# Issuance Activity and Interconnectedness in the CMBS Market[1]

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**ABSTRACT**

The purpose of this paper is to provide background information on commercial mortgage backed securities (CMBS) by providing an analysis of issuance volumes, structure and participants. In addition, we analyze concentration and interconnectedness in the CMBS market before and after the global financial crisis.

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This study was prepared for Mark Flannery, Director and Chief Economist of the Division of Economic and Risk Analysis (DERA). This analysis is not intended to inform the Commission about compliance with or enforcement of federal securities laws.

## I. Summary

- In 2015, there were 304 CMBS deals, accounting for more than $168.8 billion raised.
- Reg 144A placements represented approximately 24% of total issuance by dollar volume, whereas SEC registered offerings and guaranteed agency issues accounted for approximately 37% of volume each.
- There were only 14 non-US deals with approximately 3% of raised dollar volume in 2015. Most CMBS issues securitized US collateral, with only 3 CMBS deals including collateral from the UK, Italy, and Canada each in 2015.
- Deals have grown in size after the financial crisis. The median deal size in 2015, excluding foreign, agency and resecuritization transactions, was $523 million, while the median deal size in 2009 was $247 million.
- Deals have also grown in the number of classes per deal, with 25% of deals having 17 or more tranches in 2015. Prevalence of interest-only classes has increased, with 25% of deals having 3 or more interest-only classes.
- The CMBS market is highly concentrated. In 2015, the top 5 book runners had 64.2% market share, the top 5 US CMBS loan contributors had a 44.1% market share, the top 5 B-piece buyers had approximately 70.4% market share by dollar volume, and a third of deals by dollar volume had the same master and special servicer.
- The individual networks of book runners and loan contributors have decreased in size and have become more interconnected after the financial crisis.

## II. Introduction

Asset backed securitization (ABS) has emerged as a significant source of financing in the US economy. As of the end of 2015, ABS issues funded approximately $1.36 trillion of total liabilities.[2] Following a rapid decline during the financial crisis, the commercial mortgage-backed security (CMBS) market has grown dramatically over the last several years. In 2015, CMBS issuance accounted for approximately $168.8 billion and roughly 25.8% of global securitization volume.[3] This paper performs background data analysis to provide information about the volume and structure of issuance as well as the degree of interconnectedness in the CMBS market before and after the financial crisis. Our analysis relies on CMBS issuance data from the Commercial Mortgage Alert (CMAlert) database, including information about 144A, SEC registered, foreign and agency issues priced between 2000 and 2015.

CMBS are debt securities representing claims to cash flows from the pool of commercial mortgages. CMBS are secured by mortgages or leases issued by banks, mortgage companies and other originators on commercial or multi-family income-producing properties. Pools of assets underlying or referenced by CMBS may include hundreds of loans and properties, the performance of which affects risks and returns of CMBS investors. Further, in the securitization process, cash flows from pools of underlying assets are tranched into multiple prioritized classes, providing investors with varying exposures to credit, interest rate and other types of risk.

The characteristics and risks of CMBS depend on the quality and characteristics of the asset pool underlying the CMBS, such as the number of underlying loans and default correlations of assets underlying the issue. For instance, combining loans from a large number of borrowers with less correlated default risks can diversify credit risk and reduce the impact of borrower-specific credit risk on CMBS investors. Further, risks and returns of CMBS issues depend on the way a particular deal is structured, such as the number of classes, presence of interest-only and principal-only classes, levels of credit support for senior classes and relative weight in the capital structure of a given CMBS.[4] These features determine how interest and credit risks are split up among various CMBS classes, and which investors may incur losses as a function of interest rate fluctuations or changing default rates. For instance, interest-only securities commonly have negative duration, increasing in value during high interest rate cycles and declining in value when interest rates are low.[5] In addition, default correlations on assets in the collateral pool affect the relative value of classes with different seniority.[6] Through securitization, collateral can be transformed and split into assets with a variety of risk

[2] Federal Reserve Statistical Release, "Financial Accounts of the United States", Level tables p.113, available at: http://www.federalreserve.gov/releases/z1/current/z1r-4.pdf.

[3] See ABAlert Market Issuance, available at https://www.abalert.com/rankings.pl?Q=105.

[4] See e.g. Coval, Jurek and Stafford (2009).

[5] See e.g. Falconio and Rhodes (2014).

[6] Higher default correlations indicate less diversified default risk and a shifting of risk from junior to senior claims. When default correlations rise, the expected payoff on the junior classes increases and the expected payoff (and, consequently, value) of more senior classes falls. See Coval, Jurek and Stafford (2009).

characteristics. This heterogeneity of risk characteristics allows the issuer to attract investors with varying degrees of risk tolerance, ranging from conservative investors that would not have otherwise allocated capital into the underlying collateral to more risk-tolerant private funds.

Securitization enables originators of assets underlying CMBS to offload balance sheet risk. This may give rise to moral hazard problems and incentivize loosened underwriting standards,[7] particularly when investors are reaching for yield across asset classes, such as in low interest rate cycles (e.g., mid 2000s and in the aftermath of the financial crisis) and when bank capital standards and regulatory requirements are weaker.[8] At the same time, securitization allows originators to reduce their risk exposure, particularly to large loans, and enables them to specialize in screening and originating functions. Further, an active and liquid secondary mortgage market facilitated by securitization can reduce the effects of lender funding shocks on the credit supply.[9] More opaque and complex structures may also increase the informational asymmetry about the inherent characteristics and risks of CMBS issues among originators, underwriters and investors, which can give rise to adverse selection[10] and increase the importance of underwriter reputation.

The effects of the above incentives may be stronger in markets where a small number of participants with large market shares repeatedly originate, pool, structure and place CMBS. Emerging finance research has used networks to represent financial markets and relationships among market participants, and explore systemic risk, resilience of certain financial markets, and corporate decisions.[11] Broadly, a network is a collection of nodes and edges between nodes. When representing financial markets and relationships with networks, nodes represent market participants, while the edges reflect certain aspects of market participants' relationship with each other, such as transactions or balance sheet exposures. In this paper, we map the network structure and activity of some of the key CMBS market participants involved in the securitization process, such as book runners, loan contributors, and B piece buyers. The network structure can reflect the relative bargaining power[12] of market participants, the shift in market centrality and size, and trends in the formation and severance of relationships. This paper uses network analysis to consider changes in the interconnectedness of market participants prior to and in the aftermath of the global financial crisis.

The rest of the paper is organized as follows. In Section III we describe the data. In Section IV, we provide an overview of CMBS issuance activity and collateral features. Section V analyzes the activity of CMBS market participants, such as book runners, loan contributors, and B-piece buyers. In Section VI, we present data on industry concentration. Section VII maps the network

[7] See e.g. Black, Chu, Cohen, and Nichols (2012), Titman and Tsyplakov (2010).

[8] See e.g. Maddaloni and Peydró (2011), Downing, Jaffee, and Wallace (2009), Demyanyk and Loutskina (2015).

[9] See e.g. Loutskina and Strahan (2009), Loutskina (2011).

[10] See e.g. Akerlof (1970), An, Deng, and Gabriel (2011).

[11] See e.g. Acemoglu, Ozdaglar, and Tahbaz-Salehi (2015), Ahern and Harford (2014), Billio, Getmansky, Lo, and Pelizzon (2012), Getmansky, Girardi and Lewis (2016), Hochberg, Ljungqvist, and Lu (2007), Hu (2015), Stojkovic (2015).

[12] See e.g. Allen and Babus (2009), Bonacich (1987).

of CMBS market participants and compares network characteristics of the CMBS market before and after the crisis.

## III. Data

The analysis relies on issue and tranche level information from the January 2016 vintage of CMAlert data provided to subscribers by Harrison Scott Publications, Inc, as well as publicly available aggregate market statistics.[13] Our sample spans issuance between January of 2000 and December of 2015 and includes information about over 2,900 deals and $2.1 trillion of issuance volume. Database coverage is limited to issues secured by commercial or multi-family mortgages or leases on income-producing properties and sold to US and non-US investors, with a trustee, and a rating from a major agency.[14] The exclusion of unrated issues from the data eliminates any issues that do not require a rating to successfully place. Year is defined based on the pricing date. Because guaranteed agency deals and resecuritizations have a unique risk profile and investor clientele,[15] our analysis excludes such transactions unless noted otherwise. In addition, due to data constraints, the analysis involving loan contributor activities omits single borrower deals. CMAlert also makes available to subscribers league table dollar credit data for loan contributors. This data covers a smaller subsample of deals than the master data, including only US CMBS non-single borrower deals consisting of loans intended to be securitized and excluding all (guaranteed and unguaranteed) agency deals. Our analysis involving credit amount of loan contributors reflects this data limitation.

## IV. CMBS issuance

First, we consider volumes of CMBS issuance and collateral characteristics. Table 1 reports the size and structure of issuance in CMBS markets from 2000 through 2015. The data indicate that CMBS issuance is cyclical, with volume of placements appearing to be increasing with improvement in general economic conditions. While post crisis growth in CMBS markets has been significant, current volumes of global CMBS issuance are just over half of the 2007 peak of $319.9 billion. The role of agency placements has also increased from approximately 1% of CMBS issues in 2007 to over a third of total issuance in 2015.

Figure 1 plots the total capital raised annually in CMBS markets after the financial crisis by type of offering. In 2015, SEC registered placements accounted for $61.9 billion of CMBS volume, compared to $39.9 billion reported raised through Rule 144A offerings. Volume of guaranteed agency CMBS issuance continued to be significant, accounting for approximately $61.8 billion or approximately 37% of global issuance.

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[13] The data and detailed information available at https://www.cmalert.com/rankings.pl.

[14] See CMAlert "About the Database" at https://www.cmalert.com/market/about_db.pl.

[15] Many agency CMBS issues carry either a US government guarantee or a guarantee by Government Sponsored Enterprises. Therefore, guaranteed agency CMBS may exhibit enhanced credit quality compared to otherwise comparable non-agency issues. CMBS Re-securitizations are securitizations of mostly subordinate tranches of CMBS transactions and may attract a less risk-averse clientele, and we do not have data about the collateral underlying such transactions to perform substantive analysis, among other things.

The reemergence of demand for CMBS after the financial crisis is also reflected in an increase in issue size. Table 2 reports the 25th, 50th and 75th percentiles of CMBS issue amounts from 2009 through 2015. The median issue amount of non-agency rated CMBS issue sold in 2015 was $523 million, and an increase of approximately 111.7% from 2009. We also observe significant variation in issue sizes, with the bottom quartile of issue size at $223 million or lower, and the top quartile issues of $962 million or greater. Further, guaranteed agency CMBS issues are significantly smaller, with the median Fannie Mae / Freddie Mac issue of approximately $290 million in 2015, with the 25th and 75th percentiles at $191 million and $868 million respectively.

**Table 1. Global CMBS issuance by type (USD millions)***

| Year | 144A & Priv | Agency | Foreign | Regist'd | Resec | Total |
|---|---|---|---|---|---|---|
| 2000 | 19,281 | 1,328 | 12,097 | 28,301 | 648 | 61,008 |
| 2001 | 32,961 | 4,931 | 22,714 | 36,243 | 1,890 | 96,849 |
| 2002 | 17,492 | 6,850 | 29,780 | 35,779 | 2,270 | 89,900 |
| 2003 | 26,682 | 7,983 | 20,802 | 51,872 | 706 | 107,339 |
| 2004 | 21,897 | 6,220 | 35,188 | 73,961 | 3,263 | 137,266 |
| 2005 | 35,010 | 4,625 | 70,014 | 136,233 | 4,933 | 245,883 |
| 2006 | 40,482 | 7,414 | 96,059 | 161,758 | 3,857 | 305,714 |
| 2007 | 40,639 | 3,166 | 85,492 | 190,567 | 2,650 | 319,863 |
| 2008 | 1,438 | 3,673 | 6,728 | 10,707 | . | 22,547 |
| 2009 | 6,863 | 8,705 | 4,576 | . | 4,119 | 20,144 |
| 2010 | 19,537 | 26,245 | 3,262 | . | 7,504 | 49,045 |
| 2011 | 26,046 | 33,585 | 3,632 | 8,454 | 1,769 | 71,716 |
| 2012 | 18,678 | 50,888 | 5,987 | 32,560 | 2,994 | 108,113 |
| 2013 | 34,769 | 59,392 | 12,533 | 53,094 | 1,727 | 159,788 |
| 2014 | 38,476 | 50,599 | 5,754 | 57,315 | 1,708 | 152,144 |
| 2015 | 39,892 | 61,819 | 5,202 | 61,900 | 784 | 168,814 |

* CMAlert does not report any registered issues in 2009 and 2010, or resecuritization transactions in 2008.

In addition to growth in the overall volume of CMBS issuance and issue size, we observe an increase in the number of classes per issue in Figure 2. A median CMBS issue in 2015 had 8 classes, compared to just 2 during the financial crisis in 2009. The distribution of the number of classes appears to be right tailed, with the top quartile of CMBS issues in 2015 having 17 or more classes.

While earlier issues were primarily comprised of principal-only tranches, recently placed issues provide investors with exposure to both interest-only and principal-only tranches, with a quarter of CMBS issues in 2015 having 3 or more interest-only classes, and a quarter of issues having 13 or more principal-only classes (Table 3). Since our database includes information about deals that placed, this suggests that investors in the current low interest rate cycle may have a demand for prepayment and credit risks of interest-only CMBS tranches.

**Figure 1. CMBS issuance by type (USD millions)***

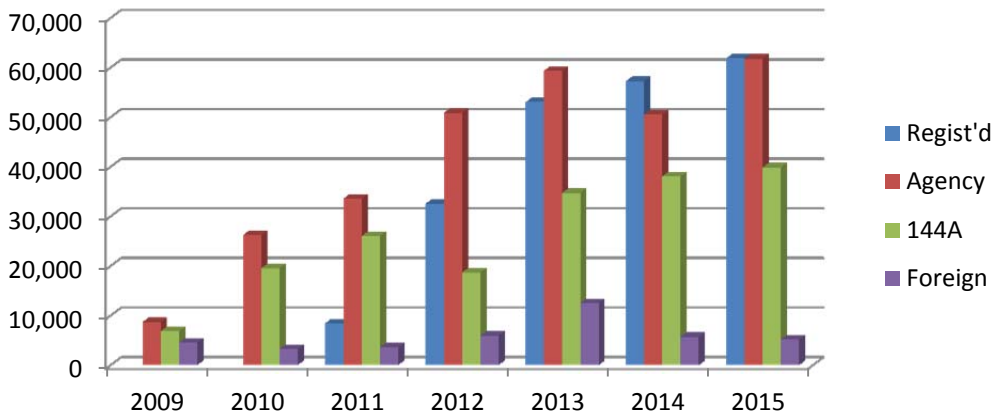



**Table 2. CMBS deal size (USD millions)***

| | Global CMBS (excl. agency & resec) | | | Agency | | |
|---|---|---|---|---|---|---|
| Year | 25%-ile | Median | 75%-ile | 25%-ile | Median | 75%-ile |
| 2009 | 119 | 247 | 500 | 215 | 237 | 321 |
| 2010 | 159 | 339 | 716 | 274 | 333 | 535 |
| 2011 | 186 | 491 | 1,214 | 239 | 342 | 525 |
| 2012 | 218 | 409 | 1,107 | 322 | 475 | 841 |
| 2013 | 267 | 508 | 1,111 | 225 | 327 | 903 |
| 2014 | 278 | 546 | 1,077 | 210 | 280 | 896 |
| 2015 | 223 | 523 | 962 | 191 | 290 | 868 |

**Table 3. Issue structure***

| | Number of classes per deal | | | Principal-only classes | | | Interest-only classes | | |
|---|---|---|---|---|---|---|---|---|---|
| Year | 25th %-ile | Median | 75th %-ile | 25th %-ile | Median | 75th %-ile | 25th %-ile | Median | 75th %-ile |
| 2009 | 1 | 2 | 4 | 1 | 2 | 4 | 0 | 0 | 0 |
| 2010 | 1 | 4 | 8 | 1 | 3 | 6 | 0 | 0 | 2 |
| 2011 | 3 | 8 | 14 | 2 | 6 | 11 | 1 | 2 | 2 |
| 2012 | 5 | 7 | 13 | 3 | 5 | 11 | 1 | 2 | 2 |
| 2013 | 5 | 7 | 15 | 3 | 6 | 13 | 1 | 2 | 2 |
| 2014 | 6 | 8 | 18 | 4 | 7 | 14 | 1 | 2 | 4 |
| 2015 | 5 | 8 | 17 | 3 | 6 | 13 | 1 | 2 | 3 |

Next, we consider collateral features. The number of loans and properties being securitized within a deal may be partly indicative of the extent of diversification in the collateral pools underlying CMBS issues. Figure 3 plots both the median number of loans per issue and the median number of properties in the collateral pool underlying CMBS issues between 2000 and 2015. In 2015, the median number of loans in the collateral pool of CMBS issues was 68 per

issue, and the median number of properties was 85 per issue.[16] While there was a wider gap between the median number of loans and properties per issue during the CMBS market boom of the mid 2000s, the gap has narrowed in the most recent period, which may suggest a decrease in the number of properties per loan in collateral pools.

**Figure 2. Classes per issue**

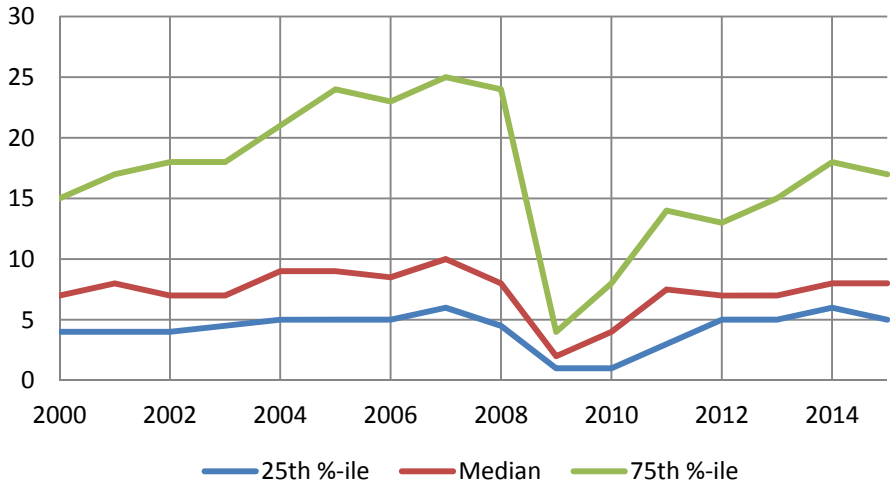
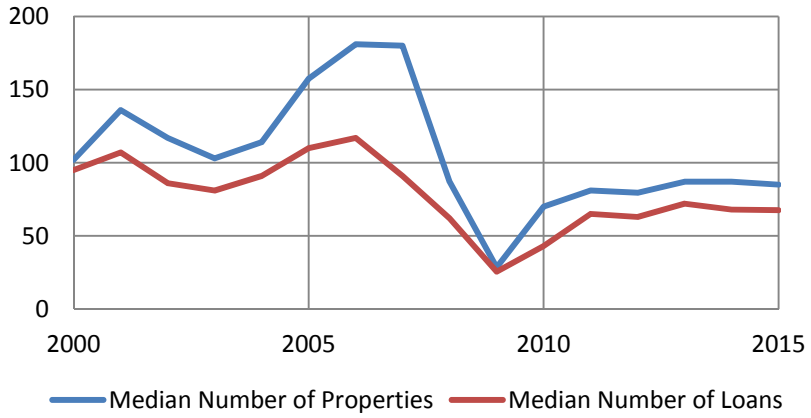



**Figure 3. Loans and properties in the pool (excluding single borrower transactions)***




The above analysis excludes single borrower deals. In Figure 4 we consider the role of single borrower issues in the CMBS market. In 2015, roughly 33% of global CMBS issuance volume excluding agency and resecuritization had collateral tied to a single borrower, compared to approximately 22% before the crisis. While the default risk of single borrower transactions may be greater due to a higher correlation of default and recovery rates across loans in the collateral pool, our sample only includes deals that are successfully placed. Hence, the relatively

[16] Single borrower transactions in our sample typically securitize just one loan, and to avoid skewing the results we exclude single borrower deals in this analysis. Separately, Figure 4 and Table 4 report the prevalence of single borrower transactions.

high prevalence of successfully placed single borrower transactions may reflect the selection of borrowers with superior credit quality. Figure 4 plots the total volume of CMBS issues with a single borrower flag in CMAlert.

**Figure 4. CMBS Issuance with collateral tied to a single borrower***

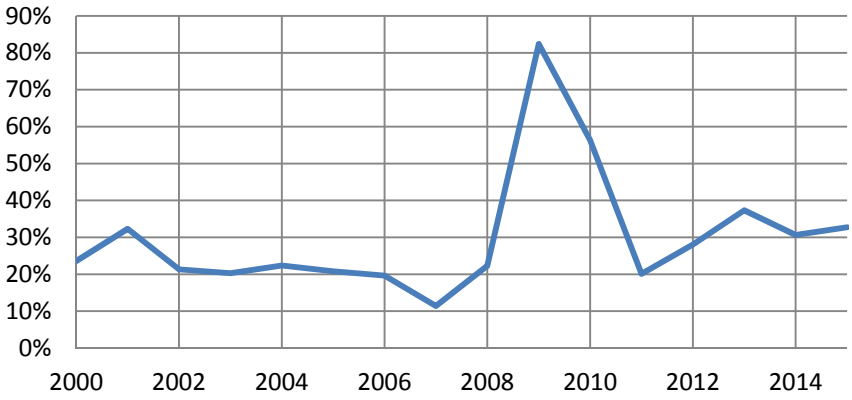



Table 4 presents the distribution of loans and properties per issue of collateral pools underlying global CMBS issues, excluding single borrower transactions. The table also reports the volume of issues in which collateral is tied to a single borrower, and the relative size of the single borrower sector in the CMBS market. There seems to be a significant degree of heterogeneity in the number of loans and properties that are being securitized. The role of single borrower CMBS spiked during the credit freeze, however, there are no clear trends in single borrower issuance over the last several years.

We repeat the analysis for guaranteed agency issues in Table 5. We observe that agency issues securitize a greater number of loans and properties, with both the median loans per issue and median properties per issue in 2015 at 80 (excluding single borrower issues). Single borrower issues are not a significant component of the agency market.

**Table 4. Loans and properties underlying global CMBS issues***

| | # of loans in the pool | | | # of properties in the pool | | | Single borrower collateral | |
|---|---|---|---|---|---|---|---|---|
| Year | 25th %-ile | 50th %-ile | 75th %-ile | 25th %-ile | 50th %-ile | 75th %-ile | Volume ($mln) | % of total (excl agency, resec) |
| 2009 | 4 | 26 | 54 | 10 | 29 | 54 | 6,033 | 82.4% |
| 2010 | 36 | 43 | 70 | 63 | 70 | 85 | 8,232 | 56.3% |
| 2011 | 44 | 65 | 76 | 67 | 81 | 109 | 7,248 | 20.1% |
| 2012 | 48 | 63 | 79 | 61 | 80 | 118 | 15,218 | 28.1% |
| 2013 | 54 | 72 | 83 | 73 | 87 | 113 | 36,830 | 37.3% |
| 2014 | 48 | 68 | 86 | 61 | 87 | 116 | 30,587 | 30.6% |
| 2015 | 54 | 68 | 83 | 64 | 85 | 116 | 34,773 | 32.7% |

*This analysis excludes guaranteed agency and resecuritization issues. Number of loans and properties analysis excludes single borrower issues.

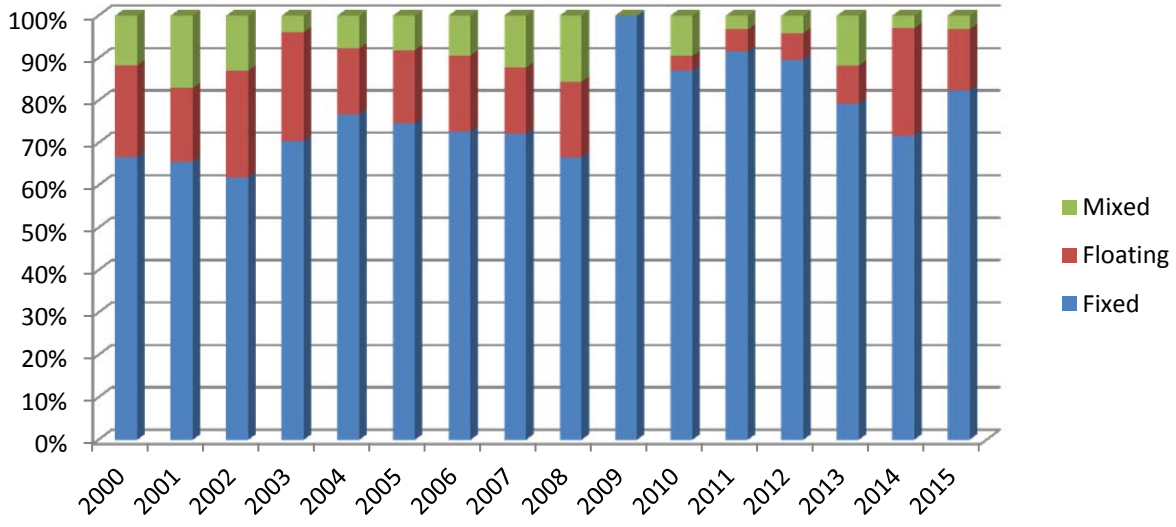
### Table 5. Loans and properties underlying guaranteed agency CMBS issues*

| Year | Number of loans in the pool 25th %-ile | 50th %-ile | 75th %-ile | Number of properties in the pool 25th %-ile | 50th %-ile | 75th %-ile | Collateral tied to single borrower Volume | % of total |
|---|---|---|---|---|---|---|---|---|
| 2009 | 43 | 62 | 80 | 41 | 57 | 80 | . | . |
| 2010 | 44 | 71 | 85 | 44 | 72 | 85 | 2,086 | 7.7% |
| 2011 | 40 | 68 | 90 | 61 | 75 | 93 | 538 | 1.6% |
| 2012 | 54 | 72 | 95 | 54 | 70 | 94 | . | . |
| 2013 | 53 | 76 | 96 | 51 | 74 | 90 | 2,309 | 3.9% |
| 2014 | 66 | 91 | 115 | 66 | 90 | 109 | . | . |
| 2015 | 62 | 80 | 96 | 61 | 80 | 96 | 3,084 | 5.0% |

* Number of loans and properties analysis excludes single borrower issues.

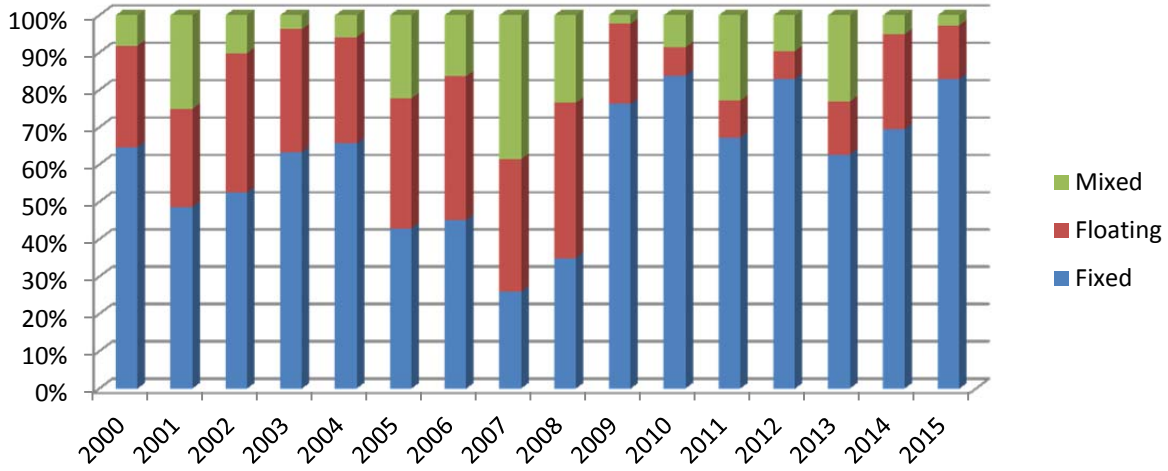
Next, we turn to the interest rate risk characteristics of CMBS issuance. Figure 5 shows the increasing proportion of floating and mixed interest rate collateral in recent years, accounting for 17% of CMBS issuance in 2015. However, it still represents a smaller fraction of CMBS issuance than during the pre-crisis years. Similarly, Figure 6 demonstrates an increasing role of floating rate notes in global CMBS (excluding agency and resecuritization). Prior to the crisis and in a higher interest rate environment, asset transformation in CMBS issues with respect to interest rate risk was more prevalent. In 2007, 28% of collateral and 74% of CMBS notes were floating or mixed; in 2015 approximately 18% collateral and 17% of CMBS notes were floating or mixed.

### Figure 5. Collateral type: interest rates*




* The figure excludes issues with missing collateral type data.

### Figure 6. CMBS note type: interest rates*




* The figure excludes issues with missing CMBS note type data.

Our data also allows us to document the geographical composition of CMBS collateral on the regional, country and state level. Considering all global CMBS issues, including agency and resecuritization transactions, Table 6 shows that most CMBS issues sold to investors in 2015 include collateral located in the US, with 289 of 304 global issues securitizing collateral located in the US. In unreported results, the importance of collateral located in the US continues to hold when excluding agency issues.

### Table 6. Country of collateral, 2015*

| Country | # of issues |
|---|---|
| Cayman Islands | 1 |
| Germany | 1 |
| Ireland | 1 |
| Netherlands | 1 |
| Pan-European | 2 |
| Canada | 3 |
| Italy | 3 |
| UK | 3 |
| US | 289 |
| Total | 304 |

*All global CMBS. Collateral location is based on the country of location identifier in CMAlert.

Similar patterns hold when considering the dollar volume of CMBS issuance. Table 7 shows the fraction of global CMBS volume by region of issuance after the financial crisis, including US, Europe and Other (Asia except Japan, Canada, Africa, Japan, Australia, Latin America & Caribbean, and Mideast flags in CMAlert). Results in Table 7 suggest that most of the post-crisis CMBS growth has centered around collateral located in the US, with some presence of investor demand for European collateral, but few issues in other regions.

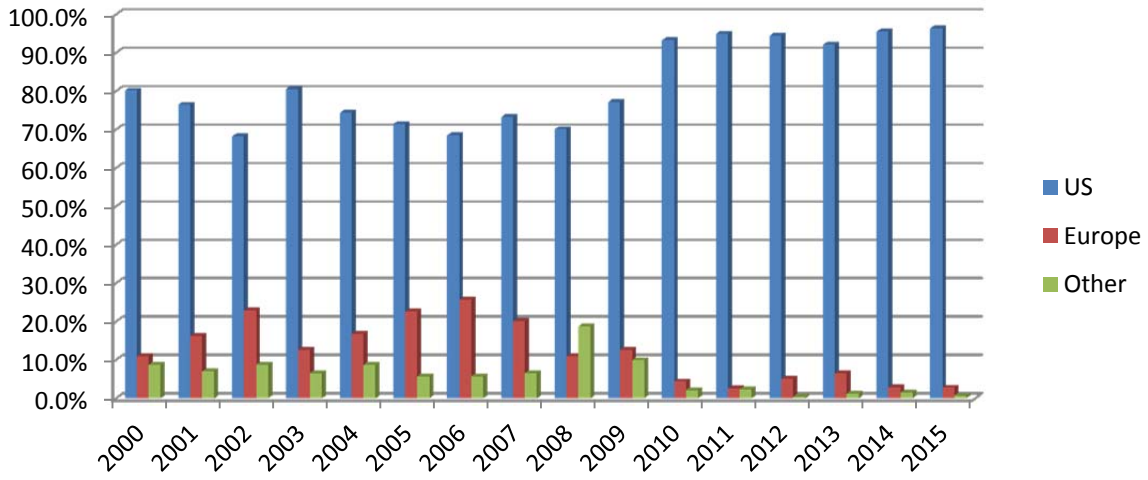
### Table 7. Region of collateral*

| Year | US | Europe | Other |
|---|---|---|---|
| 2009 | 77.3% | 12.7% | 10.0% |
| 2010 | 93.3% | 4.5% | 2.2% |
| 2011 | 94.9% | 2.6% | 2.4% |
| 2012 | 94.5% | 5.1% | 0.5% |
| 2013 | 92.2% | 6.5% | 1.3% |
| 2014 | 95.6% | 2.9% | 1.5% |
| 2015 | 96.5% | 2.8% | 0.7% |

***** Location is based on the region of location identifier in CMAlert.

Figure 7 plots CMBS issuance by region dating back to deals priced in January of 2000. We find that issuance during the pre-crisis period exhibited significantly higher placement rates of issues securitizing non-US collateral. CMBS issues backed by European collateral have fallen from approximately 26% in 2006, to 2.5% in 2015, and by 2015 over 96% of issuance was backed by US collateral. In unreported tests, this trend remains when we exclude from the sample agency CMBS issues.

### Figure 7. Region of collateral before and after the crisis*




*Issues are classified based on the region of collateral as reported by CMAlert. Other collateral includes Asia (except Japan), Canada, Africa, Japan, Australia, Latin America and Caribbean, and Mideast. Issues with missing collateral region data are excluded.

Table 8 and Figure 8 quantify geographical concentration of collateral pools. Panel A shows volume of CMBS issues with 1 or more states representing at least 10% of the underlying real estate collateral. This measure reflects geographic concentration of an issue's underlying collateral pool. We find that 2 issues in 2015 had over 60% of collateral located in just 6 states, with the median CMBS collateral pool having more than 20% of underlying collateral located in just 2 states. To the extent that this reflects the sensitivity of CMBS performance to real estate markets in individual states, these figures are consistent with geographic diversification of

credit risk in CMBS collateral issues. However, if performance of real estate markets across states is correlated, particularly during periods of acute market stress, geographic diversification may not reduce these correlated risks in CMBS issues.

In Panel B, we report the most common states in which at least 10% of CMBS collateral pools are located. We find that in 2015 over 50% of global non-agency issues included at least 10% of collateral located in Texas and California each, with New York, Florida and Illinois collateral also serving as common components of CMBS asset pools.

**Table 8. States with at least 10% of underlying collateral**

**Panel A. CMBS issuance by state asset concentration (USD millions)***

| Year | 1 State | 2 States | 3 States | 4 States | 5 States | 6 States |
|---|---|---|---|---|---|---|
| 2009 | 460 | 900 | 0 | 80 | 81 | 0 |
| 2010 | 2,854 | 2,618 | 2,388 | 2,578 | 857 | 0 |
| 2011 | 4,710 | 9,814 | 10,177 | 7,085 | 425 | 0 |
| 2012 | 11,818 | 10,695 | 17,772 | 7,347 | 738 | 0 |
| 2013 | 23,440 | 17,931 | 33,723 | 8,076 | 1,655 | 0 |
| 2014 | 20,554 | 25,782 | 29,993 | 16,194 | 277 | 0 |
| 2015 | 28,391 | 36,908 | 22,822 | 9,652 | 593 | 1,519 |

*This table reports issuance volume by the number of states accounting for 10% or more of the underlying real estate collateral as reported in CMAlert under "location". Issues with missing collateral location data are excluded. 5 observations with collateral locations in District of Columbia, Puerto Rico and US are excluded.

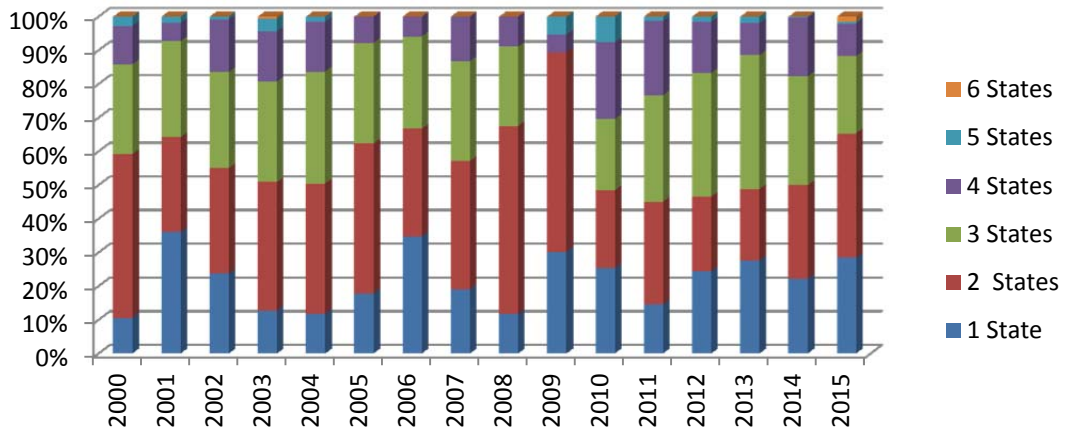
**Panel B. Most commonly referenced states with at least 10% of collateral, 2015***

| State | # of issues | Fraction of issues |
|---|---|---|
| TX | 84 | 53% |
| CA | 79 | 50% |
| NY | 52 | 33% |
| FL | 38 | 24% |
| IL | 16 | 10% |

*States are identified based on the location variable.

CMAlert data identify both the pricing and the closing date for each issue. Table 9 describes the distribution of the number of days between pricing and closing, excluding observations with closing dates before pricing dates as they may be data errors. The median global CMBS issue in 2015 required 9 days to close, a figure which has remained stable over time, whereas the median agency issue took 7 days to close. We note a significant degree of variation in the time between pricing and closing, with some issues taking as much as 28 days to close. The maximum number of days between pricing and closing in 2015 is 28, which is lower than similar figures for 2007-2009. Issues with more opaque or heterogeneous collateral may require more time to place, but this may also reflect heterogeneity in book runner reputations, changes in investor demand for a specific type of credit risk between pricing and closing for some issues, and willingness to warehouse risk.

## Figure 8. States with at least 10% of underlying collateral (by $ volume)*




*The figure shows issuance volume by the number of states accounting for 10% or more of the underlying real estate collateral as reported in CMAlert under "location" between 2000 and 2015. Issues with missing collateral location data are excluded. 5 observations with collateral locations in District of Columbia, Puerto Rico and US are excluded.

## Table 9. Days between pricing and closing*

| Indicator | Global 2015 | Global (excl. resec, agency) 2015 | US (excl. resec, agency) 2015 | Agency 2015 | Global 2007 | Global 2008 | Global 2009 |
|---|---|---|---|---|---|---|---|
| # of obs | 304 | 174 | 160 | 124 | 206 | 43 | 65 |
| Minimum | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 %-ile | 7 | 8 | 8 | 7 | 7 | 0 | 3 |
| Median | 9 | 12 | 12 | 7 | 9 | 7 | 7 |
| 75th %-ile | 14 | 14 | 14 | 13 | 14 | 13 | 9 |
| Maximum | 28 | 26 | 26 | 24 | 41 | 40 | 38 |

*Observations with closing date prior to pricing date are dropped

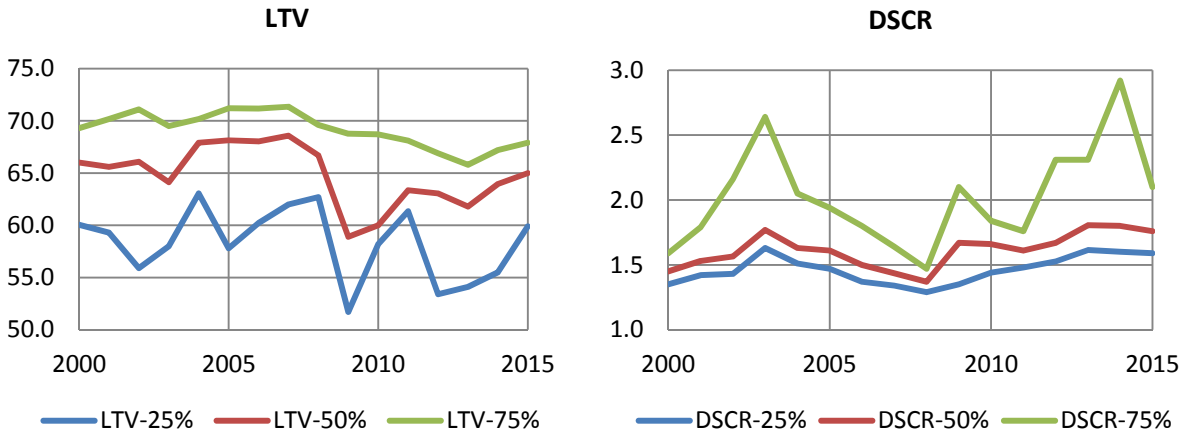
Loan to value (LTV) and debt service coverage ratios (DSCR) may reflect the credit risk of CMBS issues. We note that because CMBS are debt claims with inherently long performance periods, the credit quality of CMBS issues may be procyclical, and the financial crisis has demonstrated that credit quality can deteriorate rapidly during periods of market stress. However, loan to value ratios may reflect the credit quality of CMBS, with lower LTV deals involving lower credit risk than otherwise similar deals with higher LTV. In addition, debt service coverage ratios reflect cash flows available to make principal and interest repayments to CMBS investors, with higher values indicating a greater ability to service CMBS. Table 10 reports the distribution of both ratios for all global CMBS deals excluding agency and resecuritization transactions, and Figure 9 plots these ratios before and after the crisis. Loan to value ratios after the crisis appear to be lower than pre-crisis levels, but have been trending up in recent years, particularly for the lowest LTV quartile. We also observe a general lack of a trend in the DSCR measure but note a recent sharp decline in the top quartile of the distribution.

**Table 10. Loan to value and debt service coverage ratios***

| Year | LTV 25th %-ile | LTV Median | LTV 75th %-ile | DSCR 25th %-ile | DSCR Median | DSCR 75th %-ile |
|---|---|---|---|---|---|---|
| 2009 | 51.7 | 58.9 | 68.8 | 1.4 | 1.7 | 2.1 |
| 2010 | 58.2 | 60.0 | 68.7 | 1.4 | 1.7 | 1.8 |
| 2011 | 61.3 | 63.3 | 68.1 | 1.5 | 1.6 | 1.8 |
| 2012 | 53.4 | 63.0 | 66.9 | 1.5 | 1.7 | 2.3 |
| 2013 | 54.1 | 61.8 | 65.8 | 1.6 | 1.8 | 2.3 |
| 2014 | 55.5 | 64.0 | 67.2 | 1.6 | 1.8 | 2.9 |
| 2015 | 59.9 | 65.0 | 67.9 | 1.6 | 1.8 | 2.1 |

*LTV is the weighted average loan-to-value ratio for all mortgages in the securitized pool. DSCR is the weighted average debt-service coverage ratio for all mortgages in the securitized pool.

**Figure 9. Loan to value and debt service coverage before and after the crisis ***




In addition, prepayment risk is a risk exposure inherent in mortgages in general, and CMBS in particular.[17] Borrowers paying a high mortgage interest rate can opt to refinance during lower interest rate cycles. Notably, borrowers are unlikely to refinance when prevailing interest rates exceed the mortgage interest rate. As a result, mortgage debt resembles callable debt, and the incentive to refinance increases as the prevailing interest rate falls below the original mortgage rates. From the standpoint of CMBS investors, accelerated prepayment by borrowers reduces the amount of interest cash flows owed on the debt underlying the CMBS. While CMAlert data does not include explicit measures of prepayment risk of each deal, Table 11 and Figure 10 report weighted average maturity (remaining term) and weighted average coupon rates for all loans in the securitized pool. We observe a considerable downward trend in the weighted average mortgage coupon during low interest rate cycles in early-mid 2000s and in the post-crisis period. In addition, we note an increase in the weighted average loan maturity in the bottom quartile, which may point to the emergence of extension risk in recent years.

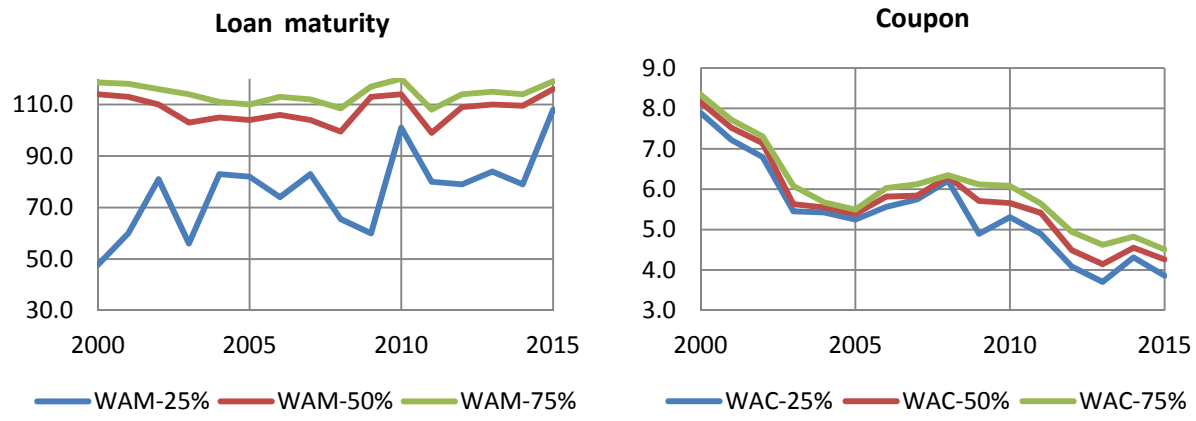
[17] See e.g. Ambrose and Sanders (2003).

**Table 11. Loan maturity and coupons***

| Year | Loan maturity (months) 25th %-ile | Median | 75th %-ile | Coupon (%) 25th %-ile | Median | 75th %-ile |
|---|---|---|---|---|---|---|
| 2009 | 60 | 113 | 117 | 4.9 | 5.7 | 6.1 |
| 2010 | 101 | 114 | 120 | 5.3 | 5.7 | 6.1 |
| 2011 | 80 | 99 | 108 | 4.9 | 5.4 | 5.6 |
| 2012 | 79 | 109 | 114 | 4.1 | 4.5 | 4.9 |
| 2013 | 84 | 110 | 115 | 3.7 | 4.1 | 4.6 |
| 2014 | 79 | 110 | 114 | 4.3 | 4.6 | 4.8 |
| 2015 | 108 | 116 | 119 | 3.9 | 4.3 | 4.5 |

* The table reports the weighted average loan maturity, or remaining term, and the weighted average coupon rate of all loans in the securitized pool.

**Figure 10. Weighted average loan maturity and coupons before and after the crisis***




## V. Market participants

Many parties may be involved in the securitization process that creates a commercial mortgage-backed security, including originators, sellers (loan contributors), issuing entities, lead (co-)managers (underwriters), and book runners.[18] The originator is the entity that creates a financial asset, such as a commercial mortgage that collateralizes the commercial-backed security. The seller (loan contributor) sells the asset to be included in a commercial mortgage-backed security issue and may be the originator of the underlying asset. The issuing entity is the trust or other vehicle that owns or holds the financial assets and in whose name the CMBS is issued. Underwriters, lead co-managers and book runners structure, underwrite and place CMBS deals. B-piece buyers purchase first loss bonds. Our analysis focuses on book runners,

[18] See Asset-Backed Securities, 70 FR at 1508. Also see Nationally Recognized Statistical Rating Organizations 79 FR at 55081.

loan contributors, B-piece buyers and servicers due to their significant role in the securitization process and data availability.

We now turn to the activities of book runners and loan contributors in CMBS markets. The median issue in 2015 had two book runners, with very few issues both by count or market share requiring three or more book runners to place. This may be a reflection of the value of book runner reputation for successful placements, investor risk appetite for CMBS and the pooling of collateral underlying issues. Table 12 reports the volume and counts of transactions with one or more book runners receiving credit for a particular issue.

**Table 12. Book runners per issue** *

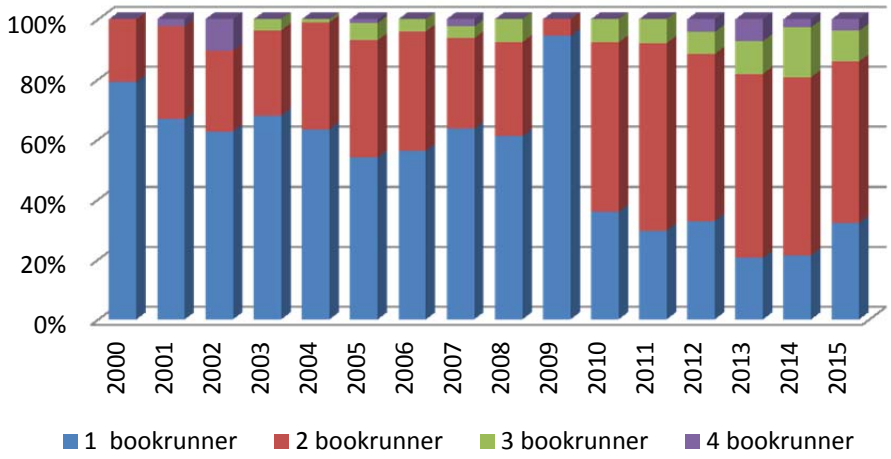
| | 1 book runner | | 2 book runners | | 3 book runners | | 4 book runners | |
|---|---|---|---|---|---|---|---|---|
| Year | Volume ($mln) | # | Volume ($mln) | # | Volume ($mln) | # | Volume ($mln) | # |
| 2009 | 6,904 | 20 | 416 | 2 | 0 | 0 | 0 | 0 |
| 2010 | 5,143 | 13 | 8,121 | 13 | 1,123 | 2 | 0 | 0 |
| 2011 | 10,669 | 20 | 22,500 | 28 | 2,878 | 3 | 0 | 0 |
| 2012 | 17,787 | 35 | 30,171 | 44 | 3,962 | 3 | 2,311 | 2 |
| 2013 | 20,178 | 47 | 60,496 | 79 | 10,774 | 11 | 7,220 | 3 |
| 2014 | 21,327 | 49 | 59,209 | 81 | 16,585 | 16 | 2,717 | 2 |
| 2015 | 34,104 | 75 | 57,145 | 82 | 10,860 | 14 | 4,101 | 3 |

*This table reports the issuance volume in millions of dollars and the number of transactions with 1 to 4 book runners in identifiers reported in CMAlert under “BOOK1” through “BOOK4”.

Book runners can facilitate placements while bearing underwriting risk, and play a certification role, reducing information asymmetries about issue quality. The reliance on multiple book runners can contribute to placement success, but may also give rise to collective action problems among book runners. Figure 11 reports the relative prevalence of issues with multiple book runners from 2000 through 2015. We observe a moderate increase in the prevalence of issues with more than two book runners, with 14% of issues in 2015 having three or four book runners, compared to the pre-crisis peak of approximately 10%. We also note that during the financial crisis, placements of issues by a single book runner spiked relative to issues with two book runners, which may reflect a deterioration of issue quality or an increased importance of book runner certification during the crisis.

Table 13 replicates the analysis in Table 12 for agency issues. Unlike other global CMBS issues, we observe no agency issues had more than 2 book runners. In 2015, approximately 57% of agency issues by $ volume had one book runner – a figure that has decreased from the pre-crisis period. This may point to an increased certification value of multiple book runners, as well as underwriting risk considerations by book runners of agency issues.

## Figure 11. Book runners per issue: before and after the crisis*




*The figure shows the fraction of global CMBS by $ volume with one through four loan contributors reported in CMAlert under "BOOK1" through "BOOK4" between 2000 and 2015.

## Table 13. Book runners per issue: guaranteed agency*

| | 1 book runner | | 2 book runners | |
|---|---|---|---|---|
| Year | Volume ($mln) | # | Volume ($mln) | # |
| 2009 | 7,710 | 25 | 995 | 1 |
| 2010 | 21,141 | 46 | 5,783 | 6 |
| 2011 | 21,587 | 61 | 11,722 | 12 |
| 2012 | 33,312 | 69 | 17,474 | 16 |
| 2013 | 36,065 | 92 | 23,327 | 18 |
| 2014 | 32,997 | 88 | 17,602 | 15 |
| 2015 | 35,475 | 102 | 26,344 | 22 |

*This table reports issuance volume in millions of dollars and number of transactions with 1 to 4 book runners reported in identifiers reported in CMAlert under "BOOK1" through "BOOK4".

Our data also identifies loan contributors for placed deals**.** Based on CMAlert data, we parse the seller information to identify names of unique loan contributors. We drop observations that list loan contributors as "(Unidentified)", "Domestic investor group" and "Unidentified investor group", and issues with missing seller information. In 2015, only 6 issues had over 5 loan contributors. Table 14 reports volume and transaction counts of issues with 5 or fewer loan contributors for global CMBS issues excluding single borrower transactions. A total of 35 issues in 2015 (and 104 issues between 2000 and 2015) represent non-guaranteed multi-family mortgage pass-through certificates sold by Freddie Mac placed by one or two book runners. Such non-guaranteed Freddie Mac issues accounted for approximately 69% by count and 49% by volume of issues with a single loan contributor in 2015. While most issues in 2015 had only one loan contributor, the median issue by $ volume had approximately 3 loan contributors, which is consistent with larger issues including collateral from multiple sellers.

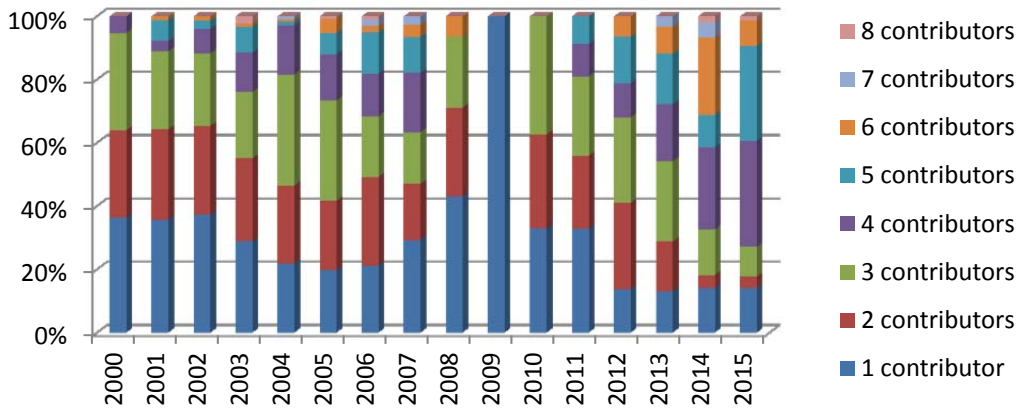
### Table 14. Loan contributors per issue*

| Year | 1 contributor Volume ($mln) | # | 2 contributors Volume ($mln) | # | 3 contributors Volume ($mln) | # | 4 contributors Volume ($mln) | # | 5 contributors Volume ($mln) | # |
|---|---|---|---|---|---|---|---|---|---|---|
| 2009 | 1,287 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2010 | 2,100 | 7 | 1,902 | 3 | 2,381 | 3 | 0 | 0 | 0 | 0 |
| 2011 | 9,440 | 22 | 6,673 | 5 | 7,201 | 4 | 2,947 | 2 | 2,537 | 2 |
| 2012 | 5,363 | 25 | 10,635 | 12 | 10,561 | 9 | 4,228 | 3 | 5,688 | 5 |
| 2013 | 8,123 | 32 | 9,658 | 9 | 15,684 | 13 | 11,188 | 10 | 9,867 | 8 |
| 2014 | 9,835 | 38 | 2,728 | 6 | 9,981 | 9 | 17,989 | 16 | 7,128 | 6 |
| 2015 | 10,143 | 51 | 2,533 | 3 | 6,658 | 7 | 24,026 | 23 | 21,408 | 20 |

*This table reports global CMBS issuance volume in millions of dollars and the number of transactions with 1 through 5 loan contributors. Loan contributors are identified based on parsed string using "seller" information in CMAlert. This table excludes deals with over 5 loan contributors.

Figure 12 shows loan contributor participation for all global CMBS deals excluding single borrower transactions, as a fraction of USD CMBS issuance volume in a given year for 2000 through 2015. During the pre-crisis period, particularly between 2004 and 2007, single loan contributor issues were on the rise. After the financial crisis, we observe a steady increase in the number of loan contributors per issue and a decline in the dollar volume of single loan contributor issues. We note that issues with 4 or more entities providing underlying collateral represented well over half of global CMBS issuance in 2015.

### Figure 12. Loan contributors per issue, % of $ CMBS volume*




*This table excludes observations with missing seller data.

As discussed above, pooling and tranching during the securitization process enables asset transformation of risky collateral into a prioritized capital structure with more and less risky classes. The most subordinated claims on a pool of CMBS mortgages carry ratings such as BB or lower. These tranches absorb the first losses on collateral pools, and are generically described as "B pieces". As a result, B piece buyers may have the right to name a special servicer to facilitate the resolution of defaults in the collateral pool, and may have bargaining power with respect to subordination levels and composition of the collateral pool. If an issue has no B-piece

buyer, the sponsor, one or more loan originators or their affiliates would bear the risk of any unplaced subordinated bonds.

Our database includes deal level information on identities of B-piece buyers, if any. B piece buyers may be particularly influential and primarily participate in conduit deals, which pool and tranche a large number of loans from multiple loan contributors. Figure 13 and Table 15 document the volume and number of issues with no, one, or more B-piece buyers for all issues excluding single borrower transactions.

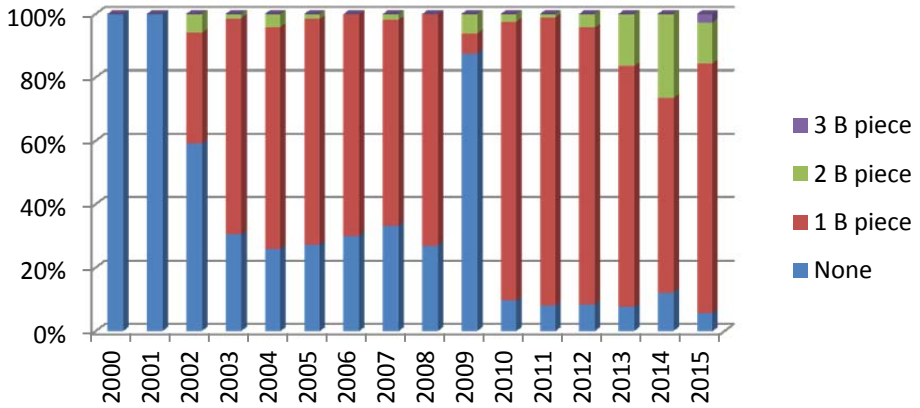
**Table 15. B-piece buyers per issue***

| | No B-piece buyer | | 1 B-piece buyer | | 2 B-piece buyers | | 3 B-Piece buyers | |
|---|---|---|---|---|---|---|---|---|
| Year | Volume ($mln) | # | Volume ($mln) | # | Volume ($mln) | # | Volume ($mln) | # |
| 2009 | 1,126 | 4 | 81 | 1 | 80 | 1 | 0 | 0 |
| 2010 | 612 | 2 | 5,621 | 10 | 151 | 1 | 0 | 0 |
| 2011 | 2,324 | 6 | 26,168 | 27 | 307 | 2 | 0 | 0 |
| 2012 | 3,260 | 11 | 34,075 | 42 | 1,679 | 3 | 0 | 0 |
| 2013 | 4,727 | 18 | 46,947 | 49 | 10,165 | 12 | 0 | 0 |
| 2014 | 8,413 | 25 | 42,462 | 48 | 18,376 | 20 | 0 | 0 |
| 2015 | 4,110 | 14 | 56,249 | 84 | 9,169 | 10 | 1,909 | 2 |

*This table reports global CMBS issuance volume in millions of dollars and the number of transactions with 0 through 3 B-piece buyers. B-piece buyer names are identified based on B-piece identifier string variable in CMAlert, correcting name changes and typos.

Figure 13 illustrates the prevalence of B-piece buyers in CMBS transactions before and after the crisis. Note that deals with no B-piece buyer were almost three times more common prior to the crisis compared with those in post-crisis years. As indicated above, we find that the overwhelming majority of conduit/fusion issues have at least one B-piece buyer, consistent with an increasing role of multiple B-piece buyers in recent years.

**Figure 13. B-Piece buyers per issue: before and after the crisis***




*This figure uses the same filter as Table 15.

Table 16 shows the number and total volume of single borrower non-agency issues that do not involve a B-piece buyer. Empirically, B-piece buyers do not appear to play a significant role in single borrower placements.

**Table 16. Single borrower global CMBS: the role of B-piece buyers***

| Year | Volume (no B-piece buyer, $mln) | Volume (all single borrower, $mln) | # Issues (no B-piece) | # Issues (all single borrower) |
|---|---|---|---|---|
| 2009 | 6,033 | 6,033 | 16 | 16 |
| 2010 | 8,179 | 8,232 | 15 | 16 |
| 2011 | 6,428 | 7,248 | 14 | 16 |
| 2012 | 14,883 | 15,218 | 27 | 28 |
| 2013 | 36,723 | 36,830 | 60 | 61 |
| 2014 | 29,912 | 30,587 | 54 | 55 |
| 2015 | 34,537 | 34,773 | 61 | 64 |

In addition, servicers and special servicers are important participants in CMBS markets. These market participants play distinct roles: master servicers administer performing mortgages, whereas special servicers handle and dispose of distressed loans in an issue's collateral pool. Existing work argues that when the same firm provides master and special servicing, the master servicer may have an incentive to bid for riskier loans in order for the special servicer to generate the largest fees.[19] At the same time, the concentration of master and special servicing rights in one firm may facilitate faster workouts of defaulted loans, and defaulted loans may be less likely to terminate in foreclosure if servicing rights are concentrated in one firm.[20] Table 17 and Figure 14 reports the number and volume, as well as the fraction of deals in our sample with the same firm acting as a master and a special servicer. In 2015, approximately a third of the deal by volume and 38% by count had the same master and special servicer.

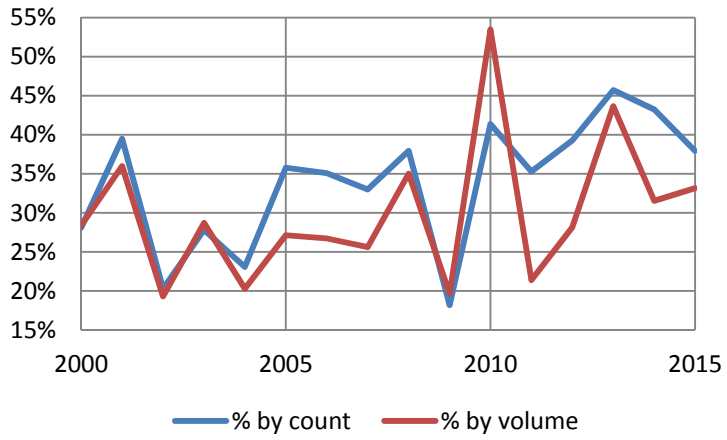
**Table 17. Cases when the firm acts as both master servicer and special servicer***

| Year | Volume ($mln) | % by volume | # Issues | % by count |
|---|---|---|---|---|
| 2009 | 1,440 | 20% | 4 | 18% |
| 2010 | 7,816 | 53% | 12 | 41% |
| 2011 | 7,712 | 21% | 18 | 35% |
| 2012 | 15,268 | 28% | 33 | 39% |
| 2013 | 43,057 | 44% | 64 | 46% |
| 2014 | 31,482 | 32% | 64 | 43% |
| 2015 | 35,222 | 33% | 66 | 38% |

* Observations with missing information about either master or special servicer identities are dropped.

[19] See e.g. Ambrose, Sanders, and Yavas (2016), Wong (2015).
[20] See Ambrose, Sanders, and Yavas (2016).

### Figure 14. Servicers: before and after the crisis*




* Observations with missing information about either master or special servicer identities are dropped.

## VI. Industry concentration

CMBS issues in our sample have between 1 and 4 book runners, each with an allocated amount of dollar credit. Aggregating these data at the annual level, Table 18 reports the market share of the leading book runners in the CMBS market for the post-crisis period. In 2015, the top 5 book runners accounted for approximately two thirds of all issuance by $ volume, with the top 10 book runners accounting for over 98% of all global non-agency issuance. This degree of book runner concentration may afford some book runners bargaining power in their transactions with loan contributors and other market participants.

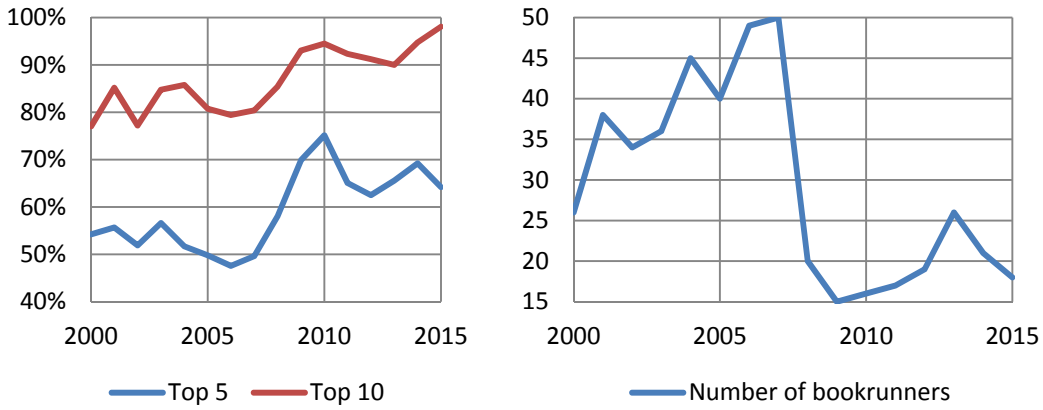
### Table 18. Market share of top book runners and the number of book runners*

| Year | Top 5 | Top 10 | # book runners |
|---|---|---|---|
| 2009 | 69.9% | 93.0% | 15 |
| 2010 | 75.1% | 94.5% | 16 |
| 2011 | 65.1% | 92.3% | 17 |
| 2012 | 62.5% | 91.2% | 19 |
| 2013 | 65.6% | 90.0% | 28 |
| 2014 | 69.2% | 94.8% | 21 |
| 2015 | 64.2% | 98.1% | 18 |

*This table reports the market share of top book runners and the total number of book runners in our sample in a given year based on "BOOK1" through "BOOK4" and "AMT1" through "AMT4" information.

Figure 15 shows that the top book runners' market share has increased significantly in the wake of the financial crisis. Prior to 2007 top 5 book runners placed approximately half of all issuance and top 10 book runners placed roughly 80% of all non-agency issues. Figure 15 demonstrates that both these figures increased significantly, consistent with exit of some book runners and post-crisis consolidation.

**Figure 15. Market share of top book runners and the number of book runners***




*This figure plots the market share of top 5 and top 10 book runners in a given year, and the total number of book runners in our sample. Book runners are identified based on "BOOK1" through "BOOK4" information and the amounts of their $ credit on global CMBS deals.

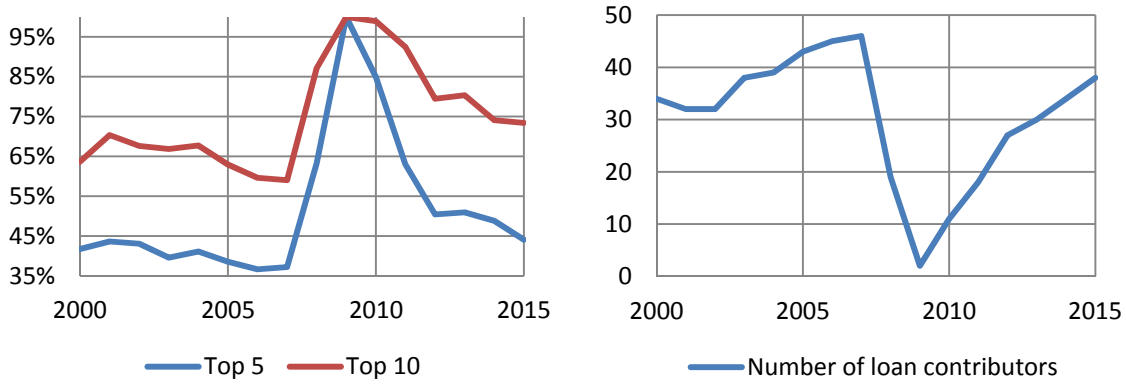
Similarly, we use CMAlert's historical loan contributor information to compute the market share of top 5 loan contributors in the post-crisis period in Table 19. Top 5 loan contributors represented approximately 44% of all US CMBS issuance in 2015. As a result of such high loan contributor concentration, the collateral quality of a few loan contributors may impact a vast majority of CMBS issuance.

**Table 19. Market share of top loan contributors and the number of loan contributors (excluding single borrower deals)**

| Year | Top 5 | Top 10 | # loan contributors |
|---|---|---|---|
| 2009 | 100.0% | 100.0% | 2 |
| 2010 | 85.0% | 98.9% | 11 |
| 2011 | 62.9% | 92.4% | 18 |
| 2012 | 50.4% | 79.5% | 27 |
| 2013 | 51.0% | 80.4% | 30 |
| 2014 | 48.8% | 74.1% | 34 |
| 2015 | 44.1% | 73.4% | 38 |

Figure 16 shows the top loan contributors' share of issuance, and the total number of loan contributors participating in CMBS markets before and after the financial crisis. Unlike the above results on book runners, loan contributor data shows an increase in the number and a decrease in concentration of loan contributors after the financial crisis, with 2015 levels approaching those during the pre-crisis period.

**Figure 16. Market share of top loan contributors and the number of loan contributors (excluding single borrower deals)**




Finally, in Table 20 we turn to B-piece buyers, and observe an even greater degree of market concentration. For instance, top 5 B-piece buyers in 2015 had an approximately 70.4% market share. Based on Figure 13, B-piece buyers play an important role in non-single borrower deals. Table 20 suggests that some B-piece buyers may enjoy significant market power.

**Table 20. Market share of top B-piece buyers***

| Year | Top 5 |
|---|---|
| 2009 | . |
| 2010 | . |
| 2011 | 88.0% |
| 2012 | 87.8% |
| 2013 | 77.4% |
| 2014 | 76.7% |
| 2015 | 70.4% |

*This table is based on aggregated statistics at: https://www.cmalert.com/rankings.pl?Q=80, accessed 3/2/2016

## VII. Network analysis

Finally, we consider the structure of the CMBS market and explore the interconnectedness of various market participants. We analyze network topology and quantitatively measure network structures using standard tools and metrics.[21] Our primary focus is on four measures of centrality: degrees (the number of other market participants an entity is connected to); betweenness (the fraction of shortest paths linking any two market participants passing through an entity of interest); closeness (the length of the average shortest path between a participant and other participants in the market), and eigenvector centrality (measuring the centrality of market participants a given entity is connected to). The last three centrality measures are calculated based on the weighted network, where the weight of each edge is

[21] See Ahern and Harford (2014), Billio, Getmansky, Lo, and Pelizzon (2012), Getmansky, Girardi, and Lewis (2016), Hochberg, Ljungqvist, and Lu (2007), Hu (2015), Stojkovic (2015).

based on the number of deals or credit amount between participants. First, we present the network topology based on activity between different types of market participants (i.e. mapping activity between book runners and loan contributors, and book runners and B-piece buyers). [22] Then, we perform the network analysis of activity within each group of participants (i.e. linkages among entities acting as book runners, or among entities acting as loan contributors).

Our sample includes deals, in which the same entity is acting both as a loan contributor and a book runner. Underwriter reputation facilitates placements, and engaging a third party book runner provides potentially valuable certification, particularly for issues securitizing opaque collateral. At the same time, selecting another financial firm (a possible competitor) to run the book may boost the competitor's league standings and strengthen the competitor's reputation.[23] Further, some market participants originating and securitizing their own assets may be using asset backed securities to alleviate funding needs through the use of collateralized lending facilities and repurchase agreements. We do not directly observe ex post collateral performance and are, therefore, unable to test whether self-run deals perform worse ex post. Our data lacks sufficient granularity to match individual securities to bilateral or triparty repo market transactions. Our primary focus is on trends in network interconnectedness in CMBS markets, and we perform network analysis both including and excluding self-run deals as discussed below.

First, we analyze the network topology between loan contributors and book runners before and after the crisis. Figure 17 presents a force-directed graph[24] of network activity among loan contributors and book runners based on their participation in the CMBS market.[25] Thickness of edges (links) between two counterparties represents the total number of CMBS deals, in which a book runner and loan contributor pair has participated during a given sample period. The node size is based on the total transaction count in a given period, including transactions on which a loan contributor also serves as a book runner. The shading of the node increases with the eigenvector centrality of each market participant and is scaled relative to the shading of other nodes in each graph. Consistent with our findings on market concentration above, only a small number of market participants exhibit high centrality. After the financial crisis, fewer book runners and loan contributors are participating in the market as evidenced by a reduction in the number of nodes in Figure 17B. Node sizes, reflecting the volume of activity by count, decrease as well.

[22] Network measures reflecting the structure of CMBS transaction activity among entities acting in various capacities on CMBS deals cannot be interpreted from the standpoint of systemic risk. See e.g. Acemoglu, Ozdaglar, and Tahbaz-Salehi (2015), Hu (2015).

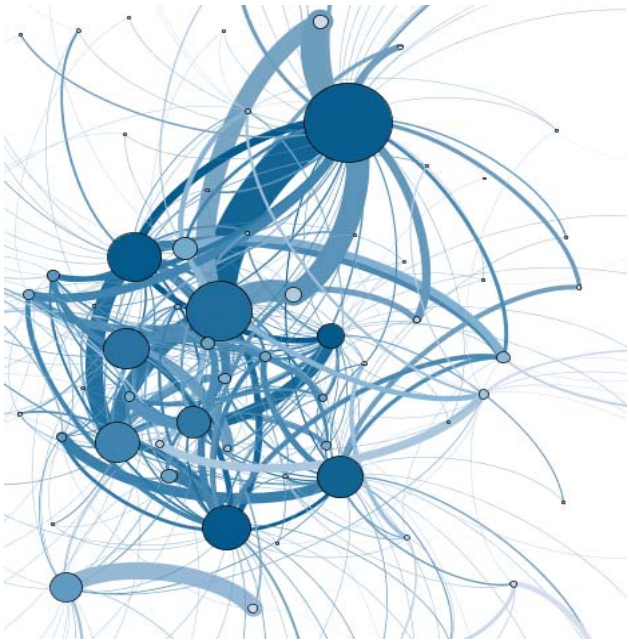
[23] See e.g. Becher, Gordon, and Juergens (2015).

[24] Fruchterman-Reingold force-directed graph algorithms attempt to draw graphs by minimizing the number of crossed edges. While the graphical position of a node in a force-directed graph may be related to measures of network centrality, it does not necessarily represent a node's centrality structure in the network. We formalize the centrality analysis by separately presenting tables and histograms of various network statistics.

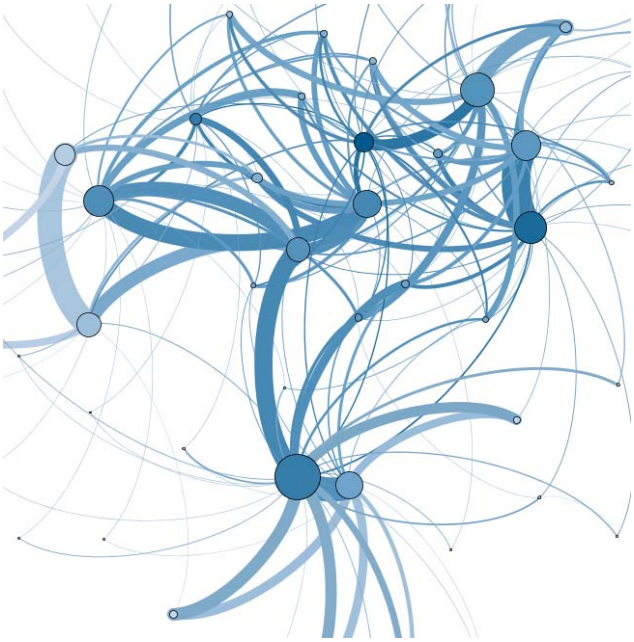
[25] We manually correct naming inconsistencies and aggregate loan contributors that belong to the same corporate group.

**Figure 17. Loan contributor – book runner network: transaction counts, all transactions***

**A. 2000-2008**



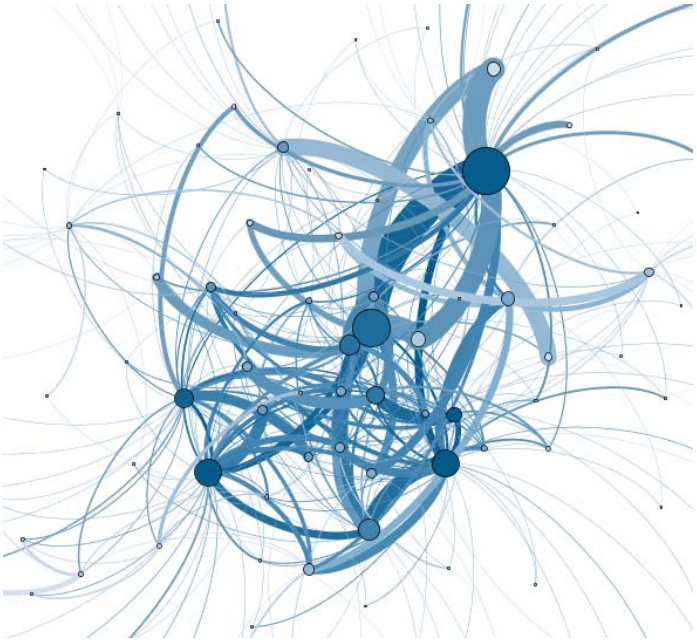
**B. 2009-2015**



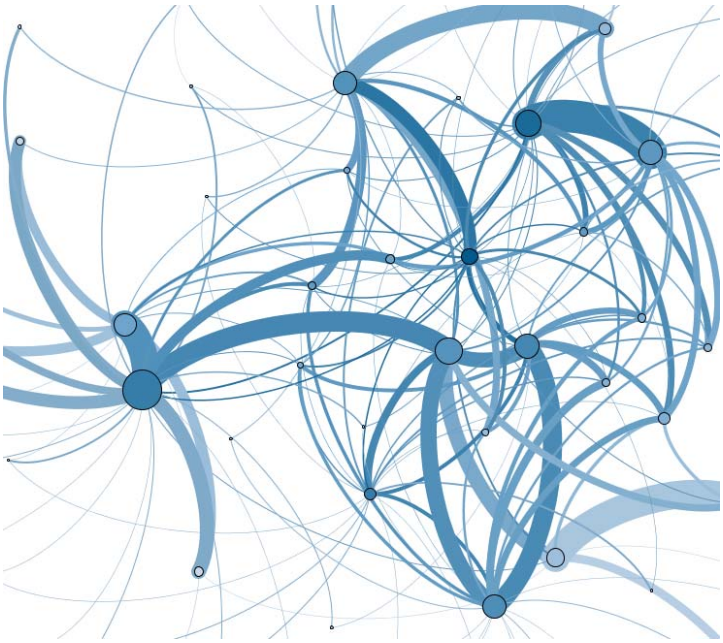
*These figures present Fruchterman-Reingold force directed graphs of CMBS transaction activity reported to CMAlert. Loan contributors are identified by parsing information in the "seller" variable, book runners are identified based on information in "BOOK1" through "BOOK4" variables in CMAlert. Node size is determined by the number of transactions by the entity. Node shading reflects eigenvector centrality measure (more central nodes presented with a stronger shade). Edge thickness is determined by the number of transactions between a loan contributor – book runner pair.

**Figure 18. Loan contributor – book runner network: transaction counts, excluding self-run deals***

**A. 2000-2008**



**B. 2009-2015**



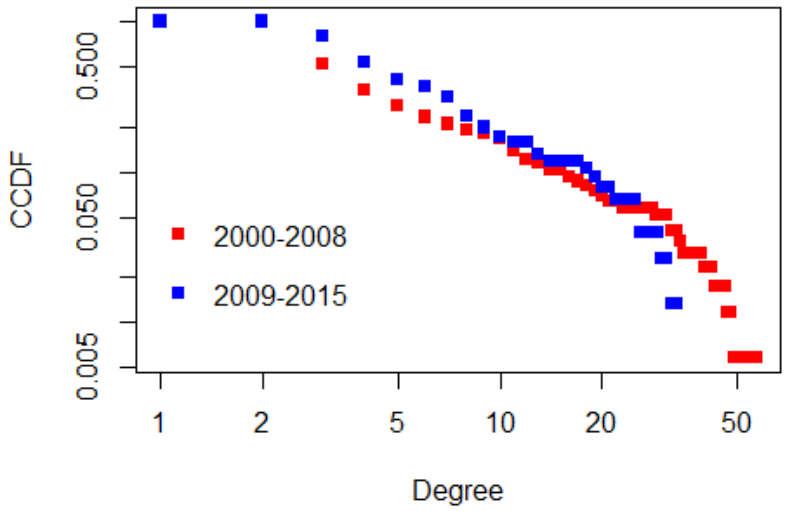
*These figures present Fruchterman-Reingold force directed graphs of CMBS transaction activity reported to CMAlert. Loan contributors are identified by parsing information in the "seller" variable, book runners are identified based on information in "BOOK1" through "BOOK4" variables in CMAlert. Node size is determined by the number of transactions by the entity. Node shading reflects eigenvector centrality measure (more central nodes presented with a stronger shade). Edge thickness is determined by the number of transactions between a loan contributor – book runner pair. The above excludes deals in which the book runner is the same as the loan contributor.

In Figure 18, we rescale node sizes to omit observations when the loan contributor also served as a book runner. The decreased network size post-crisis and the high centrality results continue to hold. Comparing Figures 17A and 18A against 17B and 18B, we observe that some of the most central market participants may have been running the book on deals against their own collateral.

Next, we consider the distribution of network connectivity by plotting the cumulative frequency of loan contributor and book runner nodes for a given degree. Figure 19 shows that a very small fraction of market participants transacts with a large number of counterparties (degrees). Compared to the pre-crisis period, the most connected participants have fewer degrees, but the tail distribution continues to be highly skewed.

Table 21 quantifies the characteristics of each network and presents aggregate statistics for the number of unique links, density and clustering before and after the crisis. We observe a large decrease in the number of unique ties among loan contributors and book runners after the crisis, with over 480 links in 2000–2008 declining to just over 230 links in 2009–2015. The maximum connectedness measured as maximum degree has decreased from 58 to 34. Further, network density has more than doubled in the six years following the financial crisis, and network diameter has decreased. However, the clustering coefficient has declined, accompanied by an increase in mean degree. Overall, these estimates point to a smaller and more concentrated network of book runners and loan contributors in the CMBS market following the financial crisis. These findings do not appear to be sensitive to filters for self-run deals.

**Figure 19: Degree distribution in the loan contributor – book runner network***




*The figure plots the complementary cumulative distribution functions (CCDF) of loan contributor and book runner degrees before and after the crisis, excluding observations in which the loan contributor and book runner identities are the same.

Similarly, Table 22 reports the distribution of closeness, betweenness and eigenvector centrality in the network of loan contributors and book runners. Panel A shows that average closeness, betweenness and centrality metrics have more than doubled (mean centrality has more than tripled) after the financial crisis. Recognizing that means are more severely affected

by outliers, we consider medians and find qualitatively similar results for various network statistics. Histograms showing the distribution of these measures before and after the crisis can be found in Appendices B and C. The inclusion of self-run deals does not appear to be driving the results, as shown in Panel B of Table 22.

**Table 21. Characteristics of the loan contributor – book runner network***

**Panel A. Transaction counts, all transactions**

| Statistic | 2000-2008 | 2009-2015 |
|---|---|---|
| Number of Unique Links | 487 | 237 |
| Density | 0.031 | 0.077 |
| Clustering Coefficient | 0.208 | 0.182 |
| Diameter | 8 | 7 |
| Mean Degree | 5.5 | 6 |
| Maximum Degree | 58 | 34 |

**Panel B. Transaction counts, excluding self-run deals**

| Statistic | 2000-2008 | 2009-2015 |
|---|---|---|
| Number of Unique Links | 452 | 221 |
| Density | 0.031 | 0.078 |
| Clustering Coefficient | 0.208 | 0.182 |
| Diameter | 8 | 7 |
| Mean Degree | 5.23 | 5.82 |
| Maximum Degree | 56 | 32 |

*This table reports the aggregate statistics for the loan contributor – book runner network. Panel A defines ties based on the number of deals of a unique book runner – loan contributor pair during a given time period, and includes firms' self-dealing. Panel B also relies on deal counts, excluding the case when the loan contributor and the book runner are the same entity. Definitions of network measures can be found in Appendix A.

**Table 22. Distribution of network measures in the loan contributor – book runner network before and after the crisis***

**Panel A. Transaction counts, all transactions**

| | Closeness | | Betweenness | | Eigenvector centrality | |
|---|---|---|---|---|---|---|
| Statistic | '00-'08 | '09-'15 | '00-'08 | '09-'15 | '00-'08 | '09-'15 |
| Mean | 0.036 | 0.085 | 0.011 | 0.029 | 0.028 | 0.099 |
| Median | 0.040 | 0.092 | 0.000 | 0.000 | 0.001 | 0.012 |
| Max | 0.042 | 0.106 | 0.228 | 0.258 | 1.000 | 1.000 |
| Min | 0.006 | 0.013 | 0.000 | 0.000 | 0.000 | 0.000 |

**Panel B. Transaction counts, excluding self-run deals**

| | Closeness | | Betweenness | | Eigenvector centrality | |
|---|---|---|---|---|---|---|
| Statistic | ’00-’08 | ’09-’15 | ’00-’08 | ’09-’15 | ’00-’08 | ’09-’15 |
| Mean | 0.043 | 0.119 | 0.011 | 0.033 | 0.039 | 0.124 |
| Median | 0.048 | 0.125 | 0.000 | 0.000 | 0.003 | 0.018 |
| Max | 0.051 | 0.153 | 0.239 | 0.279 | 1.000 | 1.000 |
| Min | 0.006 | 0.014 | 0.000 | 0.000 | 0.000 | 0.000 |

*This table reports the distribution of closeness, betweenness and eigenvector centrality for the loan contributor – book runner network. Panel A defines interconnectedness based on the number of deals between book runner – loan contributor pairs during a given time period. Panel B also uses the number of deals, excluding the case when loan contributor – book runner pairs are the same entities. Definitions of network measures can be found in Appendix A.

Our analysis so far has relied on the main CMAlert deals database, which identifies up to four book runners and the amounts of their book runner credit. This data also identifies loan contributors (in the “seller” string), but not the amounts they are contributing to the collateral pool for each deal. The analysis above measures the network connections between loan contributors and book runners based on the number of transactions per unique loan contributor – book runner pair.

We are cognizant of the potential biases transaction counts may introduce in our analysis if, for instance, some market participants engage in a large number of transactions but do not have significant dollar exposure. To address this concern, as discussed in Section III, we use additional data from CMAlert on loan contributor league table credit for CMBS deals. This dataset covers a narrower subset of loans originated with the purpose of being securitized, excludes non-US, guaranteed and non-guaranteed agency, and single borrower deals, and corrects loan contributor and book runner names for mergers and acquisitions.[26]

Figure 20 replicates the network topology in Figure 17, weighing book runner and loan contributor relationships using the book running dollar and loan contributor credit. The node size reflects logged dollar deal amount of a given participant and includes self-run deals, and edge thickness reflects logged dollar deal amount between a given book runner and loan contributor pair. We observe a moderate decrease in node sizes and only a small number of market participants exhibiting high centrality in the post-crisis period. Table 23 Panel B presents network statistics for this network map before and after the crisis, using loan contributor and book runner credit amount to quantify the intensity of transaction activity among market

[26] We note that our loan contributor and book runner credit data used in Figure 20 and Table 23 is a different sample from those in Figure 17. While the sample in Figure 17 excludes resecuritization, single-borrower transactions, and guaranteed agency deals, the sample used in Figure 20 and Table 23 excludes loans that were not originated with the purpose of being securitized (such as distressed or seasoned collateral) and foreign deals, in addition to single-borrower transactions and guaranteed agency placements, and covers only approximately half of our overall global CMBS issuance sample. Therefore, our conclusions concerning network concentration and interconnectedness using these data may be limited by the above sample selection criteria. The difference in the sample size can be further seen in Panel A of Table 21 and Table 23.

participants. Network statistics based on credit amount show that average closeness, betweenness, and centrality metrics have increased in the post-crisis period, but the magnitude of the change appears to be attenuated. The number of unique links has decreased over time while the density has increased, illustrating a relatively more connected yet smaller network post crisis. As opposed to the analysis based on transaction counts, the mean path declined in the volume-based network during the post-crisis period.

**Table 23. Characteristics of the loan contributor – book runner network, $ credit amount***

**Panel A. Network characteristics, $ credit amount***

| Statistic | 2000-2008 | 2009-2015 |
|---|---|---|
| Number of Unique Links | 268 | 158 |
| Density | 0.108 | 0.146 |
| Clustering Coefficient | 0.297 | 0.243 |
| Diameter | 4 | 4 |
| Mean Degree | 7.55 | 6.72 |
| Maximum Degree | 40 | 28 |

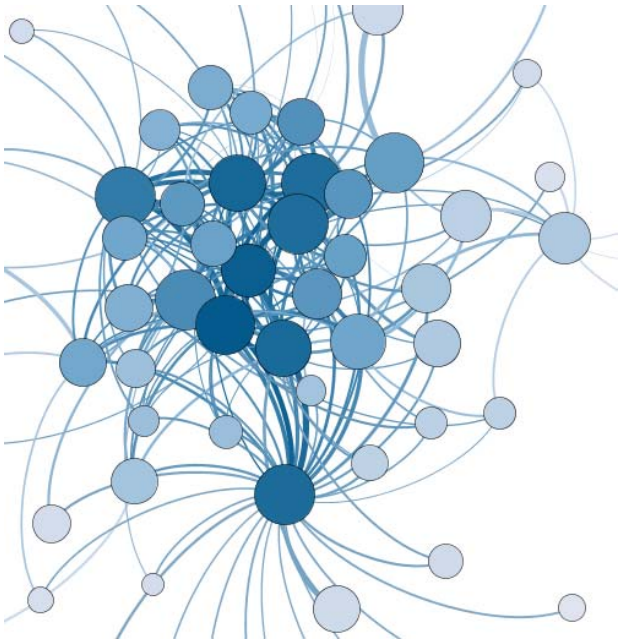
**Panel B. Distribution of network statistics, $ credit amount**

| | Closeness | | Betweenness | | Eigenvector centrality | |
|---|---|---|---|---|---|---|
| Statistic | ’00-’08 | ’09-’15 | ’00-’08 | ’09-’15 | ’00-’08 | ’09-’15 |
| Mean | 0.070 | 0.079 | 0.025 | 0.029 | 0.228 | 0.283 |
| Median | 0.069 | 0.079 | 0.000 | 0.000 | 0.131 | 0.196 |
| Max | 0.100 | 0.116 | 0.409 | 0.235 | 1.000 | 1.000 |
| Min | 0.014 | 0.051 | 0.000 | 0.000 | 0.000 | 0.045 |

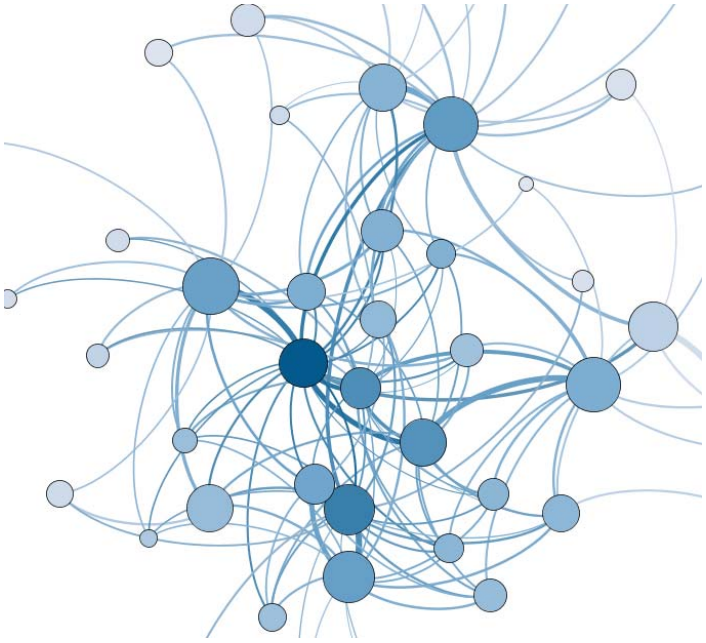
*This table reports network statistics for the loan contributor – book runner network for the subsample of transactions with available loan contributor credit information. Panel A defines ties based on the number of deals of a unique book runner – loan contributor pair from the league table credit amount data during a given time period. Definitions of network measures can be found in Appendix A.

**Figure 20. Loan contributor – book runner network: $ credit, all transactions***

**A. 2000-2008**



**B. 2009-2015**



*These figures present Fruchterman-Reingold force directed graphs of CMBS issuance volume reported by CMAlert for the subsample of transactions with available loan contributor credit information. Node size is determined by the log sum of the dollar loan contributor and book runner credit, including self-run deals. Node shading reflects eigenvector centrality measure (more central nodes presented with a stronger shade). Edge thickness is determined by the log of the dollar business between a loan contributor – book runner pair, based on the percentage of credit attributed to each firm for each deal.

As discussed in Section V, B-piece buyers buy junior first-loss bonds in conduit transactions. While B-piece investors are compensated for the higher risk of such investments with higher expected returns, their participation in the CMBS market may enable loan contributors and book runners to offload loan portfolios without retaining the risk of the most junior securities. As a result, B-piece buyers may have bargaining power with respect to the composition of the collateral pool and the appointment of special servicers. Further, the willingness of B-piece buyers to participate in a given CMBS transaction may affect the ability and costs of underwriting and placing an issue.

Figure 21 presents the network topology of B-piece buyers and book runners in the CMBS market before and after the crisis, with the shading of each node reflecting the eigenvector centrality of a given market participant. We do not see a dramatic increase in concentration as we observed with loan contributor mappings above, suggesting that book runners may seek to maintain relationships with multiple B-piece buyers. We note that our data includes B-piece buyer identities, but does not include the dollar amount of each buyer's investment, and the connections between B-piece buyers and book runners are measured using transaction counts. If, for instance, some B-piece buyers participate in a large number of placements but have low dollar exposure, our results may be skewed. However, measuring network interconnectedness with dollar exposure may introduce its own biases related to credit ratings.[27] Therefore, it is unclear whether and how such an approach may affect our analysis.

B-piece buyers and book runners may play different roles in the securitization process. In Figure 22, we replicate the network topology identifying the type of market participant by color of the node and observe an increase in the number of links between B-piece buyers and book runners after the financial crisis. Next, we plot the degree distribution of B-piece buyer and book runner participants. Figure 23 shows that a very small fraction of market participants in this network map transacts with a large number of counterparties. Connectedness (as measured by the number of degrees) in the right tail of the degree distribution has increased from 20 in the pre-crisis period to 37 in the post-crisis period, while connectedness in the left tail has decreased after the financial crisis.[28]

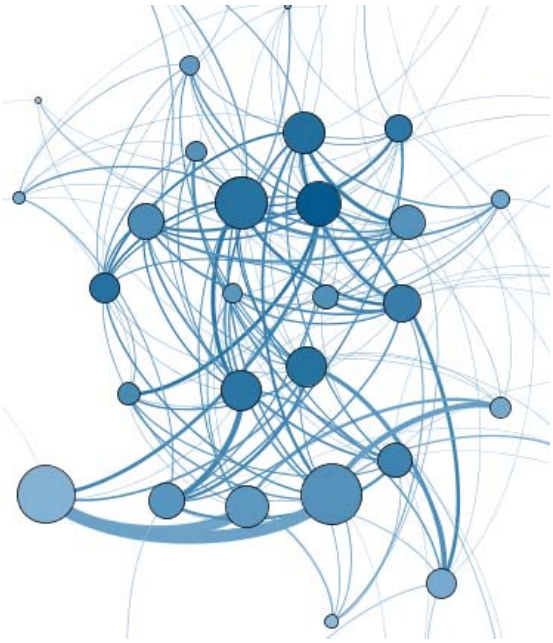
Finally, Table 24 presents network statistics that quantify these changes. We observe an increase in the number of unique links, a decrease in the density, and an increase in the right tail of connectivity (maximum degrees). We also document a decrease in clustering coefficient, median betweenness, and eigenvector centrality and no significant change in median closeness in the B-piece buyer – book runner mapping, implying fewer central market participants and participants with decreased influence beyond the first node. Histograms showing the distribution of these centrality measures before and after the crisis can be found in Appendix D.

[27] B-piece buyers are commonly identified as investors in CMBS classes with low credit ratings, such as BB or below, and multiple rating agencies solicited by book runners may issue preliminary ratings on various CMBS classes without being purchased or published.

[28] The number of degrees includes transactions between any b-piece buyers and book-runners.

## Figure 21. Book runner – B-piece buyer network: transaction counts, all transactions*

### A. 2000-2008

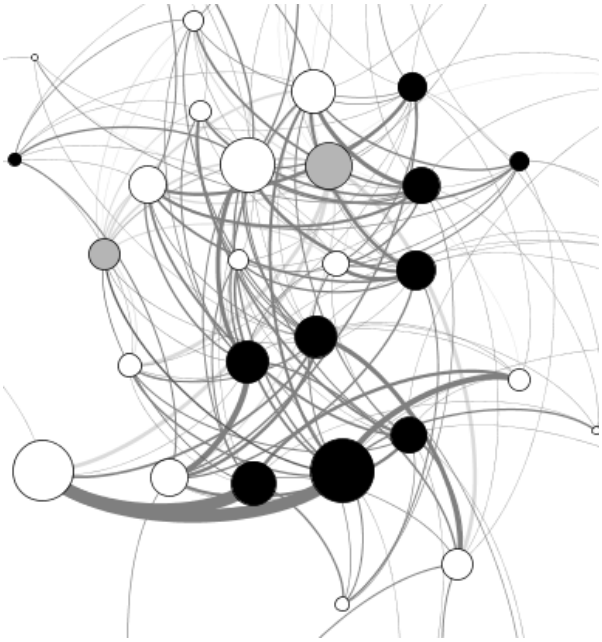


### B. 2009-2015

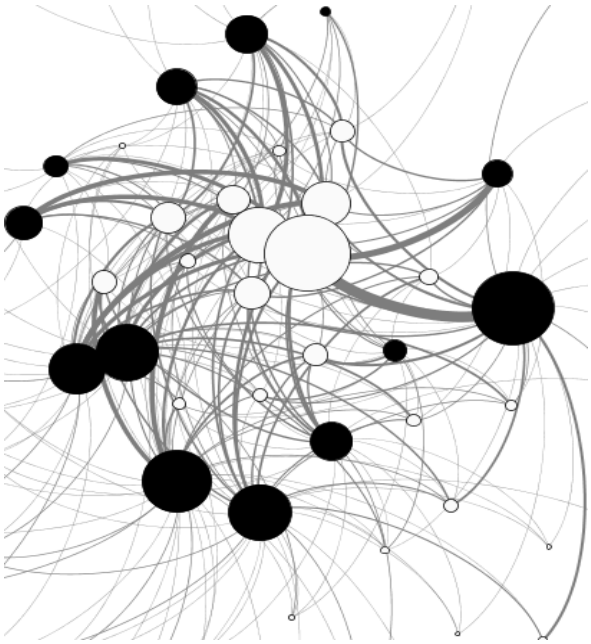
*These figures present Fruchterman-Reingold force directed graphs of CMBS transaction activity reported to CMAlert. B-piece buyers are identified based on the "B-piece" variable, book runners are identified based on information in "BOOK1" through "BOOK4" variables in CMAlert. Node size is determined by the number of transactions by the entity. Self-run deals appeared only in the 2000-2008 period, and are reflected in node sizes. Node shading reflects eigenvector centrality measure (more central nodes presented with a stronger shade). Edge thickness is determined by the number of transactions between a B-piece buyer– book runner pair.

## Figure 22. Book runner – B-piece buyer network by role: transaction counts, all transactions*

### A. 2000-2008

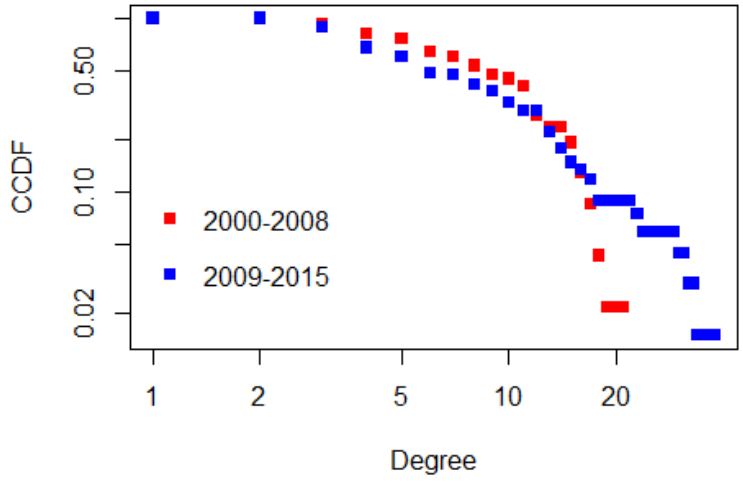


### B. 2009-2015



*These figures present Fruchterman-Reingold force directed graphs of CMBS transaction activity reported to CMAlert. B-piece buyers are identified based on the "B-piece" variable, book runners are identified based on information in "BOOK1" through "BOOK4" variables in CMAlert. Node size is determined by the number of transactions by the entity. Self-run deals appeared only in the 2000-2008 period, and are reflected in node sizes. Node shading reflects the role of the firm (white: B-piece buyer, black: book runner, grey: both B-piece buyer and book runner). Edge thickness is determined by the number of transactions between a B-piece buyer – book runner pair.

### Figure 23. Degree distribution in the Book runner and B-piece buyer – network*




*This figure plots the complementary cumulative distribution function (CCDF) of book runner and b-piece buyer ties (degrees) before and after the crisis.

### Table 24. Book runner – B-piece buyer network, all transactions

#### Panel A. Network characteristics, transaction counts*

| Statistic | 2000-2008 | 2009-2015 |
|---|---|---|
| Number of Unique Links | 184 | 262 |
| Density | 0.170 | 0.115 |
| Clustering Coefficient | 0.085 | 0 |
| Diameter | 5 | 4 |
| Mean Degree | 7.83 | 7.71 |
| Maximum Degree | 20 | 37 |

#### Panel B. Distribution of book runner – B-piece buyer network statistics, transaction counts*

| | Closeness | | Betweenness | | Eigenvector centrality | |
|---|---|---|---|---|---|---|
| Statistic | ’00-’08 | ’09-’15 | ’00-’08 | ’09-’15 | ’00-’08 | ’09-’15 |
| Mean | 0.190 | 0.202 | 0.035 | 0.023 | 0.168 | 0.168 |
| Median | 0.200 | 0.210 | 0.025 | 0.003 | 0.103 | 0.056 |
| Max | 0.230 | 0.246 | 0.189 | 0.269 | 1.000 | 1.000 |
| Min | 0.022 | 0.015 | 0.000 | 0.000 | 0.000 | 0.000 |

*Definitions of network measures can be found in Appendix A.

The above analysis focuses on mapping and quantifying the transaction activity between entities acting in the capacity of book runners, those acting as loan contributors, and those serving as b-piece buyers on various CMBS deals. This illustrates the intensity and interconnectedness of CMBS transaction activity among market participants serving in different capacities.

Complementing the above, we perform an analysis of network activity within each group of participants. We note that a given market participant can serve as a book runner, a loan contributor and as a B-piece buyer on various deals in our sample. The book runner network map in Figure 24 represents only book running activity, and identifies the intensity of links among various book runners using $ book runner credit on jointly run deals. Similarly, the loan contributor network map in Figure 25 represents only loan contributor activity, and defines links among loan contributors based on $ loan contributor credit on deals with multiple loan contributors. Histograms showing the distribution of centrality measures before and after the crisis can be found in Appendices E and F.[29]

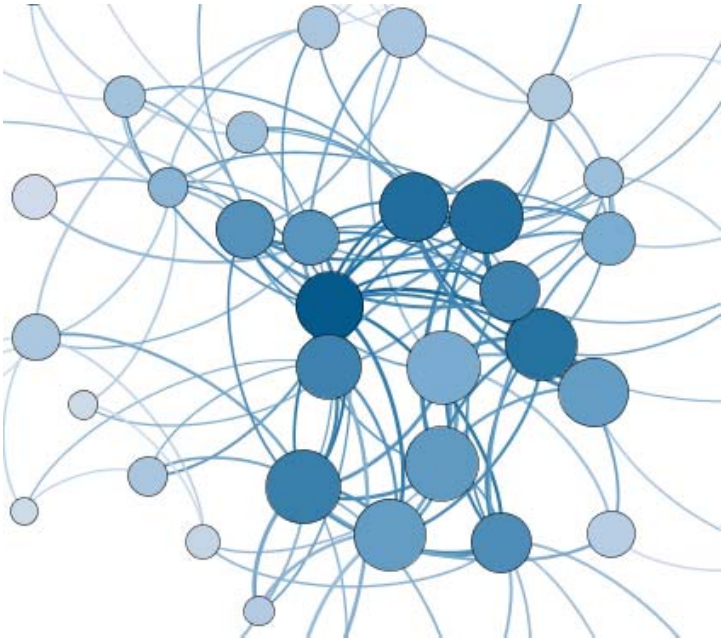
The network map of book runners based on credit amount and the related network statistics are presented in Figure 24 and Table 25. Consistent with earlier findings, we observe a smaller, more interconnected network of book runners post crisis, as demonstrated by, among other things, fewer unique links, higher density, and decreased diameter. An increase in the clustering coefficient in the post-crisis period suggests that book runners are more likely to transact with other book runners who share the same partner.[30] In addition, the median closeness and eigenvector centrality values have increased in the post-crisis period. We also observe a decrease in the median value and an increase in the maximum value of betweenness. This implies that book runners at the right tail of the distribution have an increased influence beyond the first co-book runner, while 50% of the firms (up to the median point) have a reduced influence post-crisis. This is further illustrated by Figure 26, which plots the degree distribution graph and shows that a very small fraction of book runners at the right tail distribution jointly runs deals with a large number of other book runners across all periods, but the number of unique links has decreased in the post-crisis period.

Similarly, a map of the network of loan contributors using loan credit amount[31] in Figure 25 shows a smaller and more interconnected network in the post-crisis period. While there has been a significant decline in the number of unique links and maximum degree, density and clustering coefficient values have increased. An overall increase in the closeness and eigenvector centrality measures with decreasing median and maximum betweenness values may suggest that some loan contributors have become more central but may exert less influence beyond the first co-loan contributor in the post-crisis period. In addition, Figure 26 shows that participants at the right tail distribution in the post-crisis period have fewer connections than those in the pre-crisis period.

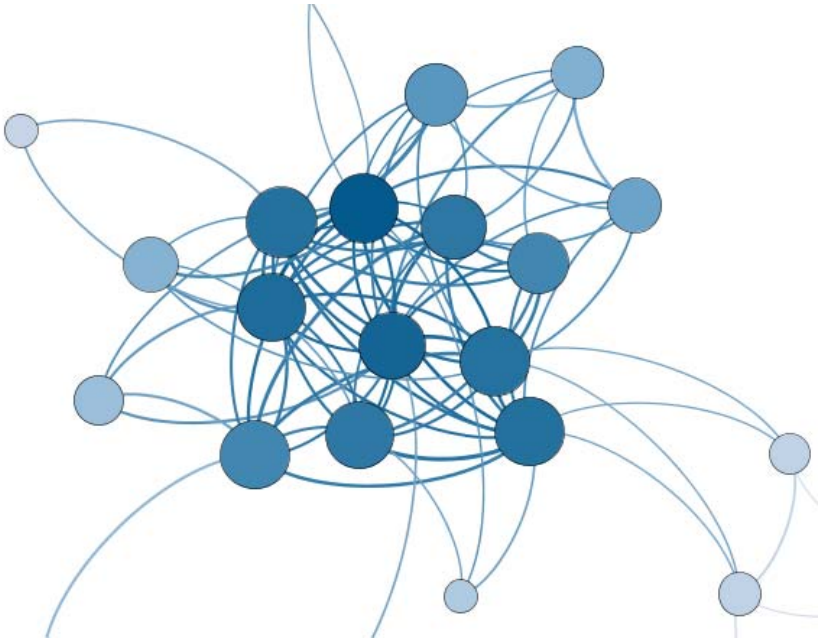
[29] Since very few transactions in our sample have multiple B-piece buyers and we lack information about their dollar exposures, this analysis does not include the B-piece buyer network.
[30] See e.g. Yang, Liu, Zhang, and Paddrik (2016).
[31] This analysis uses the same data sample in Figure 20.

**Figure 24. Book runner network: $ credit amount, excluding deals with a single book runner***

**A. 2000-2008**



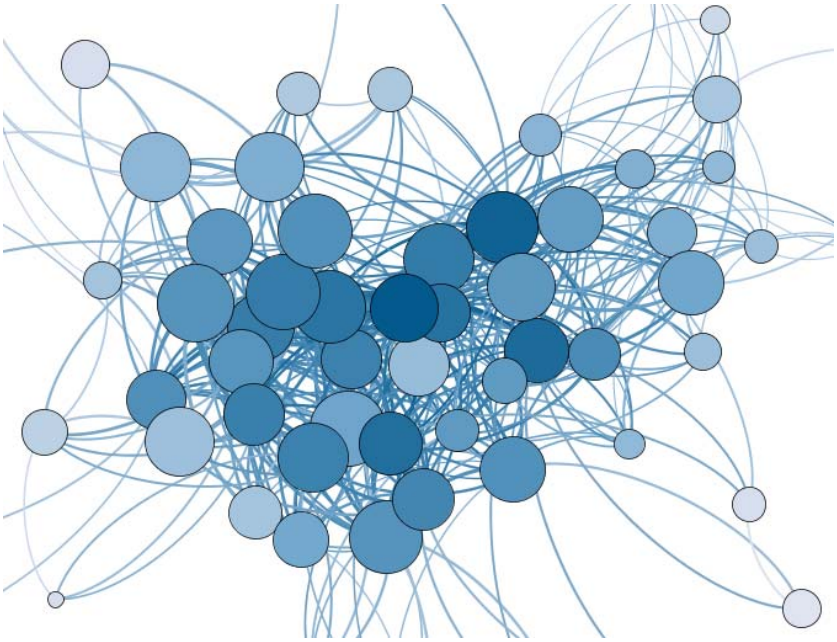
**B. 2009-2015**



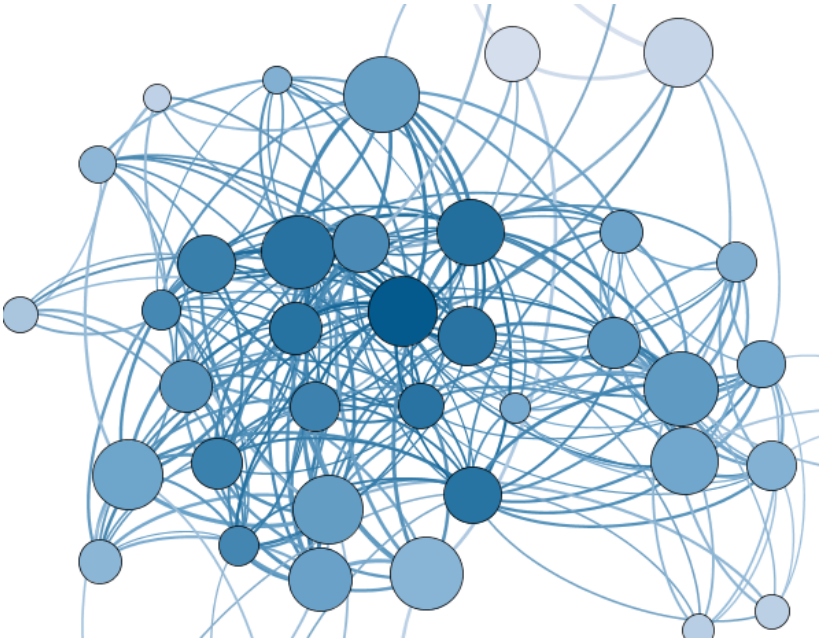
*These figures present Fruchterman-Reingold force directed graphs of CMBS transaction activity reported to CMAlert. Book runners are identified based on information in "BOOK1" through "BOOK4" variables, and deal amount is determined based on variables "AMT1" through "AMT4" in CMAlert. Node size is determined by the log sum of the dollar book runner, excluding credit amount in deals with a single book runner. Node shading reflects eigenvector centrality measure (more central nodes presented with a stronger shade). Edge thickness is determined by log of the dollar business between book runners.

**Figure 25. Loan contributor network: $ credit amount, excluding deals with a single loan contributor***

**A. 2000-2008**



**B. 2009-2015**



*These figures present Fruchterman-Reingold force directed graphs of CMBS issuance volume reported by CMAlert for the subsample of transactions with available loan contributor credit information. Node size is determined by the log sum of the dollar loan contributor, excluding credit amount in deals with a single loan contributor. Node shading reflects eigenvector centrality measure (more central nodes presented with a stronger shade). Edge thickness is determined by log of the dollar business between loan contributors.

## Table 25. Network of book runners, network of loan contributors, all transactions

### Panel A. Network characteristics, credit amount*

| | Loan Contributors | | Book runners | |
|---|---|---|---|---|
| Statistic | 2000-2008 | 2009-2015 | 2000-2008 | 2009-2015 |
| Number of Unique Links | 444 | 264 | 158 | 91 |
| Density | 0.213 | 0.307 | 0.074 | 0.196 |
| Clustering Coefficient | 0.486 | 0.558 | 0.314 | 0.620 |
| Diameter | 4 | 4 | 6 | 5 |
| Mean Degree | 13.66 | 12.57 | 4.79 | 5.87 |
| Maximum Degree | 35 | 26 | 17 | 17 |

### Panel B. Distribution of loan contributor network statistics, credit amount*

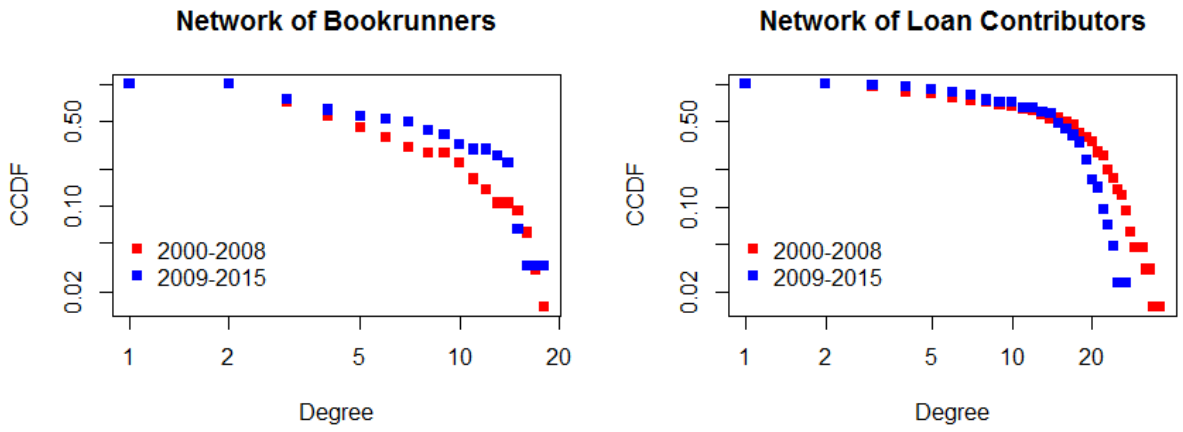
| | Closeness | | Betweenness | | Eigenvector centrality | |
|---|---|---|---|---|---|---|
| Statistic | '00-'08 | '09-'15 | '00-'08 | '09-'15 | '00-'08 | '09-'15 |
| Mean | 0.097 | 0.110 | 0.017 | 0.022 | 0.390 | 0.493 |
| Median | 0.099 | 0.110 | 0.010 | 0.005 | 0.336 | 0.546 |
| Max | 0.128 | 0.139 | 0.139 | 0.102 | 1 | 1 |
| Min | 0.060 | 0.055 | 0 | 0 | 0.020 | 0.043 |

### Panel C. Distribution of book runner network statistics, credit amount*

| | Closeness | | Betweenness | | Eigenvector centrality | |
|---|---|---|---|---|---|---|
| Statistic | '00-'08 | '09-'15 | '00-'08 | '09-'15 | '00-'08 | '09-'15 |
| Mean | 0.047 | 0.060 | 0.026 | 0.026 | 0.229 | 0.392 |
| Median | 0.048 | 0.065 | 0.006 | 0.002 | 0.081 | 0.190 |
| Max | 0.064 | 0.080 | 0.131 | 0.223 | 1 | 1 |
| Min | 0.015 | 0.032 | 0 | 0 | 0 | 0 |

*These tables report network statistics for each network of loan contributors and book runners for the sample of transactions with available credit dollar amount information. Log of the credit dollar amount was calculated for this analysis. Definitions of network measures can be found in Appendix A.

## Figure 26. Degree distribution in the networks of book runners and loan contributors*




## VIII. Conclusion

The paper presents information on issuance and market participants in the CMBS market relying on CMAlert data. Our analysis includes three main groups of results. First, we examine the structure of issuance before and after the financial crisis, including 144A placements, registered offerings, foreign and agency deals. Our data suggests that the CMBS market has experienced resurgence in recent years, accounting for more than $168.8 billion raised in 2015. We also consider a number of deal and collateral features. For instance, we find that deals increased in size and number of classes per deal, with a growing prevalence of interest-only classes. Second, CMBS markets are highly concentrated, with top 5 book runners, loan contributors and B-piece buyers accounting for 64.2%, 44.1% and 70.4% market share by dollar volume respectively. Third, we perform a network analysis of activity of various participants in CMBS markets and find, among other things, that individual networks of book runners and loan contributors are smaller and more interconnected after the financial crisis.

## IX. Appendices

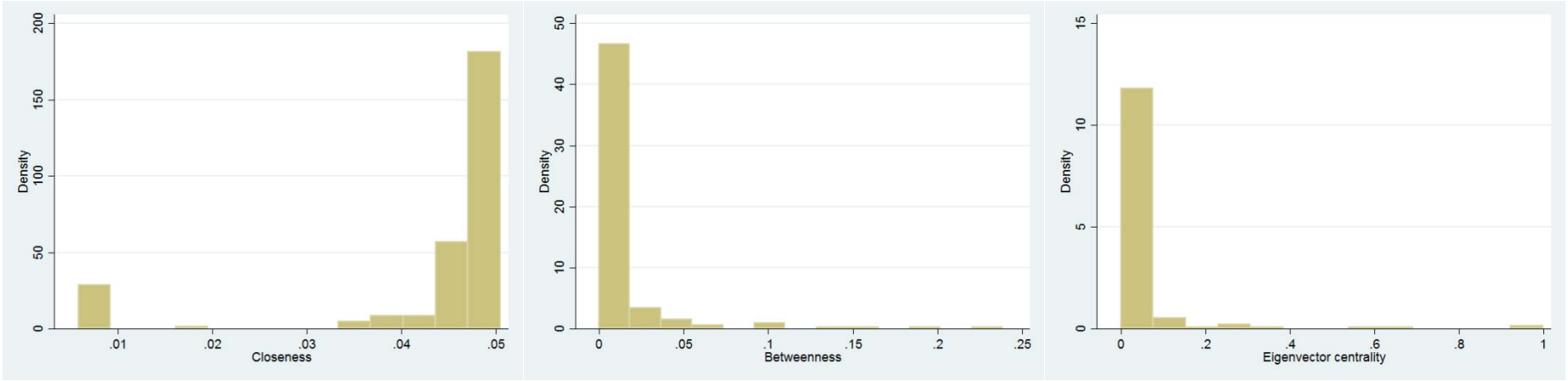
### Appendix A. Measures of centrality and network statistics[32]

| | |
|---|---|
| Betweenness | The betweenness of a market participant is the number of shortest paths linking two market participants in the network that go through that market participant. We use undirected betweenness, which measures the absolute position of a market participant in the market. The scores are normalized as follows: $B_{norm}=2*B/(n*n-3*n+2)$, where $B_{norm}$ is the normalized and $B$ is the raw betweenness, $n$ is the number of market participants (vertices) in the graph. Higher values indicate higher betweenness centrality. |
| Closeness | A measure of centrality based on the length of the average shortest path between a market participant (vertex) and all other participants (vertices). The measure is undirected and normalized, multiplying raw closeness by (n-1), where n is the number of participants (vertices) in the graph. Higher values indicate higher closeness centrality. |
| Clustering coefficient | The clustering coefficient reflects the likelihood that two nodes a participant is connected to, are connected to each other. |
| Degree | The degree of a market participant is computed as the sum of all direct links that participant has with other participants in the network, scaled by the total number of participants in the network. We use undirected measure of degree. Degree reflects local connectedness of a market participant. |
| Density | The number of actual links in a network, scaled by the total number of theoretically possible pairwise links among all market participants |
| Diameter | The maximum of the shortest paths between any two market participants in the network. |
| Eigenvector centrality | Eigenvector centrality assigns a score to a market participant based on the centrality of other participants it is connected to. This measure reflects the influence of a node and is scaled to have a maximum score of 1. Higher values indicate higher Eigenvector centrality. |
| Number of Unique Links | The total number of unique ties among participants in the network. |

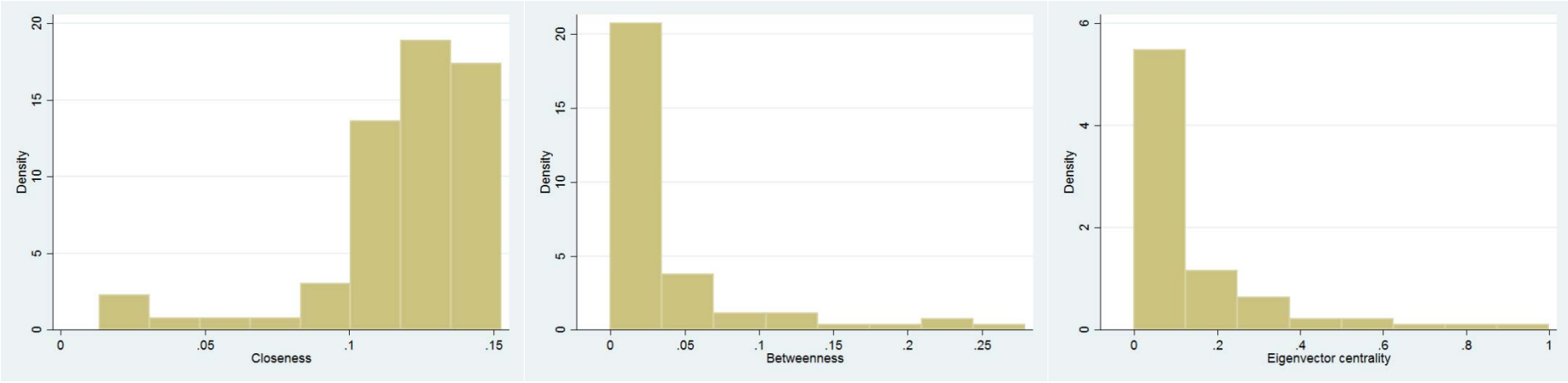
[32] See e.g. Billio, Getmansky, Lo, and Pelizzon (2012), Clauset, Newman, and Shalizi (2009), Hochberg, Ljungqvist, and Lu (2007), Li and Schurhoff (2014).

## Appendix B. Distribution of centrality measures in the loan contributor – book runner network: transaction counts, excluding self-deals

### 2000-2008

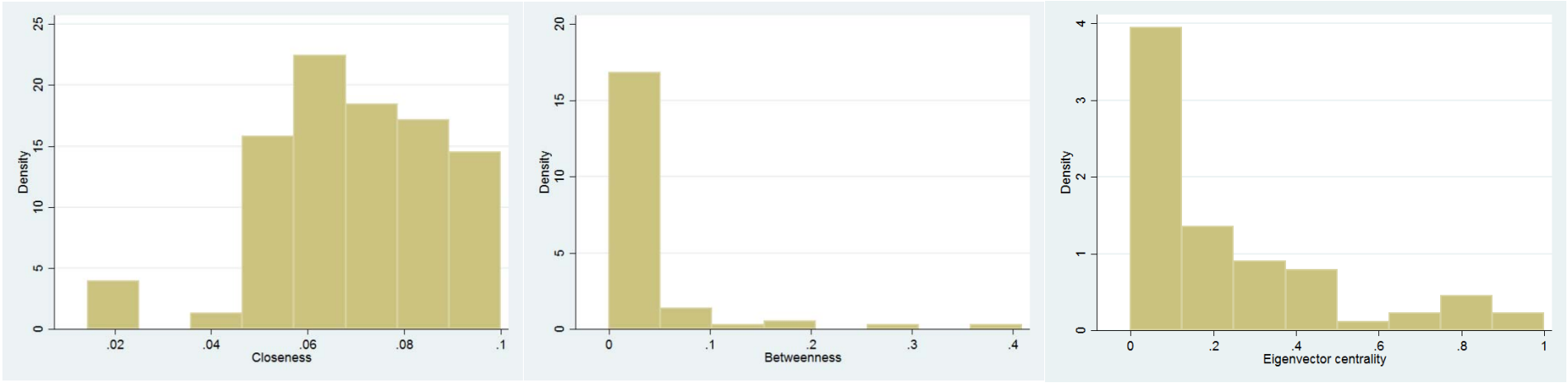



### 2009-2015

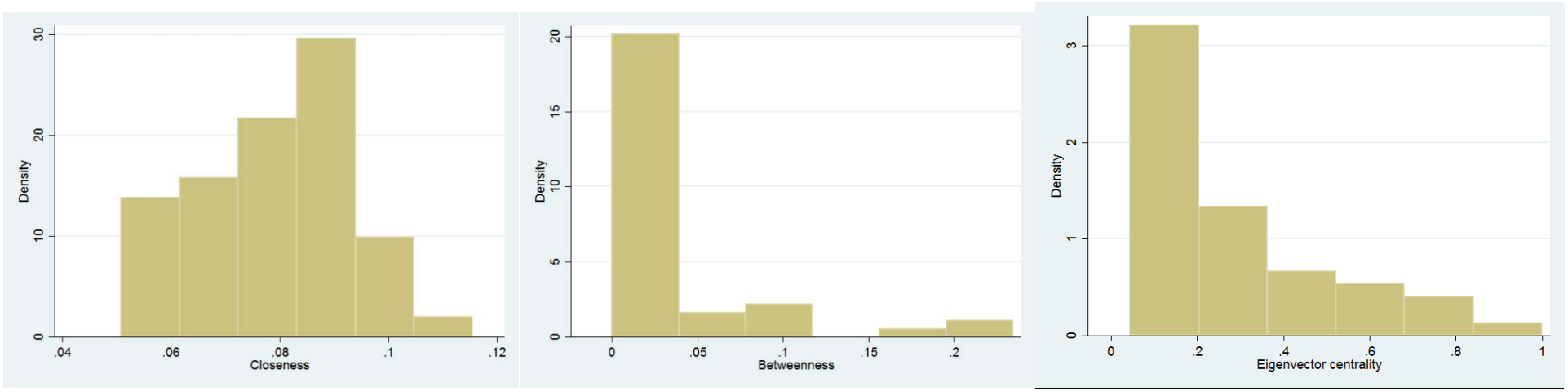


## Appendix C. Distribution of centrality measures in the loan contributor – book runner network: credit amount

### 2000-2008

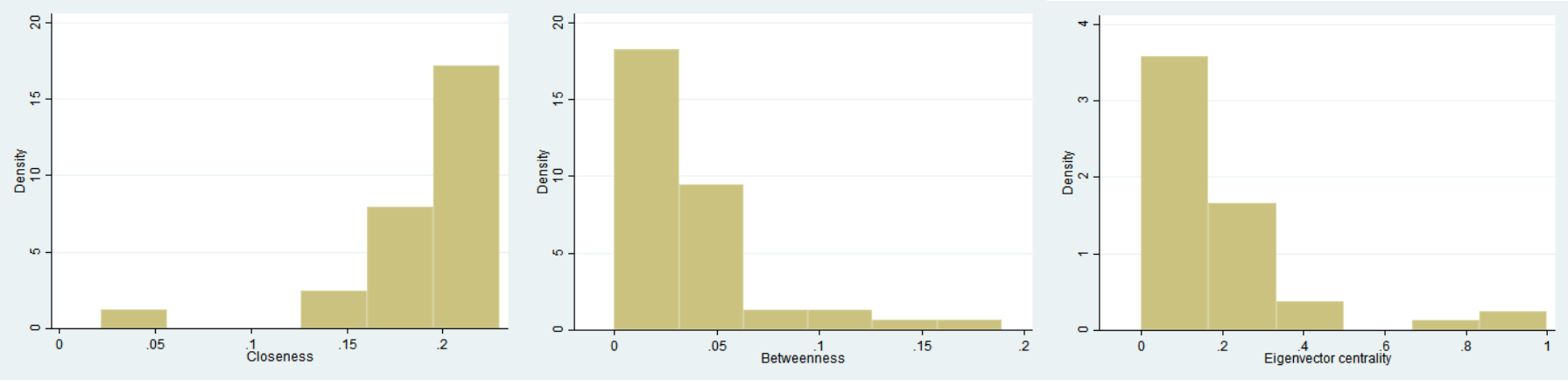



### 2009-2015

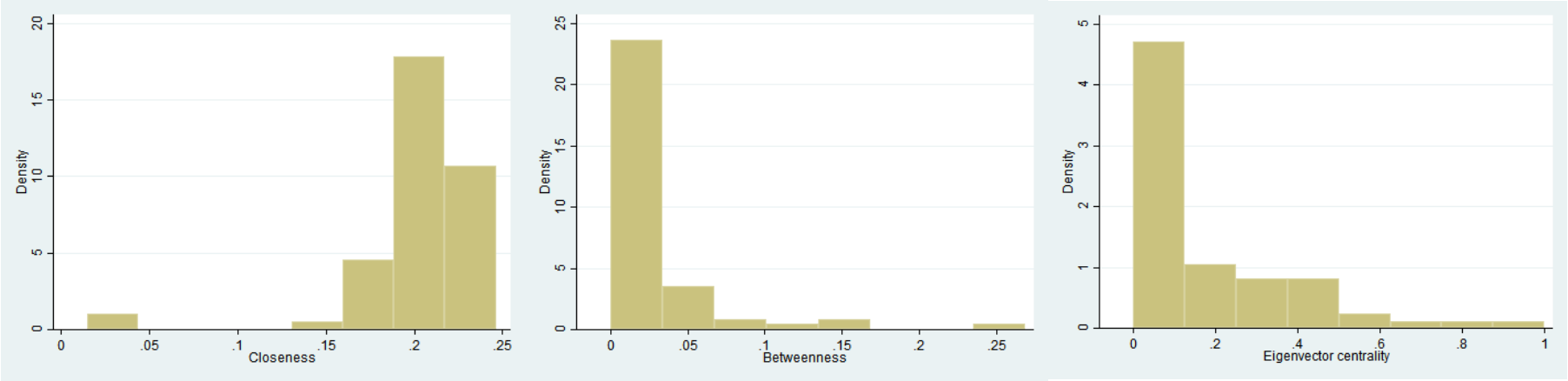


## Appendix D. Distribution of centrality measures in the book runner – B-piece buyer network: transaction counts, all transactions*

### 2000-2008



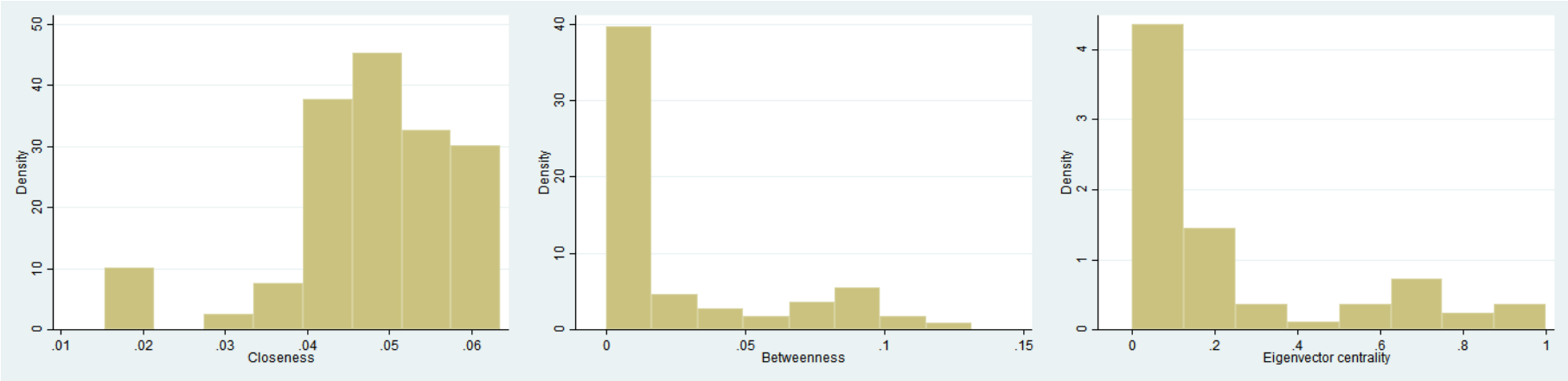

### 2009-2015



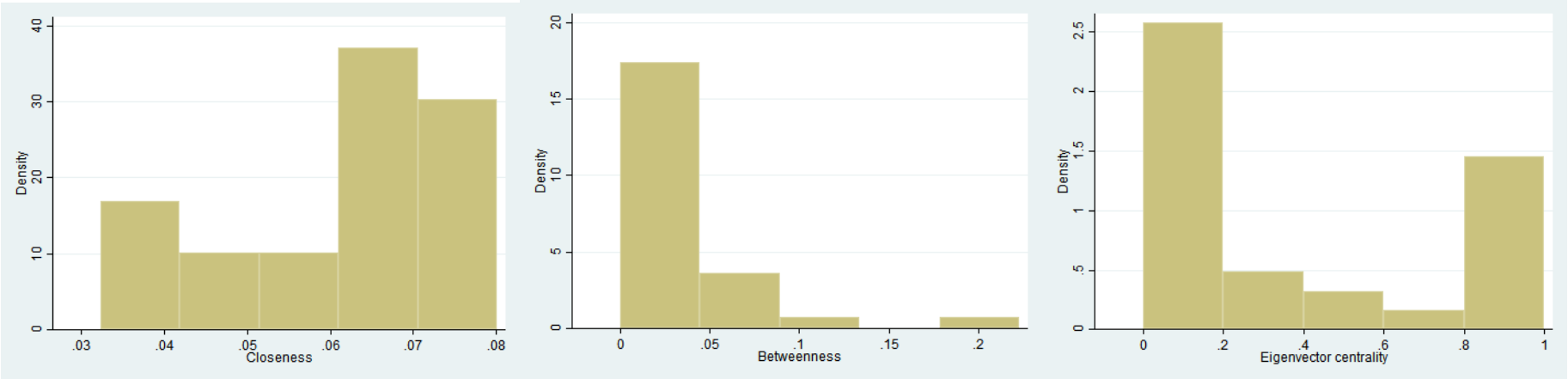

*There are only two firms who perform self-dealing in the book runner and B-piece buyer network

## Appendix E. Distribution of centrality measures in the book runner network: credit amount

### 2000-2008

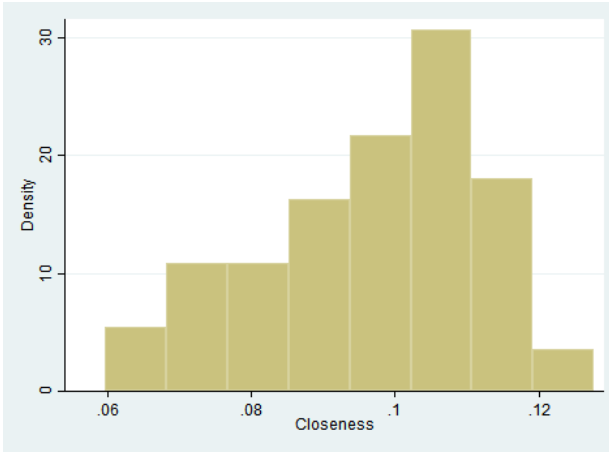


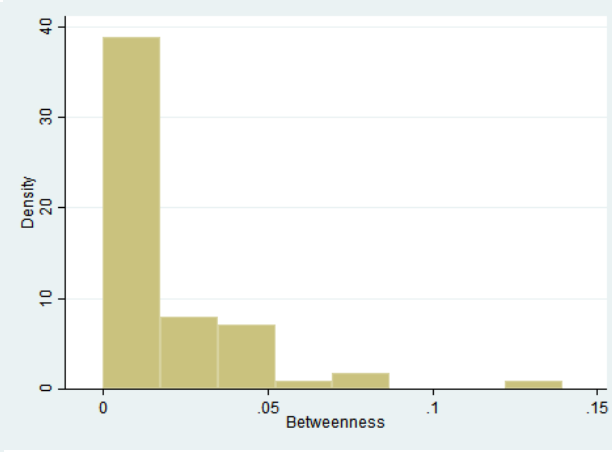

### 2009-2015

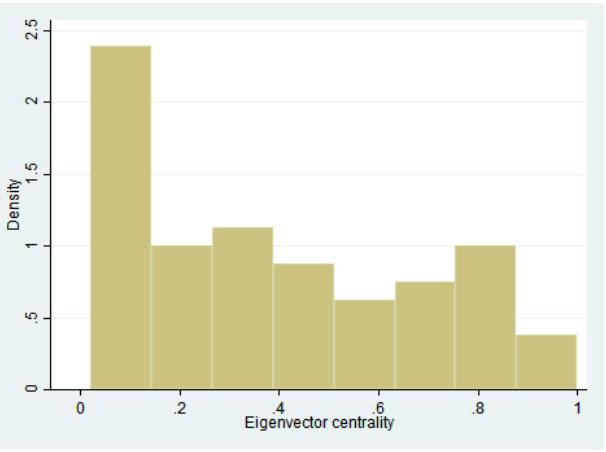


## Appendix F. Distribution of centrality measures in the loan contributor network: credit amount

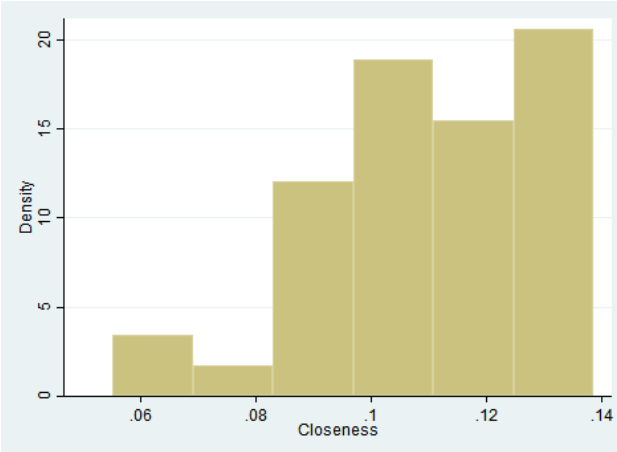
### 2000-2008

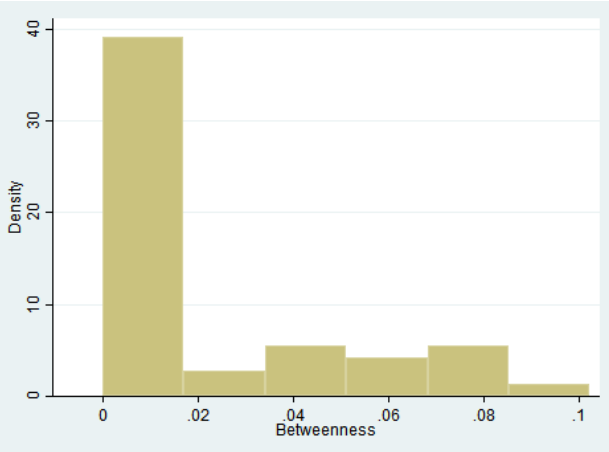


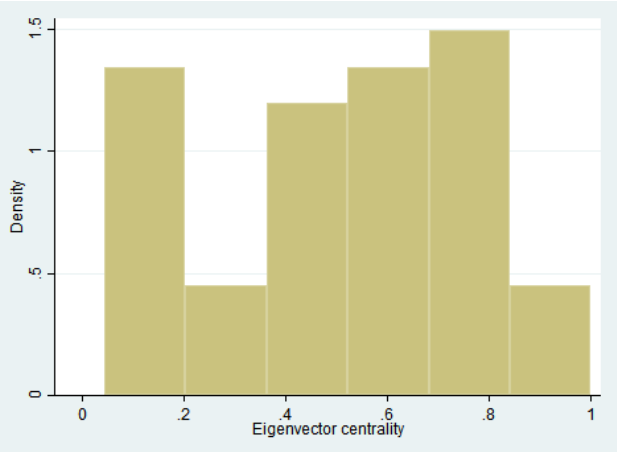




### 2009-2015



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