# Private Capital and Mortgage Stress. Evidence from Natural Disasters and the Credit Risk Transfers.

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**Abstract**

We study how private capital in mortgage markets would absorb credit risk. Our identification exploits Hurricanes Harvey and Irma and the Credit Risk Transfers (CRT) issued by the GSEs. CRTs are structured securities to transfer some of their credit risk to private investors. CRTs differ in the geographical and loan-to-value composition of their reference pool, and in subordination class. These heterogeneities generate differences in exposure to the mortgage defaults caused by the hurricanes. We find significant increases in the price of credit risk right after the hurricanes' landfall. One percentage point larger geographical exposure to disaster areas increases the compensation investors demand by 200 basis points on average, which is 80% of the standard deviation of the CRT secondary market pricing.

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# 1 Introduction

Currently, U.S. taxpayers back almost all securitized mortgages through the GSEs and Ginnie Mae.[1] Most proposals to reform the current housing system propose to bring private capital back to mortgage securitization through an extended use of the Credit Risk Transfers (CRTs) that Fannie Mae and Freddie Mac started to use in 2013. The CRTs are structured securities with multiple tranches that rank the losses in case of mortgage defaults. The CRT performance is linked to the credit performance of pools of mortgages underlying agency mortgage backed securities (MBS). The Federal Housing Finance Agency (FHFA), asked Fannie Mae and Freddie Mac to use the CRTs to transfer much of their credit risk to private investors.

A key policy question for a reformed system is how private capital will react during a period of market stress. That is, do CRTs provide a stable source of capital through the economic cycle? In this paper we provide answers to these questions.

We exploit the timing of Hurricane Harvey in Houston, Texas, in late August 2017 and Hurricane Irma in Florida, in early September 2017. Hurricane Harvey and Hurricane Irma generated expectations of credit losses. For example, in October 2017, DoubleLine, Alliance Bernstein and other top mortgage credit buyers asked to remove natural catastrophe risk from credit-risk transfer bonds after watching the market quiver in the wake of Hurricane Harvey and Hurricane Irma that followed. The Association of Mortgage Investors, in a letter sent to CRT executives at Fannie Mae and Freddie Mac, and the FHFA, recommended that Fannie Mae and Freddie Mac strip catastrophe risk from their CRT bonds or risk the "longevity" of the capital currently supporting the market (Yoon 2017). Thus, these hurricanes provide a natural experiment to study stress in the CRT market.

We use a difference-in-difference strategy to measure the market reaction to the hurricanes reflected on the prices of CRTs with different exposures to default. CRTs differ in the seniority of claims of credit losses, and the loan-to-value (LTV) ratio and geographical composition of their reference pool. These heterogeneities generate differences in exposure to the mortgage defaults caused by Hurricanes Harvey and Irma. The hurricanes were unexpected events. Thus, before the hurricanes arrive creating credit risk, we find similar behavior across CRTs with different exposure to default risk. Once the risk appears we measure the effects on CRT prices in the secondary market and the market implied guarantee fees (g-fees) that the GSEs charge to guarantee payments to agency MBS investors.

[1] This does not take into account the credit risk that is covered by private mortgage insurance (PMI). This is an alternative way to bring private capital into a risk-taking position ahead of the taxpayer.

The difference-in-difference results show that expectations of credit losses caused significant increases in the price of credit risk for those securities more exposed to the risk. The expectations of credit losses affected only CRT securities with subordinated claims to losses, and even more these CRTs with relatively larger geographical exposure to the areas hit by the hurricanes.

This is one of the first academic paper to study the CRT transactions. Our findings have implications for mortgage markets and can inform the debate about housing finance reform. Our paper builds on Finkelstein, Strzodka, and Vickery (2018), which evaluates and discusses the performance of the CRT programs. Our paper contributes to the literature that studies the financial implications of natural disasters (e.g. Cortés & Strahan 2017; Rehse, Riordan, Rottke, Zietz 2019). Our paper also expands the literature on mortgage risk pricing during the economic cycles (Levitin, Lin, and Wachter 2017) by exploiting a period of unexpected market stress.

# 2 Brief Introduction to CRT Securities

## 2.1 Background

The GSEs have historically been exposed to significant mortgage credit risk, mainly because they provide a credit guarantee of timely payment of principal and interest to investors of the agency mortgage-backed securities (MBS) they issue.[2] The 2008 financial crisis resulted in high mortgage credit losses for the GSEs, which led to their conservatorship by the FHFA in September 2008.[3] Under this conservatorship, the MBSs that the GSEs issue are effectively guaranteed by the federal government. The guarantee exposes the government and the U.S. taxpayers to the risk of significant mortgage defaults.

Directed by the FHFA, the GSEs developed credit risk transfer (CRT) transactions, and brought them to the market in the middle of 2013. These transactions are loss sharing agreements with private investors who would share the credit risk on mortgage loans underlying agency MBSs. The CRT debt securities are Freddie Mac's Structured Agency Credit Risk (STACR) securities and Fannie Mae's Connecticut Avenue Securities (CAS). The STACR and CAS debt securities have been the most widely used from the credit risk mitigation instruments,

[2] The GSEs own or guarantee $5.1 trillion of residential mortages, as of the end of 2017.

[3] At the time of the 2008 finiancial crisis the GSEs were managing credit risk by charging guarantee fees to the MBS investors, by requiring private mortgage insurance or additional credit enhancement for mortages with loan-to-value ratios exceeding 80%, by setting minimum undewriting standards, by requiring representations and warranties from the loan sellers, and by keeping equity capital as additional buffer against insolvency. These credit risk management tools did not prevent the high mortgage losses during the 2007 financial crisis.

accounting for 77% of the risk in force shed from the GSEs' balance sheets.[4] CRT transactions currently are being executed in a fully functioning liquid market, and have gained a broad investor base. Since their inception CRTs provided GSEs with loss protection on more than $1.6 trillion of mortgage loans.

## 2.2 CRT structure

The CRTs are notes that pay principal and interest to investors linked to the performance of a reference pool of mortgages, recently securitized in agency MBSs.[5] The principal balance of a CRT note is a percentage of the total outstanding principal balance of the reference pool.[6]

Figure 1 shows a sample CRT transaction. The outstanding principal balance at issuance is divided into tranches with different levels of seniority. The most senior tranche is retained entirely by the GSEs. Next in seniority are typically two or three "mezzanine" tranches, and immediately lower in seniority is the subordinate tranche, which are sold to investors. The most subordinate tranche, or "first loss", was retained by the GSEs in the early CRT transactions, but it is sold to investors in the most recent transactions. A typical allocation of the outstanding principal balance is 96.0% to the most senior tranche retained by the GSEs, 3.5% to the mezzanine tranches, and 0.5% to the subordinate and first loss tranches.[7]

Appendix A1 contains detailed calculations of the CRT cash flows. The scheduled and unscheduled principal payments from the borrowers on mortgages in the reference pool are used to repay the most senior tranche owned by investors still outstanding at any given point. The principal balance of the CRT notes is reduced by the amount of these payments. Once the principal balance of most senior tranche outstanding is eliminated, the next tranche in seniority starts getting repaid and having its principal balance reduced by the scheduled and unscheduled principal payments. The losses on mortgages in the reference pool are used to reduce the principal balance of the most subordinate tranche outstanding. Once the principal balance of most subordinate tranche outstanding is eliminated, the next most subordinate tranche starts having its principal balance reduced by the mortgage losses.

The monthly interest paid to the investors is a floating rate on the outstanding principal

[4] The other risk sharing instruments include having mortgage originators retain some of the risk on the loans sold to the GSEs, and purchasing reinsurance on pools of mortgages.

[5] To date all CRTs have reference 30-year fixed rate mortgages, which represent the majority of mortgages securitized into MBSs. The reference pools consist of mortages with either 60-80 LTV or >80 LTV.

[6] Each reference pool consists of around 139 million mortgages, with total unpaid principal of approximately $30 billion at the time of issuance.

[7] The GSEs also retain a vertical slice of each of the tranches sold to investors.

balance equal to one month U.S. Dollar LIBOR plus a "floater spread" determined at the time of the primary market issuance. The floater spread is higher for the subordinate tranches. For example to date, the subordinate tranche of Fannie Mae's CRTs paid a spread of 8 percentage points on average, whereas the mezzanine tranches paid a spread of 3 percentage points on average. The floater spreads are generally set to ensure that the CRT notes are priced at par, that is, investors pay $1 for every $1 of principal of the CRT note. Figure 2 shows the historical spreads of the CRTs in the primary market, for the mezzanine tranches.

# 3 Data

We assembled a unique database of CRTs, by combining information from four data sources. First we collected data about the mortgages in the reference pool for the CRTs from the web pages of the GSEs.[8] The GSEs make public the features and performance over time of the mortgage loans in the reference pool of CRTs. Specifically, for Fannie Mae's CRTs we collected the LTV ratios of the mortgages in the reference pool of the securities, the geographical composition of the reference pool, and the delinquencies over time of the CRT deals. Second we built a database of all CRT issuances from Bloomberg, including issuance dates, the tranches determining the seniority of credit protection and the ones retained by the GSEs, the original principal balance per tranche, and the floater spread paid by each tranche. Third to collect the time series of prices and yields in the secondary market of CRTs we used Thomson Reuters Eikon. We also used the 1-month US Dollar LIBOR benchmark from Thomson Reuters Eikon, to calculate the spread over LIBOR we use in the analysis. Finally we used TRACE to built a time series of CRT trading volume in the secondary market. TRACE does not report the exact trade size for trades larger than $5 million, so the trading sizes we use are capped at $5 million. TRACE also contains a high, low and close price for each transaction, which we cross-checked with the prices from Thomson Reuters Eikon.

This paper focuses on Fannie Mae's and Freddie Mac's CRTs, issued from July 2013 to August 2017. Table 1 presents the distribution of CRTs in our sample based on risk characteristics. Figure 3 shows the historical spreads and Figure 4 the historical volume of the CRTs in the secondary market.

[8]Fannie Mae's CAS webpage http://www.fanniemae.com/portal/funding-the-market/credit-risk/conn-ave.html. Freddie Mac's STACR webpage http://www.freddiemac.com/creditriskofferings/stacr_debt.html.

# 4 Specification

We use a difference-in-difference specification with panel data and treatment the first trading date after the landfall in the U.S. coast of Hurricane Irma on September 11th 2017. This specification aims to capture the combined effects of the two hurricanes, since Hurricane Irma hit the U.S. two weeks after Hurricane Harvey. We measure the effects of the hurricanes on the daily spreads of CRTs with heterogeneous credit risk exposure due to three factors: different geographical exposure to the areas hit by Hurricane Harvey and Hurricane Irma, different LTV ratios in the mortgage loan reference pool, and different claims to losses depending on tranche subordination. Our baseline specification is

$$S_{i,t} = \beta_0 + \beta_1 T_t + \beta_2 E_i + \beta_3 T_t E_i + a_i + C_i + D_t + u_{i,t}, \tag{1}$$

where $i$ indexes securities and $t$ days. $S_{i,t}$ is the spread of security $i$ at time $t$ calculated as the yield to maturity minus the one month U.S. Dollar LIBOR. $T_t$ is the treatment variable of hurricanes that takes the value of 1 for $t$ on and after the first trading date after Hurricane Irma's landfall, and zero otherwise. $E_i$ is the percentage of CRT unpaid principal balance geographically exposed to Hurricane Harvey and Hurricane Irma, as reported by the GSEs. $a_i$ are issuance year fixed effects to capture differences in the spread of the issuance year cohorts of CRTs. The specification includes cross-sectional controls $C_i$. The cross-sectional controls that are related to the riskiness of the securities and can affect spreads are the floater spread, the original average weighted life of the CRT, and a binary indicator for >80 LTV. We also include an indicator for the issuer, Fannie Mae or Freddie Mac. Time series controls $D_t$ are included to isolate the effect of the timing of the hurricanes from other potential economic influences happening at the same time. The time series controls are the 10-year treasury rates, in line with the original time to maturity of the CRTs, and 2-year treasury rates to reflect shorter maturities. We also include the one month U.S. Dollar LIBOR rate that is directly linked to the CRT spreads. We estimate the model for time windows of 2 to 8 weeks before and after the treatment date.

Specifications for the effect of the hurricanes on spreads using different measures of riskiness of the CRTs are the following:

$$S_{i,t} = \beta_0 + \beta_1 T_t + \beta_2 L_i + \beta_3 T_t L_i + a_i + C_i + D_t + u_{i,t}, \tag{2}$$

where $L_i$ is the binary indicator that takes the value of 1 for CRTs referencing >80 LTV

mortgages and zero otherwise. The cross-sectional and time-series controls are the same as in (1), with $E_i$ included in the controls. Also

$$S_{i,t} = \beta_0 + \beta_1 T_t + \beta_2 F_i + \beta_3 T_t F_i + a_i + C_i + D_t + u_{i,t}, \tag{3}$$

where $F_i$ is a binary indicator that is 1 for CRTs of first loss or subordinated class and zero otherwise. The cross-sectional and time-series controls are the same as in (1) and (2).Table 2 presents summary statistics of the key variables.

The mortgage loans in the reference pools of CRTs suffered significant losses in the metropolitan area of Houston, Texas damaged by Hurricane Harvey and in the state of Florida damaged by Hurricane Irma. Figure 5 shows the reaction of the CRT spreads implied by the transactions in the secondary market immediately after the hurricanes. The losses depend on the credit risk exposure of the CRTs. First, the larger the geographical exposure to the damaged areas, the larger is the credit risk of CRTs, and the higher the realized losses. Figure 6 shows that the mortgage delinquencies and realized losses in the hurricane affected areas for the CRTs with larger geographical exposure (bigger than the mean plus one standard deviation) to the hurricanes increased significantly more compared to the CRTs with smaller geographical exposure (smaller than the mean minus one standard deviation). The additional increase in delinquencies and losses for the top exposed CRTs illustrates the additional risk of losses the investors faced due to the unexpected event of the hurricanes.

Second, the risk of losses increases with the credit risk of the reference mortgage loans. The CRT deals reference a pool of mortgages with LTV ratios either 60-80 or >80. Figure 7 shows that, in the Harvey affected areas, there are notably more delinquencies and realized losses of mortgages with >80 LTV, compared to the mortgages of 60-80 LTV. The increase in delinquencies and losses of riskier loans reflects the higher risk of losses to CRT investors, in the presence of systematic losses caused, in this case, by Hurricanes Harvey and Irma.

Third, depending on the magnitude of losses, there is heterogeneity among the risk exposure of CRT investors based on the specific tranche of the securities they hold. The riskiest tranches, first loss and subordinated tranches, are the first ones take losses, protecting the mezzanine tranches. Accordingly, the first loss and subordinated tranches of the CRTs have the highest probability of default and consequently the highest exposure to credit risk.

The additional credit risk exposure of riskier CRTs due to the previous factors translates into higher expectations of losses and larger realized losses after Hurricanes Harvey and Irma. This is reflected in the yield spreads in the secondary market. The yield spreads are the

compensation the investors demand for taking on credit risk. Immediately after the hurricanes there is a larger increase in spreads for CRTs with larger geographical exposure to Hurricanes Harvey and Irma (Figure 8), higher LTV ratios of the reference loans (Figure 9), and first and subordinated claims to losses (Figure 10).

# 5 Results

Tables 3, 4 and 5 present the estimates of the baseline specifications for spreads. Spreads increase significantly after the hurricanes for CRTs with larger exposure to the hurricanes for time windows between 2 and 5 weeks after Hurricane Irma's landfall. Spreads also increase significantly after the hurricanes for CRTs of first loss and subordinated tranches for time windows between 2 and 8 weeks after Hurricane Irma's landfall.

Table 3 shows that one percentage point larger geographical exposure to disaster areas increases the spread by 200 basis points on average, when we take into account a window of 2 to 3 weeks around the landfall. To put this into perspective, this increase is about 80% of the standard deviation of the CRT secondary market spreads.

Our results provide a baseline of the pricing of credit risk by the markets during a period of market stress. Overall, we find that credit risk exposure increases the price of credit risk in CRTs during a period of market stress. The magnitude of losses in our study only affected the securities with the first and subordinated claim to losses.

Based on the CRT spreads in the secondary market, we estimate the market implied g-fees using the approach outlined by the FHFA (2017). The g-fees are calculated at the reference pool level, to be comparable with the actual g-fees that the GSEs charge. The calculations are described in Appendix A2. Figure 11 shows the market implied g-fees of CRTs across exposure to hurricanes, and Figure 12 shows the market implied g-fees of CRTs across loan-to-value of the reference pools. There is a significant jump in the market implied g-fees when the hurricanes hit, especially for CRTs more exposed to default risk. Despite the jump following the hurricanes, the market implied g-fees rarely surpass the actual g-fees charged by the GSEs.

# 6 Conclusions

This paper studies how private capital in mortgage markets would absorb credit risk. CRTs differ in the geographical and loan-to-value composition of their reference pool. Moreover,

CRTs differ in their exposure to mortgage default, due to different subordination classes. These heterogeneities generate differences in exposure to the defaults caused by the hurricanes. This paper finds significant increases in the price of credit risk, during stress times.

Moreover, this paper estimates the market implied g-fees, based on the pricing in the CRT secondary market. Despite the sudden increase of the implied g-fees following the hurricanes, the market implied g-fees rarely surpass the actual g-fees. The exposure to losses due to the hurricanes was geographically concentrated. The CRTs did not experience large unexpected losses due to the geographical diversification of their mortgage pools. More sensitivity tests are needed to access the stability of the CRT market in periods of market stress.

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# Figures

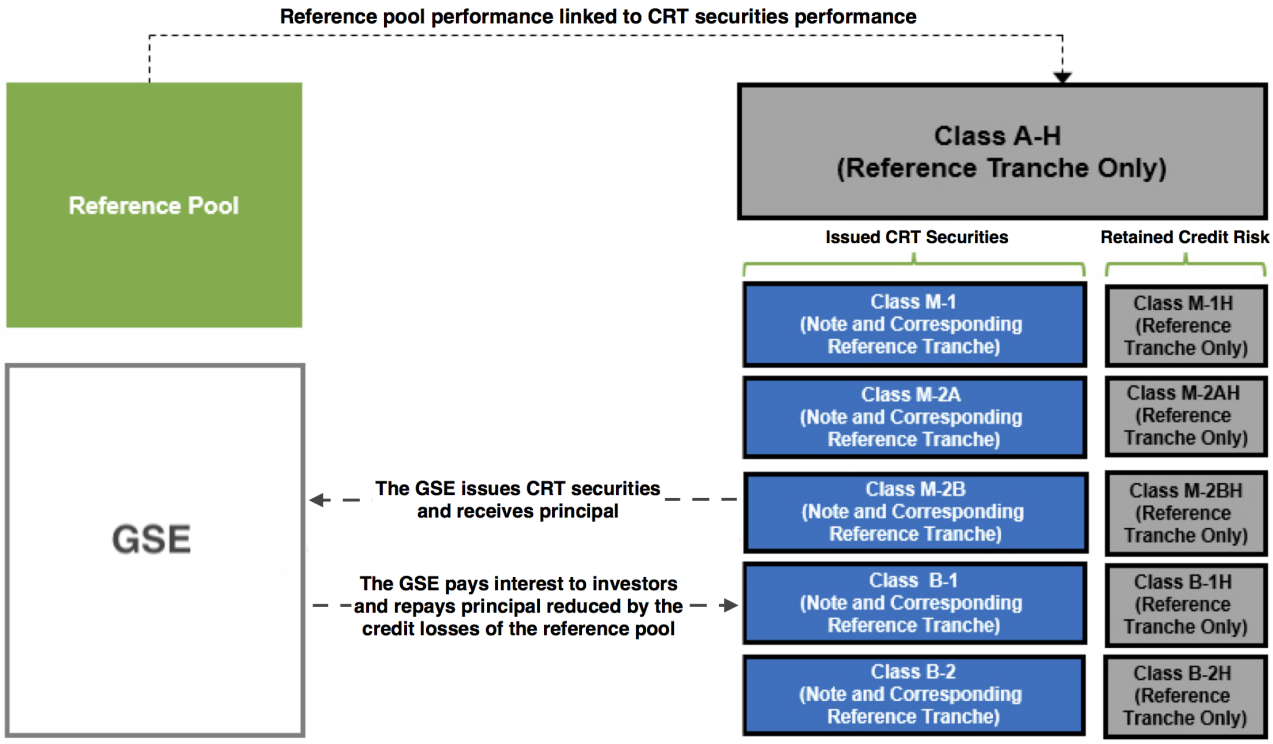


**Figure 1. Structure of Sample Credit Risk Transfer Transaction.** The figure shows a sample CRT transaction linked to a reference pool of loans. Credit losses on the reference pool reduce the obligation of the GSE to pay interest and repay principal on the CRT securities. This sample transaction contains, from the most subordinate to the most senior, a first loss tranche (Class B-2), a subordinate tranche (Class B-1) and two mezzanine tranches (Class M-1 and M-2). The credit losses are allocated to tranches starting with the most subordinate tranche, while repayments are allocated starting from the most senior tranche. A vertical slice of each of the tranches is retained by the GSE, while the remaining credit risk is sold to investors. The most senior tranche (Class A-H) is a reference tranche and is fully retained by the GSE. Source: GSEs.

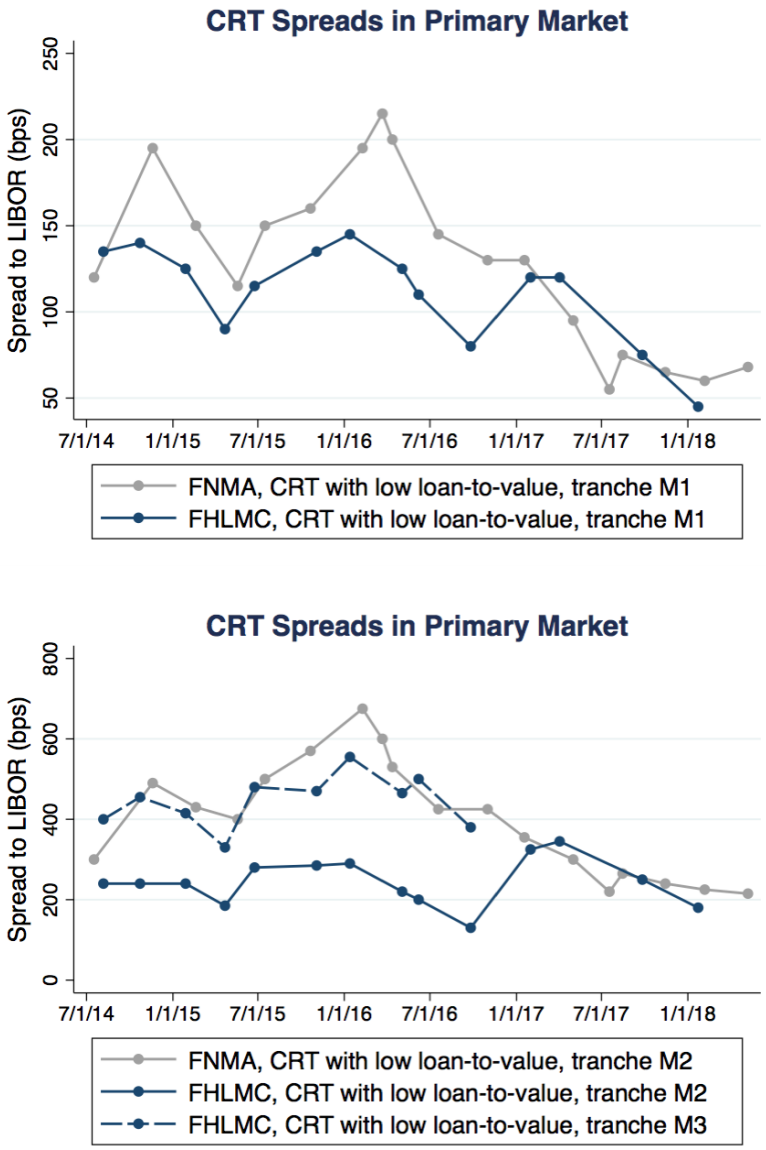


**Figure 2. Spread of Credit Risk Transfers in the Primary Market.** The figures plot the spreads in annualized basis points in the primary market at time of issuance, for CRTs with reference pools of 60-80 LTV, and for the mezzanine tranches, M1 and M2 of Fannie Mae and M1, M2 and M3 of Freddie Mac. The interest rate received by the CRT investors is one month U.S. Dollar LIBOR plus this spread, applied on the principal outstanding of the CRT note. The spreads are determined by market demand at time of issuance. Source: Bloomberg, GSE websites.

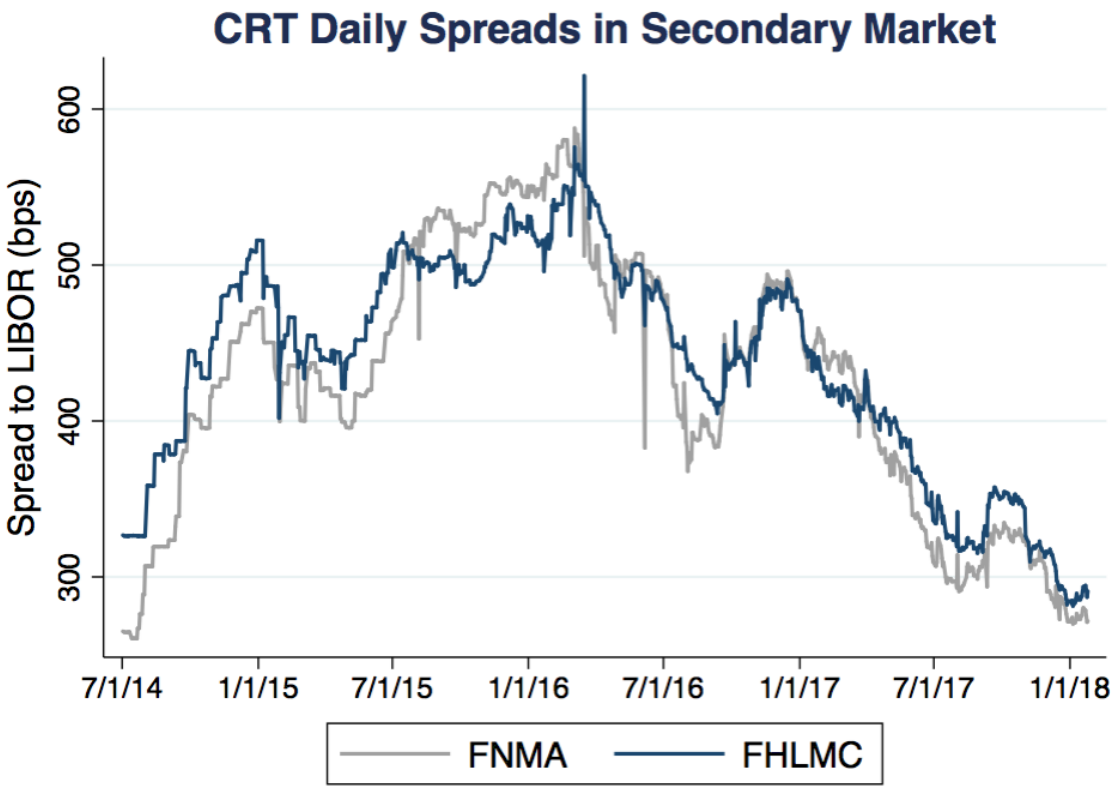


**Figure 3. Historical Spread of Credit Risk Transfers.** The figure plots the time series of average daily spreads (yield to maturity minus one month U.S. Dollar LIBOR) implied by the transactions in the secondary market of all CRTs from Fannie Mae and Freddie Mac. Source: Thomson Reuters Eikon.

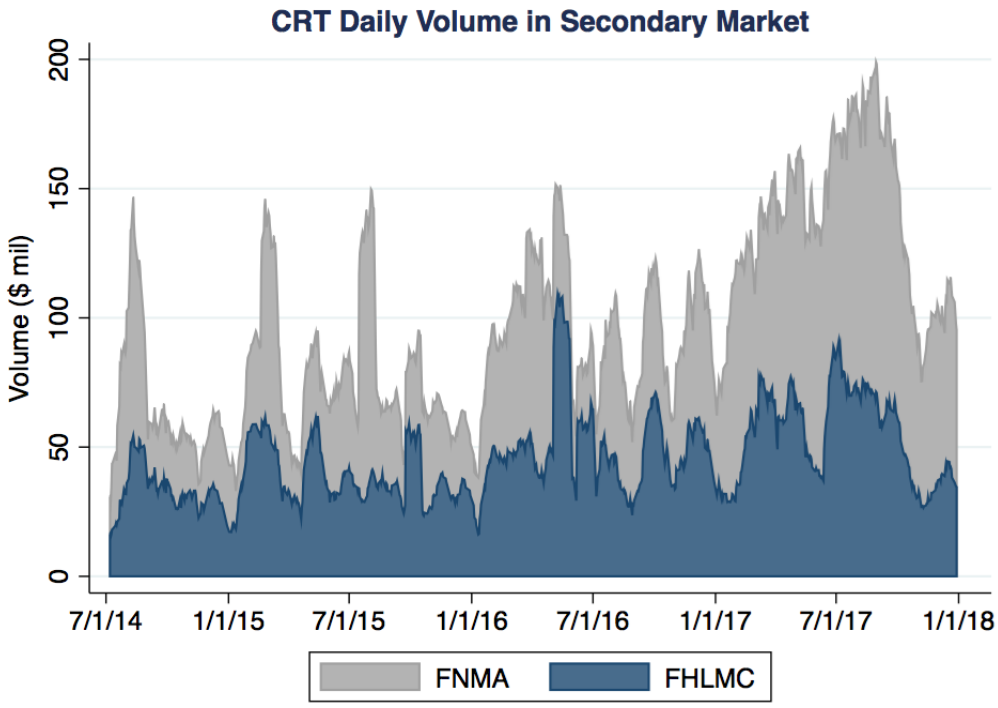


**Figure 4. Historical Volume of Credit Risk Transfers.** The figure plots the time series of the total daily volume (20 days moving average) of the transactions in the secondary market of all CRTs from Fannie Mae and Freddie Mac. The trade size per transaction is capped to $5 million. Source: TRACE.

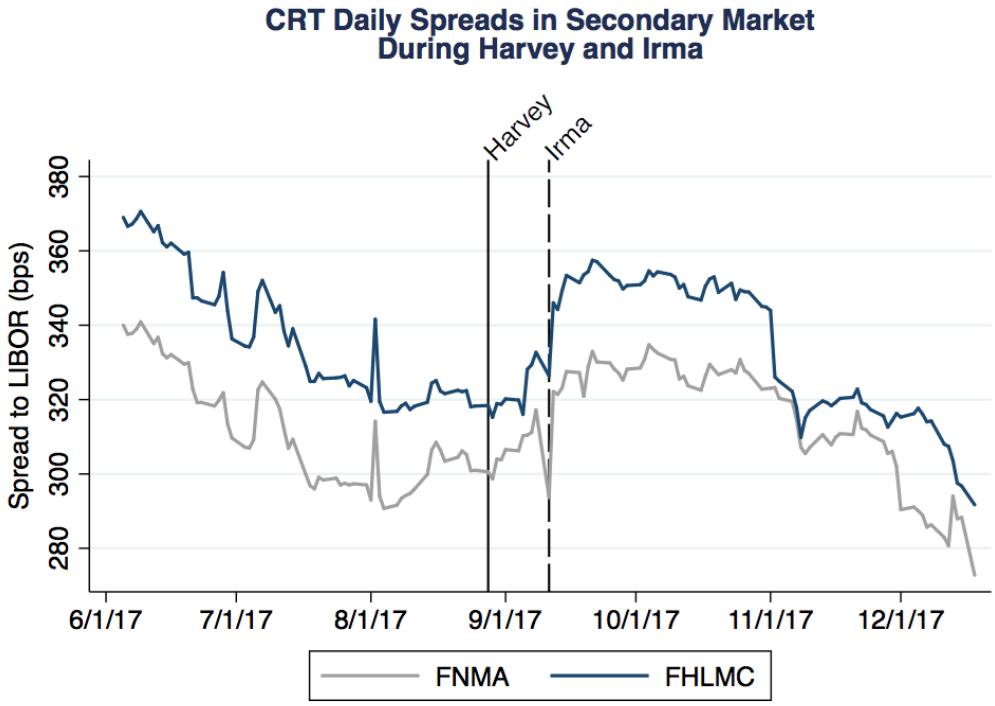


**Figure 5. Spread of Credit Risk Transfers During Hurricane Harvey and Hurricane Irma.** The figure plots the time series of average daily spreads (yield to maturity minus one month U.S. Dollar LIBOR) in the secondary market of all CRTs from Fannie Mae and Freddie Mac, specifically for the period 14 weeks before and 14 weeks after Hurricane Irma hit the U.S. The solid vertical line indicates August 28th, 2017, the trading day after Hurricane Harvey's first landfall, and the dashed vertical line September 11th, 2017, the trading day after Hurricane Irma's first landfall in the U.S. coast. Source: Thomson Reuters Eikon.

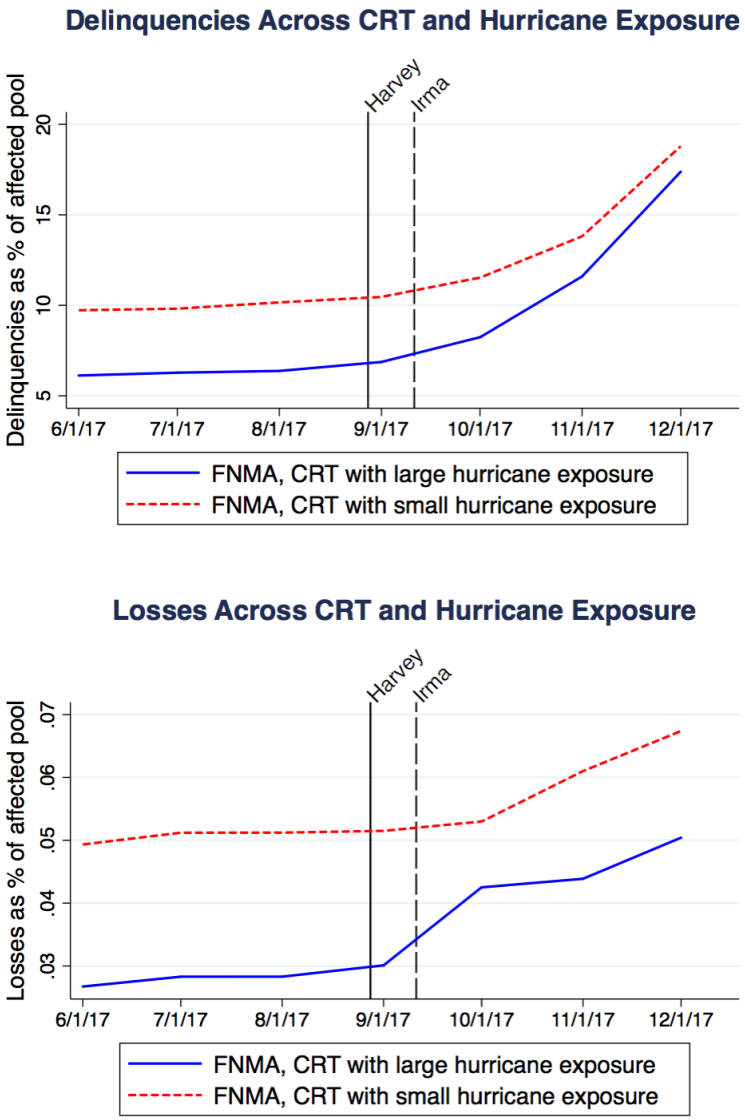


**Figure 6. Mortgage Delinquencies and Losses in Harvey and Irma Affected Areas of Credit Risk Transfers with Different Exposures.** The figures plots the average percentage of unpaid principal balance from (a) delinquent and (b) defaulted loans in the areas affected by Harvey and Irma within the reference pool of Fannie Mae's CRTs. Data are reported monthly. Large exposure means exposure greater than the mean plus one standard deviation, and small exposure means smaller than the mean minus one standard deviation. The solid vertical line indicates August 28th, 2017, the trading day after Hurricane Harvey's first landfall, and the dashed vertical line September 11th, 2017, the trading day after Hurricane Irma's first landfall in the U.S. coast. Source: Fannie Mae.

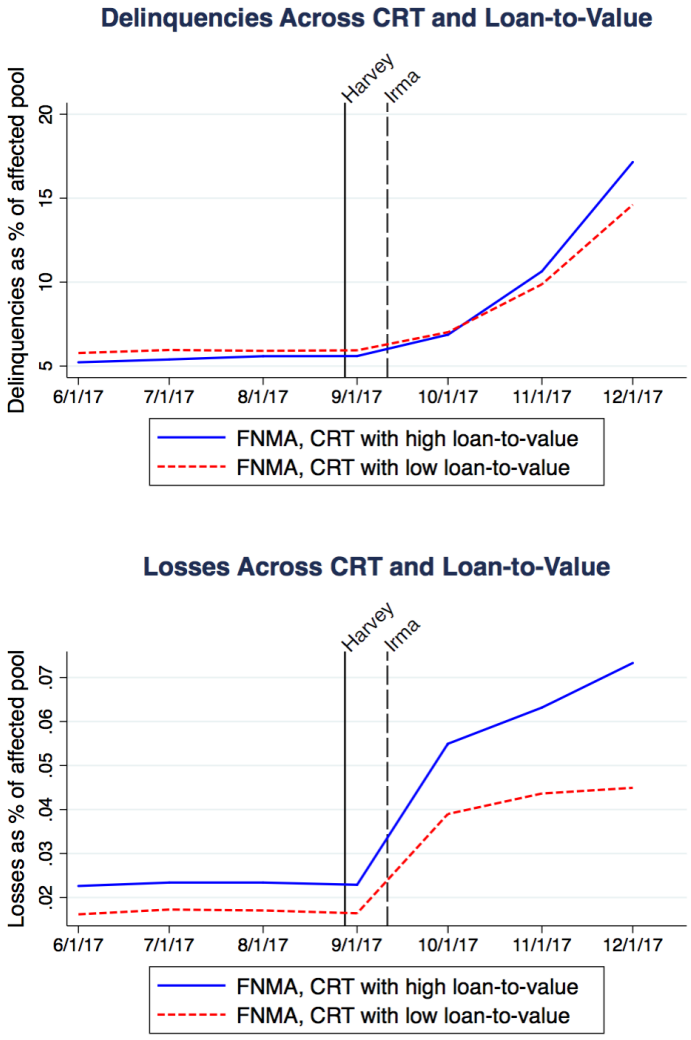


**Figure 7. Mortgage Delinquencies and Losses in Harvey and Irma Affected Areas of Credit Risk Transfers with Different Loan-to-Value Ratios.** The figures show the average percentage of unpaid principal balance from (a) delinquent and (b) defaulted loans in the areas affected by Harvey and Irma within the reference pool of Fannie Mae's CRTs. Data are reported monthly. High loan-to-value loans have >80 LTV, whereas low loan-to-value loans have 60-80 LTV. The solid vertical line indicates August 28th, 2017, the trading day after Hurricane Harvey's first landfall, and the dashed vertical line September 11th, 2017, the trading day after Hurricane Irma's first landfall in the U.S. coast. Source: Fannie Mae.

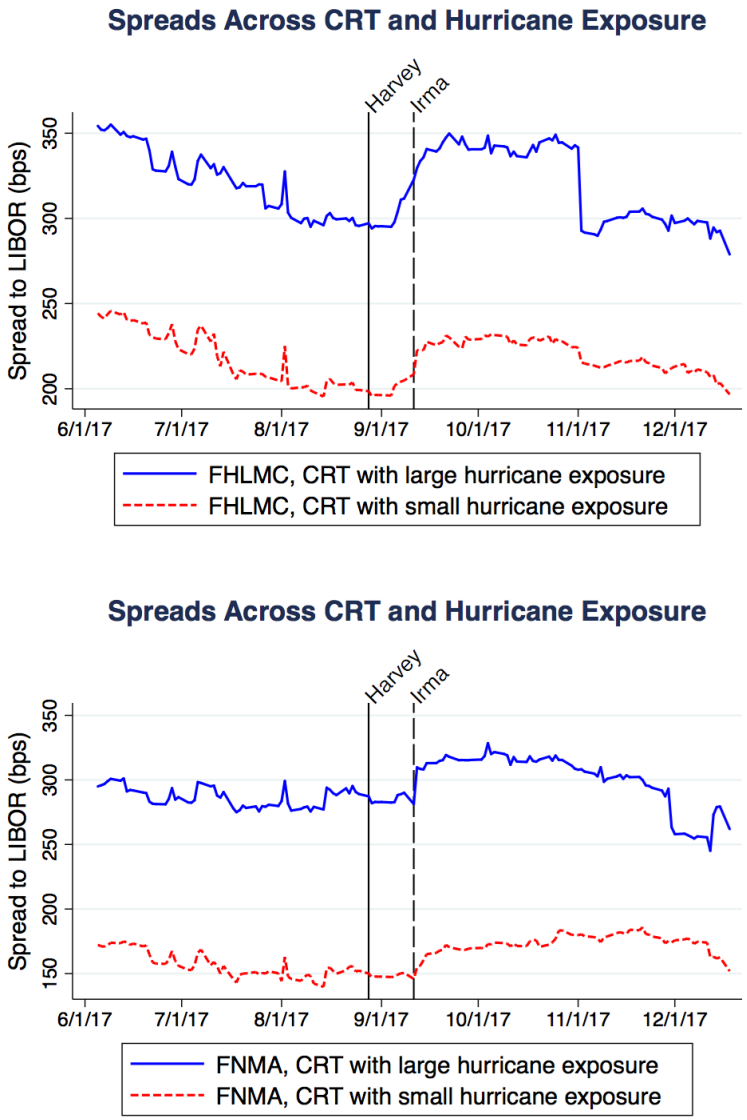


**Figure 8. Spreads for Credit Risk Transfers with Different Exposure to Harvey and Irma.** The figures plot the average daily spread (yield to maturity minus one month U.S. Dollar LIBOR) in the secondary market of CRTs. The geographical exposure to hurricanes is estimated as the percentage of unpaid principal balance in the reference pools of loans in the counties affected by the hurricanes. Large exposure means exposure greater than the mean plus one standard deviation, and small exposure smaller than the mean minus one standard deviation. The solid vertical line indicates August 28th, 2017, the trading day after Hurricane Harvey's first landfall, and the dashed vertical line September 11th, 2017, the trading day after Hurricane Irma's first landfall in the U.S. coast. Source: GSEs, Thomson Reuters Eikon.

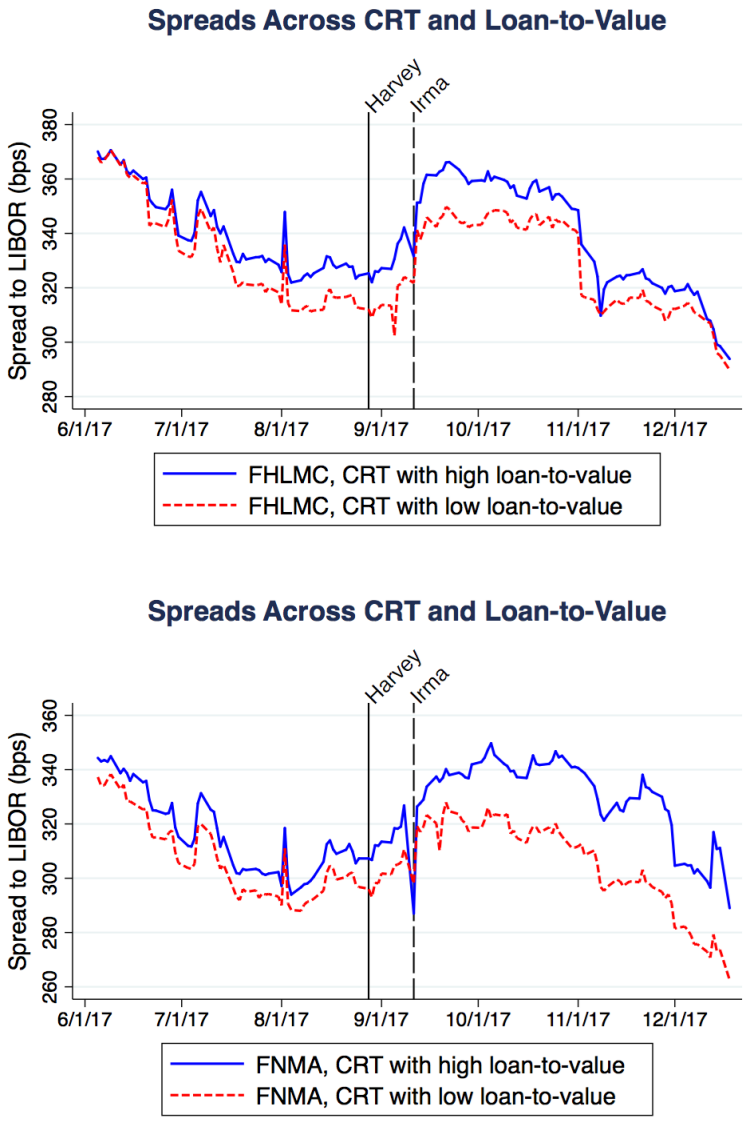


**Figure 9. Spreads for Credit Risk Transfers with Different Loan-to-Value Ratios.** The figures plot the average daily spread (yield to maturity minus one month U.S. Dollar LIBOR) in the secondary market of Freddie Mac's and Fannie Mae's CRTs. High loan-to-value loans have >80 LTV, whereas low loan-to-value loans have 60-80 LTV. The solid vertical line indicates August 28th, 2017, the trading day after Hurricane Harvey's first landfall, and the dashed vertical line September 11th, 2017, the trading day after Hurricane Irma's first landfall in the U.S. coast. Source: GSEs, Thomson Reuters Eikon.

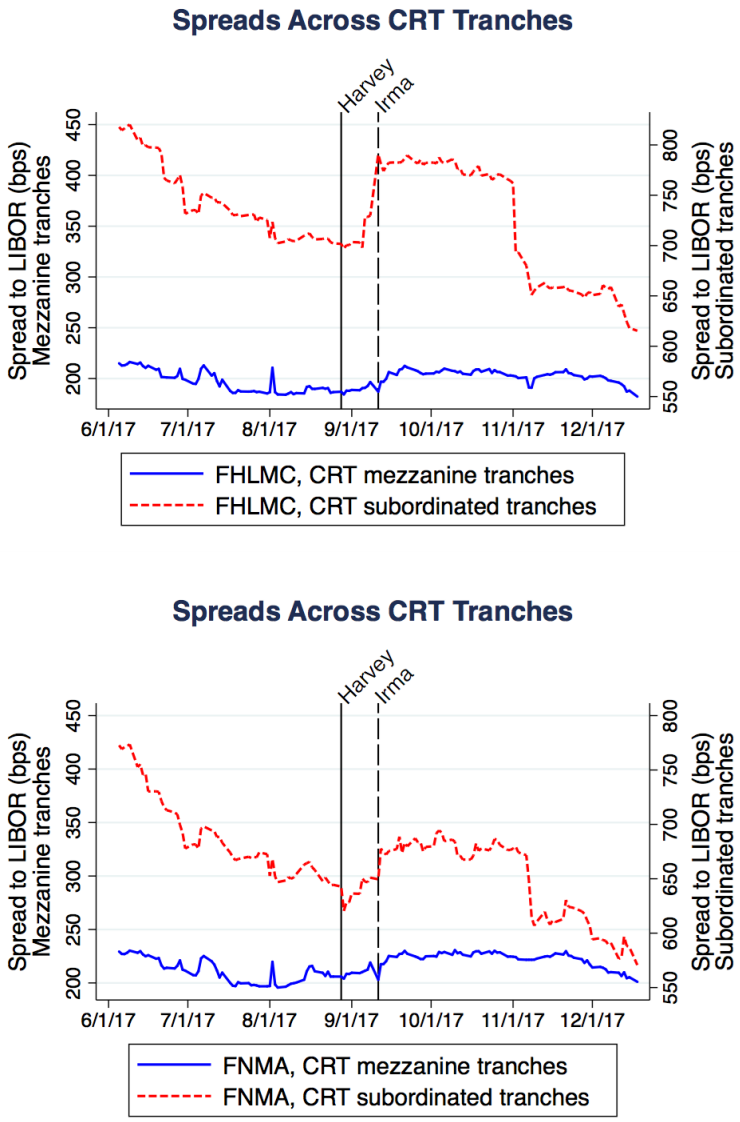


**Figure 10. Spreads for Credit Risk Transfers with Different Claims to Losses.** The figures plot the average daily spread (yield to maturity minus one month U.S. Dollar LIBOR) in the secondary market of Freddie Mac's and Fannie Mae's CRTs. The figure compares the spreads of the subordinated tranches, including the first loss tranches sold to investors with the mezzanine tranches. The subordinated tranches suffer the first losses before the mezzanine tranches begin to suffer losses. The solid vertical line indicates August 28th, 2017, the trading day after Hurricane Harvey's first landfall, and the dashed vertical line September 11th, 2017, the trading day after Hurricane Irma's first landfall in the U.S. coast. Source: GSEs, Thomson Reuters Eikon.

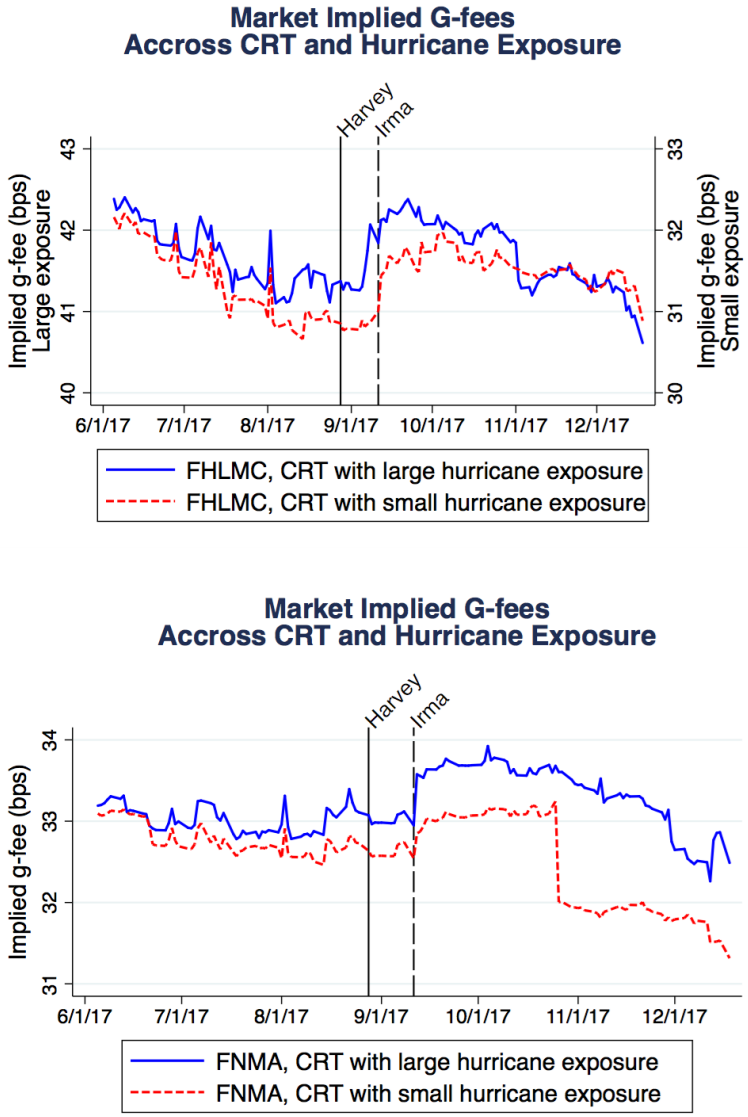


**Figure 11. Market Implied Guarantee Fees for Credit Risk Transfers with Different Exposures to Harvey and Irma.** The figure plots the average daily implied g-fees of Fannie Mae's and Freddie Mac's CRTs. The calculation of the implied g-fees is based on the daily spreads in the secondary market and is described in Appendix A2. Large exposure means exposure greater than the mean plus one standard deviation, and small exposure means smaller than the mean minus one standard deviation. The solid vertical line indicates August 28th, 2017, the trading day after Hurricane Harvey's first landfall, and the dashed vertical line September 11th, 2017, the trading day after Hurricane Irma's first landfall in the U.S. coast. Source: Thomson Reuters Eikon, Bloomberg, GSEs, Authors' calculations.

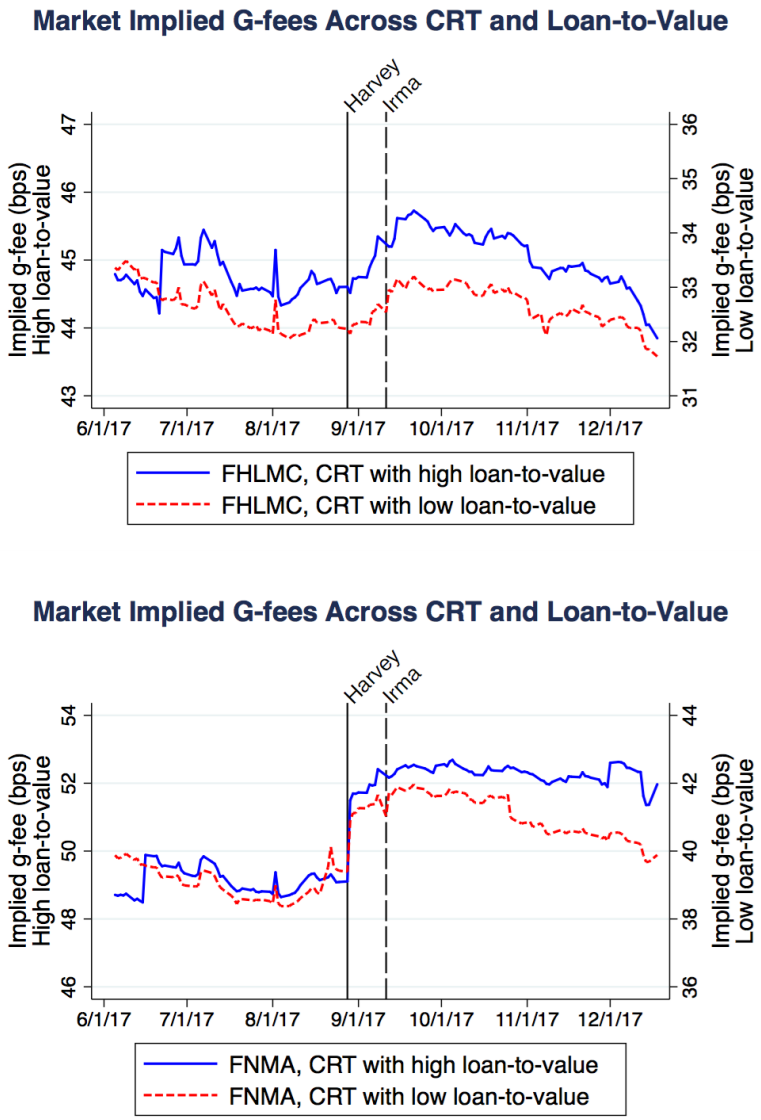


**Figure 12. Market Implied Guarantee Fees for Credit Risk Transfers with Different Loan-to-Value Ratios.** The figure plots the average daily implied g-fees of Fannie Mae's and Freddie Mac's CRTs. The calculation of the implied g-fees is based on the daily spreads in the secondary market and is described in Appendix A2. High loan-to-value loans have >80 LTV, whereas low loan-to-value loans have 60-80 LTV. The solid vertical line indicates August 28th, 2017, the trading day after Hurricane Harvey's first landfall, and the dashed vertical line September 11th, 2017, the trading day after Hurricane Irma's first landfall in the U.S. coast. Source: Thomson Reuters Eikon, Bloomberg, GSEs, Authors' calculations.

# Tables

Table 1. Credit Risk Transfers Traded in Secondary Market

| | | Number of securities | | |
|---|---|---|---|---|
| | | Fannie Mae | Freddie Mac | All |
| Loan to Value Ratio | 60-80% | 46 | 51 | 97 |
| | > 80% | 30 | 44 | 74 |
| Mezzanine Tranches | M1 | 23 | 17 | 40 |
| | M2 | 36 | 29 | 65 |
| | M3 | 0 | 23 | 23 |
| Subordinate Tranche | B1 | 17 | 23 | 40 |
| First Loss Tranche | B2 | 0 | 3 | 3 |
| Issuance Year | 2013 | 4 | 4 | 8 |
| | 2014 | 9 | 12 | 21 |
| | 2015 | 8 | 24 | 32 |
| | 2016 | 26 | 31 | 57 |
| | 2017 | 26 | 21 | 47 |
| | 2018 | 3 | 3 | 6 |
| Credit Rating | A | 1 | 8 | 9 |
| (Current) | AA | 0 | 5 | 5 |
| | AAA | 4 | 7 | 11 |
| | B | 15 | 10 | 25 |
| | BB | 7 | 9 | 16 |
| | BBB | 18 | 16 | 34 |
| | Not Rated | 31 | 40 | 71 |
| **Total** | | **76** | **95** | **171** |

Note: The table presents the distribution of Fannie Mae's and Freddie Mac's CRT securities traded in the secondary market. These are all CRT securities that have been issued from July 2013 to February 2018. The rating of the CRTs is the Fitch rating in January 2018, as reported by Bloomberg.

Table 2. Summary Statistics

| | Mean | SD | Min | Max |
|---|---|---|---|---|
| Spread daily (bps) | 327.18 | 249.18 | 40.50 | 1312.20 |
| Exposure (%) | 0.05 | 0.03 | 0.01 | 0.10 |
| High loan-to-value | 0.45 | 0.50 | 0 | 1 |
| Subordinated | 0.24 | 0.43 | 0 | 1 |
| Weighted Average Life (years) | 6.98 | 3.43 | 1.03 | 12.53 |
| Floater spread (bps) | 445.40 | 316.29 | 55.00 | 1275.00 |
| Ten year treasury rate (%) | 2.27 | 0.09 | 2.05 | 2.46 |
| Two year treasury rate (%) | 1.43 | 0.11 | 1.27 | 1.63 |
| One month USD LIBOR (%) | 1.24 | 0.04 | 1.22 | 1.85 |

Note: Number of observations is 12,773. The table presents summary statistics of the key variables in the baseline specifications for spreads. The statistics are calculated for the window of 8 weeks before and after the treatment date.

Table 3. Spreads After Hurricanes for Hurricane Exposed Credit Risk Transfers

| | Spread | | | | | | |
|---|---|---|---|---|---|---|---|
| Irma | 10.75* | 10.87** | 12.43*** | 17.32*** | 20.46*** | 23.03*** | 29.68*** |
| | (6.27) | (5.10) | (4.55) | (4.20) | (3.82) | (3.58) | (3.37) |
| Exposure | 95.18 | 86.90 | 83.55 | 99.81 | 115.89 | 129.87* | 143.86** |
| | (125.39) | (103.32) | (90.10) | (81.09) | (74.32) | (69.04) | (64.83) |
| Irma × Exposure | 212.88** | 195.46*** | 164.27** | 124.97** | 88.49 | 50.49 | -6.48 |
| | (91.33) | (75.61) | (66.17) | (59.68) | (54.78) | (50.93) | (47.85) |
| Issue Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Window (Weeks) | ±2 | ±3 | ±4 | ±5 | ±6 | ±7 | ±8 |
| Observations | 3,350 | 4,923 | 6,486 | 8,056 | 9,626 | 11,199 | 12,773 |
| R-squared | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 |

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The sample consists of all Fannie Mae's and Freddie Mac's CRTs issued from July 2013 to September 2017. The daily spread is the yield to maturity minus the one month U.S. Dollar LIBOR, as reported by Thomson Reuters Eikon. The "treatment" time for the effects of the hurricanes is the first trading date after the first landfall in the U.S. coast of Hurricane Irma on September 11th, 2017. The exposure to Hurricane Harvey and Hurricane Irma is estimated by Fannie Mae and Freddie Mac as the percentage of unpaid principal balance in the reference pools of loans secured by properties in the counties affected by the hurricanes. We control for high LTV reference pools, weighted average life of the securities at issuance, floater spread, GSE issuer, 10-year treasury rate, 2-year treasury rate and one month U.S. Dollar LIBOR.

Table 4. Spreads After Hurricanes for High Loan-to-Value Credit Risk Transfers

| | Spread | | | | | | |
|---|---|---|---|---|---|---|---|
| Irma | 21.52*** | 19.85*** | 19.63*** | 22.57*** | 23.79*** | 24.38*** | 27.94*** |
| | (4.72) | (3.77) | (3.42) | (3.21) | (2.89) | (2.73) | (2.56) |
| High LTV | 15.08*** | 14.03*** | 13.90*** | 13.68*** | 13.45*** | 13.31*** | 13.24*** |
| | (3.76) | (3.10) | (2.71) | (2.44) | (2.24) | (2.08) | (1.95) |
| Irma × High LTV | 0.49 | 2.56 | 2.92 | 2.75 | 2.84 | 2.84 | 3.12 |
| | (5.09) | (4.21) | (3.68) | (3.32) | (3.04) | (2.83) | (2.66) |
| Issue Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Window (Weeks) | ±2 | ±3 | ±4 | ±5 | ±6 | ±7 | ±8 |
| Observations | 3,350 | 4,923 | 6,486 | 8,056 | 9,626 | 11,199 | 12,773 |
| R-squared | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 |

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The sample consists of all Fannie Mae's and Freddie Mac's CRTs issued from July 2013 to September 2017. The daily spread is the yield to maturity minus the one month U.S. Dollar LIBOR, as reported by Thomson Reuters Eikon. The "treatment" time for the effects of the hurricanes is the first trading date after the first landfall in the U.S. coast of Hurricane Irma on September 11th, 2017. High loan-to-value loans have >80 LTV. We control for geographical exposure to hurricanes, weighted average life of the securities at issuance, floater spread, GSE issuer, 10-year treasury rate, 2-year treasury rate and one month U.S. Dollar LIBOR.

Table 5. Spreads After Hurricanes for Credit Risk Transfers of Subordinated Rank

| | Spread | | | | | | |
|---|---|---|---|---|---|---|---|
| Irma | 11.47*** | 10.08*** | 9.65*** | 12.77*** | 14.29*** | 15.77*** | 20.90*** |
| | (3.92) | (3.11) | (2.84) | (2.68) | (2.41) | (2.28) | (2.15) |
| Subordinated | 114.81*** | 114.82*** | 115.64*** | 116.52*** | 117.26*** | 120.42*** | 123.00*** |
| | (5.79) | (4.81) | (4.22) | (3.82) | (3.52) | (3.28) | (3.10) |
| Irma × Subord. | 45.32*** | 46.99*** | 47.57*** | 45.74*** | 43.78*** | 39.90*** | 33.34*** |
| | (5.31) | (4.39) | (3.83) | (3.46) | (3.19) | (2.97) | (2.80) |
| Issue Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Window (Weeks) | ±2 | ±3 | ±4 | ±5 | ±6 | ±7 | ±8 |
| Observations | 3,350 | 4,923 | 6,486 | 8,056 | 9,626 | 11,199 | 12,773 |
| R-squared | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |

Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The sample consists of all Fannie Mae's and Freddie Mac's CRTs issued from July 2013 to September 2017. The daily spread is the yield to maturity minus the one month U.S. Dollar LIBOR, as reported by Thomson Reuters Eikon. The "treatment" time for the effects of the hurricanes is the first trading date after the first landfall in the U.S. coast of Hurricane Irma on September 11th, 2017. CRTs of subordinated rank correspond to first loss (B2) and subordinated tranches (B1 or B). We control for geographical exposure to Hurricane Harvey and Hurricane Irma, high LTV reference pools, weighted average life of the securities at issuance, floater spread, GSE issuer, 10-year treasury rate, 2-year treasury rate and one month U.S. Dollar LIBOR.

# Appendix

## A1. Credit Risk Transfer Cashflows

In this section we describe the sequence of cashflows from CRT notes to investors. We consider a given time $t$, measured in months, during the life of the CRT note in which $L_t$ is the outstanding principal of the CRT note at the beginning of the period. Then we can derive the following quantities for the CRT note at time $t$:

$$\begin{aligned} &\text{Scheduled interest:} && I_t = (r_t^L + s)\ L_t, \\ &\text{Principal prepayment:} && PREP_t = p_t\ L_t, \\ &\text{Mortgage default:} && DEF_t = d_t\ L_t, \end{aligned}$$

where $r_t^L$ is the one month U.S. Dollar LIBOR, $s$ is the floater spread, $p_t$ is the share of outstanding principal that was prepaid between time $t-1$ and $t$, and $d_t$ is the share of outstanding principal that defaulted between time $t-1$ and $t$.

Given the scheduled principal payments $SCHED_t$, prepayments and defaults, the outstanding principal of the CRT note for the following month $t+1$ is given by

$$L_{t+1} = L_t - SCHED_t - PREP_t - DEF_t,$$

or equivalently,

$$L_{t+1} = (1 - p_t - d_t)\ L_t - SCHED_t.$$

The new outstanding principal is equal to the previous month principal minus scheduled principal payments, prepayments and defaults. If, for example, 100% of the mortgages default between time $t-1$ and $t$, then $d_t = 1$ and $SCHED_t = 0$ and the outstanding principal at time $t+1$ is eliminated. Conversely, if nobody from the homeowners prepay their mortgages or default between time $t-1$ and $t$, then $p_t = d_t = 0$, and $L_{t+1} = L_t - SCHED_t$, that is the outstanding principal is reduced by the scheduled principal payments.

The scheduled principal payment, mortgage prepayment and interest rate sum up to the total cash flow of the CRT note at the given month

$$CF_t = SCHED_t + PREP_t + I_t.$$

Figure A1 shows the actual principal payments (scheduled and prepayments) to holders of the first CRT notes issued from each GSE referencing a high loan-to-value pool.

## A2. Market Implied G-Fees Calculation

We derive the market implied guarantee fees (g-fees) using the approach outlined by the FHFA in their Credit Risk Transfer Progress Report (2017). The calculation of implied g-fees is elaborated by Palmer (2017).

The market implied g-fee of a CRT deal is calculated by

$$Implied\ guarantee\ fee_{i,t} = Credit\ cost_{i,t} + Non\ credit\ cost_i,$$

where $i$ indexes the CRT deal, and $t$ indexes the date. $Credit\ cost_{i,t}$ is calculated by

$$Credit\ cost_{i,t} = \sum_j \frac{size_j \times spread_{j,t} \times WAL_j}{WAL_i},$$

where $j$ indexes the tranches within the CRT deal. $Size_j$ is the percentage of the original principal balance of the reference pool allocated to tranche $j$. $Spread_{j,t}$, as defined by the FHFA, is the "credit spread paid to investors as compensation for bearing the risk" (FHFA 2017, p. 11) for the CRT security linked to tranche $j$ at time $t$. Our credit spread measure is the time series of CRT spreads, which equal the yield to maturity minus the one month U.S. Dollar LIBOR, as implied by the prices of CRTs in the secondary market.[9] [10] $WAL_j$ is the weighted average life of tranche $j$ and $WAL_i$ is the weighted average life of the whole reference pool of the CRT deal $i$. The numerator gives the credit cost over the lifetime of tranche $j$, hence the annual cost is obtained by dividing by the lifetime of the pool of the CRT deal $i$. The calculation of $WAL$ simulates the payments of interest and repayment of principal of the specific tranche. These payments are based on the following scenario: the CRT reference pools are faced with 10% constant prepayment rate, 0.2% constant default rate, and 25% loss given default. The calculations also assume that 100% of the CRT securities are sold to investors,

[9] In their sample calculations the FHFA's credit spread measure is the static floater spread of CRT securities at issuance. The floater spread plus the one month U.S. Dollar LIBOR equals the monthly coupon rate paid to investors.

[10] For the last loss tranches (B2) that are not sold to investors the credit spread reflects the indication price reported in the prospectus of the GSEs. In our calculation this credit spread remains constant over time, since there are no secondary market transactions for the specific tranches.

i.e. there is no retention by the GSEs.

$$Non\ credit\ cost_i = expense + tax + residual\ risk_i,$$

where *expense* indicates the general and administrative expenses, *tax* is the statutory payroll tax, and $residual\ risk_i$ is the the residual risks that cannot be transferred through CRT transactions (e.g. operational risk, term risk and counterparty risk). The FHFA sets the following corresponding values in basis points for non credit cost:

$$Non\ credit\ cost_i = \begin{cases} 8 + 10 + 7 = 25,\ for\ low\ loan - to - value\ pools \\ \\ 8 + 10 + 17 = 35,\ for\ high\ loan - to - value\ pools. \end{cases}$$

# Figures for the Appendix

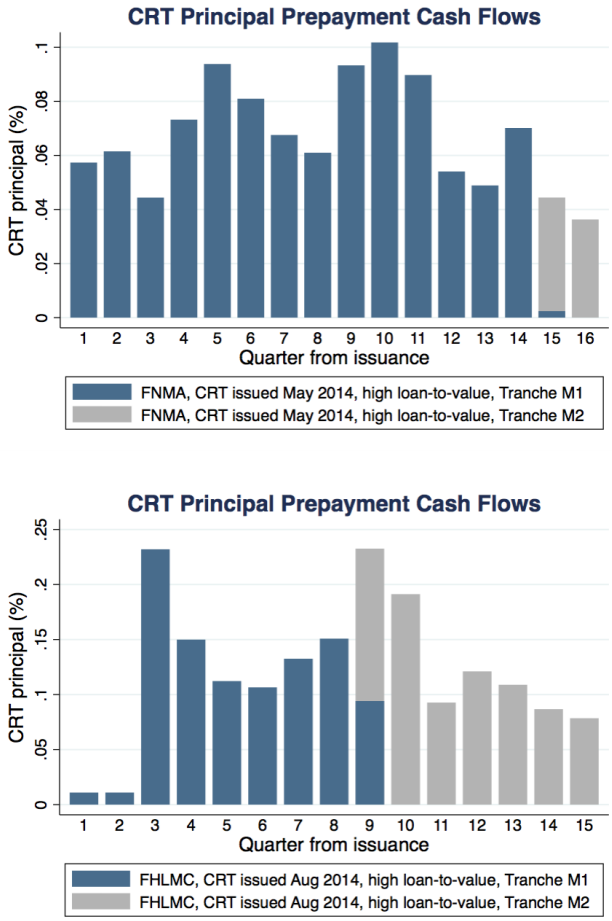


**Figure A1. Credit Risk Transfer Deal Principal Payments.** The figure shows the actual principal payments to holders of specific tranches of a CRT deal from each GSE. The CRT deals illustrated are the first ones issued from each GSE referencing a high loan-to-value pool.[11] The most senior tranche M1 is the first to receive the scheduled and unscheduled principal payments as the principal outstanding in the reference pool is being repaid. These payments reduce the principal balance of the M1 tranche. Once tranche M1 is eliminated, tranche M2, which is the next in seniority, starts receiving principal payments. Fannie Mae's most senior tranche was fully repaid in 15 quarters from issuance, whereas Freddie Mac's most senior tranche was fully repaid in 9 quarters from issuance. Source: Thomson Reuters Eikon.

[11] The deals illustrated are Fannie Mae's CAS 2014 C02B, and Freddie Mac's STACR 2014 HQ1.