Modeling Flood Insurance Claim Payouts

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Abstract

The flood insurance program in the US is managed by Federal Emergency Management Agency through the National Flood Insurance Program. In this article, we review the claims filed during the period 1970 - 2019, and examine how the claims payments can be modeled. We look at the claims both at a global level and at an individual event level. We suggest an approach to model the payout coverage ratio and show that the log-normal distribution provides a reasonable option to model the payments between 0% and 100% of the total policy coverage levels.

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1 Introduction

This article provides an introduction to flood insurance claims filed in the United States. The flood insurance program in the US is managed by Federal Emergency Management Agency (FEMA) through the National Flood Insurance Program (NFIP). The management of individual policies is done via a network of approx. 60 insurance companies and NFIP Direct [1]. In this article, we review the claims filed during the period 1970 - 2019, and examine how the claims payments can be modeled.

We look at the claims both at a global level and at a discrete event level. While an individual property can experience flood damage due to several reasons (regular rainfall, hurricane related rainfall, riverine or coastal flooding, etc.), large scale flood damage is generally caused extreme weather events such as hurricanes or heavy rainfalls causing rivers to overflow. In this article while analyzing discrete events, we will focus on individual hurricane related events.

While the examples and website references provided in this article are US-centric, the ideas presented herein are general and can be applied to all locations. In other regions and countries, the analyst will need to substitute the appropriate data sources for flood insurance claims data.

2 Data Sources

NFIP provides excellent summary level data as downloadable spreadsheets on their website [2]. More detailed data-sets are available from OpenFEMA website [3]. The analysis presented in this paper rely primarily on two datasets:

- OpenFEMA Dateset: Disaster Declarations Summaries - v2 [4]. This dataset provides the dates associated with individual declared disasters.
- OpenFEMA Dateset: FIMA NFIP Redacted Claims - v1 [5].

The datasets from OpenFEMA are in *csv* format and can be easily processed using statistical software. OpenFEMA also provides detailed descriptions of the data fields on their website. Note that FEMA and the Federal Government cannot vouch for the data or analyses derived from these data after the data have been retrieved from the Agency's website(s) and/or Data.gov.

The FIMA NFIP Redacted Claims dataset [5] provides the details of each individual claim filed. However, it does not associate the claim with any specific disaster event (such as a hurricane or severe flooding). The disaster event information is available from the Disaster Declarations Summaries dataset [4]. We combine the two dataset by linking the County and date of loss of the claim in the Claims dataset to the county and incident begin/end dates from disaster declaration dataset. We recognize that this process may leave out some claims for a specific disaster event or include some claims that should not be associated with a specific event; however, we

believe that we are still able to assign the correct event names to the claims for a vast majority of cases.

3 Analysis

In the following sub-sections, we provide a general overview of the claims filed, amount paid and consider a statistical approach to model the payout coverage ratio. The analysis is based on the datasets discussed earlier and downloaded by the author in September 2020.

3.1 General Overview

Since 1970, over 2.4 million flood insurance claims have been filed in the US and the NFIP has made over $70 billion in payments against these claims. These claims have been filed in all the US States and cover over 95% of the counties. Figure 1 shows the geographic distribution of the claims. As expected, the counties on the Gulf Coast and the Atlantic Coast have the largest numbers of claim filings.

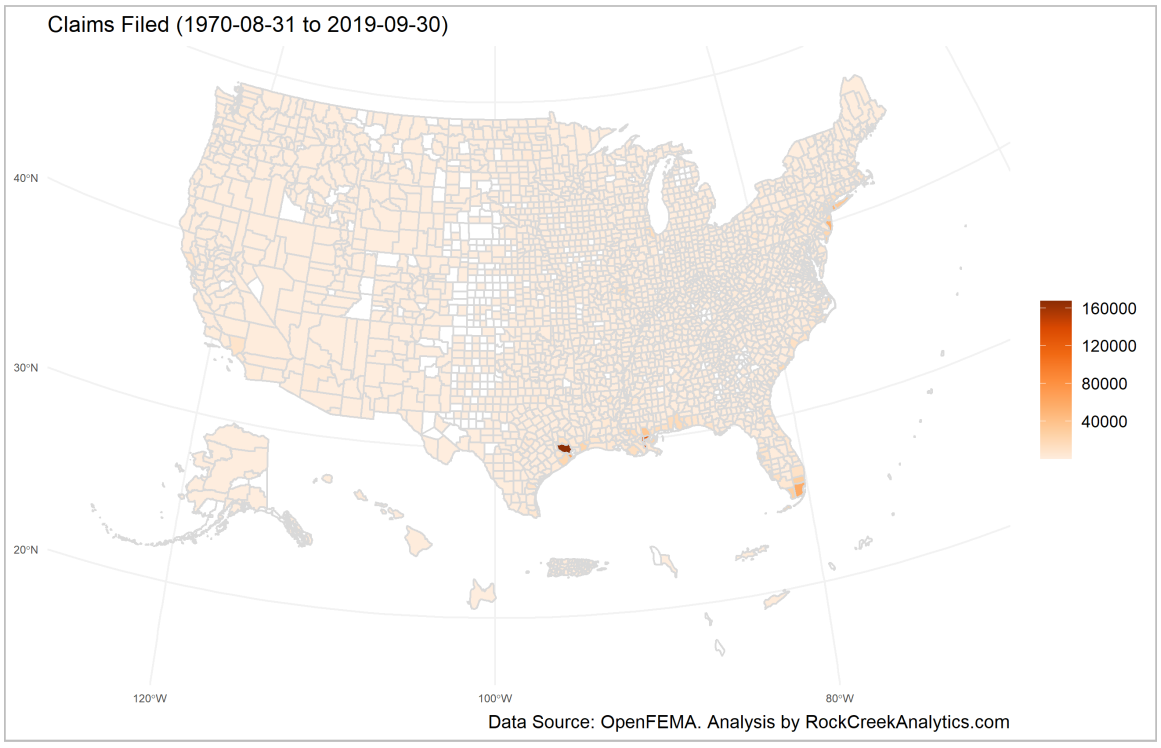

Figure 1: Flood insurance claims filed by county.

In the Appendix, we provide similar information for several different hurricane

events reflecting very large levels of damage[1] (Hurricane Katrina, Hurricane Sandy and Hurricane Harvey), large level damage (Hurricane Irma, Hurricane Ike and Hurricane Irene) and medium damage amounts (Hurricane Matthew and Hurricane Isaac).

Figure 2 shows the evolution of the total claims payments over the past fifty years. The payment amounts were quite modest up to the early 2000s. A very large spike occurred in year 2005 reflecting the damage caused by Hurricane Katrina. Since then large payments have occurred in years 2008 (Hurricane Ike, Hurricane Hanna, etc.), 2012 (Hurricane Sandy, Hurricane Isaac, etc.), 2016 (Hurricane Hermine, Hurricane Matthew, etc.) and 2017 (Hurricane Harvey, Hurricane Irma, etc.)

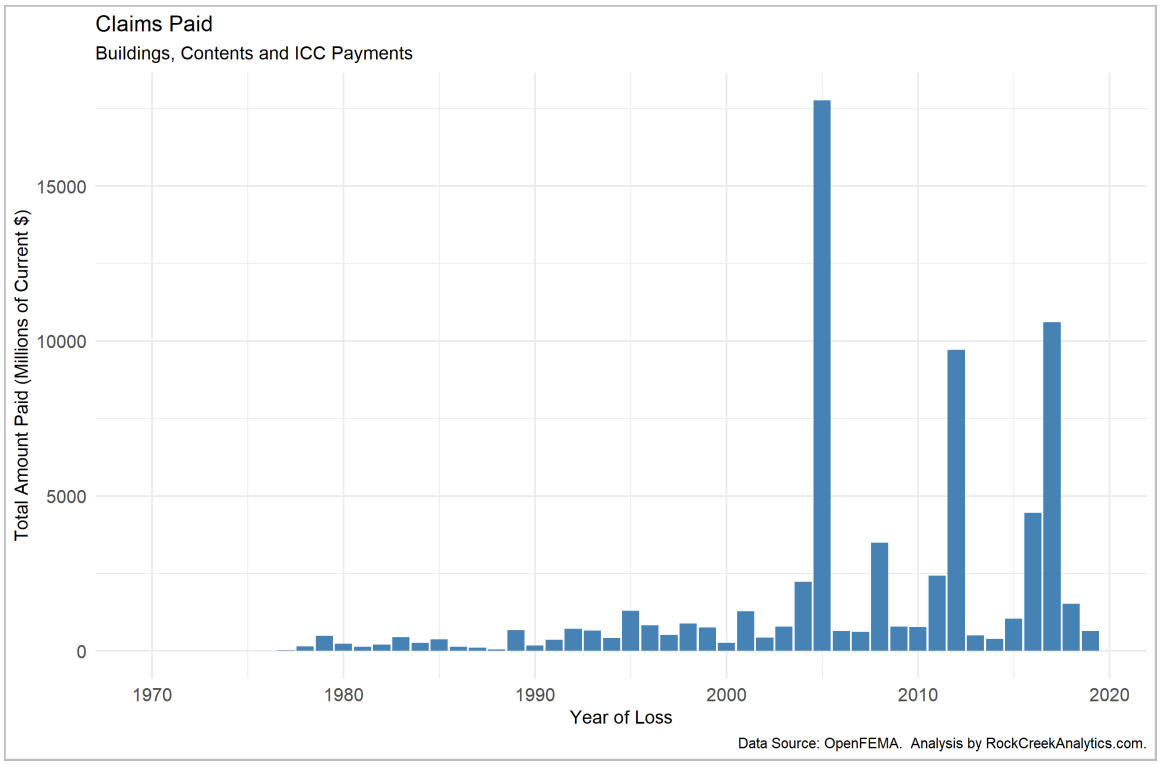

Figure 2: Claims paid by year.

Table 1 provides a summary of the claims filed and amount paid against the claims. As can be seen in panel (a) of the table, about 23% of the claims get paid nothing either because the claim is denied or it's a duplicate claim or for some other reason, about 6% of the claims get paid 100% of their coverage amount, a small number (about 1%) get paid over 100% of the coverage amount. The majority (approx. 70%) get between 0% and 100% of the coverage amount. We have summed the building insurance coverage and the contents insurance coverage to reflect total insurance coverage.

[1] As indicated by the total amount paid (author's categorization).

Panel (b) of Table 1 shows the amount paid by type of payment. There are three types of payments made by the NFIP: building payments, contents payments, and increased cost of compliance (ICC) payments. The ICC coverage is available to some policyholders who need "additional help rebuilding after a flood ... and provides up to $30,000 to help cover the cost of mitigation measures that will reduce the flood risk" [5]. As the table shows, the majority of the payments are towards building claims.

The Appendix provides similar tables for individual hurricane events - most show similar trends. One notable exception is Hurricane Katrina that shows approx. 40% of claims getting 100% of the coverage amount or more (see Table 3.)

Table 1: All Events - claims filed and amount paid during Aug. 1970 - Sep. 2019

(a)

Total Claims	2,444,951
Paid less than 0%	6 (0%)
Paid 0%	553,218 (23%)
Paid 0% - 100%	1,712,001 (70%)
Paid 100%	152,653 (6%)
Paid more than 100%	22,505 (1%)

(b)

Total Paid ($M)	70,118
Building Amount ($M)	55,968 (80%)
Contents Amount ($M)	13,266 (19%)
ICC Amount ($M)	885 (1%)

Panel (a) shows the total claims and amount paid as a % of coverage amount. Panel (b) shows the total claim amount paid by type. Counts and/or percentages will not add up to the total because of missing data or rounding.

3.2 Modeling the Payout Ratio

In terms of forecasting claims payments for a future event, the ratio of the total payment and total policy coverage (*payout ratio*) is a key component as it defines the amount a claimant is likely to get on their claim. Using the payout ratio instead of total payment allows the analyst to combine data from multiple events from different time periods as it normalizes the property value and effects of inflation.

Figure 3 shows the payout ratio for all claims analyzed (for clarity, we do not show data for payout ratio over 2.0 in the figure). Consistent with the data shown in Table 1, there are a large amount of claims with a payout ratio of 0.0 and another large amount of claims with a payout ratio of 1.0. Figures for individual hurricane events are provided in the Appendix and they show similar pattern (except for Hurricane Katrina).

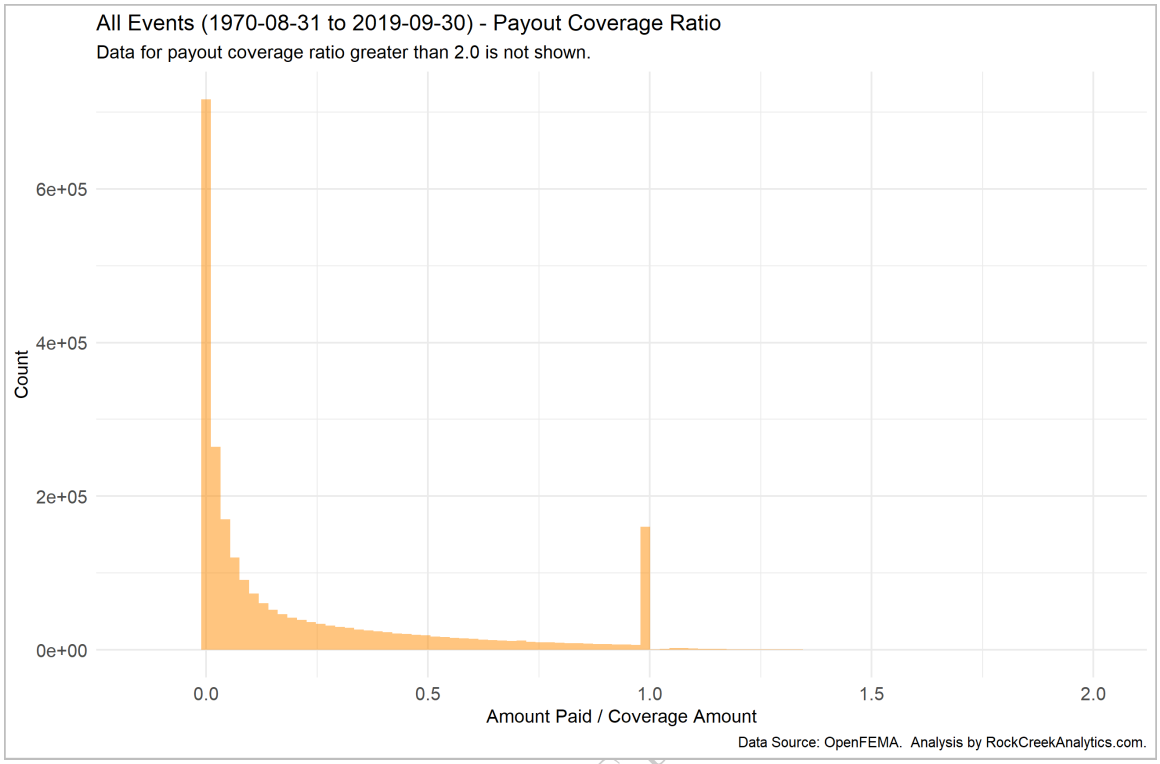

Figure 3: All Events - payout coverage ratio.

Given the peculiarity of the data with the two spikes at 0% and 100% levels, it is difficult to fit one of the standard statistical distributions to the data. One approach to address this is to consider only the claims that get paid between 0% and 100% of the coverage amount. The resulting data as shown in Figure 4 follows a more recognizable statistical distribution pattern akin to a log-normal, Weibull or gamma distribution.

After testing some different options, we find that the log-normal distribution fits the data reasonably well. A log-normal distribution is a continuous distribution whose logarithm is normally distributed (i.e., if $ln(x)$ has a normal distribution then x has a log-normal distribution.) Log-normal distributions are useful for many quantities that are always positive and have long upper tails, such as amount of rainfall, stock prices, failure times, etc.

The fitted log-normal curve is shown in Figure 4 and the details of the fit results are shown in Figure 5. We also fitted the log-normal distribution to individual hurricane events - these results are shown in the Appendix - the curves fit reasonably well in most of the cases.

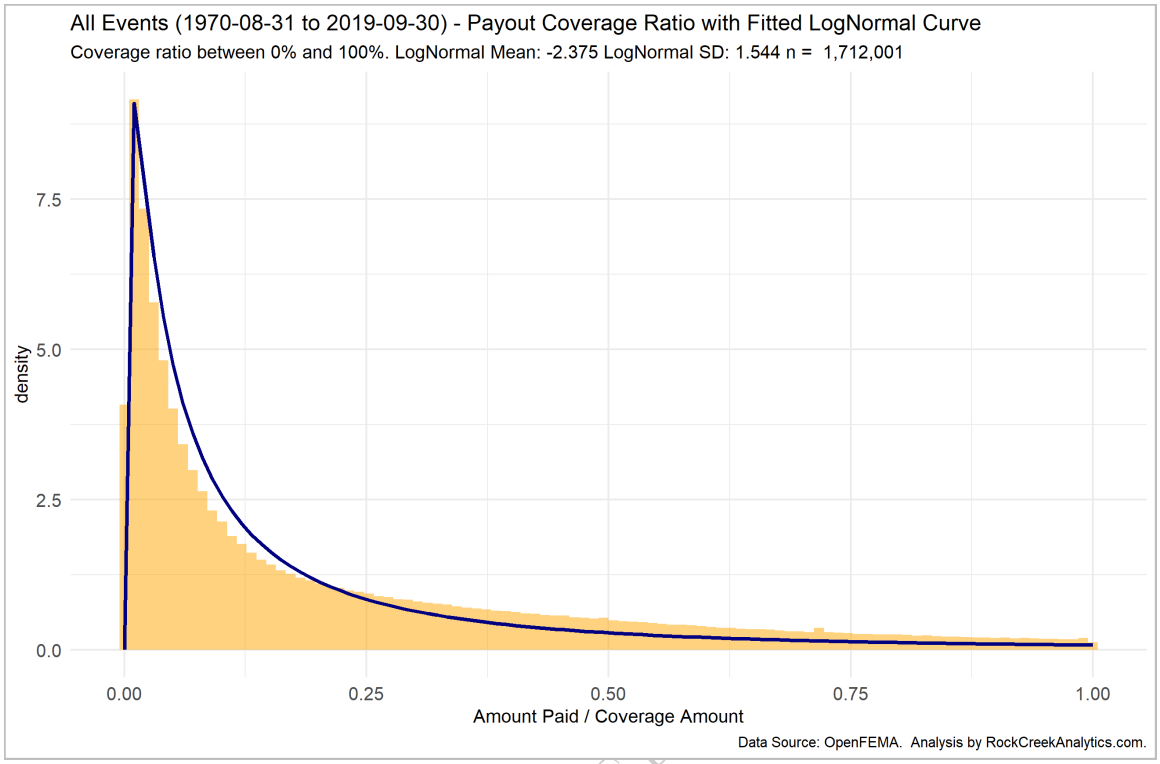

Figure 4: All Events - payout coverage with fitted log-normal distribution.

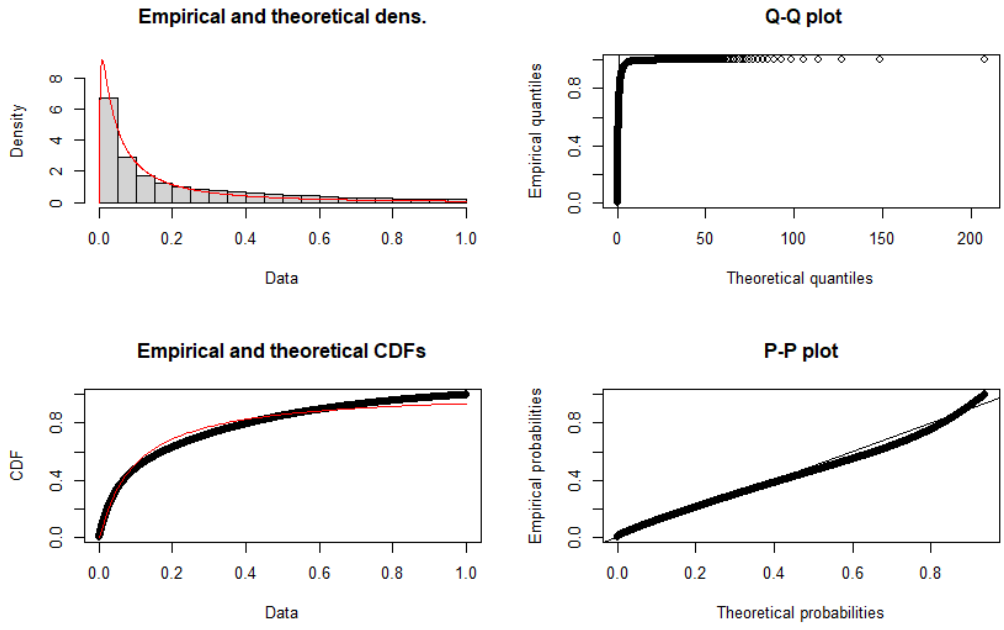

Figure 5: All Events - lognormal distribution fit results.

4 Closure

This article has provided an overview of the flood insurance claims in the US. We have suggested an approach to model the payout coverage ratio and shown that the log-normal distribution provides a reasonable option to model the payments between 0% and 100% of the policy coverage amounts.

This finding is consistent with the research on insurance claim modeling. Hewitt and Lefkowitz [6] have described the use of five different distributions (gamma, log-gamma, log-normal, gamma+log-gamma, and gamma+log-normal) to fit insurance loss data. Zuanetti *et al.* [7] describe the statistical details of a log-normal model for insurance claims data. Tiwari [8] provides an overview of modeling the claim frequency using generalized linear models. David and Jemna [9] show how Poisson and negative binomial distributions can be used to model auto insurance claims. Chang *et al.* [10] have suggested the use of Poisson distribution to model the occurrence of individual typhoon/flood events.

Note that one important consideration in flood claims modeling is the fact that for large scale events (as experienced after a hurricane), individual claims are not necessarily independent of each other (e.g., an entire neighborhood flooding). The analyst should, thus, be careful about using some of the statistical distributions (such as the Poisson distribution) that assume independence of individual claims.

References

[1] *National Flood Insurance Program*. Federal Emergency Management Agency. https://www.fema.gov/flood-insurance.

[2] *Flood Insurance Analytics Reports and Data*. National Flood Insurance Program, FEMA. https://nfipservices.floodsmart.gov/reports-flood-insurance-data.

[3] *OpenFEMA*. FEMA Office of the Chief Information Officer. https://www.fema.gov/about/reports-and-data/openfema.

[4] *OpenFEMA Dataset: Disaster Declarations Summaries - v2*. FEMA Office of the Chief Information Officer. https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v2. Accessed September 2020.

[5] *OpenFEMA Dataset: FIMA NFIP Redacted Claims - v1*. FEMA Office of the Chief Information Officer. https://www.fema.gov/openfema-data-page/fima-nfip-redacted-claims-v1. Accessed September 2020.

[6] Charles C. Hewitt, Jr. and Benjamin Lefkowitz. *Methods for Fitting Distributions to Insurance Loss Data*. Paper Presented at the November 1979

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[8] Ajay Tiwari. *Modeling Insurance Claim Frequency*.
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[9] M. David and D. Jemna. *Modeling the Frequency of Auto Insurance Claims by Means of Poisson and Negative Binomial Models*. Scientific Annals of Economics and Business 62(2):151-168. July 2015.
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[10] Ching-Cheng Chang, Wenko Hsu, and Ming-Daw Su. *Modeling Flood Perils and Flood Insurance Program in Taiwan*. 2008 Annual Meeting of the Agricultural and Applied Economics Association.
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Appendices

A Claims for Individual Hurricanes

The number of claims and total amount paid for each individual event are approximate since the FEMA datasets do not provide the event name for the claim. We have imputed the event name using the Disaster Declaration dataset but this process is an approximation.

A.1 Hurricane Irma

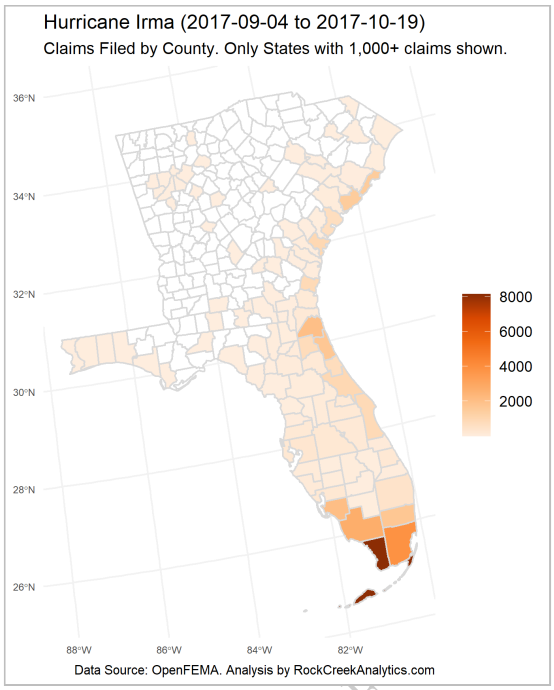

Figure 6: Hurricane Irma - claims filed by county (approximate).

Table 2: Hurricane Irma - claims filed and amount paid (approximate)

(a)

Total Claims	34,000
Paid less than 0%	0 (0%)
Paid 0%	12,000 (35%)
Paid 0% - 100%	22,000 (65%)
Paid 100%	1,000 (3%)
Paid more than 100%	0 (0%)

(b)

Total Paid ($M)	1,110
Building Amount ($M)	940 (85%)
Contents Amount ($M)	160 (14%)
ICC Amount ($M)	0 (0%)

Panel (a) shows the total claims and amount paid as a % of coverage amount (rounded to the nearest thousand). Panel (b) shows the total claim amount paid by type (rounded to nearest ten millionth). Counts and/or percentages will not add up to the total because of missing data or rounding.

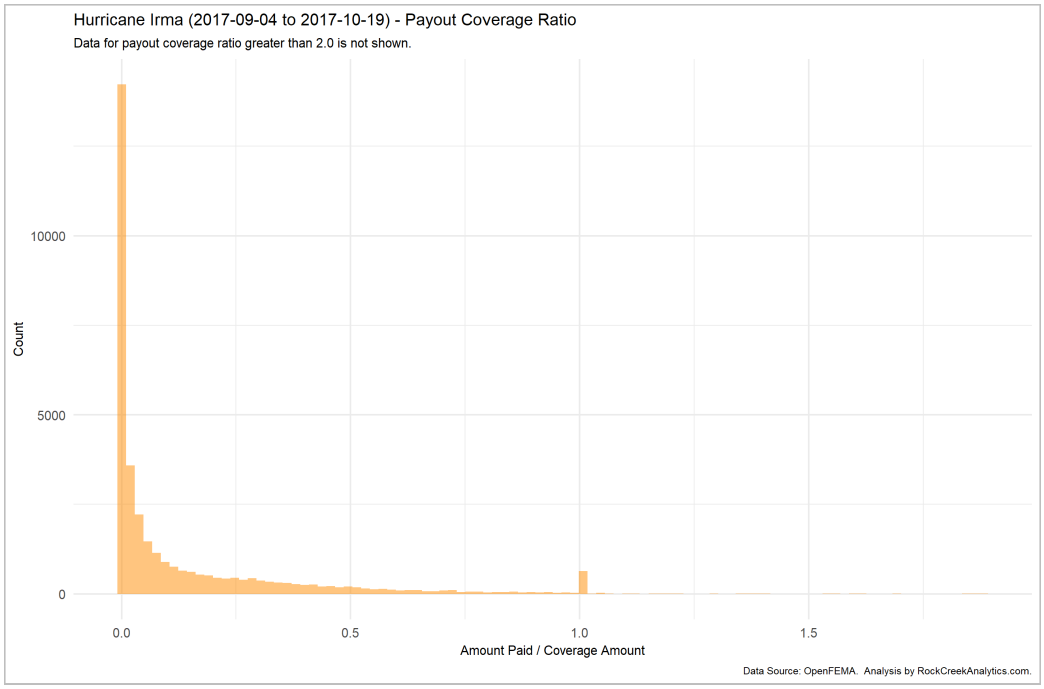

Figure 7: Hurricane Irma - payout coverage ratio.

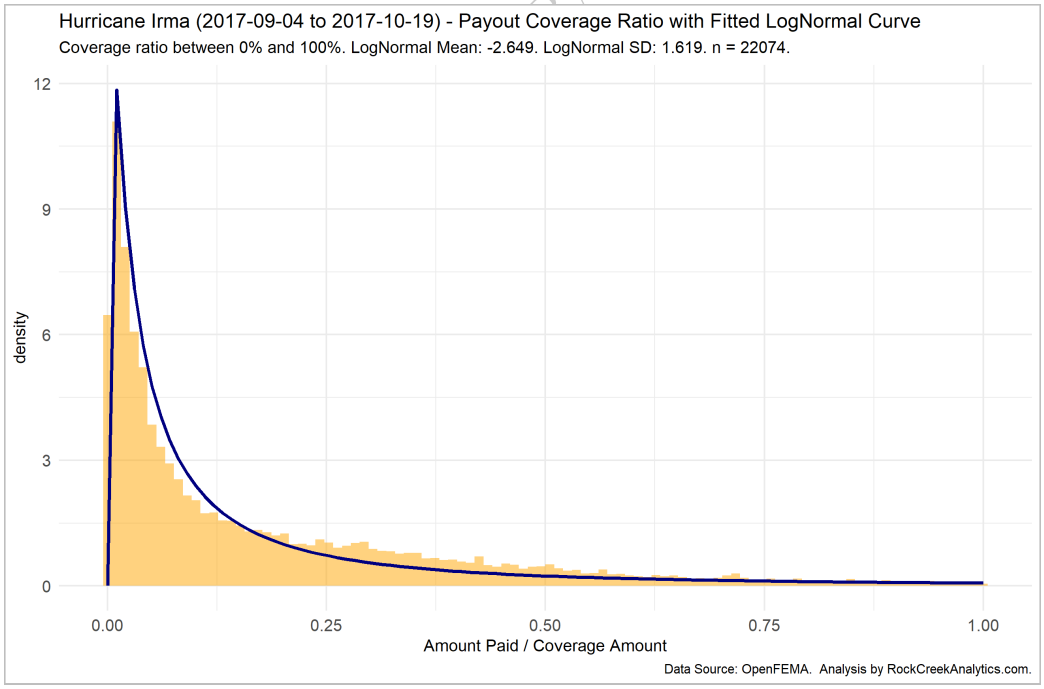

Figure 8: Hurricane Irma - payout coverage with fitted log-normal distribution.

A.2 Hurricane Katrina

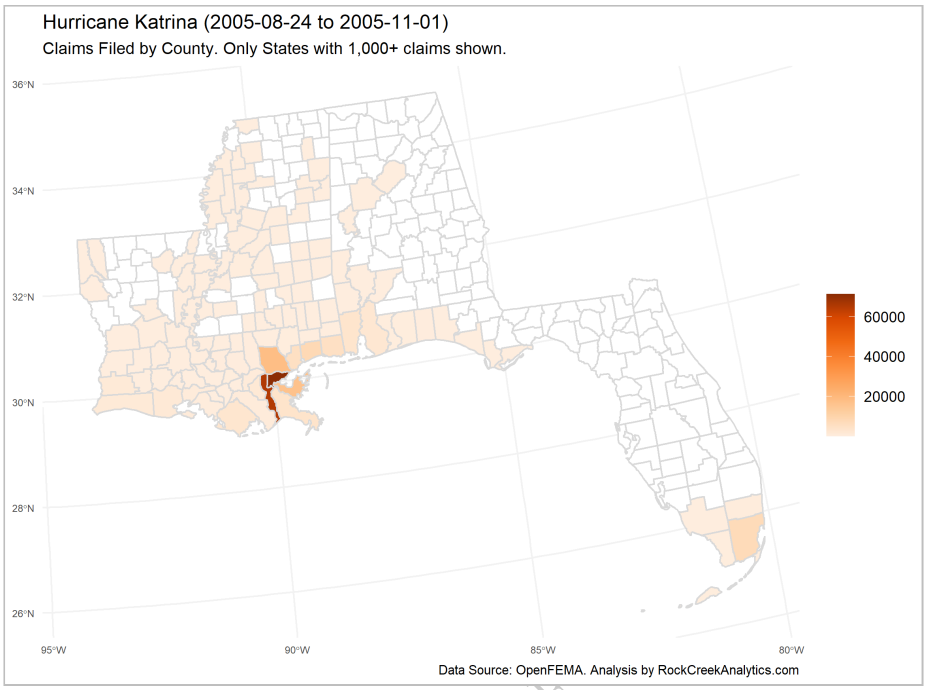

Figure 9: Hurricane Katrina - claims filed by county (approximate).

Table 3: Hurricane Katrina - claims filed and amount paid (approximate)

(a)

Total Claims	222,000
Paid less than 0%	0 (0%)
Paid 0%	46,000 (21%)
Paid 0% - 100%	88,000 (40%)
Paid 100%	74,000 (33%)
Paid more than 100%	14,000 (6%)

(b)

Total Paid ($M)	16,750
Building Amount ($M)	13,020 (78%)
Contents Amount ($M)	3,450 (21%)
ICC Amount ($M)	280 (2%)

Panel (a) shows the total claims and amount paid as a % of coverage amount (rounded to the nearest thousand). Panel (b) shows the total claim amount paid by type (rounded to nearest ten millionth). Counts and/or percentages will not add up to the total because of missing data or rounding.

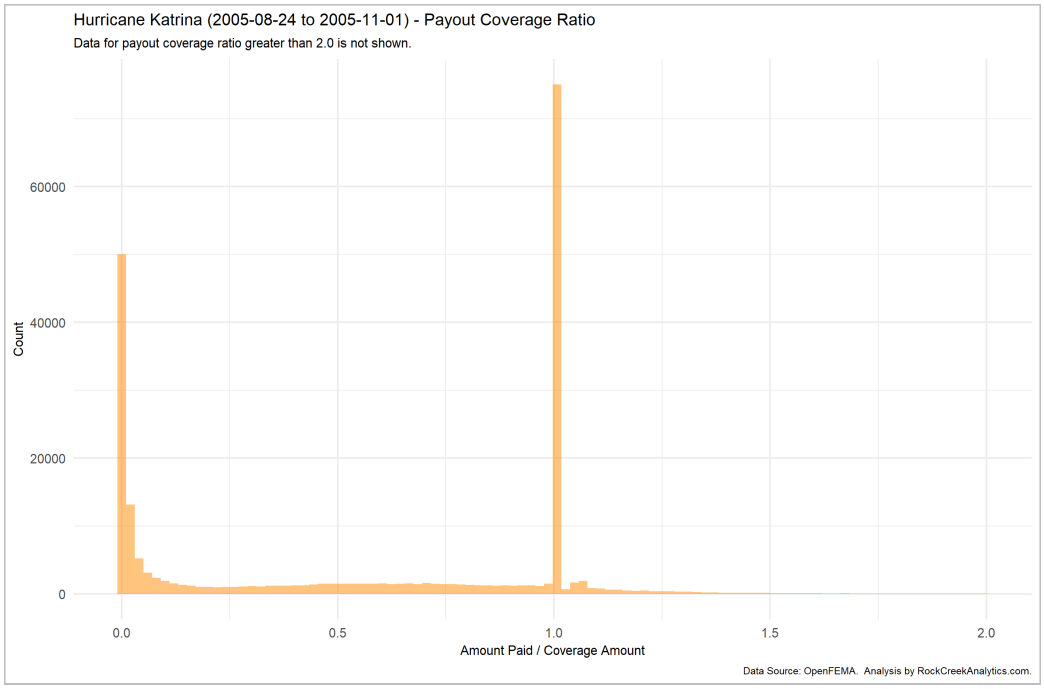

Figure 10: Hurricane Katrina - payout coverage ratio.

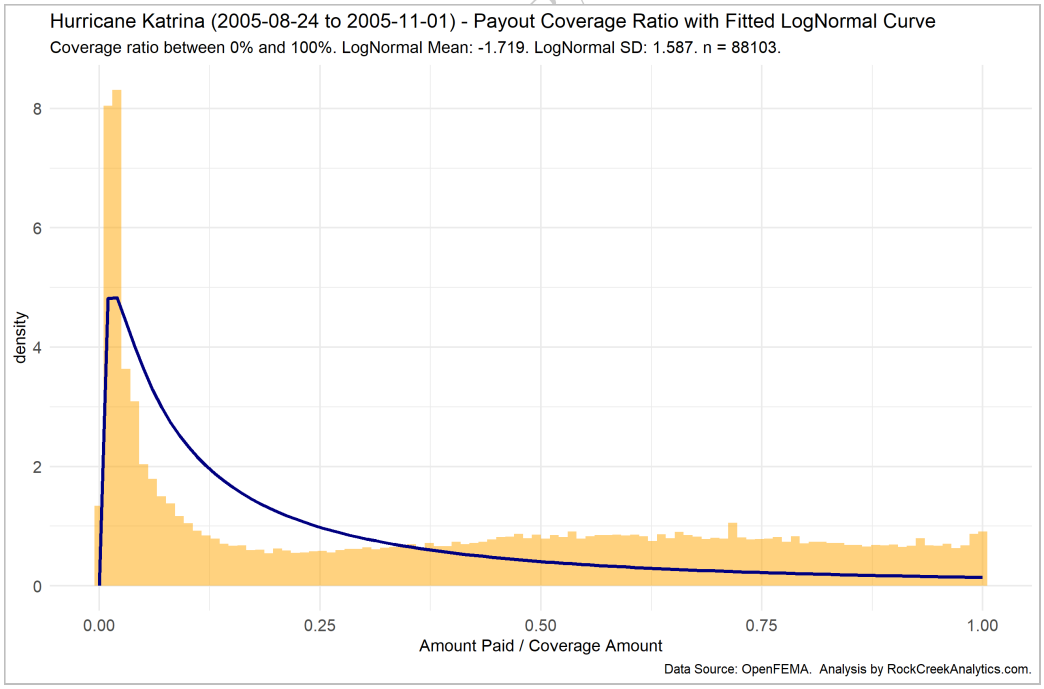

Figure 11: Hurricane Katrina - payout coverage with fitted log-normal distribution.

A.3 Hurricane Harvey

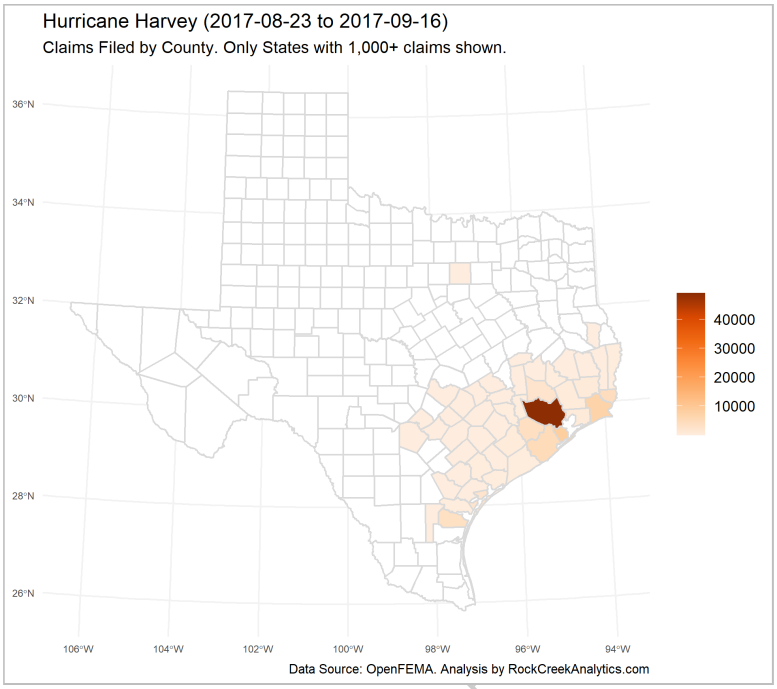

Figure 12: Hurricane Harvey - claims filed by county (approximate).

Table 4: Hurricane Harvey - claims filed and amount paid (approximate)

(a)

Total Claims	92,000
Paid less than 0%	0 (0%)
Paid 0%	15,000 (16%)
Paid 0% - 100%	68,000 (74%)
Paid 100%	8,000 (9%)
Paid more than 100%	0 (0%)

(b)

Total Paid ($M)	9,010
Building Amount ($M)	6,890 (76%)
Contents Amount ($M)	2,110 (23%)
ICC Amount ($M)	10 (0%)

Panel (a) shows the total claims and amount paid as a % of coverage amount (rounded to the nearest thousand). Panel (b) shows the total claim amount paid by type (rounded to nearest ten millionth). Counts and/or percentages will not add up to the total because of missing data or rounding.

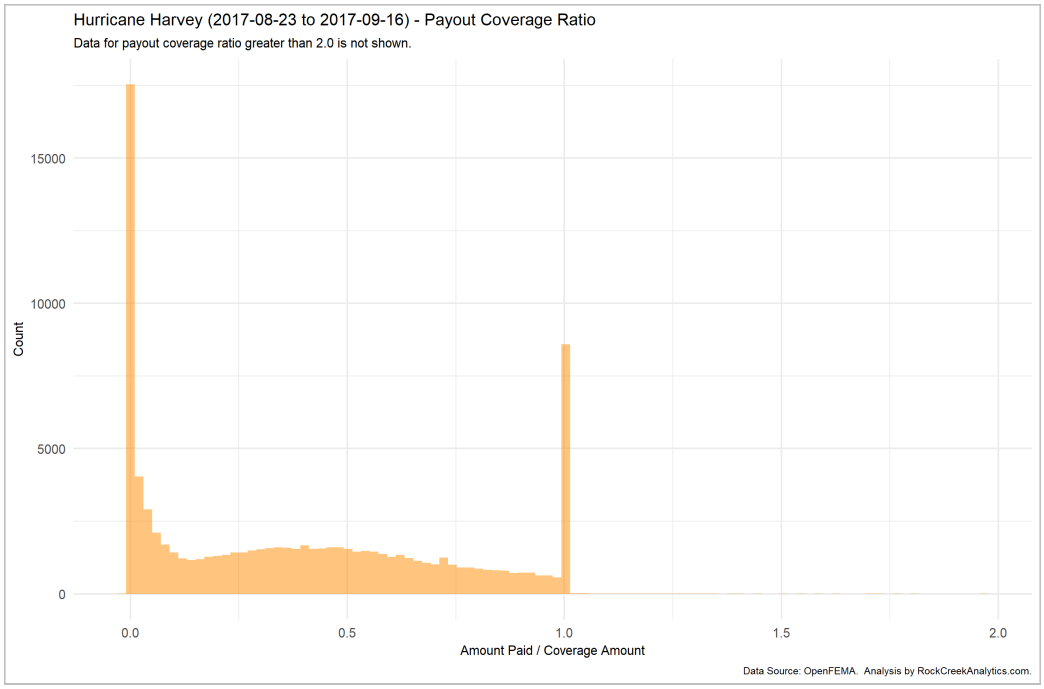

Figure 13: Hurricane Harvey - payout coverage ratio.

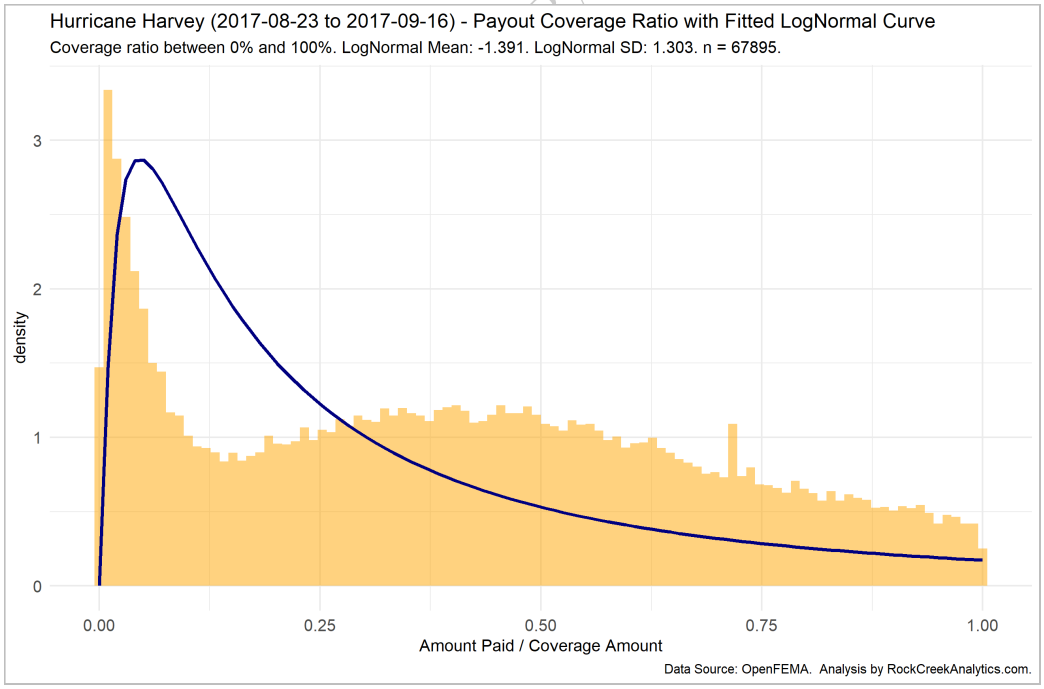

Figure 14: Hurricane Harvey - payout coverage with fitted log-normal distribution.

A.4 Hurricane Matthew

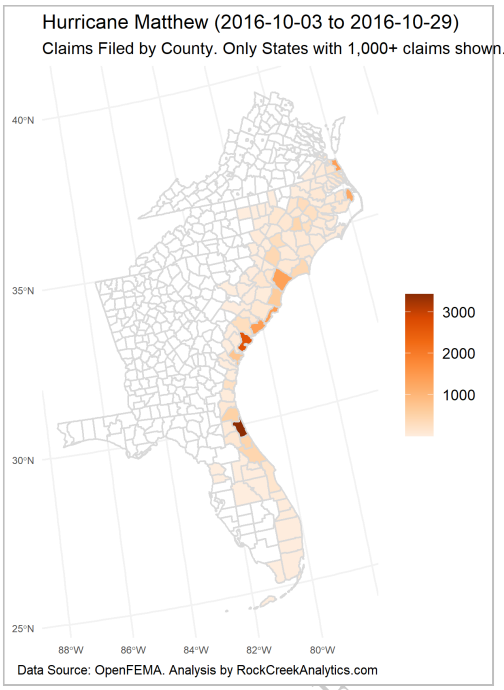

Figure 15: Hurricane Matthew - claims filed by county (approximate).

Table 5: Hurricane Matthew - claims filed and amount paid (approximate)

(a)

Total Claims	22,000
Paid less than 0%	0 (0%)
Paid 0%	5,000 (23%)
Paid 0% - 100%	16,000 (73%)
Paid 100%	0 (0%)
Paid more than 100%	0 (0%)

(b)

Total Paid ($M)	660
Building Amount ($M)	560 (85%)
Contents Amount ($M)	90 (14%)
ICC Amount ($M)	10 (2%)

Panel (a) shows the total claims and amount paid as a % of coverage amount (rounded to the nearest thousand). Panel (b) shows the total claim amount paid by type (rounded to nearest ten millionth). Counts and/or percentages will not add up to the total because of missing data or rounding.

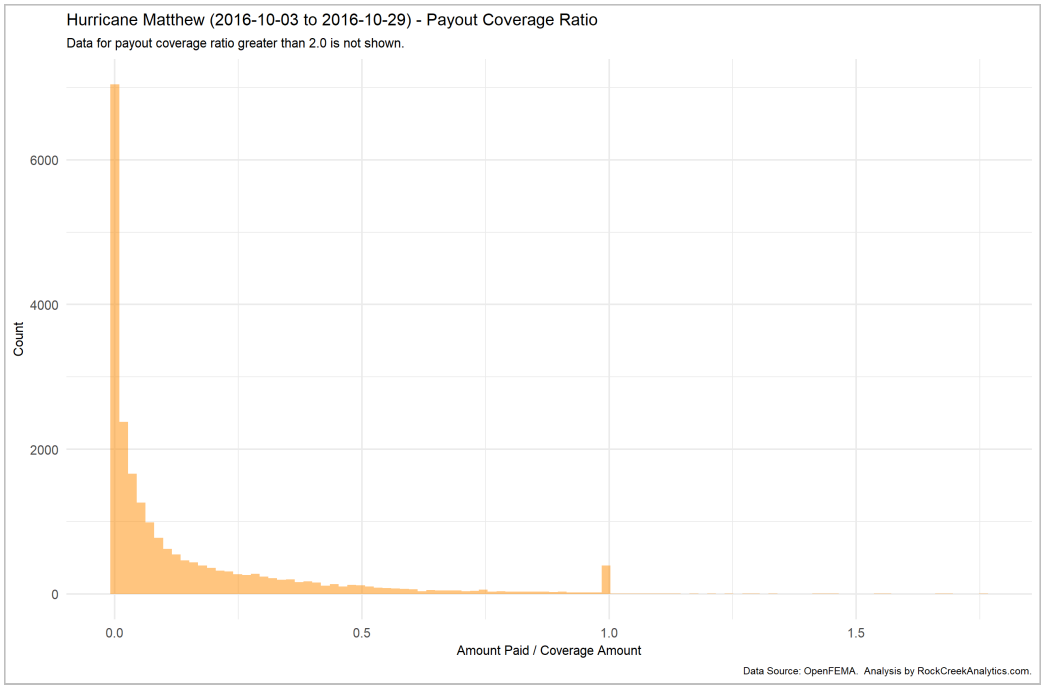

Figure 16: Hurricane Matthew - payout coverage ratio.

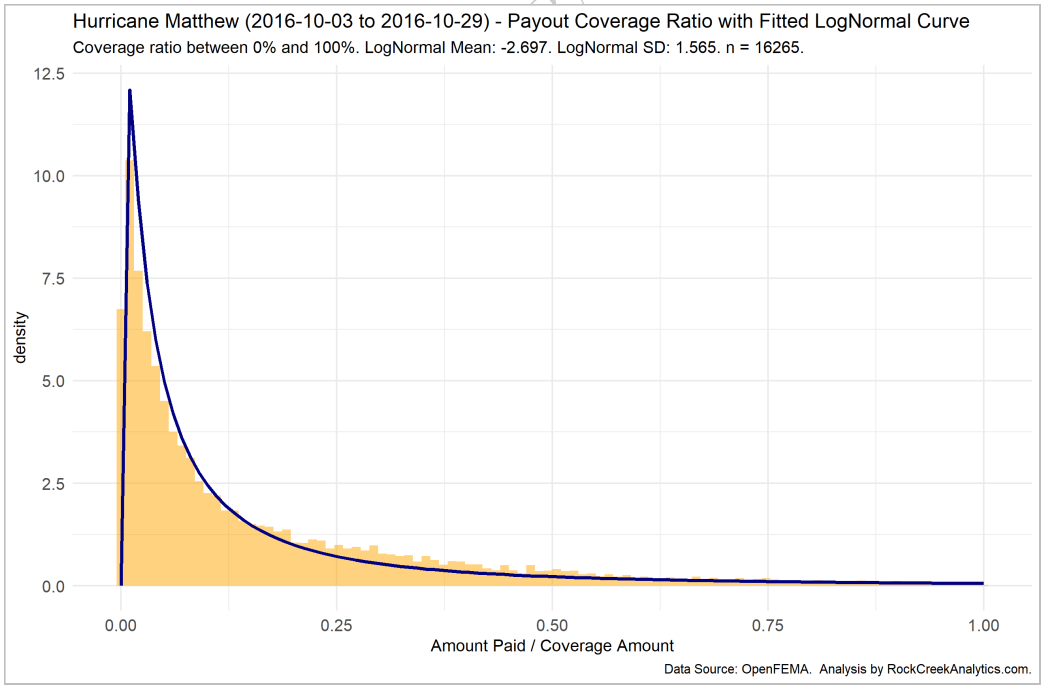

Figure 17: Hurricane Matthew - payout coverage with fitted log-normal distribution.

A.5 Hurricane Sandy

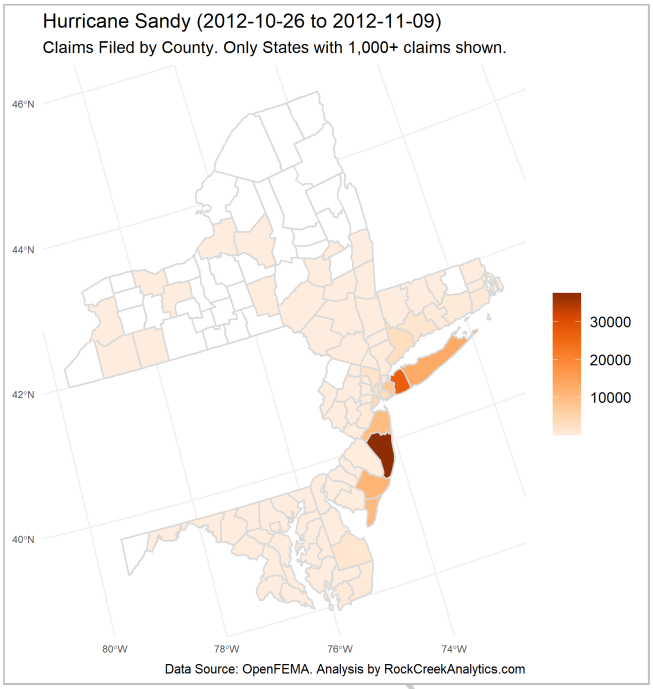

Figure 18: Hurricane Sandy - claims filed by county (approximate).

Table 6: Hurricane Sandy - claims filed and amount paid (approximate)

(a)

Total Claims	144,000
Paid less than 0%	0 (0%)
Paid 0%	11,000 (8%)
Paid 0% - 100%	127,000 (88%)
Paid 100%	5,000 (3%)
Paid more than 100%	1,000 (1%)

(b)

Total Paid ($M)	8,920
Building Amount ($M)	7,700 (86%)
Contents Amount ($M)	950 (11%)
ICC Amount ($M)	270 (3%)

Panel (a) shows the total claims and amount paid as a % of coverage amount (rounded to the nearest thousand). Panel (b) shows the total claim amount paid by type (rounded to nearest ten millionth). Counts and/or percentages will not add up to the total because of missing data or rounding.

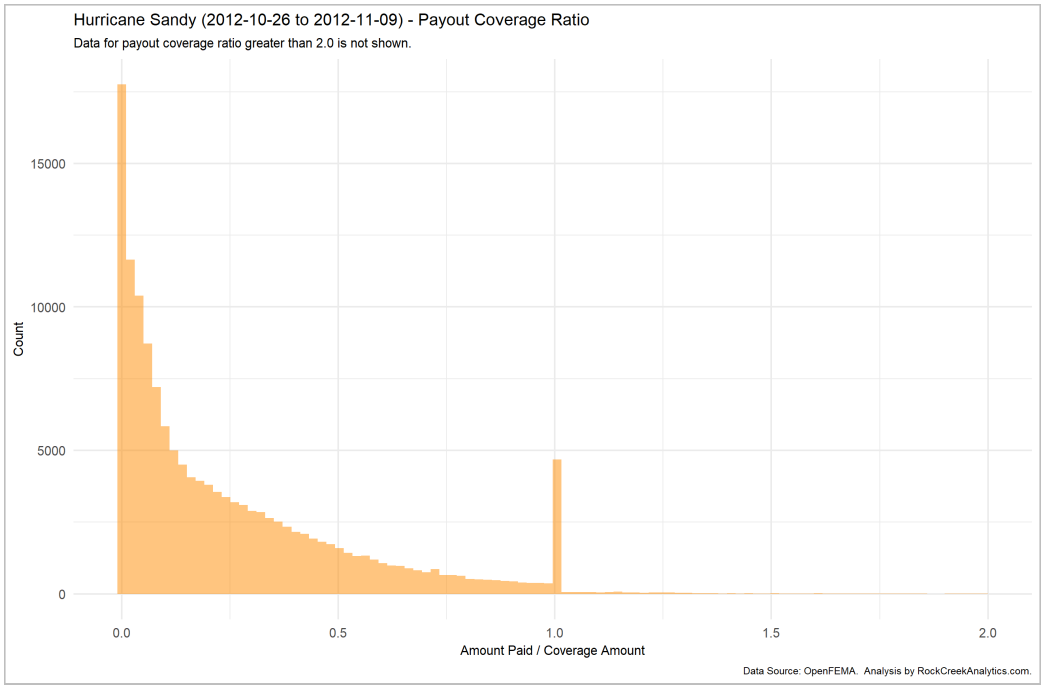

Figure 19: Hurricane Sandy - payout coverage ratio.

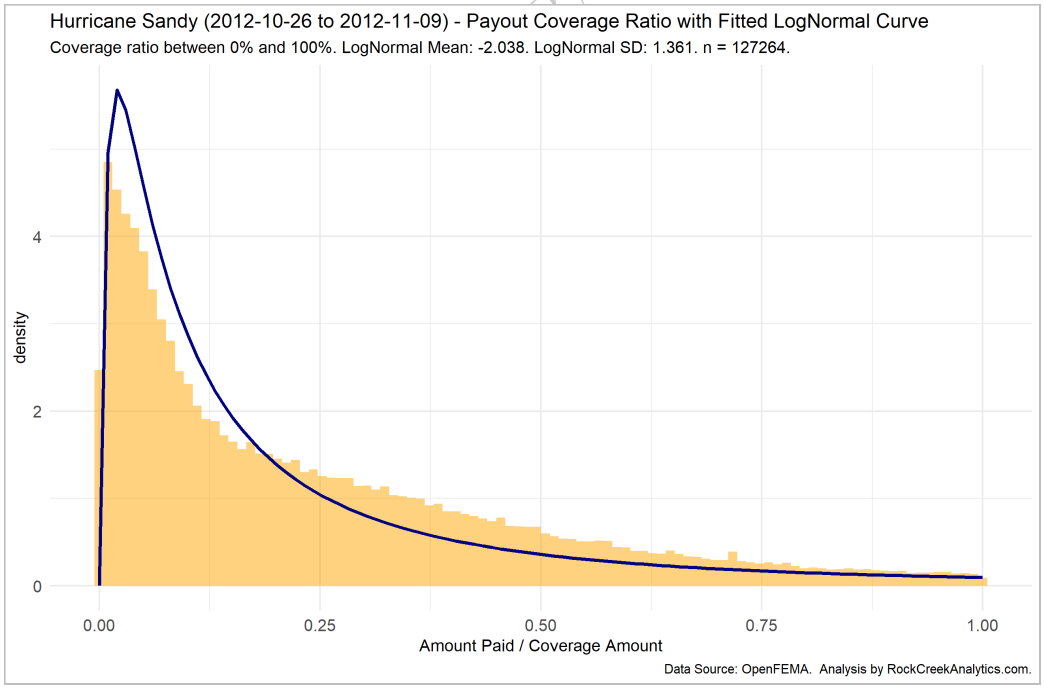

Figure 20: Hurricane Sandy - payout coverage with fitted log-normal distribution.

A.6 Hurricane Irene

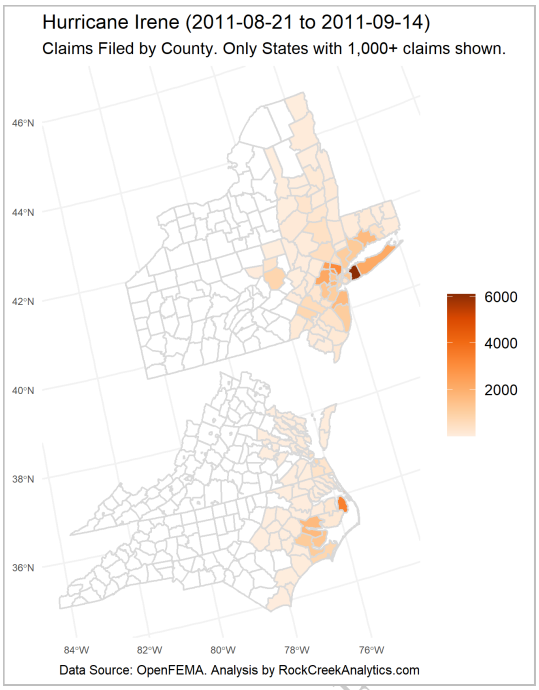

Figure 21: Hurricane Irene - claims filed by county (approximate).

Table 7: Hurricane Irene - claims filed and amount paid (approximate)

(a)

Total Claims	54,000
Paid less than 0%	0 (0%)
Paid 0%	8,000 (15%)
Paid 0% - 100%	44,000 (81%)
Paid 100%	1,000 (2%)
Paid more than 100%	0 (0%)

(b)

Total Paid ($M)	1,440
Building Amount ($M)	1,220 (85%)
Contents Amount ($M)	200 (14%)
ICC Amount ($M)	30 (2%)

Panel (a) shows the total claims and amount paid as a % of coverage amount (rounded to the nearest thousand). Panel (b) shows the total claim amount paid by type (rounded to nearest ten millionth). Counts and/or percentages will not add up to the total because of missing data or rounding.

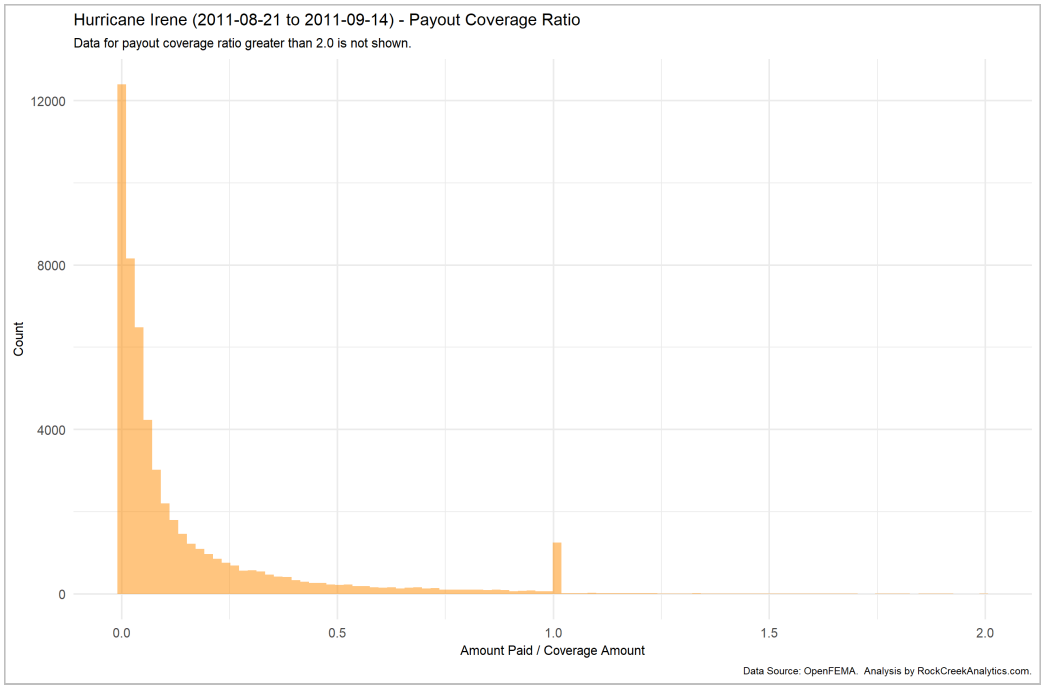

Figure 22: Hurricane Irene - payout coverage ratio.

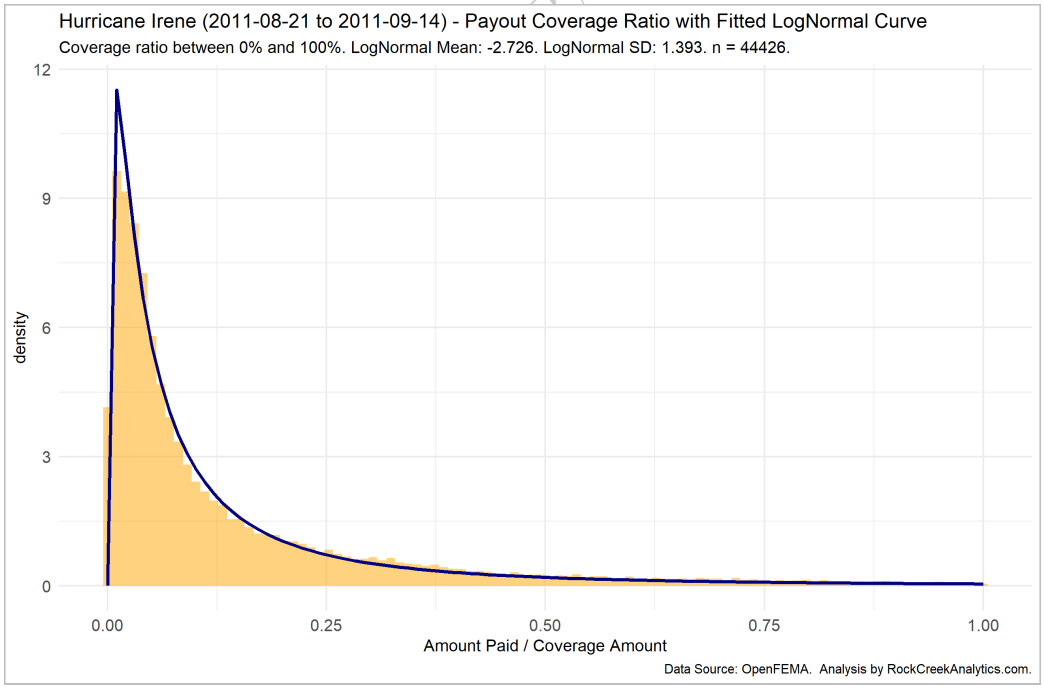

Figure 23: Hurricane Irene - payout coverage with fitted log-normal distribution.

A.7 Hurricane Isaac

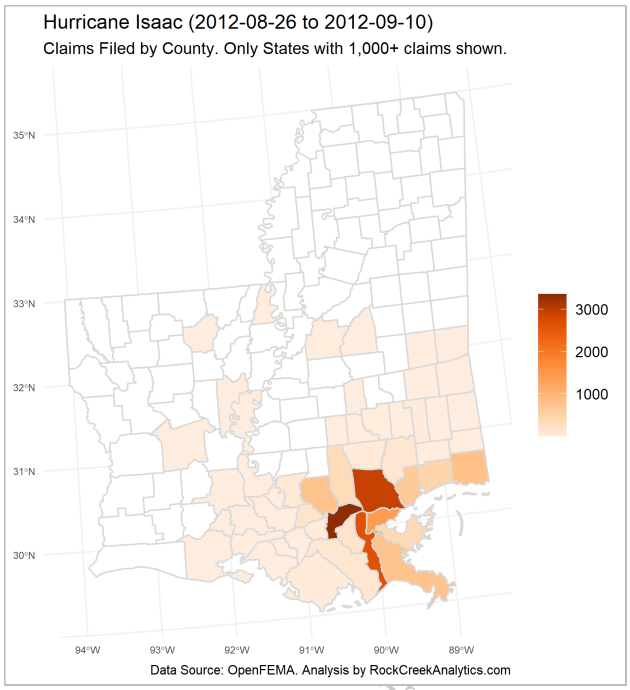

Figure 24: Hurricane Isaac - claims filed by county (approximate).

Table 8: Hurricane Isaac - claims filed and amount paid (approximate)

(a)

Total Claims	16,000
Paid less than 0%	0 (0%)
Paid 0%	4,000 (25%)
Paid 0% - 100%	11,000 (69%)
Paid 100%	0 (0%)
Paid more than 100%	0 (0%)

(b)

Total Paid ($M)	560
Building Amount ($M)	410 (73%)
Contents Amount ($M)	140 (25%)
ICC Amount ($M)	10 (2%)

Panel (a) shows the total claims and amount paid as a % of coverage amount (rounded to the nearest thousand). Panel (b) shows the total claim amount paid by type (rounded to nearest ten millionth). Counts and/or percentages will not add up to the total because of missing data or rounding.

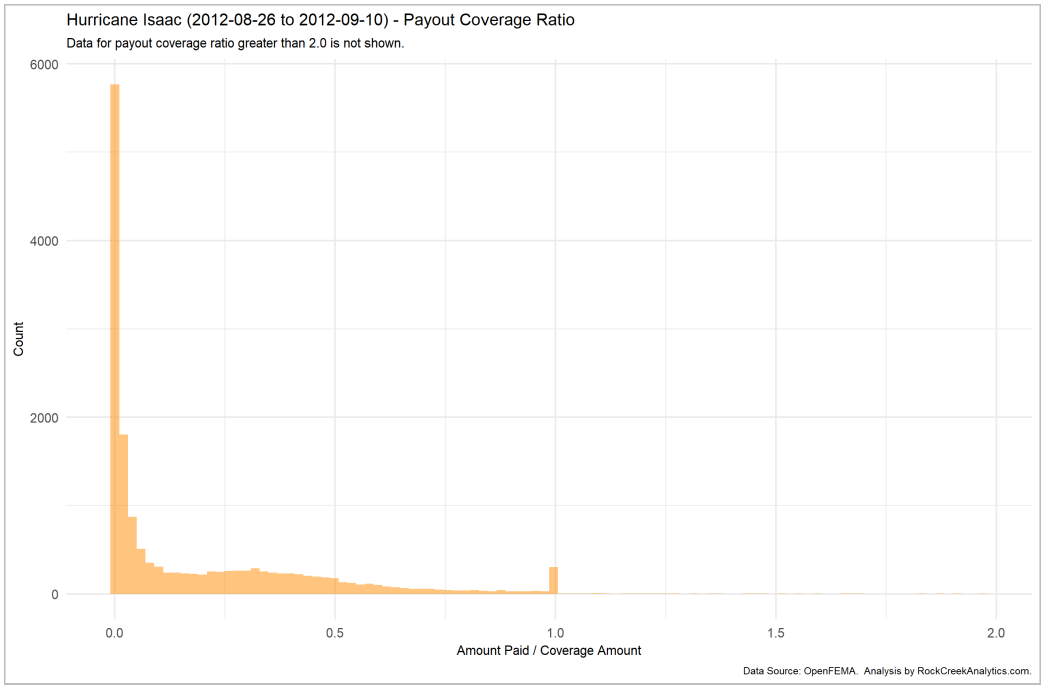

Figure 25: Hurricane Isaac - payout coverage ratio.

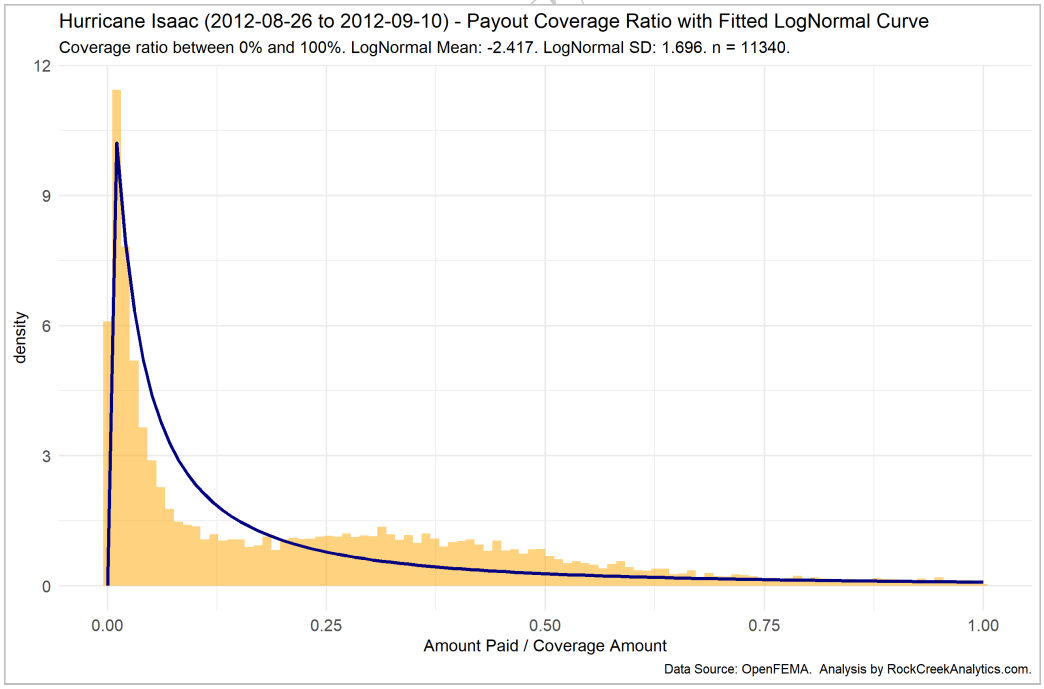

Figure 26: Hurricane Isaac - payout coverage with fitted log-normal distribution.

A.8 Hurricane Ike

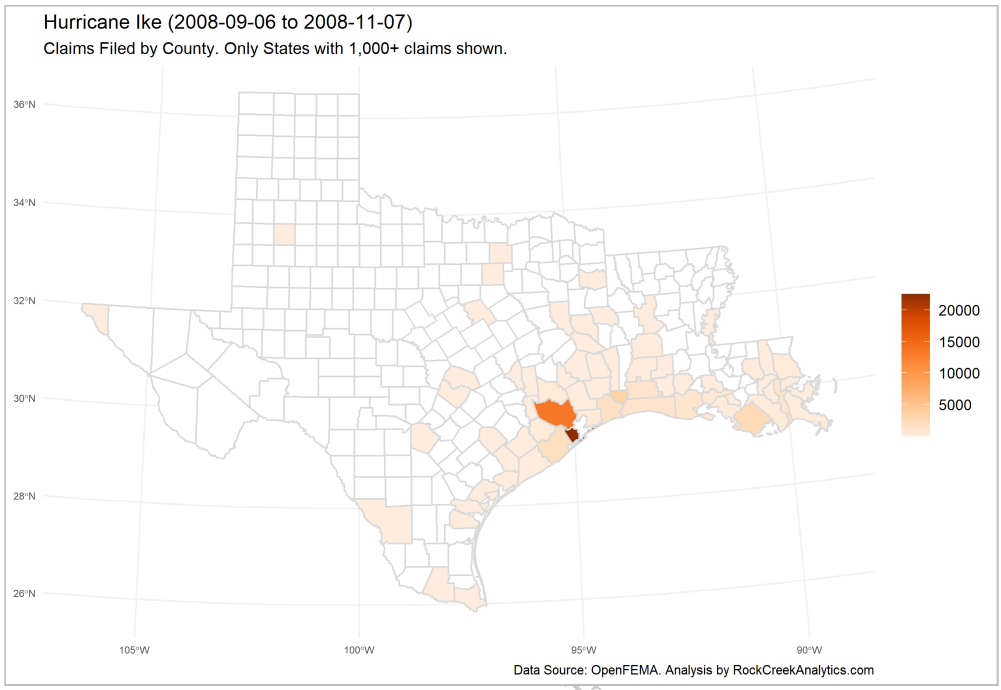

Figure 27: Hurricane Ike - claims filed by county (approximate).

Table 9: Hurricane Ike - claims filed and amount paid (approximate)

(a)

Total Claims	53,000
Paid less than 0%	0 (0%)
Paid 0%	11,000 (21%)
Paid 0% - 100%	37,000 (70%)
Paid 100%	4,000 (8%)
Paid more than 100%	1,000 (2%)

(b)

Total Paid ($M)	2,580
Building Amount ($M)	1,970 (76%)
Contents Amount ($M)	560 (22%)
ICC Amount ($M)	50 (2%)

Panel (a) shows the total claims and amount paid as a % of coverage amount (rounded to the nearest thousand). Panel (b) shows the total claim amount paid by type (rounded to nearest ten millionth). Counts and/or percentages will not add up to the total because of missing data or rounding.

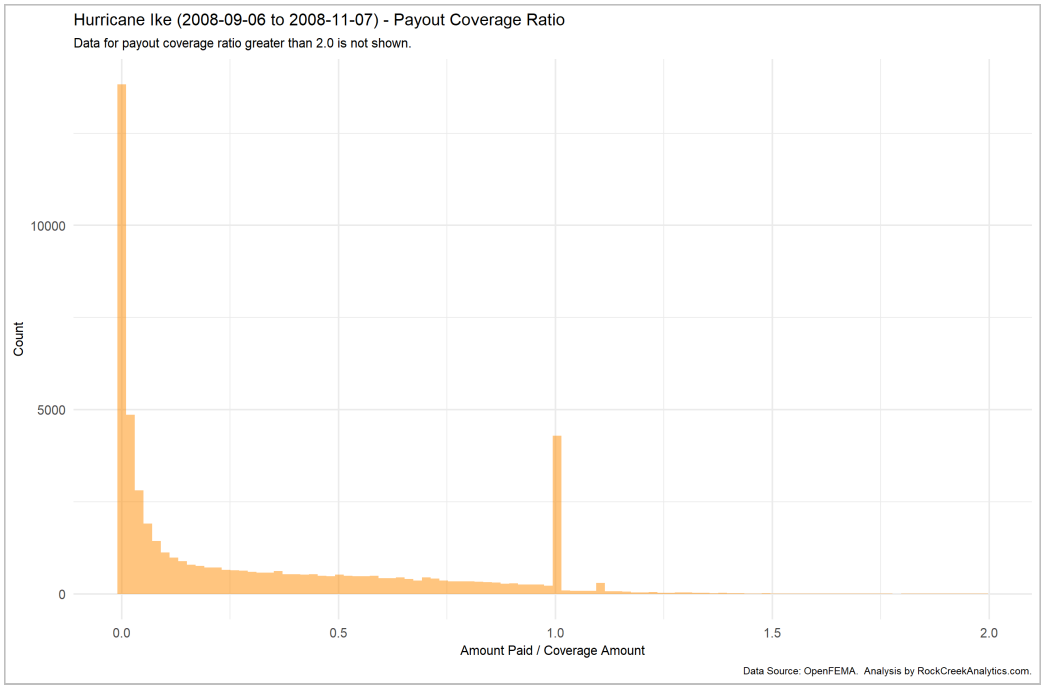

Figure 28: Hurricane Ike - payout coverage ratio.

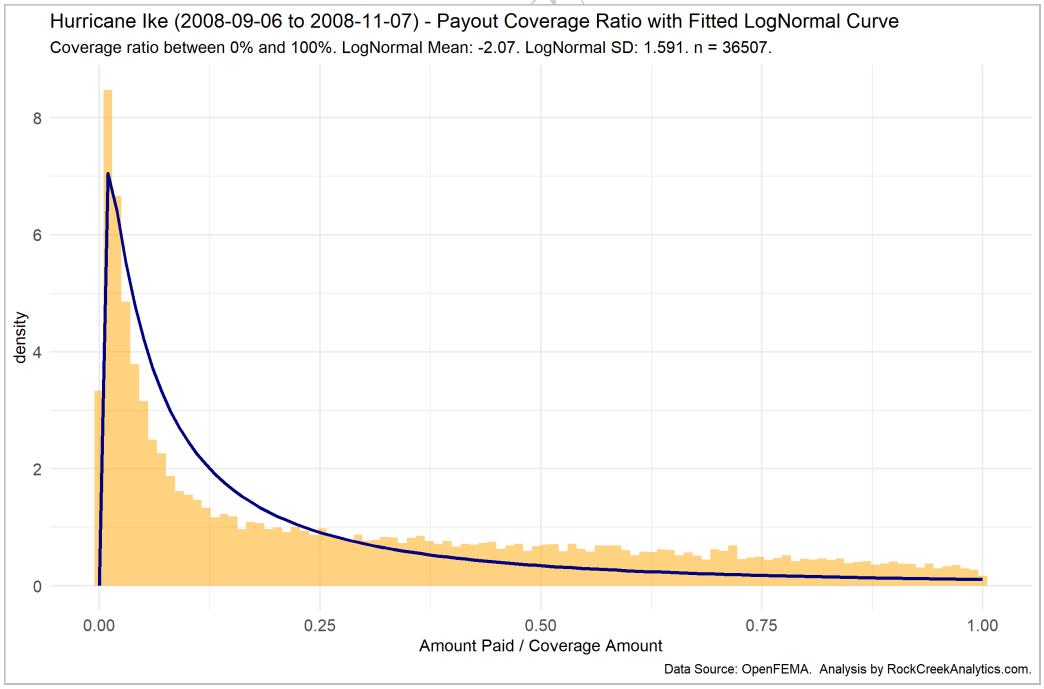

Figure 29: Hurricane Ike - payout coverage with fitted log-normal distribution.