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Subprime Mortgage Defaults and Credit Default Swaps

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ABSTRACT

We offer the first empirical evidence on the adverse effect of credit default swap (CDS) coverage on subprime mortgage defaults. Using a large database of privately securitized mortgages, we find that higher defaults concentrate in mortgage pools with concurrent CDS coverage, and within these pools the loans originated after or shortly before the start of CDS coverage have an even higher delinquency rate. The results are robust across zip code and origination quarter cohorts. Overall, we show that CDS coverage helped drive higher mortgage defaults during the financial crisis.

THE SHARP INCREASE IN DEFAULTS on residential mortgage loans was a driving force behind the 2007 to 2008 financial crisis.[1] Several recent studies attribute the surge in defaults to looser lending standards associated with the "originate-to-distribute" mortgage loan model—under this model, loans are quickly sold to securitizers, which may reduce lenders' incentive to carefully screen and monitor borrowers (see, e.g., Mian and Sufi (2009), Keys et al. (2010), and Purnanandam (2011)).[2] In this paper, we contribute to the growing

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[1] The increase in mortgage defaults was particularly significant for subprime mortgages, which are loans made to borrowers with poor credit histories and/or high levels of personal debt. For example, Mayer, Pence, and Sherlund (2009) report that the proportion of subprime mortgages in default increased from 5.6% in mid-2005 to over 21% in mid-2008.

[2] Under the originate-to-distribute model, the lender sells loans to a financial institution that packages them into mortgage-backed securities, which are then sold to investors—a process referred to as securitization. Parlour and Plantin (2008) show theoretically that the process by which banks sell loans to securitizers may reduce banks' incentive to monitor. Others argue that inaccurate credit ratings on subprime mortgage-backed securities—driven in part by the

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literature on the 2007 to 2008 financial crisis by providing the first evidence of a link between credit default swaps (CDS) and subprime mortgage defaults. We argue that the subprime mortgage supply chain, from the originator selling the loans to the securitizer pooling them and selling mortgage-backed securities (MBS) to investors, was influenced significantly by the credit derivatives market. In particular, CDS on subprime MBS allowed securitizers and investors to hedge the credit risk of the underlying loans.[3] Since MBS market participants could limit their exposure to securitizations of risky loans, they were less concerned about the decline in credit quality of loans being pushed out by originators. The decrease in sensitivity to loan quality together with the increase in demand for highly rated MBS by investors chasing high yields drove a reduction in lending standards by mortgage loan originators who earned lucrative fees to supply the loans.[4]

According to this argument, CDS contracts referencing subprime MBS deals were positively related to the default rate of loans underlying the MBS. To test this prediction, we use a large sample of subprime mortgage loans originated during the 2003 to 2007 period and privately securitized by commercial banks (e.g., Bank of America), investment banks (e.g., Bear Sterns), and finance companies that specialized in loan origination (e.g., New Century Financial Corporation). Our sample comes from a database constructed by First American CoreLogic Loan Performance. This database contains more than 90% of the subprime loans that were privately securitized during this 2003 to 2007 period. In addition to loan origination date and information on the mortgage loan pool, the securitizer, and the MBS where the loan is placed, the database provides detailed information on borrower and loan characteristics. We supplement this information with data from various sources on regional housing and economic conditions at the time of loan origination.

Next, we identify which loans in the LoanPerformance database were covered by CDS contracts. Since privately securitized loans were placed in mortgage pools that were used to construct MBS deals, we work backwards by first identifying whether an MBS is referenced by a CDS contract and then identifying the

issuer-pays model of credit ratings—contributed to the 2007 to 2008 financial crisis (see, e.g., Opp, Opp, and Harris (2013)).

[3] CDS are insurance contracts where the buyer pays a premium to the seller, who in the event of default must compensate the buyer for the difference between the notional principal insured and the amount recovered. Purchasers of CDS on MBS are compensated in the event of defaults on loans in mortgage pools underlying the MBS tranches. Note that the purchaser of protection (the entity with the long position) and the seller of protection (the entity with the short position) may not own the underlying asset referenced in the CDS contract. Thus, the sum of the notional principal on any single referenced asset (e.g., an MBS tranche or a corporate bond) can be many times the principal of the asset.

[4] During this time period there was a huge increase in the size of the market for CDS. According to statistics reported by the International Swaps and Derivatives Association, CDS notional principal increased almost 100 times from $631.5 billion in the first half of 2001 to $62,173.20 billion in the second half of 2007, before starting to decline in 2008. Stulz (2010) examines the dramatic growth and decline in the overall CDS market from its inception in the mid-1990s through the end of 2008.

mortgage pools underlying the MBS and the individual subprime loans in the mortgage pools. In particular, we use synthetic collateralized debt obligations (CDOs) compiled by Intex Solutions to identify CDS contracts on MBS,[5] and use the unique deal number in the LoanPerformance database to determine whether a loan is in a mortgage pool used to construct an MBS with tranches referenced by a CDS contract.

We find that more than 35% of the subprime loans in the sample are in a mortgage pool with CDS coverage in close proximity to the closing date of the MBS that contains the pool. We use this variation across mortgage pools to test whether CDS protection encouraged the origination of risky subprime loans with a higher default rate compared to subprime loans without CDS protection or subprime loans covered by CDS contracts well after the MBS closing date.

Using a probit model that controls for a wide variety of factors predicted to influence mortgage default, we find that CDS coverage has a significantly positive effect on subprime loan delinquency. Specifically, for loans in pools where the CDO settlement date is no later than 180 days after the MBS closing date, we find that CDS coverage increases the probability of loan delinquency by 3.3% over the full sample period (2003 to 2007) and 5.4% over the 2004 to 2006 subperiod when CDS coverage of subprime loans reached its highest level. The effect of CDS coverage becomes more significant when we use a narrower window and require that the CDO settlement date be before the MBS closing date. For example, if the CDO settlement date is within the 90 days prior to the MBS closing date, the increase in the probability of loan delinquency is 6.7% and 5.9% over the 2003 to 2007 and 2004 to 2006 periods, respectively.

To mitigate the concern that our results are due to CDS contracts being used to hedge the risk of already-outstanding loans, rather than CDS contracts encouraging the origination of riskier loans, we use propensity score matching (PSM). Specifically, we compare the delinquency rates in our sample of loans with CDS coverage to a matching sample of loans without CDS coverage. The matching is based on a propensity score model that uses borrower and loan characteristics to predict the likelihood that a loan will have CDS coverage. We continue to find a significant effect of CDS coverage on the loan delinquency rate.

Another potential concern is that our results could be explained by geography or time period if loans with CDS coverage concentrate in regions of the country and/or time periods with high mortgage defaults. We control for this possibility by constructing zip code and origination quarter loan cohorts and grouping the cohorts by percentage of loans with CDS coverage. We continue

[5] Synthetic CDOs are portfolios of CDS contracts on underlying assets that may include MBS, corporate bonds, or other fixed income securities. Synthetic CDOs are typically divided into credit tranches based on the level of credit risk assumed. Investors can buy components of synthetic CDOs. All tranches receive periodic payments based on the cash flows from the CDS. If a credit event occurs in the underlying portfolio of assets (e.g., MBS), the synthetic CDO investors are responsible for the losses, starting from the lowest-rated tranches up through the highest-rated tranches.

to find a strong CDS effect within all groups except the loan group with the lowest percentage of CDS coverage.

To tighten the connection between CDS coverage and subprime loan delinquency, we next exploit variation in the timing of CDS coverage *within* pools of subprime loans referenced by CDS contracts. For this analysis, we use the subsample of subprime loans with CDS coverage and examine how variation in loan origination dates relative to the CDO settlement date influences loan delinquency within a pool. If the CDS coverage date is before a loan's origination date, then the loan originator and loan securitizer are likely to be less sensitive to default risk because the credit risk of the loan is insured. Thus, we expect a higher likelihood of loan delinquency when a loan in a pool with CDS coverage is originated after rather than before the coverage date. We find that within-pool variation in the timing of CDS coverage has a large predictable effect on loan delinquency. In particular, in probit regressions with a comprehensive set of controls (including mortgage pool fixed effects) there is an 18% increase in the probability of delinquency for loans originated after CDS coverage in comparison to loans originated before CDS coverage. Further, the CDS timing effect is robust to propensity score analysis, which mitigates possible reverse causality and continues to be strong across zip code and origination quarter loan cohorts grouped by CDS coverage.

Our analysis also uncovers several notable results for the impact of MBS issuer type on subprime mortgage delinquency. A widely held belief is that investment banks played a major role in the subprime mortgage crisis because their demand for large pools of subprime loans to securitize induced a decline in lending standards by mortgage loan originators (see, e.g., Ashcraft and Schuermann (2008)). Although we find that the performance of subprime loans in MBS issued by investment banks is worse than the performance of subprime loans in MBS issued by other MBS issuers, we find the opposite when we condition on CDS coverage. In particular, we find that the effect of CDS coverage on the probability of delinquency for loans in pools securitized by commercial banks is significantly larger than that for loans in pools securitized by investment banks. Since commercial banks originated and securitized loans and were actively involved in the CDS market, this result suggests that the commercial banks used a borrower's soft information (e.g., job and income stability) in addition to hard information (e.g., FICO score) to allocate riskier subprime loans to MBS deals that were insured with CDS contracts.[6]

Interestingly, the CDS timing effect is strong across all issuer types. We find that there is a 15%, 16%, and 22% increase in the probability of delinquency for loans originated after CDS coverage (relative to before) in pools securitized by independent finance companies, commercial banks, and investment banks, respectively. Overall, these results strengthen our argument that CDS coverage

[6] As shown by Weistroffer (2009), commercial banks were the largest buyers and sellers of CDS protection up through the 2007 to 2008 financial crisis. Our evidence suggests that commercial banks held their best loans and either securitized lower quality loans or sold them to other securitizers.

encouraged the origination of risky subprime loans and thereby had an economically significant effect on subprime loan losses.

The remainder of the paper is organized as follows. Section I describes the data and presents descriptive statistics. Section II presents empirical results. Section III concludes.

I. Data and Descriptive Statistics

A. Data

We use the First American CoreLogic LoanPerformance database to construct a sample of subprime single-family residential mortgages originated during the 2003 to 2007 period. As noted by Keys et al. (2010), the LoanPerformance database encompasses over 90% of the subprime loans that are privately securitized by MBS issuers.[7] Each loan in the database has detailed information on borrower credit risk characteristics at loan origination, including FICO score, combined loan-to-value (CLTV) ratio, back-end debt-to-income (DTI) ratio, and whether the lender has complete documentation on the borrower's income and assets. The data also include information on loan characteristics such as the loan origination date, loan amount, appraised value or sale price of the property, location of the property (zip code), and whether the borrower-owner occupies the property. As for loan characteristics, the data include whether the interest rate is fixed or adjustable, the initial interest rate, the margin and first rate reset date for adjustable rate loans, and whether the loan has a prepayment penalty or balloon payment at maturity. These and other borrower and loan characteristics are described in the Appendix.

The LoanPerformance data set also contains information on whether a loan is current, delinquent, or in foreclosure. Our empirical analysis examines the determinants of the probability of delinquency by tracking the number of days that mortgage payments are past due. Following the convention in the residential mortgage industry, a loan is classified as delinquent if it is at least 60 days past due within the first 24 months of origination.

For each loan in the sample we collect regional economic data for the borrower's geographic area.[8] Specifically, we compute housing price appreciation

[7] The First American CoreLogic LoanPerformance database is used by Keys et al. (2010) and Demyanyk and Van Hemert (2011). A popular alternative mortgage loan database is the one constructed by LPS Applied Analytics, Inc. (formerly known as the "McDash data"). This database is used by, for example, Foote et al. (2009) and Piskorski, Seru, and Vig (2010). In comparison to the LoanPerformance database, the LPS database includes a large number of loans held in agency pools. For example, 67% of the loans reported in the LPS database originated in the 2001 to 2007 period are in Fannie Mae and Freddie Mac portfolios. Since these government-sponsored enterprises implicitly or explicitly guarantee the performance of the loans in the mortgage pools, there is no need for credit insurance such as CDS contracts. In contrast, privately securitized subprime loans have no such guarantee and credit protection and/or enhancement is provided by structuring MBS deals so that pools of subprime loans are put into tranches with different priorities and by seeking credit protection using CDS contracts.

[8] Doms, Furlong, and Krainer (2007) document that regional economic weakness and declining house prices contribute significantly to subprime mortgage delinquencies during our sample period.

over the 24 months after origination using the housing price index for the borrower's metropolitan statistical area reported by the Office of Federal Housing Enterprise Oversight. We also compute the change in the state-level unemployment rate over the 24 months after origination using data reported by the Bureau of Economic Analysis. Finally, we collect the median household income in 1999 for the borrower's zip code as reported by the U.S. Census Bureau in 2000.

To test the prediction that CDS contributed to the subprime mortgage crisis, we need to identify which subprime loans in our sample are covered by CDS contracts. In addition to borrower and loan characteristics, the LoanPerformance database provides information on the mortgage pool (identified by a unique pool ID) in which the loan was placed. One or more of these pools are combined into a mortgage deal (identified by a unique deal number) from which MBS are issued. These MBS are identified by their unique CUSIPs.[9] For each mortgage deal we obtain information on the MBS closing date and the name of the MBS issuer. Using this information, if we can identify the CDS contracts that reference the MBS issued from a mortgage deal, we can identify the mortgage pools and ultimately the individual loans that are covered by CDS contracts. Because most subprime MBS have a tranche structure and not a pass-through structure, all of the loans within a referenced mortgage pool are covered by CDS if one or more tranches have CDS contracts written on them.

Since CDS contracts are traded over-the-counter between private parties, it is impossible to account for all of the CDS contracts that reference subprime MBS during our sample period. Fortunately, the majority of CDS contracts are included in synthetic CDOs and traded as a portfolio.[10] Our strategy is therefore to identify synthetic CDOs constructed with CDS contracts that reference MBS on subprime mortgages. We identify this subset of synthetic CDOs over the 2003 to 2007 period using data provided by Intex Solutions Inc. We then back out the underlying subprime MBS and the mortgage deals from which these MBS are formed. Finally, we employ the unique ID of the mortgage pools used to construct these MBS to identify the underlying subprime loans. In this manner we are able to determine which subprime loans in our sample have CDS coverage.

For a CDS contract to have an impact on the loan origination decision, the originator or the securitizer pooling loans purchased from the originator should know that the loan is or will be covered by the CDS contract. Of course, this is much more likely if CDS coverage is initiated before or shortly after a loan is originated and placed in a mortgage pool. Since we do not know the exact date when a CDS contract is written, we use the settlement date for the enclosing synthetic CDO as a proxy for the start of credit protection. As a practical matter,

[9] We supplement the mapping of mortgage pools to CUSIPs using data provided by TCW Group Inc. whenever the LoanPerformance database mappings are incomplete.

[10] A synthetic CDO is a portfolio of short positions in CDS. The seller of credit protection is said to have a short position in a CDS and receives periodic insurance premiums in exchange for standing ready to cover losses in the event of default.

the synthetic CDO settlement date is generally after the CDS start date if the CDS contract is included in the synthetic CDO.[11]

In our analysis of the effect of CDS coverage on loan performance, we compare the CDO settlement date to the MBS closing date and then to the individual loan origination date. Thus, we first examine whether CDS coverage influences the delinquency of loans *across* pools by focusing on the performance of loans in pools with CDS protection versus loans in pools without CDS protection. For this analysis, we define CDS coverage as "concurrent" if the CDO settlement date is no later than 180 days after the MBS closing date. Any CDS coverage outside this window is not likely to influence the loan origination decision and so loans falling into this category are grouped with loans in pools that do not have CDS protection. Our across-pool analysis uses the 180-day timeframe as the base case and examines subperiods inside and outside the 180-day range.[12]

We next exploit *within*-pool variation in CDS coverage by comparing a loan's origination date to the CDO settlement date and examine the effect of the timing of CDS coverage on loan delinquency. Although this analysis focuses on the subsample of loans in pools with CDS coverage, it allows for a more powerful test of whether CDS coverage influences loan origination decisions. Specifically, we compare the performance of loans with CDS coverage at or possibly before origination to the performance of loans with CDS coverage after origination. If the credit protection provided by CDS coverage encouraged the origination of risky loans, then we would expect the likelihood of delinquency for loans with coverage at or before origination to be higher than that for loans with coverage after origination. We provide further details on this test below.

B. Descriptive Statistics

Our sample of privately securitized subprime loans from the LoanPerformance database shows that the origination of subprime loans as measured by both the number of loans and the dollar amount of loans jumped in 2004, reaching a peak in 2006, and then fell sharply in 2007.[13] This pattern is especially evident for adjustable rate mortgages (ARM) and hybrid fixed and ARM mortgages with a low initial "teaser" rate for two (*Hybrid2*) or three (*Hybrid3*) years. The dramatic growth in loan types with low initial payments mirrors a

[11] CDO portfolio turnover that replaces a maturing CDS contract with a new CDS contract can result in CDS contract start dates after the CDO settlement date.

[12] For the sample of subprime loans in pools with CDS coverage, 17.3% have a CDO settlement date more than 180 days before the MBS closing date, 4.9% have a CDO settlement date 90 to 180 days before the MBS closing date, 8.2% have a CDO settlement date zero to 90 days before the MBS closing date, 16.4% have a CDO settlement date zero to 90 days after the MBS closing date, 18.1% have a CDO settlement date 90 to 180 days after the MBS closing date, and 29% have a CDO settlement date more than 180 days after the CDO settlement date. The remaining 6.1% of loans in pools with CDS coverage are missing a CDO settlement date and cannot be placed in a window relative to the MBS closing date.

[13] See the Internet Appendix for details. The Internet Appendix is available in the online version of this article on the *Journal of Finance* website.

general decline in the credit quality of borrowers and an uptick in questionable lending practices. In particular, the percentage of loans with complete documentation of income and assets (*Full Doc*) decreased from 60.3% in 2003 to 43.8% in 2007, while the CLTV over the same period increased from 74.7% to 81.2%. Subprime borrowers were more likely to be locked into loans during this period—the frequency of prepayment penalties in loans increased from 48.8% in 2003 to a peak of 59.2% in 2006—and were encouraged to borrow with interest-only loans—the frequency of which increased from 8.4% in 2003 to 30.4% in 2007.

Table I reports the time trend of subprime MBS deals and synthetic CDO deals (Panel A), the percentage of subprime loans in loan pools with concurrent CDS coverage (Panel B), and characteristics of subprime loans with and without CDS coverage (Panel C). Coincident with the surge in the origination of subprime loans over the 2004 to 2006 period, Panel A shows that the largest number of subprime MBS and synthetic CDOs were created during this time period. As seen in Panel B, 35.4% of the subprime loans in the sample have concurrent CDS coverage and an additional 19.1% have "subsequent" CDS coverage (i.e., coverage outside the 180-day window). On a year-over-year basis, the percentage of subprime loans with concurrent CDS coverage experienced dramatic growth starting in 2004—jumping from 3% in 2003 to 25.7% in 2004—reaching a peak in 2006 of 53.5% and then declining sharply to 21.5% in 2007. Panel B also shows that this pattern of CDS coverage is mirrored in every loan type, but is particularly evident for adjustable rate loans (ARM), balloon loans (*Balloon*), and hybrid 2/28 loans (*Hybrid2*).

Consistent with the argument that CDS coverage helped fuel lending to lower quality borrowers, note in Panel C of Table I that the FICO score of borrowers with CDS coverage is on average more than 50 points lower than the FICO score of borrowers without CDS coverage. Similarly, the CLTV is higher and the percentage of borrowers who are investors is lower when the loan has CDS coverage. In addition, consistent with the view that subprime loans with CDS coverage are riskier than subprime loans without CDS coverage, CDS-covered loans have a much higher incidence of prepayment penalties, are smaller in amount, and have much higher initial interest rates.

There were three types of subprime MBS issuers during our sample period, with various levels of involvement in loan origination, securitization, and participation in the CDS market. Type D (depository) issuers are financial institutions and their affiliates that have commercial banking operations (e.g., Washington Mutual). These issuers actively participated in the entire supply chain of subprime mortgage loans from origination and securitization to the CDS market. Type M (multisector) issuers are the investment banks. Examples of these types of issuers include Goldman Sachs and the now-defunct Bear Stearns and Lehman Brothers. These issuers were active in the securitization process and the CDS market but had no direct involvement in loan origination. Lastly, Type I (independent) issuers are mortgage finance companies (e.g., Countrywide and New Century Financial) that specialized in mortgage loan origination but had

Table I

Sample Descriptive Statistics

The years correspond to origination years for subprime loans, closing dates for mortgage-backed security (MBS) deals, and settlement dates for synthetic collateralized debt obligations (CDOs). The table reports time trends for subprime MBS deals, synthetic CDO deals, subprime loans with credit default swap (CDS) coverage, and characteristics of loans with and without CDS coverage. Subprime MBS are issued on tranches of mortgage pools stratified by credit rating and serve as reference entities for CDS contracts. Synthetic CDOs are portfolios of CDS contracts on MBS. A subprime loan has CDS coverage if it is in a mortgage pool that is part of an MBS that is referenced by a CDS contract in a synthetic CDO. CDS coverage is concurrent if the CDO settlement date is no later than 180 days after the MBS closing date; otherwise, CDS coverage is subsequent. Borrower and loan characteristics are mean values. Mortgage loan characteristics and type are defined in the Appendix.

Loan Origination Year	2003	2004	2005	2006	2007	2003–2007
Panel A: Number of subprime MBS and synthetic CDO deals in the sample						
Subprime MBS	712	908	1,138	1,117	742	4,617
Synthetic CDOs	3	12	39	119	23	196
Panel B: Subprime loans with concurrent and any (concurrent or subsequent) CDS coverage						
Loans with concurrent and any CDS coverage						
Concurrent (%)	3.0	25.7	52.9	53.5	21.5	35.4
Any coverage (%)	29.8	66.8	67.0	59.7	22.9	54.5
Concurrent coverage by loan type						
ARM (%)	0.2	2.0	30.1	25.5	2.6	18.3
Hybrid2 (%)	5.4	38.4	79.1	82.2	53.7	56.0
Hybrid3 (%)	1.8	18.1	36.8	34.5	9.8	23.1
Balloon (%)	0.7	9.4	84.2	78.3	36.9	65.6
Fixed rate (%)	2.1	19.5	32.2	33.6	13.8	20.6
Panel C: Borrower and loan characteristics with concurrent CDS coverage and no (including subsequent) CDS coverage						
Borrower and loan characteristics with concurrent CDS coverage						
FICO	624.98	612.62	625.29	622.55	616.58	621.56
Full doc (%)	61.10	66.13	60.69	59.95	64.18	61.55

(*Continued*)

Table I—*Continued*

Loan Origination Year	2003	2004	2005	2006	2007	2003–2007
Panel C: Borrower and loan characteristics with concurrent CDS coverage and no (including subsequent) CDS coverage						
CLTV (%)	80.75	81.31	84.49	85.00	83.72	84.05
Investor (%)	5.70	5.95	7.03	6.80	6.25	6.69
DTI (%)	38.77	38.95	39.61	40.61	40.69	39.95
Miss DTI (%)	10.44	22.55	29.60	20.44	34.23	24.94
Cash-out (%)	11.91	8.21	7.53	7.07	10.90	7.74
PrePayPen (%)	69.13	71.90	72.22	70.94	68.90	71.42
Loan amt. ($)	188,951	174,838	203,935	215,423	216,774	204,035
Interest only (%)	2.37	9.90	20.49	14.47	13.92	15.74
Initial rate (%)	7.34	7.32	7.11	8.05	8.33	7.58
Margin (%)	5.71	6.01	5.66	5.78	5.77	5.77
Rate reset (mos.)	27.84	27.13	25.92	26.72	28.47	26.59
Borrower and loan characteristics with no CDS coverage or subsequent CDS coverage						
FICO	660.19	663.19	688.81	687.31	683.51	674.06
Full doc (%)	60.24	56.37	46.71	34.64	38.16	49.31
CLTV (%)	74.48	80.47	79.90	81.29	80.51	79.06
Investor (%)	7.84	10.08	11.23	11.71	10.15	10.05
DTI (%)	37.35	37.86	37.45	38.26	39.05	37.91
Miss DTI (%)	47.25	44.75	58.91	51.86	43.10	49.02
Cash-out (%)	25.82	15.16	13.52	13.64	19.96	17.79
PrePayPen (%)	48.19	50.10	39.71	45.65	44.85	46.28
Loan amt. ($)	247,998	241,867	300,767	326,482	365,515	285,030
Interest only (%)	8.58	23.24	37.37	34.13	34.92	25.69
Initial rate (%)	6.84	6.32	5.85	6.44	6.77	6.44
Margin (%)	5.25	4.67	3.85	3.87	3.95	4.42
Rate reset (Mos.)	34.97	32.86	38.23	37.84	43.44	36.42

limited access to the CDS market.[14] The Internet Appendix lists the subprime MBS issuers in the sample by number of deals, number of deals referenced by CDS, and total dollar value of MBS issued.

Panel A of Table II shows that each of the three MBS issuer types securitized roughly equal numbers of subprime loans during the 2003 to 2007 period. Note, however, that a larger proportion of loans securitized by Type M and I issuers were covered by CDS contracts. Panel B of Table II reports loan type and CDS coverage by MBS issuer type. As can be seen, the highest proportions of CDS coverage are for the riskiest subprime loan types. In particular, irrespective of issuer type, more than half of all 2/28 hybrid loans (*Hybrid2*) and approximately two-thirds of all balloon loans (*Balloon*) have concurrent CDS coverage.

Lastly, as reported in the Internet Appendix, we find that the subprime loans underlying MBS issued by Type D issuers (i.e., commercial banks) have higher credit worthiness than the subprime loans underlying MBS issued by Type M issuers (i.e., investment banks) or Type I issuers (i.e., origination and/or securitization specialists). Specifically, over the 2003 to 2007 period, the FICO scores on loans of Type D MBS issuers average 20 points higher than those on loans of Type M or Type I issuers. However, there appears to be less information about borrower debt burden for Type D issuers; over the 2003 to 2007 period, the percentage of loans with a missing DTI ratio (*Miss DTI*) is much higher for loans underlying MBS issued by Type D financial institutions than loans underlying MBS issued by Type M or Type I financial institutions.

II. Subprime Loan Performance and CDS

In this section we test the prediction that CDS contributed to the subprime mortgage crisis by encouraging mortgage loan originators to expand credit to more risky borrowers to meet demand for subprime loans by MBS issuers and investors. We first provide descriptive statistics on subprime mortgage loan performance. We then examine the effect of CDS coverage on loan performance and the differential performance of loans in mortgage pools with and without CDS coverage. We next focus on mortgage pools with CDS coverage and examine the effect of the timing of CDS coverage on loan delinquency. Lastly, we examine the effect of MBS issuer type on the relation between CDS coverage and loan delinquency.

A. Subprime Loan Delinquency Rates

Following Keys et al. (2010) and Demyanyk and Van Hemert (2011), we proxy for subprime loan performance using loan delinquency. A loan is delinquent

[14] Type I issuers focused more on origination and distribution of loans than on securitization and therefore it was not economical for them to participate in the CDS market. In comparison, Type D and M issuers had large portfolios of MBS and other credit-sensitive assets and they typically had dedicated trading desks where credit risks were assessed and hedged. Weistroffer (2009) notes that during our sample period most CDS dealers resided in Type D and M financial institutions.

Table II

Loan Volume and CDS Coverage by MBS Issuer Type

The table reports the number of loans, proportion of loans with concurrent CDS coverage, and loan type for MBS issuer types by loan origination year. Type D (depository) issuers are financial institutions and their affiliates that have banking operations (i.e., accept deposits and originate loans). These financial institutions originate loans, securitize loans, and typically make a market in CDS contracts. Type M (multisector) issuers are financial institutions such as investment banks and hedge funds that do not have banking operations. These financial institutions securitize mortgages and use and/or make a market in CDS contracts but do not participate in mortgage loan origination. Type I (independent) issuers are REITs and mortgage finance companies that specialize in mortgage loan origination and/or loan securitization but do not make a market in CDS contracts. Information on whether a mortgage is referenced by a CDS is determined by whether the loan is in a mortgage pool in an MBS that is referenced by a CDS contract enclosed in a synthetic CDO. CDS coverage is concurrent if the CDO settlement date is no later than 180 days after the MBS closing date. The Appendix defines loan types and borrower and loan characteristics. The Internet Appendix lists the names of MBS issuers by type (D, M, and I), number of MBS deals, and the number of deals referenced by CDS contracts.

Panel A: Number of loans and proportion of loans with concurrent CDS coverage by MBS issuer type

Loan origination year	2003	2004	2005	2006	2007	2003–2007
Number of loans by MBS issuer type						
Type D issuer	567,256	621,798	701,637	822,787	348,915	3,062,393
Type M issuer	496,765	827,341	888,247	657,104	298,606	3,168,063
Type I issuer	496,041	778,410	804,798	948,536	348,556	3,376,341
Proportion (in %) of subprime loans with concurrent CDS coverage by MBS issuer type						
Type D issuer	3.9	18.6	44.3	48.5	19.2	29.9
Type M issuer	1.6	28.3	54.0	50.8	30.4	36.2
Type I issuer	3.4	28.4	59.2	59.7	16.1	39.6

Panel B: Loan type and proportion of loans with concurrent CDS coverage by MBS issuer type

	ARM	Hybrid2	Hybrid3	Balloon	Fixed rate	All loans
Number of loans by loan type and issuer type						
Type D issuer	199,797	880,228	721,114	144,147	1,117,084	3,062,370
Type M issuer	306,249	1,115,625	584,885	94,434	1,066,870	3,168,063
Type I issuer	186,318	1,246,041	748,974	280,764	914,171	3,376,268
Proportion (in %) of loans by loan type and issuer type with concurrent CDS coverage						
Type D issuer	16.0	56.8	15.3	71.5	15.2	29.9
Type M issuer	21.8	51.9	34.5	67.1	22.0	36.2
Type I issuer	14.9	59.2	21.7	62.0	25.7	39.6

if the borrower is at least 60 days past due within the first 24 months of origination. This measure includes foreclosed loans since all foreclosed loans in the sample were delinquent prior to foreclosure.

Table III reports delinquency rates for subprime loans by CDS coverage. As seen in Panel A, over the entire sample period the delinquency rates of loans with concurrent CDS coverage (labeled "CDS coverage") are almost double the delinquency rates of loans with no coverage or subsequent coverage (labeled "No CDS coverage"). The difference in delinquency rates for loans with and without CDS coverage increases from 1.2% in 2003 to 15.3% in 2006. The gap narrows in 2007 but the higher delinquency rate for loans with CDS coverage is still readily apparent.

Panel B focuses on differences in delinquency rates across loan types. As can be seen, fixed rate loans (FRM) and hybrid loans (*Hybrid2* and especially *Hybrid3*) show the most dramatic differences in delinquency rates across loans with and without CDS coverage. For the entire loan origination period from 2003 to 2007, the loan delinquency rates across the CDS and no CDS categories for FRM, hybrid 2/28 loans, and hybrid 3/27 loans are 20.2% versus 10.3%, 31.6% versus 23.6%, and 24.4% versus 13.7%, respectively.

Panel C reports subprime loan delinquency rates by type of MBS issuer. Across all three types of issuers and in each loan origination year, the delinquency rate is always higher when the loan has concurrent CDS coverage. The largest difference in delinquency rates is observed for loans in MBS deals issued by Type D issuers (commercial banks) with the *difference* in delinquency rates for loans with and without CDS coverage equaling 7.5%, 16.6%, 21.9%, and 19.8% for loans originated in 2004, 2005, 2006, and 2007, respectively. Although these delinquency comparisons do not control for differences in borrower and loan characteristics, they suggest that Type D issuers show the strongest CDS effect. This is consistent with the active participation of commercial banks in all phases of the mortgage market, from origination and securitization to CDS on MBS. Thus, in addition to having hard information on borrower credit quality, commercial banks have access to detailed soft information that they can use to differentiate between mortgage pools in MBS deals to determine whether credit protection is warranted.[15]

[15] Keys et al. (2010) note that, when a borrower fills out a credit application to obtain a mortgage loan, the hard information consists of the borrower's FICO score, the loan-to-value ratio, the type of loan, and the interest rate. The other information is soft, including employment stability, sources of income, assets, number of household wage-earners, and many other items. They observe that only the hard information was used by Wall Street (i.e., Type M issuers) when buying loans from originators. When loan originators and securitizers are under the same roof, such as in a commercial bank, both the hard and soft information are more likely to be used in assessing borrower credit risk.

Table III

Subprime Loan Delinquency Rates by CDS Coverage, Loan Type, and MBS Issuer Type

The table reports the delinquency rate (in percent) for subprime loans with no CDS coverage or no concurrent (i.e., subsequent) CDS coverage (no CDS coverage), for subprime loans with concurrent CDS coverage (CDS coverage), and for all sample loans (all loans) by loan origination year, loan type, and MBS issuer type. CDS coverage is concurrent if the CDO settlement date is no later than 180 days after the MBS closing date; otherwise, CDS coverage is subsequent. A loan is classified as delinquent if it is at least 60 days past due within the first 24 months after origination. Loan types are defined in the Appendix, except for FRM, which indicates that the interest rate on the mortgage is fixed over the life of the loan. Issuer types are defined in Table II.

Loan Origination Year	2003	2004	2005	2006	2007	2003–2007
Panel A: Delinquency rates (in %) by whether a loan has CDS coverage						
No CDS coverage	10.2	10.7	10.1	22.4	34.0	15.5
CDS coverage	11.4	18.3	22.9	37.7	48.4	29.2
All loans	10.2	12.6	16.9	30.6	37.1	20.4
Panel B: Delinquency rates (in %) by loan type and whether a loan has CDS coverage						
ARM						
No CDS coverage	2.0	2.6	5.2	21.3	34.4	12.9
CDS coverage	8.9	9.1	7.9	22.0	48.3	15.2
All loans	2.0	2.8	6.0	21.5	34.7	13.3
Hybrid2						
No CDS coverage	18.7	18.8	24.2	43.6	54.5	23.6
CDS coverage	14.0	20.5	26.7	41.9	53.8	31.6
All loans	18.4	19.4	26.2	42.2	54.2	28.1
Hybrid3						
No CDS coverage	7.5	6.8	7.6	20.1	36.1	13.7
CDS coverage	8.4	17.9	19.8	31.9	44.0	24.4
All loans	7.5	8.8	12.1	24.1	36.9	16.2
Balloon						
No CDS coverage	13.4	8.1	25.0	47.0	56.0	47.7
CDS coverage	26.7	10.1	28.9	45.7	55.2	45.5

(*Continued*)

Table III—*Continued*

All loans	13.4	8.3	28.3	46.0	55.7	46.3
FRM						
No CDS coverage	6.1	7.4	7.0	14.5	22.3	10.3
CDS coverage	7.8	12.8	15.5	25.8	35.4	20.2
All loans	6.1	8.4	9.8	18.3	24.1	12.3
Panel C: Delinquency rates (in %) by MBS issuer type						
Loans with concurrent CDS coverage						
Type D issuer	9.0	16.7	23.4	37.2	45.7	29.9
Type M issuer	13.3	18.3	23.4	38.8	49.3	30.0
Type I issuer	14.2	19.0	22.1	36.2	50.0	27.7
Loans with no CDS coverage or subsequent CDS coverage						
Type D issuer	9.1	9.2	6.8	15.3	25.9	12.1
Type M issuer	10.5	10.4	11.7	29.9	43.5	19.0
Type I issuer	11.1	12.1	12.1	22.8	31.7	15.6

B. Subprime Mortgage Delinquency across Loan Pools with and without CDS Coverage

We test the prediction that CDS coverage had a positive effect on subprime mortgage delinquency using a multivariate probit model that estimates the effect of CDS coverage on the probability of loan delinquency. Table IV reports marginal effects from probit regressions using loans included in MBS deals originated between 2003 and 2007 and the loans originated between 2004 and 2006.[16] For each sample period, we report a baseline probit regression without any CDS variables, a regression with a CDS dummy variable equal to one if the CDO settlement date is no later than 180 days after the MBS closing date (i.e., concurrent CDS coverage), and a regression with CDS dummy variables for different windows of the CDO settlement date around the MBS closing date. In the regressions with CDS dummy variables, the omitted baseline group in regressions (2) and (5) comprises loans with no CDS coverage or CDS coverage outside the 180-day concurrent window, and the omitted baseline group in regressions (3) and (6) comprises loans with no CDS coverage. All regressions include control variables for borrower characteristics, loan characteristics, and regional housing and economic conditions, as well as semiannual loan origination dummies. Marginal effects are computed for a one-standard-deviation change for continuous variables and for a change from zero to one for dummy variables. Standard errors clustered by states are in parentheses below each marginal effect.

Consistent with CDS coverage influencing the performance of subprime mortgages during the financial crisis, we find a positive effect of concurrent CDS coverage on the probability of delinquency for loans in MBS deals originated between 2003 and 2007 and between 2004 and 2006. Thus, based on the predicted probabilities of loan delinquency for regressions (2) and (5), the marginal effects of CDS coverage translate into a 3.3% (0.40%/12%) and 5.4% (0.76%/14%) increase in the probability of delinquency for loans originated over the 2003 to 2007 and 2004 to 2006 periods, respectively.

We next examine the strength of the CDS effect by estimating marginal effects for CDS coverage variables that capture the timing of the CDO settlement date relative to the MBS closing date. We expect that the closer the CDO settlement date is to the MBS closing date the stronger the effect of CDS coverage is on loan delinquency, especially when the CDO settlement date is before the MBS closing date and it is more likely that the loans in the MBS mortgage pools are originated after CDS coverage is in place. As seen in regressions (3) and (6), CDS coverage has the largest effect on loan delinquency when the CDO settlement date is immediately before or after the MBS closing date. For example, in the full sample of loans (i.e., those originated over the 2003 to 2007 period) we see in regression (3) that the largest effect of CDS coverage on loan delinquency is for loans in pools where the CDO settlement date is in a 90-day

[16] The narrower origination window from 2004 to 2006 might be more appropriate because CDS coverage of subprime MBS did not take off until 2004 and was in decline by 2007. This can be seen in Panel B of Table I.

Table IV

The Effect of CDS Coverage on the Probability of Subprime Mortgage Delinquency

The table reports marginal effects from probit regressions of the probability of subprime mortgage delinquency by whether a loan has CDS coverage, controlling for borrower and loan characteristics, regional housing and economic conditions, and loan origination time dummy variables. Marginal effects are computed for a one-standard-deviation change for continuous variables and for a change from zero to one for dummy variables. A loan is defined as delinquent if it is at least 60 days past due within the first 24 months of origination. Regressions (1) and (4) are baseline regressions without CDS variables for the sample periods 2003 to 2007 and 2004 to 2006, respectively. Regressions (2) and (5) include a dummy variable for concurrent CDS coverage for the sample periods 2003 to 2007 and 2004 to 2006. In these regressions, CDS is equal to one if the loan has concurrent CDS coverage and zero otherwise, where CDS coverage is concurrent if the CDO settlement date is no later than 180 days after the MBS closing date. The omitted baseline group in regressions (2) and (5) comprises loans without CDS coverage or with a CDO settlement date more than 180 days after the MBS closing date. Regressions (3) and (6) include dummy variables for various windows between the CDO settlement date and the MBS closing date for the sample periods 2003 to 2007 and 2004 to 2006. In these regressions, *CDS1* is equal to one if the CDO settlement date is more than 180 days before the MBS closing date and zero otherwise, *CDS2* is equal to one if the CDO settlement date is 90 to 180 days before the MBS closing date and zero otherwise, *CDS3* is equal to one if the CDO settlement date is zero to 90 days before the MBS closing date and zero otherwise, *CDS4* is equal to one if the CDO settlement date is zero to 90 days after the MBS closing date and zero otherwise, *CDS5* is equal to one if the CDO settlement date is 90 to 180 days after the MBS closing date and zero otherwise, and *CDS6* is equal to one if the CDO settlement date is more than 180 days after the MBS closing date and zero otherwise. The omitted baseline group in regressions (3) and (6) comprises loans without CDS coverage. All other variables in regressions (1) to (6) are defined in the Appendix. The variables *CLTV* and *DTI* are winsorized at the 0.5% level in the right tail, and *Loan amt.*, *Local income*, *Unemployment*, and *Price appr.* are winsorized at the 0.5% level in both tails. Loan origination time dummies are defined for each half-year from the second half of 2003, *YR03H2*, to the second half of 2007, *YR07H2*, with the omitted base year being the first half of 2003. The predicted probability is computed at the sample means of the explanatory variables. Standard errors clustered by states are in parentheses below marginal effects. ***, **, and * indicate statistical significance at the 0.001, 0.01, and 0.05 levels, respectively.

	Loan Origination Years 2003–2007			Loan Origination Years 2004–2006		
	(1)	(2)	(3)	(4)	(5)	(6)
CDS = 1 if CDO ≤ MBS + 180 days		0.0040**			0.0076***	
		(0.0015)			(0.0014)	
CDS1 = 1 if CDO +180 days before MBS			−0.0012			0.0050**
			(0.0017)			(0.0019)

(*Continued*)

Table IV—*Continued*

	Loan Origination Years 2003–2007			Loan Origination Years 2004–2006		
	(1)	(2)	(3)	(4)	(5)	(6)
CDS2 = 1 if CDO 90–180 days before MBS			0.0057**			0.0071**
			(0.0020)			(0.0026)
CDS3 = 1 if CDO 0–90 days before MBS			0.0087***			0.0083**
			(0.0021)			(0.0031)
CDS4 = 1 if CDO 0–90 days after MBS			0.0070***			0.0101***
			(0.0017)			(0.0021)
CDS5 = 1 if CDO 90–180 days after MBS			0.0048*			0.0068**
			(0.0019)			(0.0023)
CDS6 = 1 if CDO +180 days after MBS			0.0002			−0.0008
			(0.0016)			(0.0027)
FICO	−0.0824***	−0.0822***	−0.0823***	−0.0888***	−0.0885***	−0.0885***
	(0.0027)	(0.0027)	(0.0027)	(0.0029)	(0.0029)	(0.0029)
Full Doc	−0.0575***	−0.0577***	−0.0577***	−0.0571***	−0.0574***	−0.0574***
	(0.0041)	(0.0041)	(0.0041)	(0.0036)	(0.0036)	(0.0036)
CLTV	0.0523***	0.0523***	0.0523***	0.0614***	0.0615***	0.0615***
	(0.0057)	(0.0057)	(0.0057)	(0.0055)	(0.0054)	(0.0055)
Investor	0.0411***	0.0413***	0.0413***	0.0443***	0.0448***	0.0448***
	(0.0091)	(0.0091)	(0.0091)	(0.0108)	(0.0108)	(0.0108)
DTI	0.0174***	0.0173***	0.0173***	0.0177***	0.0176***	0.0176***
	(0.0016)	(0.0017)	(0.0017)	(0.0023)	(0.0023)	(0.0023)
Miss DTI	0.0289***	0.0293***	0.0294***	0.0291***	0.0301***	0.0301***
	(0.0043)	(0.0043)	(0.0042)	(0.0053)	(0.0054)	(0.0055)

(*Continued*)

Table IV—*Continued*

	Loan Origination Years 2003–2007			Loan Origination Years 2004–2006		
	(1)	(2)	(3)	(4)	(5)	(6)
Cash-out	0.0030	0.0031	0.0031	0.0026	0.0029	0.0028
	(0.0058)	(0.0059)	(0.0059)	(0.0057)	(0.0057)	(0.0057)
PrePayPen	0.0416***	0.0414***	0.0414***	0.0422***	0.0417***	0.0418***
	(0.0089)	(0.0090)	(0.0089)	(0.0087)	(0.0087)	(0.0088)
Loan amt.	0.0136***	0.0136***	0.0136***	0.0120***	0.0120***	0.0120***
	(0.0025)	(0.0025)	(0.0025)	(0.0029)	(0.0029)	(0.0029)
Interest only	0.0178***	0.0182***	0.0182***	0.0166***	0.0173***	0.0173***
	(0.0027)	(0.0026)	(0.0026)	(0.0027)	(0.0026)	(0.0026)
Initial rate	0.0288***	0.0287***	0.0287***	0.0367***	0.0363***	0.0364***
	(0.0029)	(0.0029)	(0.0029)	(0.0024)	(0.0024)	(0.0024)
Margin	0.0189***	0.0187***	0.0187***	0.0211***	0.0207***	0.0207***
	(0.0029)	(0.0029)	(0.0028)	(0.0034)	(0.0034)	(0.0035)
Rate reset	−0.0137***	−0.0134***	−0.0134***	−0.0180***	−0.0172***	−0.0173***
	(0.0010)	(0.0010)	(0.0010)	(0.0014)	(0.0013)	(0.0013)
ARM	0.0375***	0.0380***	0.0382***	0.0604***	0.0608***	0.0608***
	(0.0064)	(0.0063)	(0.0063)	(0.0058)	(0.0057)	(0.0057)
Hybrid2	0.0168***	0.0161***	0.0162***	0.0208***	0.0191***	0.0192***
	(0.0036)	(0.0036)	(0.0037)	(0.0051)	(0.0050)	(0.0048)
Hybrid3	0.0222***	0.0216***	0.0219***	0.0251***	0.0234***	0.0235***
	(0.0037)	(0.0036)	(0.0037)	(0.0052)	(0.0050)	(0.0049)
Balloon	0.0353***	0.0342***	0.0344***	0.0474***	0.0453***	0.0452***
	(0.0048)	(0.0049)	(0.0049)	(0.0046)	(0.0046)	(0.0045)
Price appr.	−0.1562***	−0.1563***	−0.1562***	−0.1345***	−0.1345***	−0.1345***
	(0.0145)	(0.0145)	(0.0145)	(0.0209)	(0.0208)	(0.0208)
Unemployment	−0.1454***	−0.1454***	−0.1454***	−0.1161**	−0.1160**	−0.1160**
	(0.0296)	(0.0296)	(0.0296)	(0.0396)	(0.0396)	(0.0397)
Local income	−0.0164***	−0.0164***	−0.0164***	−0.0154***	−0.0154***	−0.0154***
	(0.0042)	(0.0042)	(0.0042)	(0.0043)	(0.0043)	(0.0043)

(*Continued*)

Table IV—*Continued*

	Loan Origination Years 2003–2007			Loan Origination Years 2004–2006		
	(1)	(2)	(3)	(4)	(5)	(6)
YR03H2	0.0159*	0.0156*	0.0157*			
	(0.0067)	(0.0067)	(0.0067)			
YR04H1	0.0086	0.0073	0.0072			
	(0.0142)	(0.0143)	(0.0141)			
YR04H2	0.0084	0.0069	0.0068	−0.0008	−0.0012	−0.0010
	(0.0209)	(0.0210)	(0.0207)	(0.0066)	(0.0066)	(0.0066)
YR05H1	−0.0250	−0.0274	−0.0276	−0.0251**	−0.0277**	−0.0276***
	(0.0193)	(0.0192)	(0.0190)	(0.0085)	(0.0085)	(0.0082)
YR05H2	−0.0023	−0.0051	−0.0057	−0.0035	−0.0065	−0.0068
	(0.0106)	(0.0111)	(0.0110)	(0.0174)	(0.0174)	(0.0172)
YR06H1	0.0370*	0.0336	0.0332	0.0361	0.0326	0.0323
	(0.0172)	(0.0175)	(0.0175)	(0.0371)	(0.0370)	(0.0366)
YR06H2	0.1682**	0.1643**	0.1647**	0.1465	0.1433	0.1430
	(0.0539)	(0.0539)	(0.0541)	(0.0836)	(0.0825)	(0.0836)
YR07H1	0.4394***	0.4361***	0.4375***			
	(0.1135)	(0.1138)	(0.1137)			
YR07H2	0.6401***	0.6378***	0.6386***			
	(0.1239)	(0.1246)	(0.1243)			
Pseudo R^2	0.26	0.26	0.26	0.20	0.20	0.20
Observations	9,606,797	9,606,797	9,606,797	7,050,658	7,050,658	7,050,658
Predicted probability	0.12	0.12	0.13	0.14	0.14	0.14
Observed probability	0.20	0.20	0.20	0.20	0.20	0.20

window before the MBS closing date. Regressions (3) and (6) also show that the effect of CDS coverage on loan delinquency is insignificant or the smallest when the CDO settlement date is outside the 180-day window around the MBS closing date.[17]

The other variables in the regressions have the predicted effects on mortgage loan delinquency and are virtually identical with or without the addition of the CDS variables. The definitions for all variables and the predicted effects on loan delinquency are reported in the Appendix. The only exception is that the state-level change in the unemployment rate has a negative rather than the predicted positive effect on loan delinquency. It is possible, however, that lenders in states with high unemployment rates were more careful screeners of borrowers, which would explain the negative effect of state-level unemployment on loan delinquency.

Since CDS coverage of subprime loans experienced dramatic growth during our sample period, the influence of CDS on subprime loan delinquency is likely stronger during originations over the 2004 to 2006 period than those in the 2003 to 2007 period. We modify the probit specification by interacting the CDS dummy variable for concurrent coverage with dummy variables representing first-half and second-half loan origination years. As can be seen in the Internet Appendix, the effect of CDS coverage on the probability of delinquency is significantly positive starting in the first half of 2004, strengthening through 2005 before becoming significantly negative in 2007. The negative effect of CDS coverage on the probability of loan delinquency in 2007 coincides with the beginning of the subprime mortgage crisis, and likely reflects a more stringent selection process by *sellers* of CDS coverage. This is consistent with the dramatic reduction in the number of synthetic CDO deals with CDS contracts referencing subprime MBS from 119 in 2006 to only 23 in 2007 as reported in Panel A of Table I.

A concern with the above analysis is that the results may simply reflect the use of CDS to hedge the risk of already outstanding risky loans, in which case CDS coverage did not encourage the origination of risky loans. We use PSM analysis to mitigate concerns about reverse causality. The goal of PSM is to statistically replicate the undoable test of "treating" an observation with a "causal effect" (e.g., CDS coverage) and comparing the outcome for the treated observation to the outcome that would obtain if the *same* observation were untreated. The problem is that it is impossible to assess the treatment effect, since we do not know the outcome for untreated observations when they are under treatment and for treated observations when they are not under treatment. PSM attempts to solve this problem by matching treated and untreated observations

[17] When the CDO settlement date is well after the MBS closing date, CDS coverage likely reflects a desire to hedge the risk of outstanding loans, which should have no influence on the loan origination decision. Similarly, when the CDO settlement date is well before the MBS closing date, the CDS contract in the synthetic CDO that references the MBS is likely a replacement for a maturing CDS contract. Consequently, the origination of the loans underlying the MBS may be less sensitive to CDS coverage.

(i.e., two *different* observations) using a propensity score model and then comparing the outcome of interest (e.g., delinquency) for the treatment and control samples.

Table V uses PSM to match loans with CDS coverage (treatment sample) to loans without CDS coverage (control sample) using a probit model to predict the probability of CDS coverage. The probit model is estimated using all subprime loans in the sample originated over the 2004 to 2006 period. The covariates used to predict CDS coverage (i.e., the variables used to estimate the probit model) are defined in Table V. We use the propensity scores from the estimated probit model (i.e., predicted probability of CDS coverage) to implement nearest-neighbor matching with replacement (see, e.g., Abadie et al. (2004)). We allow for replacement because a control loan can be a best match for more than one treatment loan. When treatment and control sample loans are matched, we compute the proportion of delinquent loans in the two samples. The significance of the difference in the delinquency rates is based on a z-statistic that is computed using the methods developed in Abadie and Imbens (2006, 2008).[18]

The table reports results for three different PSM techniques. Panel A reports results using a technique proposed by Lechner (2002) to generate a common support for the propensity scores of the treatment and control samples before matching. This makes the two samples more homogeneous, increasing the model's ability to find better matches. Under this approach, the minimum and maximum propensity scores in both groups are determined and all observations with propensity scores smaller than the minimum and larger than the maximum in the opposite group are deleted. Panel B reports results using a tolerance level for the maximum propensity score distance (caliper) to mitigate the risk of bad matches. Finally, Panel C reports results when we match treatment and control loans within zip code and origination quarter cohorts grouped by CDS coverage. The reported number of observations in each panel is the combined treatment and control samples before matching.

As can be seen in Panel A, every level of support generates a statistically significant difference between delinquency rates in the treatment and control samples. The maximum difference in Panel A is for a support of [0.50, 0.75], which generates a difference in delinquency rates between the treatment and control samples of 2.1%. Using the total dollar amount of loans originated over the 2004 to 2006 period, this difference equals $36.7 billion in delinquent loan value. The differences in Panel B using the caliper algorithm are also economically and statistically significant, especially when the maximum allowable propensity score difference between treatment and control samples decreases. Finally, the results for the zip code and origination quarter cohorts grouped by CDS coverage in Panel C also show significant differences in delinquency rates

[18] Abadie and Imbens (2008) argue that bootstrapping methods should not be used for inference with matching estimators. We follow their prescription and compute a z-statistic for the difference in delinquency rates using their estimator of the asymptotic variance of matching estimators developed in Abadie and Imbens (2006).

Table V

Difference in Delinquency Based on Propensity Score Matching of Subprime Loans with and without CDS Coverage

This table uses propensity score matching to match subprime loans with CDS coverage (treatment sample) to those without CDS coverage (control sample) using a probit model to predict the probability of CDS coverage. The probit model is estimated using all subprime loans in the sample originated over the 2004 to 2006 period. The covariates used to predict CDS coverage are the standardized FICO score, whether the loan has full documentation at the time of origination, the combined loan-to-value ratio, whether the borrower is an investor, the loan amount, loan type (see the Appendix for definitions), standardized local income of borrower at origination, MBS issuer type (see Table II for definitions), MBS issuer type ranked by dollar volume of subprime MBS issued, and semiannual loan origination dummies. We categorize MBS issuers into dollar quartiles, where quartile 1 includes MBS issuers with total dollar volume below $15 billion, quartile 2 includes MBS issuers with total dollar volume greater than or equal to $15 billion but less than $100 billion, quartile 3 includes MBS issuers with total dollar volume greater than or equal to $100 billion but less than 160 billion, and quartile 4 includes MBS issuers with total dollar volume greater than 160 billion. The Internet Appendix lists the MBS issuers by type of issue, CDS coverage, and total dollar volume of MBS issues. We use the propensity scores from the estimated probit model (i.e., predicted probability of CDS coverage) to implement nearest-neighbor matching with replacement (see, e.g., Abadie et al. (2004)). We allow for replacement because a control loan can be a best match for more than one treatment loan. When treatment and control sample loans are matched, we compute the proportion of delinquent loans in the two samples. The significance of the difference in proportions is based on a z-statistic that is computed using the analytical estimator of the asymptotic variance of matching estimators proposed by Abadie and Imbens (2006, 2008). Panel A uses a technique proposed by Lechner (2002) to generate a common support for the propensity scores of the treatment and control samples *before* matching. This makes the two samples more homogeneous and enhances the model's ability to find better matches. Under this approach, the minimum and maximum propensity scores in both groups are determined and all observations whose propensity score is smaller than the minimum and larger than the maximum in the opposite group are deleted. Thus, if the propensity scores in the treatment group lie in the interval [0.10, 0.95] and the propensity scores in the control group lie in the interval [0.05, 0.90], the common support is [0.10, 0.90]. Panel B uses a tolerance level for the maximum propensity score distance (caliper) to mitigate the risk of bad matches. Panel C separates the treatment and control samples into cohorts based on zip code and origination quarter and then groups the cohorts by CDS coverage. We then match the treatment and control loans *within groups*. The reported number of observations in each panel is the combined treatment and control samples before matching. ***, **, and * indicate statistical significance at the 0.001, 0.01, and 0.05 levels, respectively.

Panel A: Matching based on interval of common support for treatment and control samples

Common Support	Proportion of delinquent loans: Treatment Sample (w/ CDS)	Proportion of delinquent loans: Control Sample (w/o CDS)	Difference	Observations
[0, 1]	0.282	0.278	0.004***	7,050,656
[0.10, 0.90]	0.277	0.272	0.005***	6,024,305
[0.20, 0.80]	0.262	0.252	0.010***	4,380,174

(*Continued*)

Table V—*Continued*

Panel A: Matching based on interval of common support for treatment and control samples

Common Support	Proportion of delinquent loans: Treatment Sample (w/CDS)	Proportion of delinquent loans: Control Sample (w/o CDS)	Difference	Observations
[0.25, 0.75]	0.256	0.244	0.012***	3,568,589
[0.25, 0.50]	0.190	0.170	0.020***	1,962,852
[0.50, 0.75]	0.297	0.276	0.021***	1,605,737

Panel B: Matching based on maximum propensity score distance (caliper)

|P-score Difference|	Proportion of delinquent loans: Treatment Sample (w/ CDS)	Proportion of delinquent loans: Control Sample (w/o CDS)	Difference	Observations
1.00	0.282	0.278	0.004***	7,050,656
0.90	0.272	0.266	0.006***	6,736,667
0.75	0.260	0.252	0.008***	6,267,268
0.50	0.242	0.230	0.012***	5,484,321
0.25	0.228	0.213	0.016***	4,618,927

Panel C: Matching within zip code and quarter cohorts grouped by fraction of loans with CDS coverage

Cohort grouping by CDS Coverage	Proportion of delinquent loans: Treatment Sample (w/ CDS)	Proportion of delinquent loans: Control Sample (w/o CDS)	Difference	Observations
(0, 0.20)	0.151	0.152	−0.001	979,046
(0.20, 0.40)	0.221	0.210	0.011***	1,958,099
(0.40, 0.60)	0.295	0.288	0.007***	2,238,837
(0.60, 0.80)	0.308	0.303	0.005***	1,659,592
(0.80, 1)	0.315	0.324	−0.009	215,084

Table VI

The Effect of CDS Coverage on Subprime Mortgage Delinquency for Borrower Zip Code and Origination Quarter Cohorts Grouped by CDS Coverage

The table reports marginal effects from probit regressions of the probability of subprime mortgage delinquency for borrower zip code and origination quarter cohorts grouped by CDS coverage. There are over 400,000 cohorts in the full sample of loans originated from 2003 to 2007. A loan is defined as delinquent if it is at least 60 days past due within the first 24 months of origination. *CDS* is a dummy variable equal to one if the loan has concurrent CDS coverage and zero otherwise. CDS coverage is concurrent if the CDO settlement date is no later than 180 days after the MBS closing date. The five groups contain zip code and origination quarter cohorts with CDS coverage of [0, 20%), [20%, 40%), [40%, 60%), [60%, 80%), and [80%, 100%]. Control variables in the regressions are those used in the regressions of Table IV and defined in the Appendix. Marginal effects are computed for a one-standard-deviation change for continuous variables and for a change from zero to one for dummy variables. The predicted probability is computed at the sample means of the explanatory variables. Standard errors clustered by states are in parentheses. ***, **, and * indicate statistical significance at the 0.001, 0.01, and 0.05 levels, respectively.

Variables	Group 1 [0, 20%)	Group 2 [20%, 40%)	Group 3 [40%, 60%)	Group 4 [60%, 80%)	Group 5 [80%, 100%]
CDS	0.0011	0.0056***	0.0076***	0.0065*	0.0130*
	(0.0009)	(0.0014)	(0.0017)	(0.0028)	(0.0059)
Controls	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.38	0.30	0.21	0.15	0.14
Observations	3,023,634	2,321,527	2,365,651	1,673,356	222,629
Predicted probability	0.04	0.12	0.19	0.24	0.27
Observed probability	0.13	0.20	0.25	0.27	0.31

between treatment and control samples for groups without extremely low or high CDS coverage. Overall, the PSM analysis helps to allay the concern that our results are driven by reverse causality.

Another possible concern with the analysis is omitted variable bias. In particular, the results could be explained by geography and/or time of origination if riskier subprime loans that have CDS coverage concentrate in certain regions of the United States and/or time periods. To mitigate this bias, we construct zip code and origination quarter cohorts using the full sample of loans and then group the cohorts by CDS coverage.[19] We form five groups with CDS coverage of [0, 20%], [20%, 40%], [40%, 60%], [60%, 80%], and [80%, 100%].

Table VI reports a probit regression for the effect of CDS coverage on the probability of loan delinquency for each of the five groups.[20] As can be seen in the

[19] There are over 400,000 zip code and origination quarter cohorts in the sample. The distribution of CDS coverage across cohorts ranges from zero at the 10th percentile to 13.5% at the 25th percentile, 34.6% at the 50th percentile, 55.8% at the 75th percentile, and 67.4% at the 90th percentile. The distribution suggests that CDS coverage is spread fairly evenly across cohorts rather than being concentrated in a handful of high (hidden) risk cohorts.

[20] Estimating the regressions by groups avoids comparing loans in high CDS coverage cohorts with those in low CDS coverage cohorts.

table, CDS coverage has a significant impact on loan delinquency for all groups except Group 1, which has the lowest amount of CDS coverage. Since loans in each group belong to cohorts with similar CDS coverage and the cohorts are formed by grouping loans with the same zip code and origination quarter, the significant difference in the probability of delinquency between loans with and without CDS coverage reflects a CDS effect that is separate from a geographic or time period effect. Thus, it appears that geography and origination quarter do not materially influence the relation between CDS coverage and subprime loan delinquency.

C. *The Effect of the Timing of CDS Coverage on Subprime Mortgage Delinquency*

A potentially more powerful test of the effect of CDS coverage on the origination of risky loans is to exploit sample variation in loan origination dates relative to CDS coverage start dates in loan pools with CDS coverage.[21] We expect CDS coverage to have a larger influence on the loan origination decision when the coverage is in place before rather than after the loan is originated. Accordingly, we predict a higher likelihood of delinquency for loans in pools covered by CDS when the loan is originated after the start of CDS coverage than when the loan is originated before the start of CDS coverage.

The challenge in testing this prediction is that we do not know the exact start dates of CDS contracts referencing subprime MBS because CDS contracts are privately negotiated. We do know, however, the enclosing synthetic CDO settlement date, which may allow us to approximate the start of CDS coverage. Since the settlement date should in general be after the CDS contract start date, our strategy is to focus on the timing of the CDO settlement date relative to the loan origination date. We start with the sample of subprime loans originated over the 2004 to 2006 period that are in loan pools with CDS coverage where the CDO settlement date ranges from 180 days before to 90 days after the MBS closing date. These criteria are satisfied by 1,467,533 loans in 850 loan pools. In this sample of loans, 5% have a CDO settlement date more than 90 days before loan origination, 19% have a CDO settlement date zero to 90 days before loan origination, 37% have a CDO settlement date zero to 90 days after loan origination, and 38% have a CDO settlement date more than 90 days after loan origination. We exploit this variation in CDO settlement relative to loan origination to examine the effect of the timing of CDS coverage on subprime mortgage delinquency.

Table VII reports marginal effects from probit regressions of the timing of CDS coverage on the probability of subprime mortgage delinquency using the sample of 1,467,533 loans in 850 loan pools. Regressions (1) to (5) model the timing of CDS coverage with a dummy variable equal to one when the CDO settlement date is less than or equal to the loan origination date plus zero

[21] We thank an anonymous referee for suggesting this test and for encouraging us to exploit this type of variation in the data.

Table VII

The Effect of the Timing of CDS Coverage in Mortgage Pools with CDS Coverage on the Probability of Subprime Mortgage Delinquency

The table reports marginal effects from probit regressions assessing the differential effect on subprime mortgage delinquency of the timing of CDS coverage in mortgage pools with CDS coverage. The sample is loans originated over the 2004 to 2006 period with CDS coverage where the CDO settlement date is from 180 days before to 90 days after the MBS closing date. This criteria is satisfied by 1,467,533 loans in 850 loan pools. Marginal effects are computed for a one-standard-deviation change for continuous variables and for a change from zero to one for dummy variables. A loan is defined as delinquent if it is at least 60 days past due within the first 24 months of origination. Regressions (1) to (5) model the timing of CDS coverage with a dummy variable equal to one when the CDO settlement date is less than or equal to the loan origination date plus zero days, 30 days, 60 days, 90 days, and 180 days, respectively. Regression (6) estimates the effect on loan delinquency of CDS coverage in time periods around loan origination. In this regression, *CDS1* is equal to one if the CDO settlement date is more than 90 days before the loan origination date and zero otherwise, *CDS2* is equal to one if the CDO settlement date is within 90 days before the loan origination date and zero otherwise, and *CDS3* is equal to one if the CDO settlement date is within 90 days after the loan origination date and zero otherwise. The omitted baseline group comprises loans where the CDO settlement date is more than 90 days after the loan origination date. The regressions include the control variables and time fixed effects (for the 2004 to 2006 period) used in Table IV and dummy variables for mortgage pools (mortgage pool fixed effects). The mortgage pool fixed effects ensure that the CDS variables in the regressions capture the effects of within-pool variation in CDS coverage. The predicted probability is computed at the sample means of the explanatory variables. Standard errors clustered by mortgage pool are in parentheses below marginal effects. ***, **, and * indicate statistical significance at the 0.001, 0.01, and 0.05 levels, respectively.

	Criterion for whether the CDS is in place before the loan origination date (Origdate)					
	(1)	(2)	(3)	(4)	(5)	(6)
	CDO date ≤ Origdate Baseline group: CDO date > Origdate	CDO date ≤ Origdate + 30 days Baseline group: CDO date > Origdate + 30 days	CDO date ≤ Origdate + 60 days Baseline group: CDO date > Origdate + 60 days	CDO date ≤ Origdate + 90 days Baseline group: CDO date > Origdate + 90 days	CDO date ≤ Origdate + 180 days Baseline group: CDO date > Origdate + 180 days	Baseline group: CDO date > Origdate + 90 days
CDS = 1 if criterion met (i.e., CDS before loan origination date)	0.0090 (0.0059)	0.0118* (0.0048)	0.0199*** (0.0052)	0.0467*** (0.0047)	0.0461*** (0.0061)	

(*Continued*)

Table VII—*Continued*

	Criterion for whether the CDS is in place before the loan origination date (Origdate)					
	(1)	(2)	(3)	(4)	(5)	(6)
	CDO date ≤ Origdate Baseline group: CDO date > Origdate	CDO date ≤ Origdate + 30 days Baseline group: CDO date > Origdate + 30 days	CDO date ≤ Origdate + 60 days Baseline group: CDO date > Origdate + 60 days	CDO date ≤ Origdate + 90 days Baseline group: CDO date > Origdate + 90 days	CDO date ≤ Origdate + 180 days Baseline group: CDO date > Origdate + 180 days	Baseline group: CDO date > Origdate + 90 days
CDS1 = 1 if CDO date is more than 90 days before the loan origination date						0.1059*** (0.0125)
CDS2 = 1 if CDO date is 0–90 days before the loan origination date						0.0591*** (0.0081)
CDS3 = 1 if CDO date is 0–90 days after the loan origination date						0.0486*** (0.0049)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Mortgage pool fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.16	0.16	0.16	0.16	0.16	0.16
Observations	1,467,533	1,467,533	1,467,533	1,467,533	1,467,533	1,467,533
Predicted probability	0.26	0.26	0.26	0.26	0.26	0.26
Observed probability	0.29	0.29	0.29	0.29	0.29	0.29

days, 30 days, 60 days, 90 days, and 180 days, respectively. Regression (6) models the timing of CDS coverage with three dummy variables for the timing of CDO settlement relative to loan origination. In this regression, *CDS1* is equal to one if the CDO settlement date is more than 90 days before the loan origination date, *CDS2* is equal to one if the CDO settlement date is within the 90 days before the loan origination date, and *CDS3* is equal to one if the CDO settlement date is within the 90 days after the loan origination date. The omitted baseline group consists of loans for which the CDO settlement date is more than 90 days after the loan origination date. All regressions include the control variables and time fixed effects (for the 2004 to 2006 period) used in Table IV and dummy variables for mortgage pools. The mortgage pool fixed effects ensure that the CDS timing variables in the regressions capture the effects of *within*-pool variation in CDS coverage. Standard errors clustered by mortgage pool are in parentheses below marginal effects.

As can be seen in the table, the timing of CDS coverage has a large effect on subprime mortgage delinquency. In regressions (1) to (5), we see that the largest effect is in regression (4) where CDS coverage *before* loan origination is captured by a dummy variable equal to one when the CDO settlement date is no more than 90 days after loan origination. Note that this specification assumes that it takes at least 3 months from the start of CDS coverage to the settlement of the enclosing synthetic CDO, so that a loan satisfying the CDS dummy variable specification in (4) would have CDS coverage at or before origination.[22] Thus, based on the predicted probability of loan delinquency, the effect of CDS coverage before rather than after loan origination in regression (4) is an 18% (4.67%/26%) increase in the probability of delinquency. Regression (6) estimates CDS timing effects for loans grouped by the number of days between the CDO settlement date and loan origination date. We find, for example, a 22.7% (5.91%/26%) increase in the probability of loan delinquency if the CDO settlement date is zero to 90 days before the loan origination date.[23] Overall, the results in Table VII provide convincing additional evidence that CDS coverage helped encourage the origination of poorly performing subprime loans.

We next conduct PSM analysis on the timing effect of CDS coverage. We match subprime loans with CDS coverage before loan origination (treatment sample) to subprime loans without CDS coverage (control sample) using a probit model to predict the probability of CDS coverage before loan origination. The treatment sample comprises loans for which the CDO settlement date is no later than 90 days after the loan origination date. Table VIII reports the results of our analysis. In the table, Panel A implements matching based on a propensity score interval of common support for treatment and control samples and Panel B implements matching within borrower zip code and origination

[22] We are not able to find any statistics for the number of days from the start of a CDS contract to the settlement of the enclosing synthetic CDO. Conversations with industry practitioners, however, suggest that our 3-month minimum time span is reasonable.

[23] The comparison group is loans where the CDO settlement date is more than 90 days after the origination date.

Table VIII

Difference in Delinquency between Loans with CDS Coverage before Origination and a Propensity Score Matched Sample of Loans without CDS Coverage

The table uses propensity score matching to match subprime loans with CDS coverage before loan origination (treatment sample) to subprime loans without CDS coverage (control sample) using a probit model to predict the probability of CDS coverage before loan origination. The treatment sample is loans with CDS coverage where the CDO settlement date is no later than 90 days after the loan origination date. The sample of 1,105,336 loans that satisfy this criterion is drawn from the subsample of 1,467,533 loans originated over the 2004 to 2006 period that are in loan pools where the CDO settles between 180 days earlier and 90 days later than the MBS closing date. The probit model includes all of the covariates used in the propensity score model of Table V plus loan pool fixed effects. Based on the estimated propensity scores for the treatment and control samples, we use nearest-neighbor matching with replacement to implement one-to-one matching of treatment and control samples (see, e.g., Abadie et al. (2004)). The significance of the difference in proportions is based on a z-statistic that is computed using the analytical estimator of the asymptotic variance of matching estimators proposed by Abadie and Imbens (2006, 2008). Panel A uses a technique proposed by Lechner (2002) to generate a common support for the propensity scores of the treatment and control samples *before* matching. This makes the two samples more homogeneous and enhances the model's ability to find better matches. Under this approach, the minimum and maximum propensity scores in both groups are determined and all observations whose propensity score is smaller than the minimum and larger than the maximum in the opposite group are deleted. Thus, if the propensity scores in the treatment group lie in the interval [0.10, 0.95] and the propensity scores in the control group lie in the interval [0.05, 0.90], the common support is [0.10, 0.90]. Panel B separates the treatment and control samples of common support (0.01, 0.99) into cohorts based on zip code and origination quarter and then groups the cohorts by CSD coverage. We then match the treatment and control loans *within groups*. The reported number of observations in each panel is the combined treatment and control samples before matching. ***, **, and * indicate statistical significance at the 0.001, 0.01, and 0.05 levels, respectively.

Panel A: Matching based on interval of common support for treatment and control samples

	Proportion of delinquent loans			
Common support	Treatment sample (CDS coverage before loan origination)	Control sample (no CDS coverage)	Difference	Observations
(0.01, 0.99)	0.307	0.281	0.026***	598,078
(0.25, 0.75)	0.316	0.285	0.031***	193,340

(*Continued*)

Table VIII—*Continued*

Panel B: Matching within zip code and quarter cohorts grouped by fraction of loans with CDS coverage				
	Proportion of delinquent loans			
Cohort grouping by CDS coverage	Treatment sample (CDS coverage before loan origination)	Control sample (no CDS coverage)	Difference	Observations
[0, 0.20)	0.156	0.178	−0.022	23,271
[0.20, 0.40)	0.245	0.244	0.001	113,444
[0.40, 0.60)	0.333	0.305	0.028***	216,863
[0.60, 0.80)	0.333	0.293	0.040***	205,905
[0.80, 1]	0.331	0.292	0.039**	33,854

Table IX

The Effect of the Timing of CDS Coverage on Subprime Mortgage Delinquency for Borrower Zip Code and Origination Quarter Cohorts Grouped by CDS Coverage

The table reports marginal effects from probit regressions of the probability of subprime mortgage delinquency for borrower zip codes and origination quarter cohorts grouped by CDS coverage. The sample for each group is loans originated in the 2004 to 2006 period with CDS coverage where the CDO settlement date is 180 days before to 90 days after the MBS closing date. Marginal effects are computed for a one-standard-deviation change for continuous variables and for a change from zero to one for dummy variables. A loan is defined as delinquent if it is at least 60 days past due within the first 24 months of origination. CDS is a dummy variable equal to one if the loan has CDS coverage before the loan origination date. This criterion is assumed to be met if the CDO settlement date is less than or equal to the loan origination date plus 90 days. The regressions include the control variables and time fixed effects (for the 2004 to 2006 period) used in Table IV as well as dummy variables for issuer type and dummy variables for mortgage pools (mortgage pool fixed effects). The predicted probability is computed at the sample means of the explanatory variables. Standard errors clustered by mortgage pool are in parentheses below marginal effects. ***, **, and * indicate statistical significance at the 0.001, 0.01, and 0.05 levels, respectively.

	Zip code and origination quarter cohorts grouped by CDS coverage				
	Group 1 [0, 20%)	Group 2 [20%, 40%)	Group 3 [40%, 60%)	Group 4 [60%, 80%)	Group 5 [80%, 100%]
CDS (= 1 if CDS before loan origination date)	0.0039 (0.0050)	0.0168** (0.0059)	0.0629*** (0.0055)	0.0544*** (0.0056)	0.0334*** (0.0076)
Controls	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Mortgage pool fixed effects	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.23	0.20	0.18	0.14	0.14
Observations	42,888	239,077	537,378	552,511	93,229
Predicted probability	0.10	0.18	0.27	0.29	0.29
Observed probability	0.16	0.24	0.31	0.32	0.32

quarter cohorts grouped by the fraction of loans with CDS coverage. In Panel B, the treatment loans with CDS coverage are matched with loans in the same zip code and quarter cohorts grouped by CDS coverage. Thus, in groups with low CDS coverage there will be few treatment loans and in groups with high CDS coverage there will be few candidates for control loans, so the number of matches will be smaller at both extremes. As can be seen in the table, the proportion of delinquent loans is always significantly larger in the treatment sample, except in Panel B, where zip code and quarter cohorts are grouped by low CDS coverage (i.e., fraction of loans with CDS coverage in the interval [0, 0.20)).

Finally, Table IX reports the effect of the timing of CDS coverage on subprime mortgage delinquency for borrower zip code and origination quarter cohorts grouped by CDS coverage. In each of the five groups, we estimate the coefficient

on a CDS timing variable using only the loans in a group with CDS coverage. The CDS timing variable is equal to one if the loan has CDS coverage before the loan origination date. As before, this criterion is assumed to be met if the CDO settlement date is no later than 90 days after the loan origination date. As can be seen in the table, there is a significantly higher probability of delinquency when CDS coverage is before rather than after loan origination in all groups except the group with the lowest CDS coverage, where the coefficient on the CDS timing variable is positive but not statistically different from zero.

Overall, the results in Tables VIII and IX help mitigate concerns that the CDS timing results are driven by reverse causality or omitted variables bias attributable to geography or time period. The finding that subprime loan performance is quite sensitive to the timing of CDS coverage strengthens our argument that CDS contracts played an important role in the financial crisis of 2007 to 2008.

D. MBS Issuer Types and the Effect of CDS Coverage on Subprime Loan Delinquency

In Panel C of Table III we report subprime loan delinquency rates for loans with and without CDS coverage by type of MBS issuer. Across all three types of issuers and in each origination year, we observe the largest CDS effect for loans in MBS deals issued by Type D issuers (commercial banks). We now extend the analysis to control for differences in borrower and loan characteristics.

Table X reports marginal effects from probit regressions that examine the effect of MBS issuer type on the relation between CDS coverage and the probability of subprime mortgage delinquency. Regression (1) adds Type D and Type I issuer dummy variables (*Type D issuer* and *Type I issuer*) to the basic probit specification with a separate concurrent CDS dummy variable (*CDS*), regressions (2) and (4) include interactions between the CDS and issuer type dummy variables, and regressions (3) and (5) include interactions between the CDS dummy variables for CDO settlement date windows around the MBS closing date and issuer type dummy variables. Note that in regressions (1), (2), and (4) Type M issuers are the omitted baseline group while regressions (3) and (5) include a separate Type M issuer dummy variable (*Type M issuer*) when interacting issuer type with the CDS timing dummy variables. Also note that regressions (4) and (5) are estimated over the 2004 to 2006 origination period.

The estimates in regression (1) show that Type M issuers—the investment banks—securitized riskier subprime loans, as the coefficients on *Type D issuer* and *Type I issuer* (which reflect the difference in delinquency rates between these issuer types and Type M issuers) are negative. This result is consistent with the popular perception that Wall Street contributed to the subprime mortgage crisis by ignoring the quality of subprime loans that they securitized, which encouraged originators to lend to riskier pools of borrowers who eventually defaulted. The estimates in regressions (2) and (4), however, reveal a more nuanced story. In particular, note that in both regressions the coefficient on *CDS* $\times$ *Type D issuer* is significantly positive while the coefficient on

Table X

The Effect of MBS Issuer Type on the Relation between CDS Coverage and the Probability of Subprime Mortgage Delinquency

The table reports marginal effects from probit regressions of the probability of subprime mortgage delinquency by MBS issuer type as a function of whether the underlying loans have CDS coverage. Control variables are defined in the Appendix. Marginal effects are computed for a one-standard-deviation change for continuous variables and for a change from zero to one for dummy variables. A loan is defined as delinquent if it is at least 60 days past due within the first 24 months of origination. In regressions (1), (2), and (4), CDS is a dummy variable equal to one if the loan has concurrent CDS coverage and zero otherwise. CDS coverage is concurrent if the CDO settlement date is no later than 180 days after the MBS closing date. The omitted baseline group in regressions (1), (2), and (4) comprises loans without CDS coverage or with a CDO settlement date more than 180 days after the MBS closing date. In regressions (3) and (5), *CDS1* is equal to one if the CDO settlement date is more than 180 days before the MBS closing date and zero otherwise, *CDS2* is equal to one if the CDO settlement date is 90 to 180 days before the MBS closing date and zero otherwise, *CDS3* is equal to one if the CDO settlement date is 0 to 90 days before the MBS closing date and zero otherwise, *CDS4* is equal to one if the CDO settlement date is 0 to 90 days after the MBS closing date and zero otherwise, *CDS5* is equal to one if the CDO settlement date is 90 to 180 days after the MBS closing date and zero otherwise, and *CDS6* is equal to one if the CDO settlement date is more than 180 days after the MBS closing date and zero otherwise. The omitted baseline group in regressions (3) and (5) comprises loans without CDS coverage. MBS issuer type dummy variables are defined as follows: *Type D issuer* is equal to one if the MBS issuer is Type D and zero otherwise, *Type I issuer* is equal to one if the MBS issuer is Type I and zero otherwise, and *Type M issuer* is equal to one if the MBS issuer is Type M and zero otherwise. Type D (depository) issuers are financial institutions and their affiliates that have banking operations (i.e., accept deposits and originate loans). These financial institutions originate loans, securitize loans, and typically make a market in CDS contracts. Type I (independent) issuers are REITs and mortgage finance companies that specialize in mortgage loan origination and/or loan securitization but do not make a market in CDS contracts. Type M (multisector) issuers are financial institutions such as investment banks and hedge funds that do not have banking operations. These financial institutions securitize mortgages and use and/or make a market in CDS contracts but do not participate in mortgage loan origination. Regression (1) estimates the difference in the marginal probability of loan delinquency between Type D and M issuers and between Type I and M issuers. Regression (2) conditions the comparisons in regression (1) by whether a loan has concurrent CDS coverage by including the interaction between the CDS dummy and the issuer type dummies. Regression (4) reestimates regression (2) using the 2004 to 2006 period. Regressions (3) and (5) estimate interaction effects of CDS coverage and MBS issuer type on the marginal probability of loan delinquency for various windows between the CDO settlement date and the MBS closing date for the sample periods 2003 to 2007 and 2004 to 2006. The predicted probability is computed at the sample means of the explanatory variables. Standard errors clustered by states are in parentheses. ***, **, and * indicate statistical significance at the 0.001, 0.01, and 0.05 levels, respectively.

	Loan Origination Years 2003–2007			Loan Origination Years 2004–2006	
	(1)	(2)	(3)	(4)	(5)
CDS (= 1 for concurrent)	0.0043**	0.0006		0.0037**	

(*Continued*)

Table X—*Continued*

	Loan Origination Years 2003–2007			Loan Origination Years 2004–2006	
	(1)	(2)	(3)	(4)	(5)
	(0.0015)	(0.0013)		(0.0014)	
CDS × Type D issuer		0.0129***		0.0185***	
		(0.0023)		(0.0021)	
CDS × Type I issuer		0.0020		−0.0008	
		(0.0013)		(0.0015)	
CDS1 × Type D issuer			−0.0010		0.0173***
			(0.0033)		(0.0033)
CDS2 × Type D issuer			0.0059		0.0092
			(0.0052)		(0.0065)
CDS3 × Type D issuer			0.0270***		0.0330***
			(0.0039)		(0.0040)
CDS4 × Type D issuer			0.0201***		0.0287***
			(0.0034)		(0.0037)
CDS5 × Type D issuer			0.0145***		0.0206***
			(0.0042)		(0.0038)
CDS6 × Type D issuer			−0.0019		0.0021
			(0.0034)		(0.0035)
CDS1 × Type I issuer			0.0021		0.0019
			(0.0017)		(0.0020)
CDS2 × Type I issuer			−0.0078**		−0.0086**
			(0.0025)		(0.0028)
CDS3 × Type I issuer			−0.0002		−0.0033
			(0.0032)		(0.0036)
CDS4 × Type I issuer			0.0051***		0.0053***
			(0.0013)		(0.0013)
CDS5 × Type I issuer			−0.0009		−0.0003
			(0.0025)		(0.0023)

(*Continued*)

Table X—*Continued*

	Loan Origination Years 2003–2007			Loan Origination Years 2004–2006	
	(1)	(2)	(3)	(4)	(5)
CDS6 × Type I issuer			−0.0043*		−0.0060**
			(0.0020)		(0.0023)
CDS1 × Type M issuer			−0.0048*		−0.0004
			(0.0020)		(0.0021)
CDS2 × Type M issuer			0.0148***		0.0166***
			(0.0033)		(0.0024)
CDS3 × Type M issuer			0.0079***		0.0063
			(0.0018)		(0.0035)
CDS4 × Type M issuer			0.0016		0.0036
			(0.0016)		(0.0029)
CDS5 × Type M issuer			0.0036		0.0040
			(0.0030)		(0.0030)
CDS 6 × Type M issuer			0.0055		0.0017
			(0.0045)		(0.0042)
Type D issuer	−0.0179***	−0.0234***	−0.0214***	−0.0275***	−0.0274***
	(0.0016)	(0.0015)	(0.0019)	(0.0017)	(0.0020)
Type I issuer	−0.0105***	−0.0117***	−0.0084***	−0.0099***	−0.0069***
	(0.0008)	(0.0009)	(0.0013)	(0.0009)	(0.0014)
Controls	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.26	0.26	0.26	0.20	0.20
Observations	9,606,797	9,606,797	9,606,797	7,050,658	7,050,658
Predicted probability	0.13	0.13	0.13	0.14	0.14
Observed probability	0.20	0.20	0.20	0.20	0.20

CDS × *Type I issuer* is not significantly different from zero. Thus, the change in delinquency for loans securitized by Type D issuers when going from no CDS to CDS coverage is larger than the corresponding change for loans securitized by Type M issuers, while the change in loan delinquency is not different for Type I and Type M issuers. This result is consistent with the notion that commercial banks (i.e., Type D issuers) used soft information on borrower credit quality to allocate the riskiest loans to MBS deals that they and/or investors insured with CDS, keeping the best quality loans on their books and/or using them in MBS deals that were not insured.

The CDS timing estimates in regressions (3) and (5) reveal another interesting dynamic. In these regressions, the interaction effects for Type D issuers are significantly positive when CDS coverage is immediately before *and* after the MBS closing date (i.e., coefficients on interactions between *CDS3*, *CDS4*, and *CDS5* and *Type D issuer*) while the interaction effects for Type M issuers are significantly positive only when CDS coverage is immediately before the MBS closing date (i.e., coefficients on interactions between *CDS2* and *CDS3* and *Type M issuer*). The key difference between Type D and M issuers is that the commercial banks (type D) originated and held inventories of loans while the investment banks (Type M) did not. Thus, the significance of the CDS interaction effects after the MBS closing date for commercial banks suggests that risky nonperforming loans were securitized and subsequently covered by CDS.

Table XI further examines the effect of MBS issuer type on the relation between the timing of CDS coverage and the probability of subprime mortgage delinquency. Regressions (1) to (3) capture CDS coverage before loan origination with a dummy variable equal to one when the CDO settlement date is no later than 90 days after the loan origination date, while regression (4) models the timing of CDS coverage with three dummy variables for the timing of the CDO settlement date relative to the loan origination date. As can be seen in the table, there is a strong CDS timing effect for each issuer type in each regression. Thus, for example, in regression (3) we see that CDS coverage before loan origination increases the probability of delinquency by 15.2% (3.95%/26%), 16.3% (4.23%/26%), and 22.3% (5.8%/26%) for Type I (independents), Type D (commercial banks), and Type M (investment banks) MBS issuers, respectively. Although investment banks appear to have the largest CDS timing effect, regression (2) shows that the higher delinquency rate for investment banks is not significantly different from that of commercial banks and regression (4) shows that commercial banks tend to have the largest CDS timing effects when the CDO settlement date is prior to the loan origination date. Importantly, these results show that there was a substantial increase in the probability of loan delinquency when CDS coverage was in place before loan origination regardless of whether loans were securitized by investment banks, commercial banks, or independent mortgage finance companies.

Table XI

The Effect of MBS Issuer Type on the Relation between the Timing of CDS Coverage and the Probability of Subprime Mortgage Delinquency

The table reports marginal effects from probit regressions of the probability of subprime mortgage delinquency by MBS issuer type as a function of whether loan origination is before or after CDS coverage. The sample comprises loans originated in the 2004 to 2006 period with CDS coverage where the CDO settlement date is 180 days before to 90 days after the MBS closing date. Marginal effects are computed for a one-standard-deviation change for continuous variables and for a change from zero to one for dummy variables. A loan is defined as delinquent if it is at least 60 days past due within the first 24 months of origination. CDS is a dummy variable equal to one if the loan has CDS coverage before loan origination. This criterion is assumed to be met if the CDO settlement date is no later than 90 days after the loan origination date. MBS issuer type dummy variables are defined as follows: *Type D issuer* is equal to one if the MBS issuer is Type D and zero otherwise, *Type I issuer* is equal to one if the MBS issuer is Type I and zero otherwise, and *Type M issuer* is equal to one if the MBS issuer is Type M and zero otherwise. Type D (depository) issuers are financial institutions and their affiliates that have banking operations (i.e., accept deposits and originate loans). These financial institutions originate loans, securitize loans, and typically make a market in CDS contracts. Type I (independent) issuers are REITs and mortgage finance companies that specialize in mortgage loan origination and/or loan securitization but do not make a market in CDS contracts. Type M (multisector) issuers are financial institutions such as investment banks and hedge funds that do not have banking operations. These financial institutions securitize mortgages and use and/or make a market in CDS contracts but do not participate in mortgage loan origination. Regression (1) estimates the difference in the marginal probability of delinquency for loans with CDS coverage between Type D and M issuers and between Type I and M issuers, respectively. Regression (2) estimates the difference in the marginal probability of loan delinquency between Type D and M issuers and between Type I and M issuers for loans where the CDS coverage is in place before loan origination (coefficients on the interaction between CDS and issuer dummies) and after loan origination (coefficients on the issuer dummies), respectively. Regression (3) estimates the separate effects of issuer type on the marginal probability of loan delinquency when the CDS coverage is in place before loan origination (coefficients on the three interaction variables between CDS and issuer type dummies). Regression (4) estimates the separate effects of issuer type on the marginal probability of loan delinquency for CDS coverage in periods around loan origination. In this regression, *CDS1* is equal to one if the CDO settlement date is more than 90 days before the loan origination date and zero otherwise, *CDS2* is equal to one if the CDO settlement date is within 90 days before the loan origination date and zero otherwise, and *CDS3* is equal to one if the CDO settlement date is within 90 days after the loan origination date and zero otherwise. The omitted baseline group comprises loans where the CDO settlement date is more than 90 days after the loan origination date. The regressions include the control variables and time fixed effects (for the 2004 to 2006 period) used in Table IV and dummy variables for mortgage pools (mortgage pool fixed effects). The predicted probability is computed at the sample means of the explanatory variables. Standard errors clustered by mortgage pool are in parentheses below marginal effects. ***, **, and * indicate statistical significance at the 0.001, 0.01, and 0.05 levels, respectively.

	(1)	(2)	(3)	(4)
CDS (= 1 if CDS before loan origination date)	0.0467***	0.0555***		
	(0.0047)	(0.0063)		
CDS × Type D issuer		−0.0150	0.0423***	
		(0.0101)	(0.0092)	
CDS × Type I issuer		−0.0175*	0.0395***	
		(0.0089)	(0.0077)	
CDS × Type M issuer			0.0580***	
			(0.0069)	

(*Continued*)

Table XI—*Continued*

	(1)	(2)	(3)	(4)
CDS1 × Type D issuer				0.1166***
				(0.0165)
CDS2 × Type D issuer				0.0707***
				(0.0133)
CDS3 × Type D issuer				0.0424***
				(0.0091)
CDS1 × Type I issuer				0.1046***
				(0.0162)
CDS2 × Type I issuer				0.0527***
				(0.0112)
CDS3 × Type I issuer				0.0402***
				(0.0079)
CDS1 × Type M issuer				0.0785**
				(0.0275)
CDS2 × Type M issuer				0.0602***
				(0.0131)
CDS3 × Type M issuer				0.0596***
				(0.0070)
Type D issuer	−0.4775***	−0.1030***	−0.4742***	−0.4823***
	(0.0146)	(0.0220)	(0.0147)	(0.0157)
Type I issuer	−0.0122	0.0694***	−0.4085***	−0.4081***
	(0.0085)	(0.0190)	(0.0059)	(0.0059)
Controls	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
Mortgage pool fixed effects	Yes	Yes	Yes	Yes
Pseudo R^2	0.16	0.16	0.16	0.16
Observations	1,467,533	1,467,533	1,467,533	1,467,533
Predicted probability	0.26	0.26	0.26	0.26
Observed probability	0.29	0.29	0.29	0.29

III. Conclusions

This paper provides the first empirical investigation of the influence of CDS on the surge in subprime mortgage defaults during the 2007 to 2008 financial crisis. In the years leading up to the crisis, private mortgage securitizers were eager to supply worldwide demand for highly rated MBS created from pools of subprime mortgage loans. The strong demand for MBS led to lax lending standards in the mortgage origination market and encouraged predatory lending and borrowing practices. The net effect was that lenders increasingly offered more loans to higher risk borrowers, which inevitably drove much higher subprime mortgage defaults.

We argue that this chain of events was fueled in part by the concurrent expansion in the market for CDS. In particular, issuers and investors in MBS could hedge the credit risk of the subprime loans underlying these securities with CDS contracts. In this way, MBS market participants could limit their exposure to the risk of securitized loans, which in turn stimulated greater demand for riskier loans that were eagerly supplied by mortgage loan originators

who earned lucrative fees. This line of reasoning suggests that CDS contracts insuring MBS backed by subprime loans had a direct effect on the surge in subprime mortgage defaults.

We test this prediction in a sample of 9,606,797 privately securitized subprime mortgages originated during the 2003 to 2007 period. We first test whether loans in pools covered by CDS contracts were more likely to become delinquent than loans in pools not covered by CDS contracts. In probit regressions with a wide variety of controls, we find that CDS coverage significantly increases the probability of loan delinquency. We then examine the effect of the timing of CDS coverage on subprime mortgage delinquency within loan pools covered by CDS contracts. If CDS contracts encouraged the origination of risky subprime mortgages, then we would expect to find a higher probability of delinquency for loans originated after the start of CDS coverage than before the start of CDS coverage. This is precisely what we find: loans originated after the start of CDS coverage have a much greater likelihood of becoming delinquent than do loans originated before the start of CDS coverage.

We also find that the largest CDS effect is for loans securitized by commercial banks. This suggests that commercial banks used their comparative advantage in the supply chain of subprime loan origination, securitization, and ready access to the credit derivatives market to allocate the riskiest subprime loans to mortgage pools in MBS deals that they and/or investors insured with CDS contracts. When examining the influence of the timing of CDS coverage on loan delinquency within mortgage pools with CDS coverage, however, we find a strong CDS timing effect across all of the major loan securitizers.

An interesting question is whether the higher default rate of loans with CDS coverage influenced the pricing of loans and ultimately the yields of MBS that were covered by CDS. To address this question, we would ideally like to have loan pricing data. In practice, however, loans are often sold in pools and yields on individual loans are not available. Thus, any pricing analysis needs to be performed at the MBS level. Unfortunately, there are at least three complications associated with interpreting differences in MBS yields with and without CDS coverage. First, there are layers of endogeneity that influence MBS yields, including MBS deal subordination structure, MBS credit rating, differences in loan types included in MBS pools, and CDS coverage itself. Second, whether *investors* learn about CDS coverage at the time MBS are priced is not known. Third, it would be difficult to interpret the results of CDS coverage on MBS yields without a correctly specified pricing model. We leave this question for future research.

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Appendix

Variable Definitions

This table reports definitions of control variables. The expected sign of each variable on the probability of subprime mortgage delinquency and default is given in parentheses.

Variable (Expected Sign)	Description
FICO (−)	Fair Isaac and Company credit score at the origination of the loan.
Full doc (−)	Dummy variable equal to one if the borrower has complete documentation on income and assets.
CLTV (+)	Combined loan-to-value (CLTV) ratio at origination, which includes the first lien and second lien (if one exists). The CLTV ratio enters regressions in decimal (e.g., a 20% downpayment equals a 0.80 CLTV ratio).
Investor (+)	Dummy variable equal to one if the borrower does not owner-occupy the property.
DTI (+)	Back-end debt-to-income (DTI) ratio, defined as the total monthly mortgage payment to monthly gross income at origination, in percent. In addition to the mortgage payment, the back-end DTI includes mortgage insurance, homeowners insurance, escrowed monthly property tax payment, and any other continuing home ownership expenses.
Miss DTI (+)	Dummy variable equal to one if DTI is missing. Demyanyk and Van Hemert (2011) interpret a missing DTI as a negative signal of borrower quality.
Cash-out (+)	Dummy variable equal to one for a cash-out refinance, where the balance of the loan is increased to raise cash. Pennington-Cross and Chomsisengphet (2007) claim that the most common reasons for a cash-out refinance are to consolidate debt and improve property.
PrePayPen (+)	Dummy variable equal to one if the loan has a prepayment penalty and/or is an option ARM or negative amortization loan. These loan features make refinancing less likely when the loan is in delinquency.
Loan amt. (+)	Size of the mortgage at origination, in dollars.
Int. only (+)	Dummy variable equal to one if the loan has an interest-only provision. For example, a 30-year fixed or adjustable rate mortgage (ARM) may permit the borrower to only pay interest for the first 60 months, switching to payments composed of principal and interest over the remaining 25 years.
Initial rate (+)	The initial loan interest rate, in percent.

Variable (Expected Sign)	Description
Margin (+)	The amount by which the interest rate on an adjustable rate or hybrid loan is above an interest rate index (e.g., LIBOR), in percent. For example, a 2/28 hybrid adjustable rate loan typically has a low "teaser" fixed rate for the first 2 years, followed by a variable rate based on 6-month LIBOR plus a margin that is fixed for the remaining life of the loan.
Rate reset (−)	Time (in months) before the interest rate on an adjustable rate loan begins to adjust. Hybrid adjustable rate loans have initial fixed interest rates for 2 or 3 years, while "pure" adjustable rate loans typically adjust within the first year after origination.
ARM (+)	Dummy variable equal to one if the loan is an ARM and the first interest rate reset period is less than or equal to 1 year from the date of origination.
Hybrid2 (+)	Dummy variable equal to one for an adjustable rate loan where the initial monthly payment is fixed for the first 2 years. This is typically referred to as a 2/28 hybrid ARM, with the interest rate over the remaining 28 years of the loan equal to an interest rate index (i.e., 6-month LIBOR) measured at the time of adjustment, plus a margin that is fixed for the life of the loan. The initial fixed rate is typically called a "teaser" interest rate because it is lower than what a borrower would pay for a 30-year fixed rate mortgage.
Hybrid3 (+)	Dummy variable equal to one for a 3/27 hybrid ARM (i.e., the interest rate is fixed for 3 years and variable thereafter).
Balloon (+)	Dummy variable equal to one for a fixed or adjustable rate loan where the payments are lower over the life of the loan, leaving a balloon payment at maturity. For example, a fixed rate mortgage that amortizes over 40 years but matures in 30 years, leaving a balloon payment after 30 years.
Price appr. (−)	Metropolitan statistical area (MSA) housing price index appreciation (in decimal) from loan origination to 24 months thereafter, as reported by the Office of Federal Housing Enterprise Oversight.
Unemployment (+)	State-level change in unemployment rate from loan origination to 24 months thereafter, reported by the Bureau of Economic Analysis.
Local income (−)	Zip code-level median income in 1999 as reported by the U.S. Census Bureau in 2000.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1: Internet Appendix