crossing the state was reduced to a category 1 hurricane (Pasch et al., 2005). The counties in north eastern Florida through which Charley passed after experiencing reduced intensity, were then not affected by a category 4 hurricane. This is depicted in figure (1) below. The dark shaded areas represent those counties which experienced hurricane winds of category 4 and above. The light shaded areas represent those areas which experienced hurricane force winds between categories 1 and 3. The intensity of the storm indicated by the green (category 1 to 3) and the red (category 4 to 5) nodes along the path of the hurricane reveal the difference in the strength of the hurricane as it traversed the state. A model not controlling for this variation would assume that all the counties through which the hurricane travelled experienced category 4 winds.

To address this concern, Strobl (2009) and Strobl (2011) employed the wind field model developed by Boose et al. (2004). The wind field model estimates the wind intensity of hurricanes at any geographical point. This allows for one to know at any given point the exact wind speed an area experienced, versus the land fall model which assume all areas that the eye of the hurricane pass through experience the same wind speeds. In my analysis I use a wind field model to allow for variation in the wind speeds experienced by different areas.

The wind field model allows one to estimate wind speeds at different localities at each point along the path of a hurricane. Equation (1) below illustrates the structure of the model as proposed by Boose et al. (2004):

$$V = GF\left[V_m - S(1-\sin(T))\frac{V_h}{2}\right]\left[\left(\frac{R_m}{R}\right)^B exp\left(1-\left[\frac{R_m}{R}\right]^B\right)\right]^{\frac{1}{2}} \tag{1}$$

V_m represents the maximum sustained wind velocity anywhere in the hurricane. T is the clockwise angle between the forward path of the hurricane and a radial line from the hurricane center to the point of interest, P. V_h is the forward velocity of the hurricane, R_m is the radius of maximum winds[2], R is the radial distance from the center of the hurricane to point P, and G is the gust wind factor. The remaining variables, F, S, and B, are scaling parameters for surface friction, asymmetry due to the forward motion of the storm, and the shape of the wind profile curve, respectively (Strobl, 2011).

The radius of maximum wind chosen by Strobl (2011) follows the work of Hsu and Yan (1998). Hsu and Yan (1998) concluded that on average, in the sample of hurricanes that they analyzed between 1893 and 1979, the R_m was 50 km. In addition, the authors provided a breakdown of the average R_m based on the intensity of the hurricanes. Taking this into consideration, I use the R_m breakdowns as weights on the sample of hurricanes in order to calculate an average R_m consistent with the sample. The resultant R_m was 40 km. This R_m was used in all calculations of the impact of each hurricane on each county in Florida. It is worth noting that at the time of the writing of this paper, there is no known database of R_m for hurricanes. Such a database would assist research such as this that attempt to incorporate natural sciences research into economic research.

[2]The radius of maximum wind is sometimes referred to as the radius of destruction. This is the area bordering the eye of the hurricane at which point the strongest winds are recorded

4.1.1 Application of Wind Field Model

Using the wind field model, I identify affected counties by the maximum wind speed experienced in localities across the state of Florida over the life of a hurricane. This allows me to estimate directly the extent of the exposure to the hurricane at varying wind speeds for each county. The wind field model identified a total of 17 tropical cyclones that achieved wind speeds of 119 km/h or greater that affected the state of Florida between 1988 and 2005.[3] A county is classified as affected by the hurricane if an area within the county experiences wind speeds at localities greater than or equal to 119 km/h. Due to the construction of the wind field model, some of the hurricanes that were identified as affecting the state of Florida did not make landfall. However, they passed within reasonable distance to produce wind speeds greater than or equal to that produced by a category 1 storm according to the Saffir-Simpson (SS) scale.[4]

Keeping in line with the work of Belasen and Polachek (2009), I separate hurricanes in two groups; category 1-3 in group one and category 4-5 in group two. However, I deviate from the literature in that I do not classify a hurricane into a specific category based solely on the wind speed that was recorded when the hurricane made land fall and maintain this classification over the life of the hurricane as it affected the state. Instead, I look at the estimated wind speed experienced by each locality in each county. In so doing, a county is classified as experiencing a group 1 or group 2 intensity hurricane depending on the strength of wind estimated in the localities of the county. Localities were determined by the geographical points provided in the state shapefile sourced from the Bureau of Labor Statistics. Designating a hurricane's impact based on the wind speed a county experienced results in counties being classified differently than models using the land fall model. Therefore, for the case where a hurricane such as Charley in 2004 which would be classified as a group 2 hurricane, the set of counties experiencing group 2 winds will be less than that in the literature.

In each hurricane event, the counties that were geographically neighboring a county that was affected by a hurricane of either grouping described above were recorded such that the spillover impact on those counties could be assessed. At this point, it should be apparent that in the event of a group 2 hurricane (category 4-5) classification, there are nearby counties that experienced hurricane winds category 1-3 winds. This study accounts for those additional group 1 hurricane effects that previous studies using a land fall model categorized as either group 2 if

[3]A list of all hurricanes analyzed in this study can be found in the appendix in table (5)

[4]The Saffir-Simpson scale categorizes wind speeds from hurricanes into 5 separate categories. Category 1:119–153 km/h, Category 2: 154–177 km/h, Category 3: 178–208 km/h, Category 4: 209–251 km/h, Category 5: $\geq$ 252 km/h

the hurricane traveled through the county or treated as neighbors if not on the hurricane path. Identification using the wind field model is motivated by the fact that within one hurricane, the wind intensity experienced is not uniform nor confined to the path of he hurricane.

Three of the hurricanes (Florence, 1988 and Allison, 1995, Gordon, 2000) identified by Belasen and Polachek (2009) as having directly hit Florida were eliminated due to the fact that the best track data provided by the National Oceanic and Atmospheric Administration (NOAA) did not indicate that they produced hurricane strength winds upon arriving in the vicinity of the state. Implementing the wind field model for these hurricanes supported this finding. The wind field model accounts for the effect of hurricanes within 500km of the hurricanes' eyes and gave no indication of hurricane force winds in any Florida county from these hurricanes. Hurricane Florence in particular, did not make land fall in Florida, but in Louisiana. Figure (2) illustrates the path of all three hurricanes. The thick section of the track for each storm represents the points where the hurricane was greater than or equal to a category 1 hurricane. The slim sections represent the points where the tropical cyclones maintained tropical storm strength winds. This figure makes it clear that even for the two storms that made landfall in Florida, they were not hurricanes at the time they made landfall and thus would not cause the level of damage that would be associated with a hurricane. Two hurricanes were added to the list previously compiled by Belasen and Polachek (2009). Hurricane Hugo, 1989 and Hurricane Floyd, 1999. Both storm produced hurricane wind speeds within Florida.

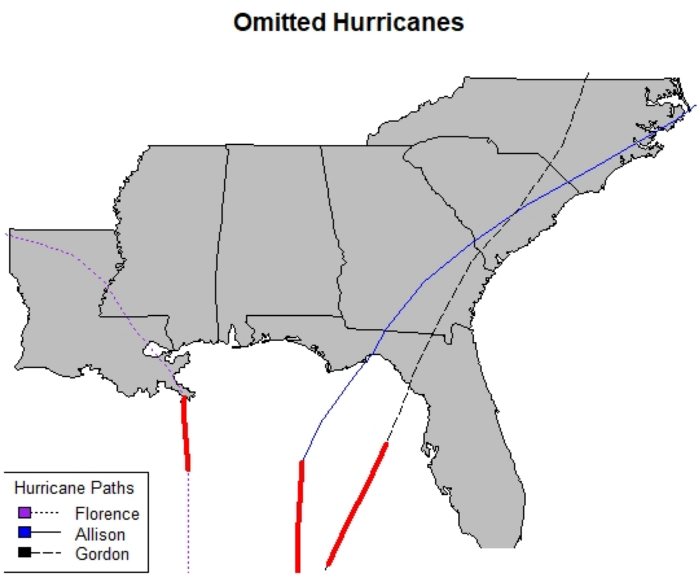

Figure 2: Hurricanes Florence,Allison, and Gordon

4.1.2 Robustness Check of Wind Field Model

I discussed earlier the extent to which land fall models are not sufficient to fully capture the exposure of an area to the effect of hurricanes. Taking note of hurricane Andrew which took place in 1992, we see that the hurricane directly crossed two counties in Florida; Miami-Dade and Monroe. Figure (3) (A) depicts those counties that were designated as disaster areas (dark shaded) by the Federal Emergency Management Agency (FEMA, 2018) due to hurricane Andrew.[5] Andrew was the only tropical cyclone in 1992 that affected Florida with hurricane force winds. As such, the disaster declaration was solely caused by that hurricane in that year. Panel (B) in figure (3) plots all those counties that experienced hurricane force winds of category 5 based in the calculations from the wind field model. From both plots, it is evident that the same counties that were classified as disaster areas, are the same areas that, according to the wind field model, experienced the strongest winds from the hurricane. This gives credence to the use of the wind field model in determining the affected areas.

In panel (B) of figure (3), we see the light shaded circle which is plotted along the path of hurricane Andrew as it entered the state of Florida. This circle has a radius of 30 km which is the maximum size of the radius of destruction used by Belasen and Polachek (2009). The authors used this distance off the path of the hurricane as the determinant of those counties that were hit by the hurricane directly. A neighbor was classified as a county that was geographically next to a county that was hit by a hurricane (ibid). Note from both panels (A) and (B) that using this method, counties that were significantly damaged by hurricane Andrew would be classified as neighbors to directly affected counties rather than affected themselves. This situation highlights one of the main criticisms of landfall models as areas that experienced category 4-5 winds are classified as unaffected neighboring counties. It is therefore evident that there needs to be a more precise measure for identifying where the directly affected counties were and the impact on their respective neighbors.

Due to this classification, I anticipate that the geographical neighbors utilized in the literature, when assessed with the measurement methods in this study, will experience effects similar in sign but lower in the magnitude to the impact on the directly affected counties. The choice of the neighbors in the previous literature was intended to select areas that were affected by the same hurricane but to a lesser extent than the counties that were directly hit. However, based on this discussion there are questions regarding whether or not the labor market effects

[5]FEMA provides a platform which allows the viewing of areas affected by disasters in each state beginning in 1951

of hurricanes in neighboring counties differs to the extent that they could be opposite between the location. The choice in this paper is driven by the same motive, taking particular note of the fact that the extent of exposure of a county to a hurricane is not confined by the physical presence of the hurricane in a county.

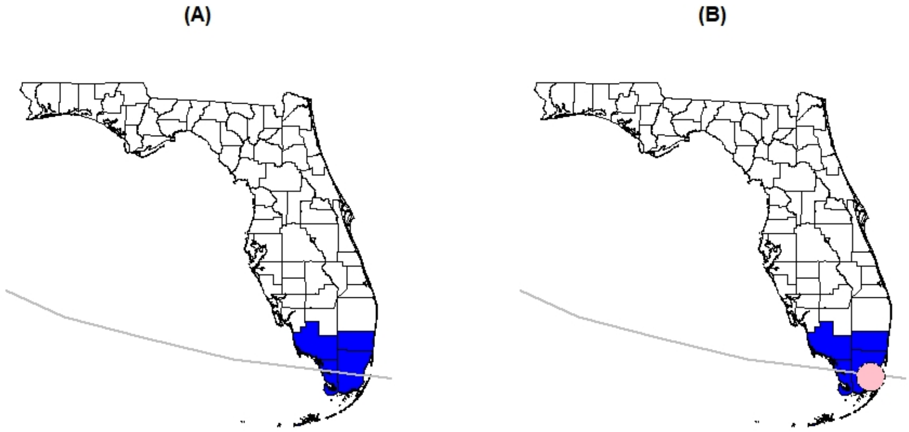

Figure 3: Hurricane Andrew 1992

4.2 Hurricane Index

Strobl (2009) and Strobl (2011) utilize the hurricane destruction index in order to circumvent the use of a simple measure of hurricane impact which fail to capture the complexities involved in a hurricane. The wind index provides a proxy for hurricane damage by taking account of the wind speed experienced in each location, the length of time the hurricane impacted a location, the size of the population impacted, size of the affected area through the number of localities affected, and a parameter that relates hurricane winds to the level of destruction. The measurement technique applied in this study operates at the intersection of two separate views on how hurricane effects can be measured. Particularly, for the main analysis, I utilize the wind field model to estimate wind intensity and apply a binary determination of affected and unaffected counties. The use of the binary determination based on maximum wind in locations was criticizes by Strobl (2011). However, this was with particular reference to such an application when a land fall model is applied which is not the case for this study. The use of the wind field model stops short of applying what Strobl (2009) refers to as a "black box" method of estimation due to the construct of the hurricane destruction index. As a robustness check to the main results and to account for another means of measuring the effects of hurricanes, I produce results from the hurricane wind index.

The structure of the hurricane wind index is described in equation 2 below:

$$WIND_{i,r,t} = \Big(\sum_{j=1}^{J} \int_{0}^{\tau} V_{jt}^{\lambda} w_{i,j,r,t} dv\Big) \text{if } V_{jt} > 119\text{km/h}(\text{SS} \geq 1) \text{ and zero otherwise} \qquad (2)$$

where V is given by equation (5) and represents the estimates of local wind speed at localities j. J is the set of localities j within county i, w are weights assigned according to population size of the county to capture the economic importance of a particular county under the premise that if counties with larger populations were to be hit by hurricanes, those impacts would be of greater effect than a county with a smaller population.

Population data for each county was gathered from the Florida office of Economic and Demographic Research. Since the analysis was conducted using quarterly data and there are no official records of county population for this time horizon, I used the annual population in each county for each year. Hence, each locality in each county was weighted by the population of the county in the particular year of the hurricane. Since the focus in the paper is at the county level, the distinctions at the level of localities is not paramount to the outcome of the study. The premise of this design is that the damage to a county with a larger population will be of greater economic significance than one with a small population. The shapefile used in the calculations did not contain any locality (centroid) specific information which could be used instead of population. Coupled with the lack of quarterly county data, the course of action taken here was the most appropriate. Strobl (2011) explored the option of both a weighted index and an unweighted. I explore both in this study. Recognizing the absence of data at the frequency of this study, I anticipate that the most appropriate means of applying the index would be the unweighted so as to not introduce any potential measurement errors into the study.

Finally, λ is a parameter that relates local wind speed to the local level of damage[6]. Table 4 below presents the wind index calculation for hurricane Andrew along with two key ingredients used in the index calculations, population and wind intensity. [7]

[6]Observing the work of Strobl (2009) and taking note of the application of the model within the United States by Strobl (2011) this was chosen to be a value of 3.17

[7]The strongest winds from Atlantic hurricanes are felt on the north eastern side of the hurricanes. As such, for Hurricane Andrew, Broward county, though with a lower population size than Miami-Dade had a larger index value.

Table 1: Counties Most Affected By Hurricane Andrew

Counties	Broward	Collier	Miami-Dade	Hendry	Lee	Monroe	Palm Beach
Index	1499.41	152.17	893.38	51.65	345.85	143.82	984.58
Max Wind (SS)	5	5	5	4	4	5	4
Population	1,255,488	152,099	1,937,094	25,773	335,113	78,024	863,518

Hurricane index is scaled by 10,000,000,000. Max wind is stated in categories of the Saffir-Simpson hurricane intensity scale.

Here, I modified the index to accommodate hurricanes below category 3 unlike Strobl (2009). This was done in order to classify all hurricanes that are pertinent to this study. The wind index has a lower bound of zero and no upper limit. The higher the index the greater the effect on the areas of focus. Economic interpretation for the index is gathered by multiplying the coefficient on our estimated effects by the sum of the index over time for all locations. The result produced indicates the effect of an average hurricane across the data set of interest.

4.3 Generalized Difference-in-Differences Approach

The primary estimation technique utilized in this paper is the Generalized Difference-in-Difference (GDD) estimation strategy, commonly known as the Two-Way Fixed effects model. This methodology is used due to the fact that the method uses multiple random control and treatment groups. Additionally, the GDD allows for comparisons to be made across multiple exogenous events and time periods (Belasen and Polachek, 2009).

There are two main reasons why previous estimates of the effect of hurricanes on local labor markets using the GDD may be biased. First, since the method proposed to identify which counties were affected by storms is narrow, it is likely that some of the counties that were selected as comparison units experienced hurricane force winds that would render them to be better classified as treated counties instead. Without addressing this issue, Belasen and Polachek (2009) potentially fell prey to one of the main problems that they set out to solve, the selection of appropriate comparison units. Second, it is unlikely that the effect of a hurricane on a county that neighbor to one directly hit by a category 4 or 5 hurricane is vastly different from the county that was hit directly. Based on the size of the average hurricane, which is approximately 500 km, and the position to the neighboring county, there is a great chance that the neighbor experiences similar wind speeds and levels of damage. There are a number of factors in a hurricane that affect the level of wind and rain exposure that an area experiences.

These range from the forward speed of the storm, location relative to the area of interest, to wind gust and most of all the peak intensity in the radius of maximum wind (Boose et al., 2004). If these factors are not taken into consideration, it may lead one to incorrect conclusions. Hence, if neighboring counties are experiencing hurricane force winds similar to "directly" affected groups of counties, this limits the extent to which spillovers could be identified, especially to the extent that the impact on the neighboring county is strictly opposite to the directly hit county. With the inability of land fall models or models which only look at small areas such as the area in the vicinity of the eye of the hurricane to capture these additional impacts, those results are potentially biased and the comparisons made between counties may thus not be accurate.

I also control for both quarter fixed effects and a modification to the previous literature of the inclusion of a regional dummy variable which is interacted with the quarter dummy variable. The interaction between the regional dummy variable and the quarter dummy variable is included to account for the seasonality in the labor markets in the state. Some regions, such as South Florida, are heavily affected by tourism and as such will respond different from regions such as Central and North Florida that may not see as much fluctuation in labor demand and supply throughout the year. Equations (3) and (4) present the models that are used to analyse the effect of hurricanes on Employment and Earning growth respectively. Specifically, I estimate the following two equations:

$$(\Delta lnQ_{it} - \Delta lnQ_t) = \alpha_{1R_i} + \alpha_2 \Delta H_{it}^D + \alpha_3 \Delta H_{ijt}^N + \epsilon_{it} \tag{3}$$

$$(\Delta lny_{it} - \Delta lny_t) = \gamma_{1R_i} + \gamma_2 \Delta H_{it}^D + \gamma_3 \Delta H_{ijt}^N + \epsilon_{it} \tag{4}$$

Q_{it} represents employment in county i at time t while y_{it} represents average earning per worker in county i at time t. The subscript i indicates an affected county while j indicates a county that was a neighbor to the directly affected county, i. R_i are the regional fixed effects. H_{it}^D represents the dummy variable which takes a value of 1 for county i that was hit by hurricane force winds from a hurricane in time t. H_{ijt}^N is a dummy variable which takes a value of 1 for a county j that was neighboring to a county i hit by hurricane force winds in time t from a hurricane. To further supplement the results from our binary estimation, I estimate equations (5) and (6) which display the models used for the estimation of the hurricane impact as measured by the hurricane wind index, our continuous measure.

$$(\Delta lny_{it} - \Delta lny_t) = \gamma_{1R_i} + \gamma_2 Index_{i,t} + \epsilon_{it} \tag{5}$$

$$(\Delta lnQ_{it} - \Delta lnQ_t) = \gamma_{1R_i} + \gamma_2 Index_{i,t} + \epsilon_{it} \tag{6}$$

5 Results

5.1 Aggregate Results

Reproducing the models from Belasen and Polachek (2009) with the wind field model, I obtain the results presented in table (2). Similar to the findings in the literature, my results indicate that hurricanes have a statistically significant and negative impact on employment growth in the counties where hurricane force winds were recorded. However, I find a negative and statistically significant effect on the employment growth in neighboring counties, contrary to the results in the previous literature. This negative but smaller effect is the anticipated result for neighboring counties. A county that neighbors one that experienced hurricane force winds, especially of strong intensity, is expected to still be negatively affected by the hurricane but not to the same degree. Thus, these estimates indicate that a directly affected county will experience a 1.44% decrease in employment growth relative to the average Florida county in the quarter that a hurricanes occurs while in the neighboring counties employment growth is reduced by 0.82%.

The extent of the hurricane's effect is lower when accounting for the variation in hurricane wind speeds than the effect estimated from the land fall model. In particular, the results differ by 93 percentage points for the directly affected county's employment effect relative to the findings of Belasen and Polachek (2009). Such an effect is not surprising due to the fact that the land fall model fails to account for the change in the hurricane intensity as the hurricane travels along its path. Accounting for the variation in the hurricane intensity using the measurement techniques described in this study reveals a major shortfall in previous estimations.

Using standard economic theory, one would anticipate an antagonistic response for employment and wages. The results here do not indicate a statistically significant impact on wages for neither the directly affected counties nor the neighboring ones. The prevailing argument in the literature suggests that the labor supply in the directly hit counties should fall as labor migrates to neighboring counties and thus result in an increase in earning growth for the directly affected. For the neighboring counties, the literature suggests that the labor force will rise due to migration and result in a fall in earning growth. As was revealed in table (2), my results do not provide support for this conclusion. The lack of growth in wages is potentially due to the fact that; the reduction in the labor supply is accompanied by a reduction in labor demand. Zhang et al. (2009) indicated a number of ways labor demand is impacted by hurricanes; infrastructural damage, establishments shutting down or downsizing in operation and the loss of ones customer base either temporarily because certain industries are not necessary in disaster situations or permanently due to displacement.

The resultant outcome of similar declines in labor supply and labor demand is a clearly defined reduction in employment growth but an insignificant impact on the wages that are paid in the event of such disasters. For neighboring counties in particularly, if hurricane damage sustained is similar, even if to a lesser degree, to the directly affected county, then those counties would not form appropriate locations to which one would desire to relocate. As the result observed in the case of employment growth for the directly affected counties were mirrored for the neighboring counties, the insignificant result presented for wage growth in the neighboring counties appears consistent.

Table 2: Aggregate Results (GDD)

Coefficients	ln(Employment)	ln(Earnings)
Direct	-0.0144***	0.0012
	(0.0041)	(0.0039)
Neighbor	-0.0082*	-0.0039
	(0.00451)	(0.0042)
R.sq.	0.07605	0.2345
n,group	4757,67	4746,67

Note: ***,**,* denotes significance at the 1%, 5%, and 10% level, respectively. Standard errors reported in parenthesis. Region fixed effects and region year-quarter interaction (not shown) are included in each model.

5.2 Intensity Results

When broken down into the two groups of hurricane intensities as shown in table 3, the results echo that presented in the literature for the most severe hurricanes. In addition, these results reflect the findings presented in table 2 when we consider the fact that in the case of severe hurricanes, the neighbors experience hurricane intensity coterminous with category 1-3 hurricanes. Particularly, we see that the results observed in the aggregate model were primarily driven by strong hurricanes (Categories 4-5). Strong hurricanes reduce employment while positively impacting earnings. It is evident that weaker hurricanes did indeed assuage the result obtained for hurricanes overall as presented in table 2. Table 3 shows a 4.9% decline in employment growth due to strong hurricanes while recording a 2.73% increase in wage growth for affected counties in the quarter when a strong hurricane hits. These results seem to indicate that labor demand and labor supply are impacted by the severe hurricane. However, the negative labor supply shock outweighs the negative labor demand shock resulting in a significant reduction in employment which by standard economic theory is followed by an increase in wage growth.

The group of counties that were impacted by hurricane winds between categories 1 and 3 include those that experienced wind speeds from strong hurricanes that fell within this range. This innovation was deemed necessary since many locations experienced hurricane force winds which would not be classified as category 4 or 5 but satisfied the condition for category 1 to 3 classification as the strong hurricane traveled along its path. Other forms of measurement such as the land fall model would ignore this dynamic which merits inclusion. The results indicate that experiencing hurricanes force winds of categories 1-3 will cause employment to fall by 0.91% relative to the average Florida county. The effect on wages was shown to be statistically insignificant. Similar to the results presented in table 2, the insignificant result for wage growth speaks to the fact that the hurricane leads to a reduction in both labor demand and labor supply, resulting in a statistically significant decline in employment with an insignificant impact on wage growth.

Due to the fact that there is overlap between the counties that would be classified as geographical neighbors to counties experiencing Category 4-5 wind intensity and those counties that experienced hurricane force wind between category 1 and 3 from the same storms, I was unable to explore the difference in neighboring effects by hurricane group for strong hurricanes. I however, produced results for neighbors of those counties which experienced category 1 to 3 winds but the results proved insignificant across both employment and wages.

Table 3: Hurricane Intensity Results (GDD)

Coefficients	ln(Employment)	ln(Earnings)
Category 4-5 Hurricanes	-0.04855***	0.0273***
	(0.0078)	(0.0073)
Category 1-3 Hurricanes	-0.0091**	-0.00004
	(0.0038)	(0.0035)
R.sq.	0.08279	0.2367
n,group	4757,67	4746,67

Note: ***,**,* denotes significance at the 1%, 5%, and 10% level, respectively. Standard errors reported in parenthesis. Region fixed effects and region year-quarter interaction (not shown) are included in each model.

5.3 Wind Index Results

The results using the wind index are reported in table (4). Looking at the table, one can see that the results are similar to that presented for the more severe hurricanes as shown in table 3, suggesting that the average hurricane in Florida will lead to a reduction in employment growth and an increase in wage growth. Particularly, the wind index results suggest that an average hurricane in the state of Florida will cause employment growth in the affected counties to fall by 0.85 percentage points and cause average wage growth to rise by 0.73 percentage points. As mentioned in section 4.2 in the description of the components of the hurricane wind index, the index is usually weighted by population characteristics in order to indicate economic relevance of a location when a hurricane strikes. The premise of this inclusion is the assumption that more populated locations will be of greater economic importance and as such, the effect of a hurricane would be greater in these locations. Though an important part of the index calculation, Strobl (2011) showed that index results without population weights are still valid. Since population data for the frequency of the study was not available at the time of this study, the index was estimated without population weights. The results of the index mirroring that of the strong hurricanes is not a surprise since the stronger hurricanes would produce both stronger winds and affect more locations significantly. These are factors that play a major role in the composition of the index.

Table 4: Wind Index (LSDV)

Coefficients	ln(Employment)	ln(Earnings)
Direct	-2.459e-07***	2.090e-07**
	(8.729e-08)	(8.152e-08)
Effect	-0.85	0.73
R.sq.	0.074	0.2354
n,group	4757,67	4746,67

Note: ***,**,* denotes significance at the 1%, 5%, and 10% level, respectively. Standard errors reported in parentheses. Quarter and region fixed effects (not shown) are included in each model. Index not weighted.

6 Conclusion

Applying the measurement strategy utilized in this paper to the same data as has been used in previous literature, I observe clear differences in the estimates gathered. Particularly, the results indicated no evidence of spillovers of labor from affected counties to neighboring counties. The result obtained in this study does not discredit the possibility that migration does indeed occur subsequent to a hurricane. This is in fact documented in the literature (Strobl, 2011; Brown, 2006; Zhang et al., 2009). However, what we observed here indicates that over the time horizon of this study, there is no movement of labor that impacts labor markets in counties that are geographically next to counties that bear the brunt of hurricanes. This finding is a significant deviation from the literature as Belasen and Polachek (2009) identified a decrease in earnings in neighboring counties up to 4.51 percent due to the effects of migrating labor in response to hurricanes. Considering that the spatial effects of hurricanes are not known to be confined to the geographical space withing 30 km of the eye of the hurricane only, I hypothesized that carefully accounting for the hurricane intensity over the life of the hurricane would produce results that showed similar effects in neighboring counties as the directly affected counties. This hypothesis was confirmed as the neighboring employment growth decreased similar to the directly affected county, only differing in the magnitude of the effect as one would expect. Wage growth in neighboring counties proved to reflect the directly affected counties similar to employment. If the locations are close enough to be neighbors, then the effects will not deviate significantly between them. The differences in the findings between this study and the previous literature was anticipated based on the findings of Strobl (2011) who highlighted that land fall models would be insufficient to develop conclusions regarding the impact of hurricanes on directly hit counties and neighboring counties in particular.

The insignificant effect on wage growth is a particularly interesting result. The result indicates that the effect of hurricanes cannot be classified solely as a matter of labor supply but must also be viewed through the lens of labor demand as well. The results suggest similar to the findings of Zhang et al. (2009) that establishments face destruction from hurricanes. The damage sustained in some cases takes time to repair and in others, establishments may shut down. This causes the labor demand curve to shift to the left along with the labor supply curve. The inward shift of both curves results in a reduction in the level of employment in the affected locations while wage growth is unaffected.

The severity of the hurricane seems to play an important part in the determination of the impact hurricanes have on labor markets. Stronger hurricanes adhere to the literature and support the findings of Belasen and Polachek (2009) who along with Strobl (2011) and Brown (2006) suggest that labor supply is the primary source of the labor market disruptions.

In this study I utilize a model of hurricane intensity to estimate the effect of hurricanes on labor markets in the state of Florida. The method utilized in this paper ensures that the variability in the intensity of a hurricane as it travels along its path is accounted for. As such, I was able to capture a more precise measure of each hurricane's labor market impact over the period of interest. Particularly, the results were consistent with expectation as I found that counties that shared borders with counties directly impacted by hurricanes will experience similar effects except in the case of major hurricanes. Specifically, where the neighboring counties saw insignificant wage growth, the directly affected counties saw positive and significant growth in wages. This study speaks volumes of models which account for hurricane intensity variability and reveals the importance of the use of such models in future work capturing the effect of hurricanes.

Overall, the result of this paper suggest that the effects of hurricanes will primarily be felt through employment wither by way of labor demand or labor supply. As hurricanes remain a constant threat to the state of Florida and other coastal states, the result which suggests that labor from the affected counties do not indeed spillover to other counties in a manner which impacts the neighboring labor market is a cause for concern. If the affected population does not indeed move and secure jobs after the hurricane, then at least in the short run, there is a portion of the affected population that the previous literature suggested would assimilate into another labor market who will be without work. This challenge calls for policy makers, especially in the event of major hurricanes to consider programs to assist displaced workers and affected establishment to maintain employment flows after hurricanes. Of particular interest for future work given the findings of this study, is the source of the labor market effects that we observe. From this study and previous literature, both labor demand and labor supply have been put forward as reasons but to what extent can one credit either and in what circumstances would either be more dominant? This finding will assist in understanding whether aid programs after hurricanes should be directed to commercial entities or residential. This study present an interesting dynamic and impetus for future exploration of the effects of hurricanes which can be extended even to other coastal states.

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7 Appendix

Table 5: Hurricanes

Hurricane	Year	Intensity (SS)	No. Counties
Hugo	1989	1-3	3
Andrew	**1992**	**4-5**	**7**
Erin	1995	1-3	37
Opal	1995	1-3	8
Danny	1997	1-3	2
Earl	1998	1-3	5
Georges	1998	1-3	4
Irene	1999	1-3	11
Floyd	1999	1-3	11
Charley	**2004**	**4-5**	**15**
Frances	2004	1-3	20
Ivan	2004	1-3	5
Jeanne	**2004**	**4-5**	**5**
Wilma	**2005**	**4-5**	**9**
Katrina	2005	1-3	7
Rita	2005	1-3	1
Dennis	2005	1-3	17

Hurricanes organized in chronological order.