Twister:

Untangling the Effects of the CDBG-DR Grant on Joplin, MO

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Submitted in Partial Fulfillment of the Requirements for the Degree of Bachelor of Arts in Mathematical Methods in the Social Sciences

June 14, 2021
Abstract

On May 22, 2011 an EF-5 tornado hit Joplin, Missouri, causing approximately $3 billion in damage. This paper analyzes the economic impact of the tornado and the Community Development Block Grant – Disaster Recovery (CDBG-DR) administered by HUD to facilitate recovery. The paper finds little evidence of major lasting economic impact of the disaster or subsequent HUD funding on unemployment or wage rates, despite seeing a temporary rise in homelessness and an increase building permit requests for reconstruction.
Acknowledgements

I would like to thank Professors Eric Auerbach, and Professor Joseph Ferrie for their invaluable guidance as this thesis project took its many twists and turns. I would also like to thank Nicole Schneider for answering all of my questions and last-minute emails, and for her help navigating this process. Lastly, I would like to thank my family for raising me in a loving environment that always encourages asking more questions and my friends for their unending support.

I could not have done it without you.
Table of Contents

Introduction ........................................................................................................................................... 5
Background ........................................................................................................................................... 7
  CDBG-DR ........................................................................................................................................ 7
  The 2011 Tornado ........................................................................................................................... 8
Literature Review ................................................................................................................................. 9
  Disaster Recovery............................................................................................................................ 9
  CDBG-DR ........................................................................................................................................ 9
  Joplin Tornado ............................................................................................................................... 10
Data Collection .................................................................................................................................... 11
  CDBG-DR Spending Data ............................................................................................................... 11
  Joplin Mo, Annual Budget Data ..................................................................................................... 12
  Housing Prices .............................................................................................................................. 12
  Unemployment ............................................................................................................................. 13
  Average Wage .............................................................................................................................. 13
  Homelessness ............................................................................................................................... 14
  Building Permits ........................................................................................................................... 14
Estimation Strategy .............................................................................................................................. 14
  Monthly Data ............................................................................................................................... 14
  Annual Data ................................................................................................................................... 15
Results .................................................................................................................................................. 16
  Unemployment Rate .................................................................................................................... 16
  City Budget ................................................................................................................................... 17
  Homelessness and Building Permits ............................................................................................ 18
  Average Weekly Wage ................................................................................................................... 19
  Home Values ............................................................................................................................... 19
Discussion & Conclusion ...................................................................................................................... 20
Works Cited .......................................................................................................................................... 23
Appendix .............................................................................................................................................. 25
  Tornado’s Path .............................................................................................................................. 25
  Homelessness Data Breakdown ..................................................................................................... 25
Introduction

Since 1980, there have been 291 weather and climate disasters with Consumer Price Index (CPI)-adjusted damages exceeding $1 billion, leading to a total of over $1.9 trillion in damage.¹ These disasters are becoming alarmingly more frequent. Just 29 were reported in the decade of the 1980s, whereas 22 were reported in 2020 alone. In the cases of large-scale disasters, it is usual, if not expected, that the federal government step in to provide financial and material support to the effected regions. Between 2005 and 2014, approximately $255 billion was spent by federal organizations in disaster aid and the costs are expected to climb in coming years with the increase in costly disasters.²

With the rising costs and frequency of disasters, it is critical that the federal government properly allocate its disaster relief funds in order to achieve its goals and provide maximum positive impact. While a majority of federal spending is provided by the Federal Emergency Management Agency (FEMA), other organizations have provided roughly 43% of total spending. Of the spending by other organizations, the Department of Agriculture has been the largest (14% of total spending) and the US Department of Housing and Urban Development (HUD) was the next largest (10.5%).³

A major program administered by HUD is the Community Development Block Disaster Recovery (CDBG-DR) program. The program requires special appropriation from Congress and has the stated goal of providing “flexible grants to help cities, counties, and states to recover

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³ “Federal Disaster Assistance Goes Beyond FEMA.”
from Presidentially declared disasters, especially in low-income areas.”

The fund can be used for a variety of re-building activities and is used at a city or state’s discretion, subject to HUD approval. (Read more in Background.)

On May 22, 2011, an EF-5 (the most severe possible rating) tornado passed through Joplin, Missouri. The tornado ripped through the city, causing roughly $3 billion in damage and taking over 150 lives, making it the deadliest and most costly tornado in the US since 1950. The principal of the local high school called the damage “total devastation” and reminiscent of World War II bombings. President Barack Obama amended an existing Disaster Declaration to include the areas affected and subsequently FEMA began providing support. In 2013, HUD received a congressional appropriation to provide financial support to Joplin, and began spending funds that October, roughly 29 months after the tornado struck the city. This thesis aims to analyze the economic impact of the May 22 tornado and the subsequent effectiveness of the CDBG-DR funding provided by HUD to the city. A number of factors make the May 22nd tornado an ideal event for analysis. That it was the deadliest and costliest tornado on record and was extremely localized maximizes the likelihood of finding economic impacts of the disaster. Additionally, unlike most other disasters warranting CDBG-DR grants, the grant was not given to the state in addition to local government. This is a factor that would cloud the ability to analyze trends in impacted regions and lead to a possible underestimation of the grant’s usefulness.

Despite the significant described carnage, and the tornado displacing over a thousand people, almost no significant long-term economic impact of the disaster or the CDBG-DR funding can be found. Looking at employment trends, including wage and unemployment data, no statistically significant effect of the disaster is able to be quantified. Though homelessness

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and construction did peak immediately after the disaster and then return toward their pre-disaster levels, the city budget was not directly correlated to CDBG-DR funding, suggesting the grant may not have impacted the community to the degree designed.

Background

CDBG-DR

The Community Development Block Grant Disaster Recovery Program (CDBG-DR) is a program administered by the U.S. Department of Housing and Urban Development (HUD) in response to select extreme disasters. The Community Development Block Grant was established by the Housing and Community Development (HCD) Act of 1974 with the stated goal of “the development of viable urban communities, by providing decent housing and a suitable living environment and expanding economic opportunities, principally for persons of low and moderate income.”5 As such, the CDBG-DR is subject to requirements from the HCD including requirements related to housing. Unlike other disaster relief programs, the CDBG-DR cannot be requested by states or local governments. Rather, the CDBG-DR is not permanently authorized, and Congress has the option each year whether or not to appropriate HUD with funding for it. If Congress provides HUD with the supplemental appropriation, HUD will notify eligible states, cities, and/or counties of their eligibility for CDBG-DR funds. Typically, funds are stipulated to be limited to areas covered under a Presidential Major Disaster Declaration pursuant to the Stafford Act of 1988. In order for an area to receive a Major Disaster Declaration the Governor must apply within 30 days of the occurrence of the disaster and typically must provide estimates

indicating significant damage occurred during the period.\textsuperscript{6,7} CDBG-DR grants may be used for a broad range of recovery activities. Typically, fund usage falls into one of four categories: Housing Activities, Voluntary Purchases of Properties, Economic Development, and Public Facilities Improvements.\textsuperscript{8} Fund usage is subject to HUD oversight and approval.

The 2011 Tornado

On May 22, 2011 an EF-5 tornado ripped through Joplin, Missouri. EF-5 is the highest ranking on the Enhanced Fujita Scale, representing 3-second gusts with wind speeds greater than 200 miles per hour.\textsuperscript{9} The tornado resulted in 161 deaths and over one thousand injuries, making it the deadliest tornado in the U.S. on the official record. Additionally, the tornado damaged roughly 8,000 residential and business structures, resulting in nearly $3 billion in damage.\textsuperscript{10} This damage made the May 22\textsuperscript{nd} tornado the costliest tornado on record as well. The tornado tracked east to west across the city, traveling roughly 13 miles through Joplin and surrounding rural counties.\textsuperscript{11} (See Appendix for Map)

\textsuperscript{10} kristy.thompson@nist.gov.
Literature Review

Disaster Recovery

Research demonstrates the importance of governmental intervention. Deryugina\textsuperscript{12} shows that there is a significant increase in non-disaster-related governmental aid to regions after natural disasters. Though she exclusively studied hurricanes, she found that over the ten years following a disaster, the increase in non-disaster-related relief through programs such as unemployment insurance and public medical payments can outweigh the actual per-capita federal disaster-relief more than fivefold. She notes that this can lead to a significant underestimation of the fiscal costs of disasters. Noy\textsuperscript{13} analyzes the impact of natural disasters across countries. Looking at GDP growth in a regression, he found that the impact of a one-standard deviation increase in direct damages to a developing country is \(\sim9\%\), but it is only \(\sim1\%\) for developed countries. This suggests the importance of institutions to disaster recovery. Hallegate and Pryzuls,ki\textsuperscript{14} in a working paper, noted the difficulty in obtaining the true cost of a disaster and that calculations often fail to include all indirect costs.

CDBG-DR

Martín et. al.\textsuperscript{15} analyzed CDBG-DR grants provided between 2005 and 2015 and determined that grants took an average of 3.2 years to be completed after funds were appropriated by Congress. Martín et. al. noted that a number of factors cause this delay including

regulatory reporting requirements and challenges collaborating with federal agencies. McDonnell et. al.\textsuperscript{16} conducted an analysis of the implementation of the CDBG-DR grant after Hurricane Sandy. Using a series of probability analyses they note that as the size of an area impacted by a storm increases, the probability of a given area being targeted as low- and moderate- income (LMI), and thus prioritized in the provision of CDBG-DR funds, drops. In response, they suggest using quantitative metrics to determine which areas qualify as LMI.

**Joplin Tornado**

Studies have come to contradictory conclusions regarding the role of government in the response to the Joplin disaster. In his doctoral dissertation, Joseph Richmond\textsuperscript{17} conducted a qualitative analysis of the federal government’s response to the disaster, primarily using information from interviews of residents of Joplin at the time of the tornado and of those involved in agencies leading the recovery. Richmond made a number of key findings based on the interviews, including that policy was essential for recovery. He stated, “If policies and programs are not in place to prevent population losses following a disaster or are at the very least existing policies are not flexible enough to prevent population losses following a disaster, then an affected area will lose population and economic recovery will be inhibited.” An article by Smith and Sutter\textsuperscript{18} published in *The Independent Review*, a peer-reviewed quarterly published by libertarian think tank The Independent Institute, disagrees. Smith and Sutter also conducted interviews with Joplin residents, and determined that the federal government largely played a


subsidiary role. They noted that one FEMA official, surprised to see the roads had already largely been cleared prior to FEMA’s arrival, asked rhetorically “Does everybody in Joplin own a chainsaw?” Smith and Sutter conclude that the volunteer-sector response, in conjunction with the local government’s actions, was primarily responsible for the recovery of the region. Paul and Stimers\textsuperscript{19} noted that a higher percentage of fatalities occurred in business structures than would be expected. This suggests a higher degree of damage to businesses than occurs in an average storm, which may be thought to negatively impact employment rates in the region. No papers analyzing the impact of the CDBG-DR grant on disaster recovery in Joplin, MO were found, and a majority of studies looking at the economic impact of disaster relief funding used qualitative interviews. As such, this paper will add to the field by using exclusively quantitative analysis to estimate the impact of the Joplin tornado and the subsequent CDBG-DR grant.

Data Collection

CDBG-DR Spending Data

HUD requires areas receiving CDBG-DR funds to provide quarterly updates on the amount of funding drawn down from the account as well as how much was actually spent in the past quarter, among other metrics. The grantee must provide the Quarterly Reports in a fashion accessible to the public.\textsuperscript{20} The Joplin municipality provides the reports for public access in PDF format on its website. Since Joplin received funding through two separate congressional allocations, it must provide separate quarterly updates for both grants. For the analysis described


in this paper, “Total Funds Expended to Date” were collected from all available reports, inserted into a spreadsheet, and summed per quarter. When necessary, the assumption was made that spending was equal during all three months covered in the quarter. “Total Funds Expended” was preferred to “Total Drawdown” as it reflects the sum flowing from the grant into the economy rather than a reallocation of funds.

Joplin, MO, Annual Budget Data

Annual budget data was collected from Joplin’s website. Adopted Budgets are available beginning in the 2005 fiscal year in PDF formats. Joplin’s fiscal year begins in November (e.g., FY2006 represents the fiscal year starting November 1, 2005 and ending October 31, 2006). The same pattern holds for all other years. As a majority of a fiscal year occurs during the corresponding calendar year, for the purpose of regression and data collection, the fiscal year budget was assigned to its corresponding calendar year.

Housing Prices

Housing prices were obtained from the Zillow Home Value Index (ZHVI). The ZHVI relies on Zillow’s proprietary home-value estimates, called “Zestimates.” ZHVI values do not determine the median home value, but rather the “typical” home value of a region. Notably, the ZHVI uses data from all houses in a market rather than just those recently sold or appraised.21 The ZHVI uses monthly Zestimate data, denoted \( z_{i,t} \) and \( z_{i,t-1} \), that measure a given house’s value in the given month and the previous month. The ZHVI calculates appreciation/depreciation in market prices using a weighted average of a home’s appreciation and the home’s weight

\[
A_t = \sum_{i=1}^{N} w_{i,t-1} a_{i,t}. \]

where \( A_t \) is a market’s appreciation during time \( t \) and \( a_{i,t} \) is a house

Zestimate’s appreciation between period $t - 1$ and $t$ such that $a_{t,t} = \frac{z_{t,t-1}}{z_{t,t-1}}$. Weights $w_{t,t-1}$ are calculated by dividing a house's Zestimate in the previous period by the Zestimate of other houses in the region. The ZHVI also is seasonally adjusted and smoothed. Zillow provides ZHVI data for three tiers of houses, those falling in a region’s 5th and 35th, 35th and 65th, and 65th and 95th percentile of estimated value.\(^{22}\) Data was available for all three tiers for Joplin’s 64804 Zip code region, which encompasses the Southern portion of the city.

**Unemployment**

The unemployment rate data for Joplin was downloaded from Federal Reserve Economic Data (FRED) from the St. Louis Federal Reserve. Data was downloaded in its Not Seasonally Adjusted form, from January 1990 to the present. The data comes from the US Bureau of Labor Statistics (BLS) Local Area Unemployment Statistics program (LAUS). LAUS estimates are produced using disaggregation techniques using inputs from the American Community Survey, annual population estimates, and state unemployment insurance claim information.\(^{23}\)

**Average Wage**

Average weekly wage data was obtained on the month level from FRED’s “Average Weekly Earnings of All Employees: Total Private in Joplin, MO (MSA).” The data was sourced from BLS’s Current Employment Statistics (CES) program, which sources its data from surveys of roughly 140,00 businesses across the country.\(^{24}\) Data was downloaded in its monthly, Not Seasonally Adjusted format beginning in 2007.

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Homelessness

Figures on the number of homeless in the Joplin area come from HUD’s Continuum of Care (CoC) Homeless Assistance Programs Homeless Populations and Subpopulations Reports. These reports are based on Point-in-Time (PIT) count data collected by organizations applying to join the CoC program. These PIT data are based on a count of all homeless (both sheltered and unsheltered) during a single night during one of the last ten days of January.

Building Permits

Building Permit information was obtained over email from Joplin’s Chief Building Official. Aggregate totals per year of residential permits were obtained beginning 2007. Data on each permit applied for was provided beginning in 2011.

Estimation Strategy

Monthly Data

For outcome variables whose data was available on a monthly basis, a series regression strategy was employed. Since data collected was on a single entity (Joplin, MO), and there is an expectation that outcome variables would change over time regardless of disasters, a series regression, allowing for nonlinear time trends was used. The following model was primarily used in these estimations:

\[ Y = \beta_0 + \beta_1 PostDisaster + \beta_2 PostSpend + \beta_3 SpentSmoothed + \beta_4 Time^1 + \ldots + \beta_8 Time^5 + \varepsilon \]

---

PostDisaster is a dummy variable indicating that the period falls between June 2011, the first month after the Tornado hit and prior to October 2013, when the first substantive CDBG-DR spending occurred. PostSpend is a dummy variable indicating the period falls after October 2013, when the first substantive CDBG-DR spending occurred (prior to which, less than $8,000 had been spent). SpentSmoothed is a continuous variable indicating the dollar amount spent of CDBG-DR funds during a given month. (Using the assumption that an even number of dollars were spent during each month of a quarter.) Time^n are variables allowing for both linear and polynomial time trends. Time is measured in months after December 1989.

Annual Data

For outcome variables only available with annual data (e.g. annual budget, homelessness PIT count), a simpler estimation model was used. To analyze the impact of CDBG-DR spending on Joplin’s city budget, model 2) was used. This model allows for the direct impact of CDBG-DR spending on budget decisions, accounting for linear annual budget growth.

2) \( Y = \beta_0 + \beta_1 \text{AnnualCDBGSpent} + \beta_2 \text{Year} + \epsilon \)

AnnualCDBGSpent is a continuous variable denoting the total number of CDBG-DR dollars spent in the given year in Joplin, summed from both CDBG-DR grants. Year denotes the year of reference and is used to account for time trends.

In analyzing homelessness and building permit data, model 3) was used in order to account for immediate impacts of the storm.

3) \( Y = \beta_0 + \beta_1 \text{AnnualCDBGSpent} + \beta_2 \text{Year} + \beta_3 \text{PostDisaster} + \beta_4 \text{PostSpend} + \epsilon \)

PostDisaster indicates that the relevant year includes time after the disaster but does not include time when CDBG-DR funding was being dispersed. (Since some metrics are measured
as of January, and others include whole year data, it varies whether \textit{PostDisaster} indicates 2011 and 2012 or 2012 and 2013). \textit{PostSpend} indicates that the relevant year is after (and not including) the years \textit{PostDisaster} is on.

\textbf{Results}

\textbf{Unemployment Rate}

Utilizing model 1) no statistically significant effects were measured of the tornado or CDBG-DR funding. Below, and in all charts in this paper, the red line indicates the date (or year) the tornado hit Joplin and the green line depicts when the first major CDGB-DR funding was spent.

Utilizing the model, there were no statistically significant coefficients. In fact, the results from the regression, which must be discounted due to their high p-values went against what would be expected, with the disaster negligibly lowering the unemployment rate and funding minimally raising it.
<table>
<thead>
<tr>
<th>Unemployment</th>
<th>Estimate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>4.718e+02</td>
<td>0.292</td>
</tr>
<tr>
<td>PostDisaster</td>
<td>-1.283e-01</td>
<td>0.698</td>
</tr>
<tr>
<td>PostSpend</td>
<td>1.020e-01</td>
<td>0.832</td>
</tr>
<tr>
<td>Time</td>
<td>-5.977e+00</td>
<td>0.318</td>
</tr>
<tr>
<td>Time²</td>
<td>2.873e-02</td>
<td>0.337</td>
</tr>
<tr>
<td>Time³</td>
<td>-5.877e-05</td>
<td>0.378</td>
</tr>
<tr>
<td>Time⁴</td>
<td>3.344e-08</td>
<td>0.571</td>
</tr>
<tr>
<td>Time⁵</td>
<td>2.302e-11</td>
<td>0.217</td>
</tr>
</tbody>
</table>

City Budget

Utilizing the estimation strategy outlined in model 2) the impact of CDBG-DR fund disbursement on the estimated city budget of Joplin was analyzed. The model found no statistically significant correlation between CDBG-DR fund disbursement during a given year and that year’s infrastructure budget or total budget (of infrastructure and capital expenditures).
Homelessness and Building Permits

Utilizing a cumulative count of homeless individuals in Joplin, including those sheltered and unsheltered as the outcome variable, regression model 3) was run. Additionally, model 3) was used to run a separate regression to analyze the total number of residential building permits applied for each year by Joplin residents. Results are listed below:

<table>
<thead>
<tr>
<th></th>
<th>Homelessness</th>
<th>Building Permit Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>P-value</td>
</tr>
<tr>
<td>Intercept</td>
<td>1.193e+04</td>
<td>0.86935</td>
</tr>
<tr>
<td><strong>PostDisaster</strong></td>
<td>8.494e+02</td>
<td><strong>0.00536</strong></td>
</tr>
<tr>
<td>PostSpend</td>
<td>-9.653e+00</td>
<td>0.97930</td>
</tr>
<tr>
<td>Year</td>
<td>-5.752e+00</td>
<td>0.87340</td>
</tr>
<tr>
<td>AnnualCDBGSpent</td>
<td>-1.595e-06</td>
<td>0.84787</td>
</tr>
</tbody>
</table>

Only the PostDisaster variable (indicating 2012 and 2013 for Homelessness and 2011 and 2012 for Building Permit Applications) was rendered significant results at the .05 confidence level. This suggests the disaster was responsible for roughly an 869 person increase in homelessness. The majority of this increase was driven by those in Emergency Sheltered Housing, which increased approximately 1085% between the 2011 and 2012 count. (See Appendix for further regression-based breakdown and charts of the homeless population.) Additionally, the PostDisaster variable indicates a 2,390 increase in the number of permit applications filed was caused by the tornado. The average number of permit applications in prior years (2007-2010) was just 640 per year. (See Appendix for an analysis of permit value spending and graphs depicting number and value of permit applications.)
Average Weekly Wage

Utilizing model 1) no statistically significant impact of the disaster on weekly wage could be measured, however statistically significant coefficients (at the $p<.01$ level) on the $Time^1, Time^2, Time^3,$ and $Time^4$ were estimated.

(Full weekly wage results can be found in the Appendix.)

Home Values

Utilizing model 1) there was a large statistically positive coefficient on PostSpend $(6.192e+03, p<.01)$ when looking at “typical home” values (those in the 35th to 65th percentile). However, when the model was adapted to include CurrentCDBGSpend during the month, the model estimated a coefficient on CurrentCDBGSpend of $6.672e-04$ ($p<.05$), which implies an additional dollar of CDBG funding may have raised typical house prices by .07 cents. Additionally, it appears that home values were on the rise prior to the first major CDBG-DR spending in the graph below.
Discussion & Conclusion

This paper found minimal evidence of long-term impacts of the 2011 tornado in Joplin, MO. After noting that neither the tornado nor the CDBG-DR recovery grant significantly affected the unemployment rate, we sought to determine through which levers the tornado and CDBG-DR grants affected the local economy in the short- and long-term. Not surprisingly, the most direct effects were seen through the impact on people’s destroyed houses. Residential permit applications increased roughly 12-fold between 2010 and 2011, with at least 400 permits directly requesting permission to repair or rebuild. Interestingly, it was hard to find a statistically significant impact of the storm on home prices, though the Top Tier homes did suffer a statistically significant drop of roughly $2,765 ($p < .05$). Homelessness did increase drastically, though the major increases were in Emergency/Traditional housing and there was no major increase in the number of people with no shelter. This can be viewed as a testament to the City of
Joplin’s response as well as that of FEMA that residents displaced by the storm were able to find shelter, even before Congress appropriated funds to HUD that in turn would be provided to Joplin. (The count occurred ~6 months after the storm.) However, the CDBG-DR grant, which began providing funding roughly 29 months after the disaster, did not seem to have much impact. No statistically significant change in average wages or unemployment could be measured as having resulted from the tornado or CDBG-DR grant, and the grant could not be shown to significantly impact local government budgeting (though this is likely partially due to the small sample size).

This paper suffered from a couple of notable limitations that warrant further analysis in the future. First, it did not account for FEMA and other federal disaster aid, as well as aid that could come through NGOs and other non-official pathways. This aid may be responsible for the lack of major long-term economic effects caused by the tornado. Since a disaster declaration was extended to the Joplin area the day after the storm and aid was rendered almost immediately, it is very difficult to determine what short- and long-term impact on the economy the tornado would have had if no government aid had been provided. However, as the CDBG-DR grant took roughly 29 months to begin dispersals, the additional impact of this grant can be estimated. Second, the belief in forthcoming aid may have influenced Joplin residents’ behaviors. Perhaps the belief a CDBG-DR grant was on its way led some people to apply for building permits or led businesses continue employing workers. Not accounting for this possibility may have led to underestimating the true impact of the grant. Another possible area for study would be an analysis of the building permits to determine how building patterns shifted in 2011 and subsequent years to determine which subgroup of the population, if any, was most impacted by the grant.
This paper is in no means intended to argue that government aid should not be provided after disasters, but that it is important that the aid is provided strategically, and further analyses of aid programs’ impacts are conducted.
Works Cited


Appendix

Tornado’s Path

Aerial photograph depicting the tornado’s path (from West to East)
Source: https://www.noaa.gov/photo-story-americas-deadliest-year-for-tornadoes-2011

Homelessness Data Breakdown

Regression 3) was used to individually analyze the impact of the tornado and recovery aid on different homeless populations. Specifically, we analyzed the number of homeless in Traditional Housing, Emergency Housing, and those unsheltered (using HUD’s Continuum of Care count definitions).

<table>
<thead>
<tr>
<th></th>
<th>Emergency Housing</th>
<th></th>
<th>Traditional Housing</th>
<th></th>
<th>Unsheltered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>P-value</td>
<td>Estimate</td>
<td>P-value</td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
<td>1.856e+03</td>
<td>0.97942</td>
<td>1.669e+04</td>
<td>0.0768</td>
<td>-6.618e+03</td>
</tr>
<tr>
<td>PostDisaster</td>
<td>8.042e+02</td>
<td>0.00706</td>
<td>8.790e+01</td>
<td>.0120</td>
<td>-4.268e+01</td>
</tr>
<tr>
<td>PostSpend</td>
<td>6.786e+01</td>
<td>0.85442</td>
<td>-1.905e+01</td>
<td>0.6704</td>
<td>-5.847e+01</td>
</tr>
<tr>
<td>Year</td>
<td>-8.816e-01</td>
<td>0.98037</td>
<td>-8.204e+00</td>
<td>0.0801</td>
<td>3.333e+00</td>
</tr>
<tr>
<td>AnnualCDBGSpent</td>
<td>-3.775e-07</td>
<td>0.96349</td>
<td>-1.270e-06</td>
<td>0.2195</td>
<td>5.302e-08</td>
</tr>
</tbody>
</table>
The regression implies that roughly an 804 person increase in those requiring emergency housing and a nine person increase in those in traditional homeless housing was caused by the tornado. Luckily, there was no significant increase in the number of unsheltered homeless caused by the tornado. Below is a plot of the homeless population (with green diamonds representing Emergency Sheltered, blue triangles representing traditional housing, and red stars representing unsheltered).

**Building Permits**

Below are two graphs, one of the number of building permits applied for each year from 2007-2020, and one the total value of the building permits applied for during each of those years. The vertical red line demarcates 2011, the year the tornado hit, and the vertical green line demarcates 2013, the year CDBG-DR funds began flowing into the community.
Below are regression results using model 3) to estimate the impacts of the disaster and recovery on total value of residential housing permits applied for during a year.

<table>
<thead>
<tr>
<th>Total Permit Values</th>
<th>Estimate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-3.049e+09</td>
<td>0.423304</td>
</tr>
<tr>
<td>PostDisaster</td>
<td>7.284e+07</td>
<td>0.000132</td>
</tr>
<tr>
<td>PostSpend</td>
<td>7.289e+06</td>
<td>0.646811</td>
</tr>
<tr>
<td>Year</td>
<td>1.527e+06</td>
<td>0.420793</td>
</tr>
<tr>
<td>AnnualCDBGSpent</td>
<td>-1.094e-01</td>
<td>0.762152</td>
</tr>
</tbody>
</table>

The disaster led to roughly $72.8 million increase in the value of housing applications in 2011 and 2012.

**Average Weekly Wage**

A regression using model 3) was run to estimate the impact of the disaster and CDBG-DR funding on average weekly wages.

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bottom Tier (5th to 35th percentile)</td>
<td>Middle Tier (35th to 65th percentile)</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Estimate</td>
<td>P-value</td>
</tr>
<tr>
<td>Intercept</td>
<td>6.790e+06</td>
<td>&lt;2e-16</td>
</tr>
<tr>
<td>PostDisaster</td>
<td>-1.849e+02</td>
<td>0.5566</td>
</tr>
<tr>
<td>PostSpend</td>
<td>8.020e+02</td>
<td>0.0807</td>
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<tr>
<td>CurrentCDBG Spend</td>
<td>7.948e-05</td>
<td>0.2112</td>
</tr>
<tr>
<td>Time</td>
<td>-9.069e+04</td>
<td>&lt;2e-16</td>
</tr>
<tr>
<td>Time²</td>
<td>4.536e+02</td>
<td>&lt;2e-16</td>
</tr>
<tr>
<td>Time³</td>
<td>-9.986e-01</td>
<td>&lt;2e-16</td>
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</tbody>
</table>

No significant impacts were found.

**Home Values**

Using the regression model described in the Home Values results section, individual regressions were run on the Bottom Tier, Middle Tier, and Top Tier homes in the 64804 Zip Code area of Joplin. The results are described below.
Below are graphs depicting the Bottom and Top Tier housing price estimates.

<table>
<thead>
<tr>
<th>Time^4</th>
<th>8.098e-04</th>
<th>&lt;2e-16</th>
<th>3.917e-04</th>
<th>0.09382</th>
<th>1.845e-03</th>
<th>3.48e-12</th>
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</thead>
<tbody>
<tr>
<td>Time^5</td>
<td>2.212e-08</td>
<td>0.2122</td>
<td>5.436e-08</td>
<td>0.45157</td>
<td>8.512e-08</td>
<td>0.2495</td>
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</tbody>
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