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Asymmetric information, adverse selection, and the pricing of CMBS ☆

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ABSTRACT

We demonstrate that asymmetric information between sellers (loan originators) and purchasers (investors and securities issuers) of commercial mortgages gives rise to a standard lemons problem, whereby portfolio lenders use private information to liquidate lower quality loans in commercial mortgage-backed securities (CMBS) markets. Conduit lenders, who originate loans for direct sale into securitization markets, mitigate problems of asymmetric information and adverse selection in loan sales. Our theory provides an explanation for the pricing puzzle observed in CMBS markets, whereby conduit CMBS loans are priced higher than portfolio loans, despite widespread belief that conduit loans are originated at lower quality. Consistent with theoretical predictions of a lemons discount, our empirical analysis of 141 CMBS deals and 16,760 CMBS loans shows that, after controlling for observable determinants of loan pricing, conduit loans enjoyed a 34 basis points pricing advantage over portfolio loans in the CMBS market.

1. Introduction

In the wake of ongoing disruption to the real estate capital markets, analysts and policy makers alike have sought to better understand the collapse of mortgage derivatives. Much attention has been paid to the abuses to securitization, notably including those associated with security design, excess leverage, opaqueness, and lax ratings. Analysts similarly have argued that conduit lending, a process whereby mortgage lenders originated loans expressly for pass-through to securitization markets, was conspicuous among deconstructing forces. Specifically, critics claim that pass-through of loans to securitization markets damped originator incentives to appropriately screen loans. Those concerns have been cited among flaws of the originate-to-distribute model (see, for example, Bernanke, 2008; Mishkin, 2008; European Central Bank, 2008; Ashcraft and Schuermann, 2008; Keys, Mukherjee, Seru, and Vig, 2010; Purnanandam, 2009).

While conduit lenders could have contributed to moral hazard in primary market loan origination, those same entities likely mitigated problems of asymmetric information and adverse selection in secondary market loan sales. Unlike portfolio lenders, conduit lenders have neither the opportunity nor the incentive to develop private information on loan quality. Accordingly, conduits potentially alleviate a lemons problem in selection of loans for sale in securitization markets by portfolio lenders. In this manner, conduit lending enhances allocative efficiency in

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Table 1
Comparison of commercial mortgage-backed securities (CMBS) conduit deal and portfolio deal spreads. The spread is calculated as the deal net coupon (paid to investors) minus comparable maturity Treasury rate at deal cutoff. Linear interpolation is applied to Treasury rates to obtain the full term structure.

Deal type	Mean	Standard deviation	Minimum	Median	Maximum	Number of observations
Conduit	2.2615	0.5835	0.6613	2.2153	4.4804	118
Portfolio	2.6951	0.8825	1.4987	2.5879	5.0899	23

the secondary mortgage market. In this paper, we investigate this hypothesis, via modeling and empirical evaluation of the pricing of conduit- and portfolio-backed commercial mortgage-backed securities (CMBS) and loans.

To demonstrate the lemons problem and to derive testable predictions about how the lemons effect varies with such parameters as the dispersion of loan quality and the cost of holding loans in portfolio, we first present a simple information economics model of loan sales in securitization markets. In our model, portfolio lenders face a sell or hold decision and possess private information about loan quality. Portfolio lender private information derives from their due diligence in loan underwriting and their experience in holding and servicing mortgages. This private information includes soft information as described in Stein (2002). In selecting loans to sell into securitization markets, portfolio lenders utilize their private information and adopt a strategy of selling lower quality loans. Our theoretical results show that, in equilibrium, only lower quality portfolio loans (lemons) are sold into the secondary markets and that their sales price incorporates a lemons discount. In contrast, conduit lenders originate loans exclusively for direct sale into the secondary market. Conduits lack the incentive to develop soft information about loan quality as their profit derives mainly from loan origination fees instead of from long-term returns associated with portfolio holding of loans.[1] In our model, information is symmetric between conduit loan sellers and buyers, all conduit loans are sold into secondary markets, and loan prices do not reflect a lemons discount. Theoretical results also suggest that the magnitude of the lemons discount associated with portfolio loan sales varies positively with the dispersion of loan quality in the mortgage pool and inversely with the seller's cost of holding loans in portfolio. The total surplus associated with the trade is higher in the case of conduit loan sales.

Our model helps to explain a puzzle in the pricing of CMBS deals. As seen in Table 1, over the course of the 1994–2000 sample period, CMBS investors paid higher prices for CMBS backed by conduit loans, as evidenced in the substantially lower spreads over Treasuries at issuance among conduit CMBS deals relative to portfolio CMBS deals. According to our theory, the discount on portfolio loans is due in part to the higher residual risk of portfolio loans sold into CMBS markets.

The theory is also consistent with growth over time in the prevalence of conduit loans in CMBS deals. In the aftermath of the advent of commercial mortgage securitization in the early 1990s, loans backing CMBS were largely contributed by thrifts and life insurance companies, which originally intended to retain those loans in portfolio. However, in the wake of CMBS market growth, conduit lending emerged whereby originators funded mortgages with the express intent of direct sale into securitization markets. Conduit lending constituted less than 5% of all CMBS deals in 1992. However, the share of conduit loans grew to 75% by 1998 and reached almost 100% by 2001. The decline in portfolio loan sales is suggestive of efficiency problems associated with securitization of those mortgages.

In our empirical analysis, we test theoretical predictions. To do so, we first study the pricing of 141 CMBS deals brought to market during the 1994–2000 period. Estimates of a reduced-form pricing model conform to theory. Results indicate that portfolio-backed CMBS deals were priced 33 basis points (bps) lower than conduit deals, after controlling for observable CMBS pool characteristics and other established determinants of CMBS pricing, including the term structure of interest rates, interest rate volatility, the Sharpe ratio, corporate bond credit spreads, and CMBS market capitalization.

We further assess the robustness of the CMBS deal-level results via a loan-level analysis of commercial mortgage loan pricing. Here our sample contains 13,655 conduit loans and 3,105 portfolio loans sold into securitization markets during the 1994–2000 period. Our findings indicate a pricing differential of 34 bps after controlling for observable credit quality and other established loan pricing determinants, including the loan-to-value (LTV) ratio, amortization term, collateral property type, property location, prepayment constraints, CMBS pool characteristics, CMBS market cap, and the like. Moreover, we find that the lemons discount is lower for multifamily loans, which are characterized by lower levels of uncertainty and lender private information than retail, office, and industrial loans. This is consistent with theoretical predictions that buyers are more reluctant to trade and that the lemons discount is larger when information asymmetry is more severe. Overall, results of both the deal-level and the loan-level analyses are supportive of our theoretical predictions.

The intuition for our paper derives from a simple application of the Akerlof (1970) "market for lemons" theory to financial markets. It is noteworthy that substantial theoretical research has sought to address information asymmetry and adverse selection problems in financial markets (see, e.g., Leland and Pyle, 1977; Stiglitz and Weiss, 1981; Myers and Majluf, 1984; John and Williams, 1985; Diamond, 1993; Winton, 1995; DeMarzo and Duffie, 1999; DeMarzo, 2005; Gan and Riddiough, 2008). However,

[1] As in Stein (2002), soft information cannot be credibly transmitted to a third party. As such, conduit lenders lack the incentive to collect soft information.

empirical evidence of lemons effects is limited. This paper, by way of application to the market for CMBS, presents empirical evidence consistent with the market for lemons theory.

Our empirical findings also are consistent with a recent study by Downing, Jaffee, and Wallace (2009), who show that residential mortgage-backed securities (RMBS) sold by Freddie Mac (Federal Home Loan Mortgage Corporation) to bankruptcy remote special purpose vehicles (SPVs) were characterized by lower credit quality than those retained by Freddie Mac in portfolio. The authors argue that their findings are consistent with the notion that Freddie Mac used private information to deliver lemons to securitization markets.

Empirical results of our paper also largely confirm findings evidenced in the broader empirical literature on mortgage and bond pricing (see, e.g., Rothberg, Nothaft, and Gabriel, 1989; Fama and French, 1989; Blume, Keim, and Patel, 1991; Bradley, Gabriel, and Wohar, 1995; Collin-Dufresne, Goldstein, and Martin, 2001; Titman, Tompaidis, and Tsyplakov, 2004; Longstaff, Mithal, and Neis, 2005; Titman and Tsyplakov, 2010). For example, our findings suggest that CMBS market cap, slope of the Treasury yield curve, amortization term, prepayment constraints, and mortgage pool diversification all negatively impact commercial mortgage spreads, whereas corporate bond spreads, CMBS loan maturity, and share of hotel loans in the CMBS pool are all positively related to spreads. In addition, we find that the lagged risk-adjusted return in commercial property markets has a strong negative impact on CMBS spreads.

We proceed as follows. In the next section, we briefly describe the rise of conduit lending and provide background of our study. In Section 3, we present our information economics model, and in Section 4 we discuss our empirical modeling and results. In Section 5, we provide concluding remarks.

2. Commercial mortgage securitization and conduit lending

Commercial mortgage debt markets recorded substantial growth over the course of recent decades. By early 2008, commercial mortgage debt outstanding (inclusive of multifamily loans) reached \$3.38 trillion, up from \$500 billion a decade earlier. Of that number, about \$0.92 trillion were held by CMBS investors.[2]

Prior to the advent of securitization markets, commercial mortgage lenders, including banks and thrifts, life insurance companies, and pension funds, originated commercial mortgages with the intention of holding those loans in portfolio. In 1984, Solomon Brothers originated \$970 million mortgages on three office buildings and offered securities to the public based on the projected mortgage cash flows. Later, in the wake of the severe real estate downturn of the early 1990s, the Resolution Trust Corporation (RTC) sought to liquidate the commercial mortgage loan portfolios of failed thrifts via large-scale securitization.

Securitization is the process whereby debt assets are pooled, packaged, and derivative securities issued against those assets. For example, an investment bank might purchase commercial mortgages from loan originators, place those loans in a trust, and then issue CMBS against the trust. Those securities, representing claims on the cash flows generated by the underlying commercial mortgage assets, would then be sold to investors. Issuance of CMBS grew rapidly from \$2 billion in 1989 to some \$630 billion in 2006, before falling back to less than \$100 billion in 2008.

In the wake of the advent of securitization markets, loans backing CMBS issues derived largely from the held for investment asset portfolios of financial institutions and life insurance companies. Those originators sold their loans to CMBS issuers either to liquidate nonperforming loans or to remove performing loans from their balance sheet, so as to reduce required capital reserves or to allow investment in other assets.[3]

As commercial mortgage securitization became prevalent, conduit lending emerged as an important market-completing element of the commercial mortgage market. The conduit lender, usually a commercial bank or a mortgage bank, originated commercial mortgages with the express intent of directly selling those loans in secondary markets. The conduit lender usually passed the originated loans through to security issuers upon loan origination and thus simply acted as a conduit.[4] In this case, it was not the lender, but rather investors on Wall Street, who funded the commercial mortgages. The lender or originator profited mainly via loan origination fees, not from longer term portfolio investment in the asset.[5]

A priori, one would expect portfolio as well as conduit lenders to avail themselves to liquidity provided by CMBS markets. After controlling for credit quality and anticipated performance, there should be no reason to observe a price differential between portfolio and conduit commercial real estate loans in securitization markets. Below, we develop an information-economics model to demonstrate why conduit CMBS deals were priced higher than portfolio CMBS deals and why conduit lending became the preferred source of loans in the CMBS market.

3. A market for lemons model

In this section, we present a simple information-economics model to examine commercial mortgage and CMBS pricing. In that regard, assume there are n loans in a

[2] See Commercial Mortgage Securities Association, Compendium of Statistics, June 26, 2008.

[3] Regulators require lower capital reserves for more liquid mortgage-backed securities relative to idiosyncratic and less liquid whole loans. Also, the RTC asset pools labeled "N-Series" and "S-Series" largely consisted of nonperforming and sub-performing loans originally held in thrifts' and banks' portfolios. In contrast, the \$1.3 billion securitization of Canadian Confederation Life Insurance's portfolio of US commercial mortgages in 1995 was made up of performing assets and was for other business purposes.

[4] In some cases, a short period of warehousing could be necessary for conduit lenders to accumulate a pool for securitization.

[5] Some lenders or originators also profit from loan servicing if they retain the servicing rights.

commercial mortgage pool and each loan is characterized by the pair $\{c_i, X_i\}$, $i=1,2,\ldots,n$, where c_i is a vector of loan terms including loan balance, maturity term, interest rate, and the like and X_i is the risk associated with the loan.[6] We denote the non-negative final payoff of loan i as Y_i, which is determined by c_i and X_i. For notational convenience, we normalize the market interest rate to zero, and thus in absence of capital market imperfections, the market value of the loan is $E(Y_i)$.

If lenders had perfect information on the risk of each loan, X_i, and applied full risk-based pricing, they would select a corresponding set of loan origination terms c_i so as to result in an equivalent expected payoff (value) for all the loans. However, due to imperfect information and the widespread market practice of average loan pricing, commercial mortgage loans have different expected payoffs. In recognition of such, we decompose Y_i into three components: $Y_i=u+V_i+Z_i$, where u corresponds to the payoff of the loan adjusted for observable risk characteristics associated with loan underwriting terms; V_i reflects unobservables, such as lender private information about loan risk developed during the underwriting process or loan holding period but not reflected in the loan underwriting documents; and Z_i represents random shocks to loan payoff.[7] Let $Y\equiv\{Y_1,Y_2,\ldots,Y_n\}$ denote the vector of payoffs for n loans in the mortgage pool and, similarly, for V and Z, we assume $E(Z_i|V)=0$. For convenience, we also assume that V_i is uniformly distributed, i.e., $V_i \sim U[\underline{v},\overline{v}]$, and thus $u+\underline{v}$ and $u+\overline{v}$ represent the lower and upper bounds of the expected payoffs, conditioning on observable risks characteristics, respectively, in the mortgage pool.[8]

We study transactions in the secondary mortgage market. Here the loan originator (lender) is the seller of the mortgage (or mortgage pool) and the security issuer or investor is the buyer. We assume all agents are risk-neutral. Further, we assume the loan originator has a discount rate of δ and hence a discount factor of $1-\delta$, which means that the lender has lower valuations of each loan than the buyer. This could be due to the incremental capital reserves required for lender holding of whole loans relative to more liquid mortgage-backed securities (Calem and LaCour-Little, 2004).[9] Also, this could be due to the fact that security issuers and investors create value through large scale securitization. Finally, lenders face incremental costs of holding and servicing loans in excess of those faced by securities issuers or investors, due to lack of scale economies in servicing retained portfolios. Define λ as the parameter that governs the lender's incremental costs of servicing retained loans. We then express the lender's valuation of a loan sold as

$$R(Y_i)=E[(1-\delta)u+V_i+Z_i+\lambda q(p)], \tag{1}$$

where $q\in[0,1]$ is the share of the mortgage pool sold. δ and λ are positive constants with $\delta<1$ and $\lambda<\delta u$.[10]

3.1. Pricing of portfolio loans

Portfolio lenders originate commercial mortgage loans with intent to hold those loans in their investment portfolios. However, for reasons discussed in Section 2, portfolio lenders could subsequently decide to offer some loans for sale in the secondary market. By the time of secondary market loan sale, the portfolio lender has acquired private information regarding loan payoff from a number of channels, including soft information developed during loan underwriting and lender due diligence as well as from knowledge created during the period of loan servicing and holding prior to loan sale in the secondary market. To reflect the seller's superior information, for the payoff $Y_i=u+V_i+Z_i$, we assume the seller knows the value of V_i while the buyer possesses information only on the distribution of V_i. The dispersion of V_i is a measure of the severity of information asymmetry between the seller and buyer.

Proposition 1 characterizes the competitive equilibrium in portfolio loan sales.

Proposition 1. *In portfolio loan sales, there is a market for lemons problem, in that only a fraction of the mortgage pool representing lower quality loans (lemons) are traded. Further, the greater the information asymmetry between buyer and seller of loans, the more severe is the lemons problem. The share of loans sold is*

$$q^*=\frac{2\delta u}{\overline{v}-\underline{v}+2\lambda} \tag{2}$$

and the selling price is

$$p^*=u+\frac{(\overline{v}-\underline{v})\delta}{\overline{v}-\underline{v}+2\lambda}u+\underline{v}. \tag{3}$$

Here we are assuming $\overline{v}-\underline{v}+2\lambda>2\delta u$ to ensure q^* that is bounded by one.

Proof. See Appendix A.

Here, the intuition of the market for lemons problem is exactly as that in Akerlof (1970). Because the seller can separate high quality loans from low quality loans and assign higher valuations (opportunity costs) to higher quality loans, only lower quality loans are sold at any

[6] The signature risk of commercial mortgage loans is default risk. There could also be prepayment risk depending on the extent to which prepayment is restricted or compensated in the mortgage contract.

[7] The term u represents loan valuation in a world of perfect information, where $E(Y_i)=E(Y_i)$, $i\neq j$. Hence no subscript is attached here. Because lenders work closely with borrowers, they often possess borrower- or firm-specific information that is not reported in the loan underwriting documents. Lenders also have insights about the quality of appraisals that affect loan risk. This type of information is similar to firms' soft information about investment projects as described in Stein (2002).

[8] The uniform distribution is used for mathematical simplicity. However, the analysis can be readily extended to other distributions with no substantive change in our findings.

[9] In other words, higher capital reserves are required for lenders holding unsold whole loans in portfolio. To the extent that capital requirements are binding, these requirements represent a tax. However, should loan sales occur, the buyers (security issuers) convert the whole loans into securities, which require lower capital reserves.

[10] Eq. (1) is essentially equivalent to $R(Y)=E[(1-\delta)u+V_i+Z_i-\lambda(1-q(p))]$, where $-\lambda(1-q(p))$ represents the incremental costs of servicing loans retained in lender portfolio. For purposes of simplicity and to focus on the effects of asymmetric information discussed below, we adopt the simple functional form indicated in Eq. (1).

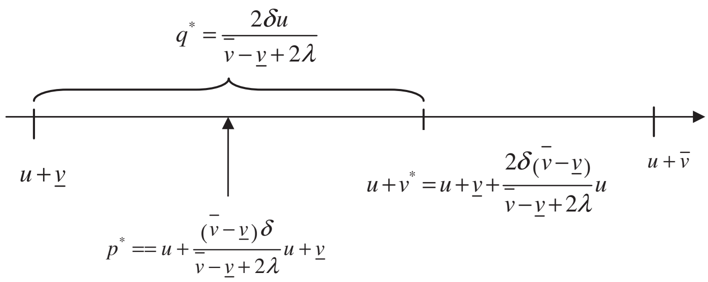

Fig. 1. Trading and pricing of portfolio loans. Here u denotes the expected payoff of the loan adjusted for observable risk characteristics associated with loan underwriting terms. $\underline{v}$ and $\overline{v}$ represent the lower and upper bounds of the expected payoffs due to unobservables, such as lender private information about loan risk developed during the underwriting process or loan holding period but not reflected in the loan underwriting documents. δ represents the loan originator's discount rate in the valuation of each loan either due to the incremental capital reserves required for lender holding of whole loans relative to more liquid mortgage-backed securities or due to the fact that security issuers and investors create value through large scale securitization. λ is the parameter that governs the lender's incremental costs of servicing retained loans. δ and λ are positive constants with $\delta < 1$ and $\lambda < \delta u$. p^* is the equilibrium sales price of portfolio loans. q^* is the share of loans sold in equilibrium. $u+v^*$ represents the cutoff in expected payoff of loans sold in equilibrium.

given price. As a result, the expected value of loans sold represents a truncated distribution made up of lower quality loans. As price decreases, fewer higher quality loans are sold. Accordingly, a market for lemons comes to prevail as lower quality loans drive higher quality loans out of the marketplace.

Beyond this intuition, it is evident that the more severe the information asymmetry, the worse is the lemons problem. As shown in the comparative statics of Eq. (2), $(\partial q^*/\partial \phi) < 0$, where $\phi = (\overline{v} - \underline{v})/u$ measures the dispersion of loan quality in the commercial mortgage pool and thus the extent of information asymmetry between the seller and the buyer.

The share of loans sold into the secondary market as well as the price of loans increases with δ, a parameter representing the seller's extra holding costs, as $(\partial q^*/\partial \delta) > 0$ and $(\partial p^*/\partial \delta) > 0$. These results are consistent with our intuition that the higher the loan holding costs, the more keen is the originator to sell loans, which in turn reduces the lemons problem. Also, if δ=0, no loans are traded. The intuition is that at any given market price p=u+v^*, where $\underline{v} < v^* < \overline{v}$, the seller is willing to offer loans only with quality less than or equal to $u+v^*$. However, knowing that the seller will offer only a truncated distribution of lower quality loans for sale, the buyer's valuation for the truncated distribution is $u+((v^*+\underline{v})/2) < u+v^*$. In this case, the market collapses.

We depict the portfolio loan sales in Fig. 1.

3.2. Pricing of conduit loans

Conduits originate loans for the purpose of direct securitization. They are compensated largely on the basis of origination fees. Furthermore, they generally pass through loans to the purchaser upon origination. Accordingly, unlike portfolio lenders, conduit lenders have weaker incentives to develop private information on loan risk. For simplicity, we assume that both the seller and the buyer of conduit loans know only the distribution of V_i and thus there is no information asymmetry.

Proposition 2 characterizes the competitive equilibrium.

Proposition 2. *All conduit loans are sold and the selling price is*

$$p^* = u + \frac{\overline{v}+\underline{v}}{2}. \tag{4}$$

Proof. See Appendix B.

In our model, the conduit lender does not exploit soft information in loan sales. Accordingly, there is no information asymmetry and hence no adverse selection in conduit loan sales. This solves the lemons problem. Fig. 2 depicts the equilibrium in conduit loan sales.

3.3. Comparing portfolio and conduit loans in the CMBS market: the market for lemons

From the above discussion, it is evident that information asymmetry results in a lemons effect in the pricing and sales of portfolio loans in the CMBS market. In this subsection, we seek to quantify the magnitudes of those loan sales and pricing effects. V_i represents residual lending risk not captured by commonly known underwriting factors. For sake of comparison, we assume here that the V_i for portfolio and conduit loans follow the same distribution.[11]

In that case, the traded share of originated portfolio loans is relatively smaller as only the low quality loans are traded. In contrast, all originated conduit loans are traded in the secondary market. To illustrate, we pick reasonable model parameters and compute the portfolio and conduit traded shares based on results in Proposition 1.

Assume that the seller's value discount parameters are λ=0.5% and δ=3% and that, among the loan origination pool, the best and worst quality loans have a value dispersion of 14% (as indicated by private information available to the portfolio lender, i.e., $\underline{v} = -7\%u$, $\overline{v} = 7\%u$, and thus $\phi = (\overline{v} - \underline{v})/u = 14\%$). In this case, model results indicate that only the bottom 40% of portfolio loans in the pool are traded. In addition, the share of loans traded decreases as a positive function of the quality dispersion of loans in the origination pool, as loan quality dispersion increases the severity of the information asymmetry and hence the reluctance of information-disadvantaged buyers to purchase. This relation is reflected in Fig. 3.

[11] In the real world, high quality borrowers are more likely to have an established banking relation with portfolio lenders and thus portfolio lenders have additional soft information about borrower default risk. Therefore, conduit lenders do not see the same right tail of the quality distribution as the portfolio lenders. For purposes of analytical tractability, our analyses abstract from these considerations.

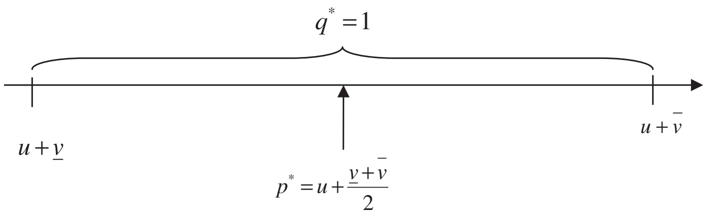

Fig. 2. Trading and pricing of conduit loans. Here u denotes the expected payoff of the loan adjusted for observable risk characteristics associated with loan underwriting terms. $\underline{v}$ and $\overline{v}$ represent the lower and upper bounds of the expected payoffs due to unobservables, such as lender private information about loan risk developed during the underwriting process or loan holding period but not reflected in the loan underwriting documents. p_* is the equilibrium sales price of portfolio loans. q^* is the share of loans sold in equilibrium.

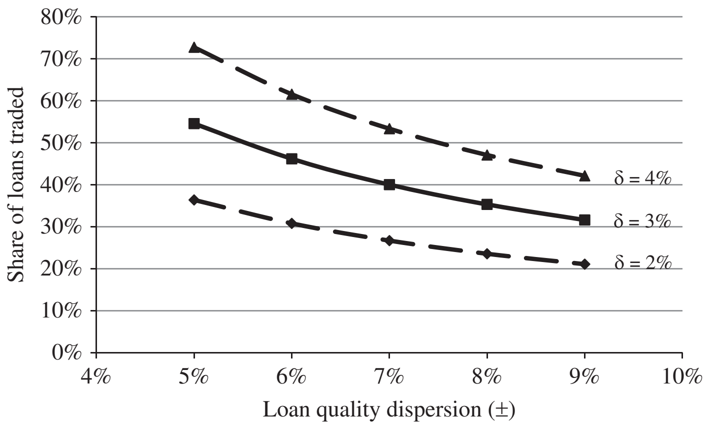

Fig. 3. The share of portfolio loans traded varies negatively with loan quality dispersion. λ is the parameter that governs the lender's incremental costs of servicing retained loans and δ is the discount rate that the lender has. In the case of the solid line, we assume λ=0.5% and δ=3%, and we calculate the share of portfolio loans sold when the loan quality dispersion increases from $\pm$5% to $\pm$9%. Those loan quality dispersion parameters represent yield differentials between high quality and low quality commercial mortgage loans (due to unobservable residual risk) ranging from 105 basis points (bps) to 191 bps. In the case that loans in a commercial mortgage pool are characterized by a 105 bps yield differential (a relatively homogeneous pool), the share of loans traded is about 55%. The share of loans traded declines to 32% when loans in the commercial mortgage pool are characterized by yield differentials as high as 191 bps (a very heterogeneous pool).

Second, we compare the price of portfolio and conduit loans sold in the CMBS market. According to our analysis in subsections 3.1 and 3.2, portfolio and conduit loan pools in the CMBS market are characterized by an equivalent u, which is the expected payoff corresponding to observable loan risk characteristics.[12] However, given unobservable information on loan quality, V_i, portfolio loans traded represent only the lower spectrum of the loan distribution (lemons) and the price of portfolio loans reflects the lemons discount. We offer Proposition 3.

Proposition 3. *The price of portfolio loans is generally lower than the price of conduit loans in the CMBS market due to the lemons discount. The discount* (*ratio of portfolio loan price to conduit loan price*) *is*

$$l=\frac{2(\overline{v}-\underline{v}+2\lambda)u+2(\overline{v}-\underline{v})\delta u+2(\overline{v}-\underline{v}+2\lambda)\underline{v}}{(2u+\overline{v}+\underline{v})(\overline{v}-\underline{v}+2\lambda).} \quad (5)$$

Proof. The lemon's discount l is defined as the ratio of the portfolio loan price in Eq. (3) to the conduit loan price in Eq. (4). Given the condition $\overline{v}-\underline{v}+2\lambda>2\delta u$ as assumed in subsection 3.1, $l<1$.

Again we select reasonable model parameters and compute the lemons discount based on the above results.

When the parameters of seller's value discount are λ=0.5% and δ=3%, and loan quality dispersion is 14% ($\underline{v}=-7\%u$, $\overline{v}=7\%u$, and thus ϕ=14%), the lemons discount is about 58 bps. The lemon's discount increases with the dispersion of loan quality, as shown in Fig. 4.

Finally, we consider the total surplus associated with the portfolio and conduit loan sales. Based on our aforementioned results, we can easily calculate the total surplus of portfolio loan sales as

$$S^P=\frac{2(\overline{v}-\underline{v})\delta^2u^2}{(\overline{v}-\underline{v}+2\lambda)^2} \quad (6)$$

and the total surplus of conduit loan sales as

$$S^C=\delta u-\lambda. \quad (7)$$

Based on our assumptions of the parameter values, the surplus of conduit loan sales is about twice that of portfolio loan sales. This result suggests that conduits provide a more efficient mechanism for sale of loans in the secondary market.[13] □

[12] We allow portfolio loans and conduit loans to be originated with different observable risk characteristics.

[13] As is evident, our analysis focuses on efficiency gains associated with conduit loan sales in securitization markets. As suggested above,

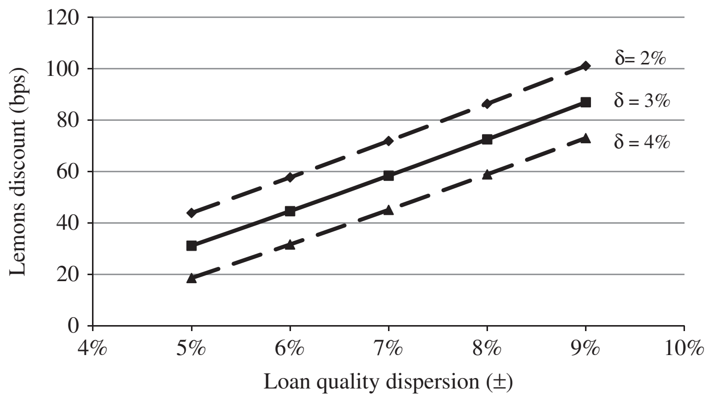

Fig. 4. The lemons discount varies positively with loan quality dispersion. δ is the discount rate that the lender has. We assume that a typical commercial mortgage loan carries an 8% interest rate and has a 20-year maturity term. In the solid line, we assume δ=3%. We further assume λ, the parameter that governs the lender's incremental costs of servicing retained loans, equals to 0.5%. Based on these parameter values, we calculate the lemons discount in accordance to Proposition 3 and then convert it to basis point (bp) yield differentials. When the mortgage origination pool loan quality dispersion (dispersion in values of V_i, the expected payoff due to unobservables) is $\pm$5%, the lemons discount is computed to be 31 bps. In the case in which the mortgage origination pool loan quality dispersion rises to $\pm$9%, the lemons discount increases to 87 bps.

4. Empirical analysis

The empirical analysis proceeds from a large data set (see Section 4.2), which provides information on both the pricing and underwriting of commercial loans sold into securitization markets. Using this information, the observable risk-adjusted value u can be computed. We do not observe lender private information V_i. Further, we do not observe the portfolio lender's choice of which loans to sell into the secondary market and hence are not able to provide direct evidence as to whether the portfolio loans traded in CMBS markets make up the lower spectrum of the distribution of all portfolio loans originated. However, in the spirit of Bond (1982), we are able to analyze loan sales in the CMBS market and test for the lemons effect. Specifically, we examine the pricing of portfolio and conduit loans and evaluate whether loan pricing is consistent with our theoretical results. Our empirical work includes pool-level and individual-level analyses of yield spread differentials between conduit and portfolio loans.

4.1. Data

We access an exceptionally rich CMBS and commercial mortgage loan database acquired through CMBS.COM, which is a major data provider on all CMBS issued in the US.[14] CMBS.COM provides detailed information on each CMBS transaction at deal, tranche (bond), loan, and property levels. For each CMBS deal, we observe the weighted average coupon (WAC) paid to investors. In a typical CMBS deal, a number of CMBS tranches (bonds) are issued with different exposures to default risk, subordination levels, and expected duration, and thus different tranches can carry different coupons (An, Deng, and Sanders, 2008). The average of all the coupons weighted by cutoff balance is the WAC, which reflects the overall price paid by CMBS investors.[15] In addition to pricing information, the CMBS deal-level data includes detailed information such as CMBS issuance date, issuer, trustee, and manager of the deal as well as the deal dollar balance, weighted average debt-service coverage ratio (DSCR), weighted average loan-to-value (LTV) ratio, weighted average maturity (WAM), and prepayment constraints. Also, the database includes information on the composition of property types, geographies, loan sizes, and like information on underlying loans.

The database further permits identification of loan pricing and lending terms on all mortgage loans included in CMBS deals. Accordingly, for each commercial loan included in the CMBS database, our loan-level database includes information on origination date, origination balance, origination LTV ratio, coupon rate, maturity, amortization term, property location, lender, prepayment constraint, and the like. Further, for each loan, we observe a net coupon rate, which is the coupon paid to CMBS investors recorded in the data. This information is applied in additional loan-level assessment of conduit versus portfolio loan pricing.

Data on corporate bond yields and the term structure of interest rates are obtained from the Federal Reserve. That information is used to construct the corporate bond credit spread as well as proxies for the slope of the Treasury yield curve and interest rate volatility. We also obtain data from the Commercial Mortgage Securities Association on CMBS issuance and CMBS debt outstanding (market cap). Finally, we use National Council of Real Estate Investment Fiduciaries data to construct a Sharpe ratio measure of volatility-adjusted excess returns in commercial real estate by property type.

(*footnote continued*)
problems of moral hazard could have been associated with conduit loan originations in the primary market.

[14] The company was sold in 2005 to Standard & Poor's and later to Backshop.

[15] This is sometimes called net WAC to distinguish it from the gross WAC, which is just the weighted average of interest rates of all loans in the deal. The difference between gross WAC and net WAC is what is earned by intermediaries in securitization markets, including CMBS issuers, servicers, rating agencies, and the like.

4.2. Comparing the pricing of portfolio and conduit loans

According to Proposition 3, upon controlling for publicly observable loan quality (underwriting) differentials, portfolio loans in CMBS pools should represent the lower spectrum of the V_i distribution and should be priced lower than conduit loans in CMBS pools. This is the lemons discount identified in the pricing of portfolio CMBS loans. We specify and control for well-known determinants of commercial mortgage loan pricing, so as to empirically identify the lemons discount.

4.2.1. Observable loan characteristics that affect the pricing of CMBS loans

Loan-to-value (*LTV*) *ratio and debt-service coverage ratio* (*DSCR*): The debt-to-asset ratio has long been considered an important predictor of corporate default (see, e.g., Altman, 1968; Frydman, Altman, and Kao, 1985). Similarly, in the real estate literature, considerable evidence suggests that the LTV ratio and the DSCR of commercial mortgage loans are important predictors of default risk (see, e.g., Episcopos, Pericli, and Hu, 1998; Archer, Elmer, Harrison, and Ling, 2002; Goldberg and Capone, 2002; Ciochetti, Deng, Gao, and Yao, 2002; Seslen and Wheaton, 2010; Yildirim, 2008; An, Deng, and Sanders, 2009). We anticipate that increases in LTV should positively affect spreads on CMBS loans, whereas increases in DSCR should have the opposite effect.

Amortization and maturity term: Episcopos, Pericli, and Hu (1998), Ciochetti, Deng, Gao, and Yao, (2002), and An (2007) have found that commercial mortgage loans that amortize (or commercial loans with longer amortization terms) have lower default risk than interest-only (or shorter amortization term) loans. An (2007) also has found that commercial mortgage loans with longer maturity terms have lower default risk than those with shorter maturity terms. We similarly control for these effects in the pricing of our sampled CMBS loans.

Property type: Existing literature (see, e.g., Vandell, Barnes, Hartzell, Kraft, and Wendt, 1993; Ciochetti, Deng, Gao and Yao, 2002; Ambrose and Sanders, 2003; An, 2007) has shown that commercial mortgage default varies systematically with collateral property type. Typically, multifamily loans are the least risky, followed by retail and office property loans. Industrial and hotel loans are viewed as the most risky of commercial property collateral. Accordingly, we control for collateral property type and anticipate like differentials in the pricing of CMBS loans.

Property location: As would be anticipated, prior research (see, e.g., Follain, Ondrich, and Sinha, 1997; Ambrose and Sanders, 2003; Archer, Elmer, Harrison, and Ling, 2002; Ciochetti, Deng, Gao, and Yao, 2002; An, 2007; Yildirim, 2008; An, Deng, and Sanders, 2009) has provided evidence of substantial geographic variation in commercial mortgage prepayment and default risk. Historically, lower default risk has been evidenced in the Pacific region, and loans in East South Central and West South Central have been characterized by elevated default risk. We control for geographic location of loans in the pricing of CMBS loan pools.

Prepayment constraint: The presence of prepayment risk should dampen the price of commercial mortgages. As such, constraints on the borrower's ability to prepay the loan should reduce the investor's required prepayment premium. Further, Ambrose and Sanders (2003) and An, Deng, and Sanders (2009) have found that the presence of prepayment constraints also affects the probability of commercial mortgage loan default. The empirical analysis controls for the presence of constraints on mortgage prepayment in sampled CMBS pools.

Diversification: Harding, Sirmans, and Thebpanya (2004) have found that geographic concentration positively affects the CMBS bond spread. Moreover, Harding, Sirmans, and Thebpanya (2004) and An, Deng, and Sanders (2008) have found that loan size and geographic diversification are important to rating agencies' CMBS subordination structure. The analysis includes a Herfindahl index of pool loan size and an entropy index of CMBS pool geographic diversification.

4.2.2. Economic and debt market conditions that affect the pricing of CMBS loans

Corporate bond credit spread: The corporate bond credit spread (defined as the yield spread between corporate bonds rated Aaa and Baa) is often used to proxy the market price of default risk. In addition, Fama and French (1989) find that credit spreads widen when economic conditions are weak. In application to mortgage pricing, we hypothesize that the default option embedded in the mortgage contract should vary directly with economy-wide credit risk. Accordingly, the corporate bond credit spread at CMBS issuance should positively affect CMBS spreads.

Slope of the yield curve: Substantial evidence exists on the role of the term structure in the determination of mortgage bond spreads (see, e.g., Merton, 1974; Bradley, Gabriel, and Wohar, 1995; Ambrose and Sanders, 2003; Titman, Tompaidis, and Tsyplakov, 2005). An increase in the slope of the yield curve suggests some future strengthening in economic activity, a reduced likelihood of put option exercise in the form of loan default, and a lower default premium. An increase in the slope of the yield curve also reduces the likelihood that the mortgage call option is in the money, so as to reduce prepayment risk and the related call option premium. Accordingly, increases in the slope of the Treasury yield curve should have a negative impact on the CMBS pricing spread.

Interest rate volatility: Mortgage put and call option values increase with interest rate volatility. In fact, in a contingent claims framework, the debt claim has elements similar to a short position on a put and a call option. This prediction is intuitive and well established in the literature: Increased interest rate volatility implies increases in the probability that both mortgage put and call option values are in the money. Accordingly, mortgage spreads should increase with rate volatility.

CMBS market cap: A number of studies have found that pricing of corporate bonds varies inversely with market liquidity (e.g., Longstaff, Mithal, and Neis, 2005; Chen, Lesmond, and Wei, 2007). We conjecture that this is also true for commercial mortgage loans. As in the literature on residential mortgage-backed securities, we proxy for liquidity effects in part via an indicator of dollar capitalization of the CMBS market.[16] In early stages of CMBS market

[16] In the corporate bond literature, liquidity effects often are proxied via bid-ask spreads. Unfortunately, information on bid-ask spreads is not available for CMBS.

Table 2
Cutoff year distribution of the conduit and portfolio deals in our sample. A total of 141 commercial mortgage-backed securities (CMBS) deals are cut off during 1994–2000, not including 1998 in which there are no portfolio deals recorded. Of these deals, 118 are conduit deals and 23 are portfolio deals.

Cutoff year	All deals		Conduit deals		Portfolio deals	
	Number of deals	Percent of total	Number of deals	Percent of total	Number of deals	Percent of total
1994	5	3.55	3	2.54	2	8.7
1995	18	12.77	13	11.02	5	21.74
1996	26	18.44	20	16.95	6	26.09
1997	23	16.31	20	16.95	3	13.04
1999	36	25.53	32	27.12	4	17.39
2000	33	23.4	30	25.42	3	13.04
Total	141	100.00	118	100.00	23	100.00

development in the mid-1990s, investors faced significant liquidity constraints. In a similar vein, Black, Garbade, and Silber (1981) and Rothberg, Nothaft, and Gabriel (1989) find that expansion of the Ginnie Mae (Government National Mortgage Association) market during the 1970s and 1980s had a significant damping effect on Ginnie Mae-Treasury yield spreads.

Past commercial property market returns: Case and Shiller (1989) and Atteberry and Rutherford (1993) provide empirical evidence that past returns to residential real estate have some predictive power for current returns. Similarly, in markets for commercial real estate, investors could interpret past returns as indicative of future performance. Accordingly, we test the hypothesis that stronger commercial property returns are associated with a contraction in risk spreads on commercial mortgages.

4.2.3. The reduced-form pricing model

Considering the CMBS pricing determinants, we estimate the following reduced form pricing model:

$$P_{it} = D_i\alpha + C_i\beta + W_t\gamma + \varepsilon_{it}, \tag{8}$$

where P_{it} is the spread (defined as the net coupon paid to CMBS investors minus the comparable maturity Treasury rate) for the ith commercial mortgage pool sold at time t. W_t is a set of economic and debt market factors that affect market-wide CMBS loan pricing. As those terms are typically time-varying, a subscript t is attached. C_i is a vector representing publicly observable CMBS loan characteristics. D_i is an indicator variable that takes on the value of one if the loan is conduit and zero otherwise and, thus, is the focus variable of our analysis. All things being equal, we expect a significant negative coefficient associated with D_i, representing the absence of a lemons discount in the pricing of conduit relative to portfolio loans.

4.3. Results of a CMBS deal-level analysis

In the secondary market, pricing usually is reported at the CMBS deal level. Those deals are typically made up of a large number of individual commercial mortgages. In our data set, CMBS deals contain an average of 149 mortgages. Accordingly, we first conduct a CMBS deal-level analysis to investigate whether investors pay higher prices, all things equal, for conduit CMBS loans than for portfolio CMBS loans.

There are a total of 718 CMBS deals in our database, among which 357 are conduit deals and 45 are portfolio deals.[17] For comparison purposes, we focus on conduit and portfolio deals transacted during the 1994–2000 period, when both portfolio loans sales and conduit loans sales were active. We exclude year 1998 because no portfolio deals are observed for that year. That leaves the 118 conduit deals and 23 portfolio deals listed in Table A1. Table 2 shows the distribution by year of conduit and portfolio deals in our sample. As is evident, with the rise in securitization markets during the latter half of the 1990s, the proportion of deals composed of conduit loans increased over time.

Table 3 reports descriptive statistics for the CMBS deals. Deal spreads, defined as the deal weighted average coupon minus comparable maturity Treasury bond rate, range from 66 to 509 bps, with an average of 233 bps. On average, the weighted debt-service coverage ratio of the 141 deals is 1.43, with a range from 1.04 to 2.32. About 29% of the loans in the included CMBS deals are multifamily loans, whereas office, retail, and industrial loans make up 15%, 29%, and 6% of the total, respectively. We compute measures of loan diversification of each deal, including a Herfindahl index of loan size, the geographic diversification entropy measure, and proportion of the deal composed of the five largest loans.[18] We also calculate the standard deviations of LTV ratio and DSCR of all loans in each deal, as reported in the table.

Table 4 reports the generalized least square (GLS) estimates of our reduced-form model in Eq. (8). Log deal balance at CMBS deal cutoff is used as a weight to correct potential heteroskedasticity. In Model 1, we include only a conduit dummy, which provides a simple comparison of the spreads of the two groups of deals. Results show that conduit deals are associated with a 43 bps lower spread. In Model 2, we add controls for market conditions that affect CMBS loan pricing. As expected, the CMBS market cap has a

[17] Other deal types include fusion deals, franchise deals, single-borrower deals, large loan deals, and the like.

[18] The geographic diversification entropy measure is calculated as

$$geo\_div = -\sum_{i=1}^{5} s_i \log_6 s_i + \left(1-\sum_{i=1}^{5} s_i\right)\log_6\left(1-\sum_{i=1}^{5} s_i\right),$$

where p_i is the proportion of loans in the top five concentrated states in the deal. The highest value this measure can take on is one, indicating that geographic diversification is evenly divided among different states.

Table 3
Descriptive statistics of commercial mortgage-backed securities (CMBS) deals in our sample. The deal spread is calculated as the deal net coupon (paid to investors) minus comparable maturity Treasury rate at deal cutoff. Prepayment coverage is calculated as the proportion of months covered by any of the following types of prepayment constraint: yield maintenance, lock out, prepayment penalty, or defeasance. The Herfindahl index for loan size, geographic diversification, and standard deviations of loan-to-value (LTV) ratio and debt-service coverage ratio (DSCR) are calculated using loan-level information for all loans in the deal.

Variable	Mean	Standard deviation	Minimum	Maximum
Deal spread	2.3322	0.6578	0.6613	5.0899
Conduit deal	0.8369	0.3708	0.0000	1.0000
Debt-service coverage ratio (DSCR) at deal cutoff	1.4338	0.1715	1.0400	2.3200
Weighted average maturity 10–20 years	0.6028	0.4911	0.0000	1.0000
Weighted average maturity > 20 years	0.0213	0.1448	0.0000	1.0000
Shares of multifamily loans	0.2858	0.2321	0.0000	1.0000
Shares of retail anchored property loans	0.1711	0.1760	0.0000	0.9338
Shares of office property loans	0.1528	0.1261	0.0000	0.5441
Shares of industrial property loans	0.0635	0.0820	0.0000	0.6239
Shares of retail unanchored property loans	0.1232	0.1561	0.0000	1.0000
Shares of health care property loans	0.0305	0.1128	0.0000	1.0000
Shares of full-service hotel loans	0.0206	0.0414	0.0000	0.3414
Log of deal cutoff balance	20.1363	0.7076	18.1717	21.5883
Weights of the five largest loans in the deal	0.3664	0.2801	0.1066	1.0000
Prepayment coverage	0.9576	0.6465	0.0000	2.1301
Herfindahl index for loan size	0.0211	0.0304	0.0009	0.3441
Geographic diversification	0.8647	0.1069	0.0005	0.9735
Standard deviation of LTV at loan origination	9.7954	2.7022	5.6235	25.9052
Standard deviation of loan DSCR	0.5415	0.2225	0.1401	2.0162
Number of loans	149	87	22	558
Number of deals	141			

significant negative effect on CMBS loan pricing, consistent with the notion that lower liquidity premia are required by investors as the market expands.[19] Similarly, as expected, the corporate bond credit spread and the interest rate volatility term are positively related to the CMBS deal spread. The slope of the yield curve enters with a significant negative sign. This result is consistent with findings from Bradley, Gabriel, and Wohar (1995), and Kau and Peters (2005). The lagged commercial real estate Sharpe ratio does not enter the analysis with a significant coefficient. Upon controlling for the observable market-wide risk characteristics, conduit deals are associated with a 26 bps lower spread than are portfolio deals.

In Model 3, we add CMBS pool characteristics as control variables. Variables representing property type compositions are mostly significant and of the expected sign. For example, consistent with the fact that multifamily and anchored retail loans are perceived to be less risky than other loan types, higher shares of multifamily and anchored retail loans are associated with lower required investor spreads. Further, findings indicate that share of hotel loans in the pool serves to boost the CMBS spread, as loans to hotel operators are generally viewed as relatively higher risk. Contrary to expectations, the prepayment constraint has a positive impact on CMBS spreads. This finding is consistent with that of An, Deng, and Sanders (2009) and perhaps reflects the borrower use of default as a means of loan termination in the case in which mortgage contract prepayment constraints are binding.[20] As would be expected, the more geographically diversified the pool, the lower the spread required by CMBS investors. Also, our Herfindahl measure of pool concentration by loan size is marginally significant and of the expected positive sign. Finally, upon controls for a large set of market conditions and CMBS pool characteristics, conduit deals are shown to enjoy a 33 bps pricing advantage.

Results of the deal-level regression indicate that investors pay significantly lower prices for portfolio loans than for conduit loans in the CMBS market. In that regard, findings here support our theoretical proposition of a lemons discount in the pricing of portfolio loans. That notwithstanding and to assess robustness of findings, we present results of loan-level analysis. Those tests allow more precise controls for loan underwriting and other observable risk characteristics.

4.4. A loan-level analysis

In this subsection, we examine individual loan-level data to assess the effects of conduit lender status on pricing of loans in commercial mortgage-backed securities markets. We focus on loans to investors in the four major property types: multifamily, office, retail, and industrial properties. Further, we restrict our sample to fixed-rate commercial loans. This leads to an exceptionally rich sample of 16,760 loans originated over the 1994–2000

[19] We also run the regression with annual CMBS issuance instead of CMBS market cap. The results are qualitatively unchanged.

[20] Similarly, in the subprime mortgage market, Quercia, Stegman, and Davis (2007) and Rose (2008) find evidence that prepayment penalties increase mortgage foreclosure risk.

Table 4
Generalized least square (GLS) estimates of the commercial mortgage-backed securities (CMBS) deal spread model. Dependent variable is the CMBS deal weighted average coupon (WAC) paid to investors (net WAC). Log deal balance is used as the weight in the GLS estimation. Standard errors are in parentheses, ***$p<0.001$, **$p<0.01$, *$p<0.05$ and b $-p<0.1$. There are 118 conduit deals and 23 portfolio deals in our sample.

Variable	Model 1	Model 2	Model 3
Intercept	2.685***	3.514***	5.088***
	(0.133)	(0.334)	(0.501)
Focus variable			
Conduit deal	−0.427***	−0.257*	−0.329**
	(0.145)	(0.116)	(0.109)
Market conditions			
Corporate bond credit spread		0.952b	1.064*
		(0.516)	(0.439)
CMBS market cap		−0.007***	−0.008****
		(0.001)	(0.001)
Slope of the Yield Curve		−1.165***	−1.007***
		(0.133)	(0.12)
Interest rate volatility		2.342*	1.868b
		(1.181)	(1.09)
Previous quarter Sharpe ratio of commercial real estate		0.011	0.019
		(0.035)	(0.029)
CMBS pool characteristics			
Debt-service coverage ratio (DSCR) at deal cutoff			−0.178
			(0.235)
Weighted average maturity 10–20 years			−0.097
			(0.089)
Weighted average maturity over 20 years			0.126
			(0.283)
Prepayment constraint coverage			0.320*
			(0.125)
Shares of multifamily loans			−1.063***
			(0.263)
Shares of anchored retail property loans			−0.786*
			(0.341)
Shares of office property loans			−0.689b
			(0.389)
Share of industrial loans			−1.226*
			(0.486)
Shares of unanchored retail property loans			−0.237
			(0.358)
Share of health care property loans			0.139
			(0.414)
Share of full service hotel loans			2.753**
			(0.981)
Herfindahl index for loan size			2.274b
			(1.289)
Geographic diversification			−0.918*
			(0.419)
Number of observations	141	141	141
Adjusted R-square	0.0516	0.4253	0.6022

period and included in the 141 CMBS deals evaluated above.

As reported in Table 5, unadjusted spreads to Treasuries on conduit loans (210 bps) were 47 bps lower than those associated with portfolio loans (257 bps). The median, minimum, and maximum of spreads were all lower for conduit loans than those for portfolio loans.

Table 6 reports the termination (cutoff) year breakout of conduit and portfolio loans. As would be expected, that distribution is roughly similar to the distribution of CMBS conduit and portfolio deals shown in Table 2.

Table 7 provides descriptive statistics on the loan-level sample. As indicated, the average spread of the 16,760 sampled conduit and portfolio loans over the 1994–2000 period was 220 bps. Average LTV was 69%, substantially lower than that of residential mortgages. Most of the commercial mortgage loans are balloon loans: about 83% of loans had amortization terms of 20–30 years and about 81% of loans had maturity terms of less than 10 years. Loans are from 10 regions all across the nation: Midwest/Eastern, Midwest/Western, Northeast/Mid-Atlantic, Northeast/New England, Southern/Atlantic, Southern/East Coast, Southern/West Coast, Western/Mountain, Western/Northern Pacific, and Western/Southern Pacific. About 74% of the loans (months) were covered by at least one form of prepayment constraint (lock out, yield maintenance, or prepayment penalty). Bank of America was the largest contributor of CMBS loans. Over 14% of loans in our sample were originated by Bank of America, either as portfolio loans or as conduit loans. Wachovia, GE Capital, JPMorgan Chase, Lehman Brothers, Wells Fargo, GMAC, Nomura, and CITI Group are among the top 10 originators of the commercial mortgage loans in our sample.

We estimate a reduced-form model in the form of Eq. (7) at the loan level. Our dependent variable is the mortgage-to-Treasury premium paid by investors in the secondary market as represented by the net spread. Our explanatory variables again include the variable of focus, the conduit dummy, and other controls representing market conditions and loan characteristics. Among the loan characteristics, controls for LTV ratio ( ), amortization term, maturity term, loan (property) location, and prepayment constraint were included in the model.[21] An important issue here is that CMBS investors are purchasing claims on the entire CMBS pool, and thus asset correlations and diversification matter. To account for this, we also include the CMBS deal-level information in our loan-level analysis.

Table 8 reports our estimates. Again, Model 1 demonstrates the raw spread differential. Conduit loans on average have a 44 bps lower spread. For the market conditions variables, the results are largely consistent with those reported in the deal-level analysis. For example, the corporate bond credit spread is significant and of the expected signs in all specifications. In contrast to findings reported in the deal-level analysis, however, the one-quarter lagged commercial real Sharpe ratio is significant and with expected sign in all specifications, suggesting that stronger lagged performance in the commercial property market is associated with lower commercial mortgage

[21] We use LTV ratio instead of debt-service coverage ratio because only a small proportion of our observations contain information on the DSCR at the CMBS deal cutoff point. For that small sample, we run a correlation analysis and find that LTV and DSCR are highly correlated, which suggests that LTV is good substitute for DSCR. In the robustness checks discussed below, we use the smaller sample to estimate the model using DSCR instead of LTV, so as to test the sensitivity of our results to this data limitation.

Table 5
Comparison of spreads of commercial mortgage-backed securities (CMBS) loans in conduit and portfolio deals. The spread is calculated as the loan net coupon (paid to investors) minus comparable maturity Treasury rate at deal cutoff. Linear interpolation is applied to Treasury rates to obtain the full term structure.

Loan type	Mean	Standard deviation	Minimum	Median	Maximum	Number of observations
Conduit	2.0984	0.7203	0.0150	2.0692	5.6800	13,655
Portfolio	2.5701	0.9409	0.0425	2.5645	7.1404	3105

Table 6
Cutoff year distribution of the loans in sampled conduit and portfolio deals. A total of 16,760 loans in 141 commercial mortgage-backed securities (CMBS) deals cut off during 1994 and 2000, not including 1998 in which there are no portfolio deals recorded. There are 13,055 loans in conduit deals and 3,105 loans in portfolio deals.

Cutoff year	All loans		Conduit loans		Portfolio loans	
	Number of loans	Percent of total	Number of loans	Percent of total	Number of loans	Percent of total
1994	332	1.98	180	1.32	152	4.9
1995	1,038	6.19	810	5.93	228	7.34
1996	2,118	12.64	1,713	12.54	405	13.04
1997	2,647	15.79	2,499	18.3	148	4.77
1999	6,739	40.21	4,950	36.25	1,789	57.62
2000	3,886	23.19	3,503	25.65	383	12.33
Total	16,760	100.00	13,055	100.00	3,105	100.00

Table 7
Descriptive statistics of sampled commercial mortgage-backed securities (CMBS) loans. The sample contains a total of 16,760 loans in the 141 commercial mortgage-backed securities (CMBS) deals.

Variable	Mean	Standard deviation	Minimum	Maximum
Spread	2.1955	0.7810	0.0167	7.1404
Loans in conduit deals	0.8147	0.3885	0.0000	1.0000
Loan-to-value (LTV) ratio	68.5743	10.9955	10.6900	125.0000
Amortization term ≤ 20 years	0.1553	0.3622	0.0000	1.0000
Amortization term > 30 years	0.0169	0.1288	0.0000	1.0000
Maturity term 10–20 years	0.1677	0.3736	0.0000	1.0000
Maturity term > 20 years	0.0232	0.1506	0.0000	1.0000
Midwest/Eastern	0.0922	0.2894	0.0000	1.0000
Midwest/Western	0.0334	0.1797	0.0000	1.0000
Northeast/Mid-Atlantic	0.1107	0.3137	0.0000	1.0000
Northeast/New-England	0.0452	0.2078	0.0000	1.0000
Southern/Atlantic	0.1847	0.3881	0.0000	1.0000
Southern/East-Coast	0.0305	0.1719	0.0000	1.0000
Southern/West-Coast	0.1465	0.3537	0.0000	1.0000
Western/Mountain	0.1001	0.3001	0.0000	1.0000
Western/Northern Pacific	0.1116	0.3149	0.0000	1.0000
Western/Southern Pacific	0.1450	0.3522	0.0000	1.0000
Prepayment constraint coverage	0.7361	0.3535	0.0000	1.4667
Quarter 2	0.2841	0.4510	0.0000	1.0000
Quarter 3	0.2137	0.4099	0.0000	1.0000
Quarter 4	0.2973	0.4571	0.0000	1.0000
Column	0.0828	0.2756	0.0000	1.0000
Bank of America	0.1430	0.3500	0.0000	1.0000
Wachovia	0.0790	0.2697	0.0000	1.0000
GE Capital	0.0431	0.2030	0.0000	1.0000
JPMorgan Chase	0.0476	0.2128	0.0000	1.0000
Lehman Brothers	0.0338	0.1806	0.0000	1.0000
Wells Fargo	0.0486	0.2150	0.0000	1.0000
GMAC	0.0436	0.2042	0.0000	1.0000
Nomura	0.0221	0.1471	0.0000	1.0000
CITI Group	0.0348	0.1834	0.0000	1.0000
Number of observations	16,760			

Table 8
Generalized least square (GLS) estimates of the commercial mortgage-backed securities (CMBS) mortgage spread model. Dependent variable is the net coupon paid to investors. Log loan balance at deal cutoff is used as the weight in the GLS estimation. Standard errors are in parentheses, ***$p < 0.001$, **$p < 0.01$, and *$p < 0.05$. There are 13,655 conduit loans and 3,105 portfolio loans in our sample.

Variable	Model 1	Model 2	Model 3	Model 4
Intercept	2.534***	3.126***	3.875***	4.151***
	(0.014)	(0.04)	(0.054)	(0.111)
Focus variable				
Loan in conduit deal	−0.443***	0.581***	−0.282***	−0.344***
	(0.015)	(0.014)	(0.016)	(0.017)
Market conditions				
Corporate bond credit spread		0.840***	0.633***	0.635***
		(0.058)	(0.055)	(0.056)
CMBS market cap		−0.005***	−0.005***	−0.006***
		(0)	(0)	(0)
Slope of the yield curve		−0.828***	−0.721***	−0.709***
		(0.017)	(0.016)	(0.016)
Interest rate volatility		3.771***	3.480***	3.943***
		(0.169)	(0.159)	(0.161)
Previous quarter Sharpe ratio of commercial real estate		−0.093***	−0.084***	−0.057***
		(0.009)	(0.008)	(0.008)
Loan characteristics				
Retail property loan			0.176***	0.159***
			(0.015)	(0.015)
Office property loan			0.170***	0.160***
			(0.012)	(0.012)
Industrial property loan			0.174***	0.170***
			(0.017)	(0.017)
Loan-to-value (LTV) ratio			−0.005***	−0.005***
			(0)	(0)
Amortization term ≤ 20 years			0.081***	0.095***
			(0.018)	(0.018)
Amortization term > 30 years			−0.227***	−0.216***
			(0.038)	(0.037)
Maturity term 10–20 years			−0.209***	−0.228***
			(0.015)	(0.015)
Maturity term > 20 years			−0.388***	−0.414***
			(0.034)	(0.034)
Midwest/Eastern			−0.031	−0.045*
			(0.021)	(0.021)
Midwest/Western			−0.066*	−0.071*
			(0.031)	(0.03)
Northeast/Mid-Atlantic			−0.014	−0.037
			(0.02)	(0.02)
Northeast/New-England			−0.039	−0.056*
			(0.027)	(0.027)
Southern/Atlantic			−0.059**	−0.078***
			(0.018)	(0.018)
Southern/East-Coast			−0.036	−0.052
			(0.032)	(0.031)
Southern/West-Coast			0.031	0.019
			(0.019)	(0.019)
Western/Mountain			−0.042*	−0.035
			(0.021)	(0.02)
Western/Northern Pacific			−0.020	−0.024
			(0.02)	(0.02)
Prepayment constraint coverage			−0.665***	−0.613***
			(0.017)	(0.017)
CMBS pool characteristics				
Weighted debt-service coverage ratio (DSCR) at deal cutoff				−0.105*
				(0.044)
Share of multifamily loans				−0.501***
				(0.06)
Share of retail anchored property loans				−0.497***
				(0.066)
Share of office loans				−0.512***
				(0.077)
Share of industrial loans				−0.789***
				(0.09)
Share of retail unanchored property loans				−0.733***
				(0.073)
Share of health care property loans				−0.867***

Table 8 (*continued*)

Variable	Model 1	Model 2	Model 3	Model 4
				(0.157)
Share of full-service hotel loans				1.370***
				(0.173)
Herfindahl index for loan size				4.276***
				(0.618)
Geographic diversification				0.311***
				(0.093)
Number of observations	16,760	16,760	16,760	16,760
Adjusted *R*-Square	0.0470	0.2154	0.3166	0.3317

Table 9
Conduit and portfolio loan spreads by property type. The spread is the difference between loan net coupon (paid to investors) and ***indicates that the difference is significant at the 0.1% level.

	Multifamily		Retail		Office		Industrial	
	Conduit	Portfolio	Conduit	Portfolio	Conduit	Portfolio	Conduit	Portfolio
Spread	2.0263	2.2851	2.1648	2.5614	2.1574	2.6752	2.1237	2.7222
	(0.7399)	(0.9411)	(0.6965)	(0.954)	(0.6757)	(0.9386)	(0.7434)	(0.8737)
Difference	26***		40***		52***		60***	
Number of observations	6,050	687	4,231	844	2,087	769	1,287	805

spreads. Regarding loan characteristics, as would be expected, findings indicate that property type matters to loan pricing. Compared with multifamily loans, the omitted category, retail, office, and industrial loans all have higher spreads. This is consistent with findings reported in Titman, Tompaidis, and Tsyplakov (2005). For the amortization term controls, the omitted group is loans with amortization terms between 20 and 30 years. Relative to the omitted category, loans with shorter amortization terms are apparently priced higher because amortization helps build equity so as to reduce default risk. This is also consistent with evidence in Episcopos, Pericli, and Hu (1998), Ciochetti, Deng, Gao, and Yao (2002), and An (2007). The omitted category among loan maturity controls is loans with maturity of less than 10 years. Interestingly, the longer the maturity terms, the higher the loan is priced. We also see variations with respect to where the property is located. For example, loans in Southern/Atlantic, Midwest/Western, and Western/Mountain areas are priced higher than those in the Western/Southern Pacific reference region. Prepayment constraints have significant positive impact on CMBS loan pricing, which is consistent with the common wisdom that investors require less prepayment premium when there are prepayment protections. Contrary to expectations, LTV ratio is shown to negatively affect loan spreads. This could be due to the endogeneity of LTV to commercial mortgage underwriting and pricing. However, further tests reveal the robustness of conduit pricing results to simultaneous equations specifications of LTV and loan pricing spread.[22] CMBS pool characteristics are shown to be important, as seen from Model 4. In that regard, variables including deal weighted debt-service coverage ratio, property type composition, and loan size diversification are significant and have the expected signs.

Finally, empirical results show a consistently negative and significant effect of our focus variable on commercial mortgage to Treasury spreads across different model specifications. In our comprehensive specification (Model 4), we find that conduit loans enjoyed a 34 bps price advantage over portfolio loans in the CMBS market after controlling for a wide array of loan quality, CMBS deal diversification, liquidity, and prepayment characteristics.

A further benefit of a loan-level analysis is that we can analyze the lemons discount by property type. Multifamily mortgage loans are much more homogeneous than retail, office, and industrial loans, suggesting that (in accordance with the comparative statics derived from Proposition 4 and as depicted in Fig. 4) the lemons discount should be lower among multifamily loans. Table 9 presents the raw difference in conduit-portfolio spreads by property types. In the model, we control for all the observable risk factors and add interactions between loan property type and the conduit dummy. Those results are reported in Table 10. As expected, results indicate that the multifamily lemons discount is the lowest among property types.

[22] In the simultaneous equations specifications, LTV ratio and other pricing variables enter the mortgage spread equation as explanatory variables while mortgage spread, as well as property type, amortization and maturity terms, and average LTV enter the LTV equation as explanatory variables. Results show that the estimated coefficient on LTV is negative and that the conduit dummy term remains highly significant and of roughly the same magnitude. We also investigate potential endogeneity of loan maturity term to the loan pricing spread. Findings again indicate the robustness of the conduit pricing effect.

Table 10
Generalized least square (GLS) estimates of the commercial mortgage-backed securities (CMBS) mortgage spread model with property type dummy interactions. The dependent variable is the net coupon paid to investors. Log loan balance at deal cutoff is used as the weight in the GLS estimation. Standard errors are in parentheses, ***$p<0.001$, **$p<0.01$, $b-p<0.05$, and $bp<$ 0.10. There are 13,655 conduit loans and 3,105 portfolio loans in the sample.

Variable	Model 4
Intercept	4.066***
	(0.112)
Focus variable	
Multifamily loan*conduit deal	−0.239***
	(0.027)
Retail loan*conduit deal	−0.325***
	(0.027)
Office loan*conduit deal	−0.365***
	(0.03)
Industrial loan*conduit deal	−0.510***
	(0.031)
Market conditions	
Corporate bond credit spread	0.637***
	(0.056)
CMBS market cap	−0.006***
	(0)
Slope of the yield curve	−0.712***
	(0.016)
Interest rate volatility	3.954***
	(0.162)
Previous quarter Sharpe ratio of commercial real estate	−0.057***
	(0.008)
Loan characteristics	
Retail property loan	0.239***
	(0.035)
Office property loan	0.271***
	(0.035)
Industrial property loan	0.373***
	(0.035)
Loan-to-value (LTV) ratio	−0.005***
	(0)
Amortization term ≤ 20 years	0.087***
	(0.018)
Amortization term > 30 years	−0.218***
	(0.037)
Maturity term 10–20 years	−0.228***
	(0.015)
Maturity term > 20 years	−0.413***
	(0.034)
Midwest/Eastern	−0.043*
	(0.021)
Midwest/Western	−0.068*
	(0.03)
Northeast/Mid-Atlantic	−0.036
	(0.02)
Northeast/New-England	−0.054*
	(0.027)
Southern/Atlantic	−0.077***
	(0.018)
Southern/East-Coast	−0.052
	(0.031)
Southern/West-Coast	0.018
	(0.019)
Western/Moutain	-0.032
	(0.02)
Western/Northern Pacific	−0.028
	(0.02)
Prepayment constraint coverage	−0.604***
	(0.017)
CMBS pool characteristics	
Weighted debt-service coverage ratio (DSCR) at deal cutoff	−0.105*
	(0.044)

Table 10 (*continued*)

Variable	Model 4
Share of multifamily loans	−0.486***
	(0.06)
Share of retail anchored property loans	−0.482***
	(0.066)
Share of office loans	−0.491***
	(0.077)
Share of industrial loans	−0.768***
	(0.09)
Share of retail unanchored property loans	−0.718***
	(0.073)
Share of health care property loans	−0.860***
	(0.157)
Share of full service hotel loans	1.387***
	(0.173)
Herfindahl index for loan size	4.348***
	(0.618)
Geographic diversification	0.285**
	(0.093)
Number of observations	16,760
Adjusted R-Square	0.3351

4.5. Robustness

In this subsection we report on results of a number of robustness analyses. We assess whether our results are sensitive to the use of DSCR instead of LTV ratio in our regression. As shown in Table A2, regression results indicate that research findings are largely robust to the substitution of DSCR for LTV in the regression analysis.

We also allow for the possibility that investors could pay a premium for loans originated by brand-name originators or by originators who have a reputation for strict underwriting. Accordingly, we include categorical controls for the top 25 originators in our sample, and the results are reported in Table A3. Investors pay a substantial premium for loans originated by lenders who had strong reputations in the commercial mortgage market, including GE Capital, JPMorgan Chase, Morgan Stanley, Wells Fargo, Principal Mortgage, and Penn Mutual. That notwithstanding, the coefficient of our focus variable remains unchanged.

We further stratify our loan-level sample by property type and rerun the analysis. Results, reported in Table A4, are consistent with those reported above in suggesting that the lemons discount is the lowest for multifamily loans and the highest for industrial loans.

In addition, we run the regressions by year of loan origination to account for potential issuance timing effects not captured by the market conditions variables used in our models. The results are reported in Table A5. As shown, those results are consistent with our prior findings.

Finally, we test the robustness of findings to the use of swap rates instead of constant maturity Treasury bond rates as the benchmark to computation of CMBS or commercial mortgage spreads. Findings are largely robust to the use of swap spreads.[23]

[23] We conduct additional robustness tests, for example, by classifying loan originators into commercial bank lenders and noncommercial bank

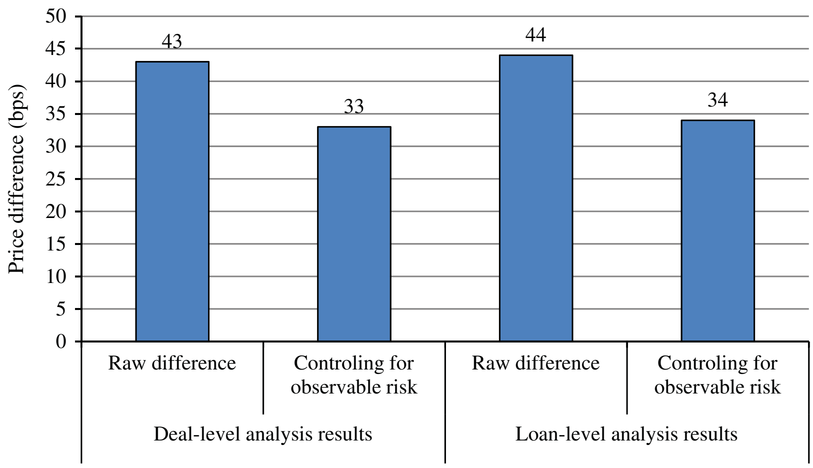

Fig. 5. Price difference between conduit loans and portfolio loans. This figure summarizes results of our empirical analysis regarding the basis point (bp) pricing premium of conduit loans over portfolio loans. For example, our commercial mortgage-backed securities (CMBS) deal-level analysis shows that after controlling for observable CMBS pool characteristics and other well-established determinants of CMBS pricing, conduit deals (loans) are priced 33 bps higher than portfolio loans.

Overall, results from both our deal-level and loan-level analyses strongly support our theoretical findings: Consistent with our hypothesis of a portfolio loan lemons discount, portfolio loans sold into the CMBS market are priced lower than conduit loans. We summarize our regression results in Fig. 5. There we observe a substantially higher price paid by CMBS investors for conduit CMBS deals (loans). While part of that difference can be explained by variations across deals in observable loan characteristics and debt market conditions, more than 30 bps of price difference remains between conduit deals (loans) and portfolio deals (loans). That pricing differential is consistent with our theoretical findings of a lemons effect, whereby portfolio loan lenders utilize private information to sell low quality loans into the CMBS market. CMBS investors take account of the adverse selection problem and accordingly pay lower prices for the portfolio loans.

5. Conclusions

While information asymmetry is a common feature of financial markets, empirical evidence of its pricing effect is limited. This paper presents an information economics model and related empirical evidence of asymmetric information and adverse selection effects in the market for commercial mortgage-backed securities. In the CMBS market, informed portfolio lenders possess private information on loan quality and seek to liquefy lower quality loans. Theoretical results show that sales of portfolio loans in securitization markets incorporate a lemons discount. In contrast, conduit lenders, who originate loans for direct sale into securitization markets and possess no private information on loan quality, serve to mitigate problems of asymmetric information and loan adverse selection. Our empirical estimates conform to theory. Results of reduced form pricing models at both the deal and loan level indicate that portfolio loans sold into securitization markets were priced 33 bps lower than conduit deals, after controlling for observable credit quality and other well-established determinants of CMBS pricing.

Our findings have important implications for the future of the mortgage derivatives market. Clearly, structural failings associated with the originate-to-distribute model require further business and policy scrutiny. However, results from this paper suggest that conduit lending has alleviated information problems associated with commercial mortgage securitization and in so doing enhanced efficiency in the CMBS marketplace. Those benefits should be retained in ongoing efforts to restructure and revitalize the commercial mortgage-backed securities markets.

Appendix A. Proof of Proposition 1

Let the supply of loans vary as a function of the sales price$p$.[24] The seller is willing to sell a loan if, and only if, the price is higher than or equal to his valuation (opportunity cost). Hence, the set of loans sold in the (Tables A1–A5) marketplace is

$$\Theta(p) = \{Y_i : R(Y_i) \le p\} \tag{9}$$

or, equivalently, the portion of the mortgage pool sold is

$$q(p) = \Pr(R(Y_i) \le p). \tag{10}$$

Given seller's valuation in Eq. (1) and the information available to the seller, the supply function is

$$\begin{aligned} q(p) &= \Pr\{E[(1-\delta)u + V_i + Z_i + \lambda q(p) | V_i] \le p\} \\ &= \Pr((1-\delta)u + V_i + \lambda q(p) \le p) \\ &= \frac{p - \lambda q(p) - (1-\delta)u - \underline{v}}{\overline{v} - \underline{v}} \end{aligned} \tag{11}$$

(*footnote continued*)
lenders, and we interact the bank indicator with the conduit dummy. The findings are largely robust to what we find here. These results are available upon request.

[24] Because the buyer cannot distinguish good loans from bad loans, there is a single price for all loans sold and thus there is no subscript in p.

Table A1
Names of commercial mortgage-backed securities (CMBS) deals in sample. There are a total of 141 CMBS deals cutoff during 1994–2000, not including 1998 in which there is no portfolio deals recorded. Among these deals, 118 are conduit deals and 23 are portfolio deals.

AETNA 1995-C5	FUNB 1999-C4	MLMI 1996-C2
AMRESCO 1997-C1	FUNB 2000-C1	MLMI 1997-C1
ASC 1995-D1	FUNB-CMB 1999-C2	MLMI 1997-C2
ASC 1996-D2	GECCMC 2000-1	MLMI 1999-C1
ASC 1996-D3	GMAC 1996-C1	MSCI 1995-GAL-1
BACM 2000-1	GMAC 1997-C1	MSCI 1996-BKU1
BACM 2000-2	GMAC 1999-C3	MSCI 1996-C1
BSCMS 2000-WF1	GMAC 2000-C1	MSCI 1996-WF1
BSCMS 2000-WF2	GMAC 2000-C2	MSCI 1997-ALIC
BSCMSI 1999-C1	GMAC 2000-C3	MSCI 1997-C1
BSCMSI 1999-WF2	GSMSCII 1996-PL	MSCI 1997-HF1
CAISSE 1999	GSMSCII 1999-C1	MSCI 1997-LB1
CCA1-2	HMAC 1999-PH1	MSCI 1997-WF1
CCMS 1996-1	HMAC 2000-PH1	MSCI 1999-CAM1
CCMS 1996-2	JPM 1995-C1	MSCI 1999-FNV1
CCMS 1997-1	JPM 1996-C2	MSCI 1999-RM1
CCMS 1997-2	JPM 1996-C3	MSCI 1999-WF1
CCMSC 1999-2	JPM 1997-C4	MSCI 2000-LIFE1
CCMSC 2000-1	JPM 1997-C5	MSDWC 2000-PRIN
CCMSC 2000-2	JPM 1999-C7	NASC 1994-C3
CCMSC 2000-3	JPM 1999-C8	NFC 1996-1
CMAC 1996-C1	JPMC 1999-PLS1	NFC 1999-1
CMAC 1999-C1	JPMC 2000-C10	NFC 1999-2
CMAT 1999-C1	JPMC 2000-C9	OCMI 1995-1
CMAT 1999-C2	KEY 2000-C1	PMAC 1996-M1
CMB-FUNB 1999-1	KPAC 1994-M1	PMAC 1999-C1
COMM 1999-1	LBCC 1995-C2	PMLI 1996-PML
COMM 2000-C1	LBCC 1996-C2	PNCMA 2000-C1
CSFB 1995-M1	LBUBS 2000-C3	PNCMAC 1999-CM1
CSFB 1995-MBL1	LBUBS 2000-C4	PNCMAC 2000-C2
CSFB 1995-WF1	LBUBS 2000-C5	PSSFC 1995-C1
CSFB 1999-C1	MCFI 1995-MC1	PSSFC 1995-MCF2
CSFB 2000-C1	MCFI 1996-MC1	PSSFC 1999-C2
DLJ 1994-MF11	MCFI 1996-MC2	PSSFC 1999-NRF1
DLJ 1995-CF2	MCFI 1997-MC1	RMF 1995-1
DLJ 1996-CF1	MCFI 1997-MC2	RMF 1997-1
DLJ 1996-CF2	MIDL 1996-C1	SASC 1995-C4
DLJ 1997-CF1	MIDL 1996-C2	SASC 1996-CFL
DLJ 1997-CF2	MLFA 1999-CAN2	SBMS 1996-C1
DLJ 1999-CG1	MLFA 2000-CAN3	SBMS 1999-C1
DLJ 1999-CG2	MLFA 2000-CAN4	SBMS 2000-C1
DLJ 1999-CG3	MLIC 1996-1	SBMS 2000-C2
DLJ 2000-CF1	MLMI 1994-C1	SBMS 2000-C3
DLJCMC 2000-CKP1	MLMI 1995-C1	SBMS-VII 2000-NL1
FUCMT 1999-C1	MLMI 1995-C2	SLCMT 1997-C1
FULB 1997-C1	MLMI 1995-C3	SMSC 1994-M1
FULB 1997-C2	MLMI 1996-C1	TIAA-RCMT 1999-1

which can be further simplified to

$$q(p) = \frac{p-(1-\delta)u-\underline{v}}{\overline{v}-\underline{v}+\lambda}. \tag{12}$$

Next, let the demand for loans in the secondary market vary as a function of price in the usual manner. If the buyer believes that the average value of the loans sold is ω, then the demand is

$$D(p) = \begin{cases} 0 & \text{if } \omega < p, \\ [0,\infty] & \text{if } \omega = p, \\ \infty & \text{if } \omega > p. \end{cases} \tag{13}$$

If loans in the set Θ^* are sold in a competitive equilibrium, and if the buyer believes the value of those

Table A2
Generalized least square (GLS) estimates of the commercial mortgage-backed securities (CMBS) mortgage spread model using debt-service coverage ratio (DSCR) instead of loan-to-value (LTV) ratio. Dependent variable is the net coupon paid to investors. Log loan balance at deal cutoff is used as the weight in the GLS estimation. This is a robustness check on whether using DSCR, not LTV, affects model results. The model specification is the same as that in Table 9, Model 4, except that the pool-level weighted average DSCR is dropped from the regression because it is highly correlated with the loan DSCR. Standard errors are in parentheses, $^{***}p<0.001$, $^{**}p<0.01$ and $^{*}p<0.05$. There are 861 conduit loans and 203 portfolio loans in the sample.

Variable	Model 4
Intercept	3.224***
	(0.745)
Focus variable	
Loan in conduit deal	−0.224***
	(0.065)
Market conditions	
Corporate bond credit spread	2.078***
	(0.325)
CMBS market cap	−0.007***
	(0.001)
Slope of the yield curve	−1.197***
	(0.09)
Interest rate volatility	3.777***
	(0.792)
Previous quarter Sharpe ratio	0.001
of commercial real estate	(0.028)
Loan characteristics	
Debt-service coverage ratio (DSCR)	−0.092***
	(0.024)
Amortization term ≤ 20 years	0.125
	(0.074)
Amortization term > 30 years	0.223
	(0.141)
Maturity term 10–20 years	−0.190**
	(0.064)
Maturity term > 20 years	−0.381***
	(0.084)
Midwest/Eastern	−0.069
	(0.089)
Midwest/Western	−0.067
	(0.114)
Northeast/Mid-Atlantic	−0.128
	(0.084)
Northeast/ New-England	0.026
	(0.104)
Southern/Atlantic	−0.143
	(0.074)
Southern/East-Coast	−0.111
	(0.117)
Southern/West-Coast	−0.016
	(0.074)
Western/Mountain	−0.031
	(0.081)
Western/Northern Pacific	−0.023
	(0.095)
Prepayment constraint coverage	−0.323***
	(0.079)
CMBS pool characteristics	
Share of multifamily loans	−1.539***
	(0.369)
Share of retail anchored property loans	−0.536
	(0.353)
Share of office loans	−0.825
	(0.451)
Share of industrial loans	−0.946
	(0.701)
Share of retail unanchored property loans	−0.929*
	(0.468)
Share of health care property loans	−0.450

Table A2 (*continued*)

Variable	Model 4
	(0.522)
Share of full service hotel loans	2.333*
	(1.155)
Herfindahl index for loan size	2.191
	(2.339)
Geographic diversification	0.784
	(0.647)
Number of observations	1,064
Adjusted *R*-Square	0.4334

Table A3

Generalized least square (GLS) estimates of the commercial mortgage-backed securities (CMBS) mortgage spread model with 25 originator dummies. Dependent variable is the net coupon paid to investors. Log loan balance at deal cutoff is used as the weight in the GLS estimation. Standard errors are in parentheses, *** $p<0.001$, ** $p<0.01$, * $p<0.05$, and $b-\ p<0.10$. There are 13,655 conduit loans and 3,105 portfolio loans in the sample.

Variable	Model 4
Intercept	4.216***
	(0.117)
Focus variable	
Loan in conduit deal	−0.261***
	(0.024)
Market conditions	
Corporate bond credit spread	−0.497***
	(0.054)
CMBS market cap	−0.006***
	(0)
Slope of the yield curve	−0.447***
	(0.015)
Interest rate volatility	4.471***
	(0.19)
Previous quarter Sharpe ratio of commercial real estate	−0.055***
	(0.009)
Loan characteristics	
Loan-to-value (LTV) ratio	−0.006***
	(0.001)
Amortization term ≤ 20 years	0.084***
	(0.018)
Amortization term > 30 years	−0.188***
	(0.039)
Maturity term 10–20 years	−0.190***
	(0.016)
Maturity term > 20 years	−0.297***
	(0.035)
Midwest /Eastern	−0.047*
	(0.022)
Midwest/Western	−0.058
	(0.031)
Northeast/Mid-Atlantic	−0.044*
	(0.021)
Northeast/New-England	−0.060*
	(0.028)
Southern/Atlantic	−0.071***
	(0.019)
Southern/East-Coast	−0.024
	(0.032)
Southern/West-Coast	0.040*
	(0.02)
Western/Moutain	−0.037
	(0.021)
Western/Northern Pacific	−0.055**
	(0.02)
Prepayment constraint coverage	−0.595***
	(0.018)

Table A3 (*continued*)

Variable	Model 4
Loan Originator	
Column Financial	0.266***
	(0.022)
Bank of America	−0.005
	(0.024)
Wachovia	0.042
	(0.024)
GE Capital	−0.189***
	(0.028)
JPMorgan Chase	−0.096***
	(0.027)
Lehman Brothers	−0.050
	(0.034)
Wells Fargo	−0.469***
	(0.031)
GMAC	−0.049
	(0.028)
Nomura	0.113**
	(0.039)
CITI Group	−0.035
	(0.031)
Midland	−0.137***
	(0.03)
Merrill Lynch	0.090**
	(0.033)
UBS	−0.041
	(0.033)
Morgan Stanley	−0.151***
	(0.038)
Conti	0.038
	(0.052)
Bear Sterns	−0.218***
	(0.039)
Key Bank	0.265***
	(0.04)
GACC	−0.183***
	(0.039)
Greenwich	−0.055
	(0.042)
Protective	0.069
	(0.071)
Provident	0.341***
	(0.062)
General American	0.078
	(0.06)
Confederation Life	0.342***
	(0.076)
Principal	−0.680***
	(0.054)
Penn Mutual	−0.445***
	(0.078)
CMBS pool characteristics	
Weighted debt-service coverage ratio (DSCR) at deal cutoff	0.264***
	(0.052)
Share of multifamily loans	−0.449***
	(0.067)
Share of retail anchored property loans	−0.284***
	(0.078)
Share of office loans	−1.411***
	(0.087)
Share of industrial loans	−0.581***
	(0.1)
Share of retail unanchored property loans	−0.126
	(0.082)
Share of health care property loans	−0.980***
	(0.171)
Share of full service hotel loans	1.620***
	(0.187)
Herfindahl index for loan size	2.488***

Table A3 (*continued*)

Variable	Model 4
	(0.72)
Geographic diversification	−0.349***
	(0.103)
Number of observations	16,760
Adjusted *R*-Square	0.3001

loans correctly reflect the actual average value of loans in equilibrium, then it must be the case that

$$\omega = E[Y_i | Y_i \in \Theta^*]. \tag{14}$$

Further, Eqs. (12) and (13) imply that the demand for loans can equal the supply of loans in an equilibrium with a

Table A4

Generalized least square (GLS) estimates of the commercial mortgage-backed securities (CMBS) mortgage spread model by property type. Dependent variable is the net coupon paid to investors. Log loan balance at deal cutoff is used as the weight in the GLS estimation. This is a robustness check on whether running the regression by property type affects model results. The model specification is the same as that in Table 9 model 4. Standard errors are in parentheses, ***$p<0.001$, **$p<0.01$ and *$p<0.05$.

Variable	Multifamily	Retail	Office	Industrial
Intercept	3.466***	5.372***	3.474***	5.076***
	(0.196)	(0.196)	(0.266)	(0.303)
Focus variable				
Loan in conduit deal	−0.320***	−0.391***	−0.341***	−0.541***
	(0.029)	(0.03)	(0.041)	(0.047)
Market conditions				
Corporate bond credit spread	1.149***	0.245*	0.204	0.393*
	(0.084)	(0.096)	(0.142)	(0.181)
CMBS market cap	−0.006***	−0.006***	−0.005***	−0.006***
	(0)	(0)	(0)	(0)
Slope of the yield curve	−0.846***	−0.651***	−0.514***	−0.555***
	(0.024)	(0.03)	(0.04)	(0.053)
Interest rate volatility	4.669***	3.920***	3.408***	3.269***
	(0.265)	(0.269)	(0.415)	(0.53)
Previous quarter Sharpe ratio	−0.079*	−0.201***	−0.190***	−0.084***
of commercial real estate	(0.037)	(0.038)	(0.027)	(0.014)
Loan characteristics				
Loan-to-value (LTV) ratio	−0.005***	−0.007***	−0.002	−0.004**
	(0.001)	(0.001)	(0.001)	(0.001)
Amortization term ≤ 20 years	0.069	−0.036	0.193***	0.169***
	(0.037)	(0.029)	(0.039)	(0.041)
Amortization term > 30 years	−0.192***	−0.158*	−0.304***	−0.167
	(0.053)	(0.074)	(0.075)	(0.206)
Maturity term 10–20 years	−0.190***	−0.199***	−0.169***	−0.329***
	(0.026)	(0.026)	(0.037)	(0.042)
Maturity term > 20 years	−0.271***	−0.428***	−1.151***	−0.381*
	(0.044)	(0.055)	(0.198)	(0.194)
Midwest/Eastern	0.009	−0.062	−0.017	−0.008
	(0.034)	(0.036)	(0.053)	(0.066)
Midwest/Western	0.011	−0.089	−0.180*	−0.107
	(0.045)	(0.053)	(0.075)	(0.108)
Northeast/Mid- Atlantic	0.099**	−0.116***	−0.145**	0.106
	(0.034)	(0.035)	(0.045)	(0.06)
Northeast/New-England	0.153***	−0.171***	−0.204***	0.049
	(0.046)	(0.044)	(0.059)	(0.082)
Southern/Atlantic	0.058	−0.143***	−0.142***	−0.025
	(0.031)	(0.03)	(0.043)	(0.053)
Southern/East-Coast	−0.022	−0.029	−0.100	0.117
	(0.046)	(0.051)	(0.09)	(0.18)
Southern/West-Coast	0.119***	0.011	−0.025	−0.030
	(0.03)	(0.035)	(0.054)	(0.061)
Western/Moutain	0.024	−0.042	−0.102*	−0.013
	(0.035)	(0.035)	(0.047)	(0.053)
Western/Northern Pacific	0.035	−0.003	−0.108**	−0.047
	(0.038)	(0.038)	(0.041)	(0.042)
Prepayment constraint coverage	−0.556***	−0.587***	−0.636***	−0.674***
	(0.029)	(0.031)	(0.039)	(0.045)
CMBS pool characteristics				
Weighted debt-service coverage ratio(DSCR) at deal cutoff	−0.167*	−0.001	0.231*	−0.659***
	(0.068)	(0.08)	(0.11)	(0.153)
Share of multifamily loans	−0.573***	−0.452***	0.531**	−0.042
	(0.087)	(0.121)	(0.195)	(0.226)

Table A4 (*continued*)

Variable	Multifamily	Retail	Office	Industrial
Share of anchored retail loans	−0.366**	−0.708***	−0.203	−0.888***
	(0.118)	(0.108)	(0.175)	(0.22)
Share of office loans	−0.397**	−0.243	−0.253	−0.701**
	(0.123)	(0.136)	(0.201)	(0.239)
Share of industrial loans	−0.941***	−1.044***	−1.281***	−0.897***
	(0.164)	(0.156)	(0.255)	(0.217)
Share of unanchored retail loans	−0.604***	−1.092***	−0.523**	−0.701**
	(0.122)	(0.126)	(0.193)	(0.216)
Share of health care property loans	−1.012***	−1.422***	0.137	−0.305
	(0.209)	(0.323)	(0.539)	(0.567)
Share of full service hotel loans	1.048***	1.031***	1.688***	1.926**
	(0.265)	(0.291)	(0.462)	(0.618)
Herfindahl index for loan size	2.077*	6.038***	9.468***	22.225***
	(0.939)	(1.042)	(1.911)	(2.41)
Geographic diversification	0.679***	−0.394*	0.333	0.402
	(0.168)	(0.165)	(0.238)	(0.234)
Number of observations	6,737	5,075	2,856	2,092
Adjusted *R*-Square	0.3313	0.3588	0.3414	0.3786

Table A5
Generalized least square (GLS) estimates of the commercial mortgage-backed securities (CMBS) mortgage spread model with stratified sample. These are weighted least square regression results. Log balance is used as the weight. Standard errors are in parentheses, ***$p<0.001$, **$p<0.01$, *<0.05, and $b-p<0.10$. Some variables are omitted from the explanatory variable list due to singularity problem. That is, there is not enough variation in those variables.

Variable	1994	1995	1996	1997	1999	2000
Intercept	−2.880	4.138***	4.657***	5.948***	2.298***	1.543***
	(1.856)	(1.032)	(1.054)	(0.515)	(0.339)	(0.323)
Focus variable						
Loan in conduit deal	−0.388**	−0.414***	−0.412***	−0.389***	−0.385***	−0.344***
	(0.134)	(0.093)	(0.072)	(0.072)	(0.035)	(0.05)
Market conditions						
Corporate bond credit spread	9.080**	0.717	7.269***	3.140***	2.018***	3.171***
	(2.755)	(1.487)	(1.404)	(0.417)	(0.116)	(0.146)
Interest rate volatility	1.328	7.044***	5.048***	1.273**	1.817***	4.469***
	(2.141)	(0.711)	(0.841)	(0.414)	(0.5)	(0.345)
Previous quarter Sharpe ratio	−0.314***	−0.239**	−0.043	−0.033***	−0.079***	−0.052**
of commercial real estate	(0.091)	(0.077)	(0.029)	(0.01)	(0.015)	(0.016)
Loan characteristics						
Loan-to-value (LTV) ratio	−0.013***	−0.010***	−0.007***	−0.008***	−0.006***	−0.001
	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Amortization term $\leq$ 20 years	−0.007	−0.032	0.061	0.024	0.100***	0.038
	(0.198)	(0.066)	(0.056)	(0.033)	(0.026)	(0.04)
Amortization term $>$30 years	−1.760***	−0.252	0.118	−0.296***	−0.315***	−0.150**
	(0.414)	(0.241)	(0.334)	(0.082)	(0.058)	(0.052)
Maturity term 10–20 years	−0.169	−0.199***	−0.248***	−0.187***	−0.266***	−0.195***
	(0.132)	(0.059)	(0.053)	(0.028)	(0.023)	(0.036)
Maturity term $>$20 years	−0.328*	−0.455***	−0.026	−0.288***	−0.452***	−0.446***
	(0.164)	(0.098)	(0.084)	(0.057)	(0.065)	(0.128)
Midwest/EasternSTERN	0.282	−0.186*	0.051	−0.029	−0.080*	0.049
	(0.194)	(0.09)	(0.064)	(0.042)	(0.034)	(0.037)
Midwest/Western	−0.309	−0.008	−0.027	−0.014	−0.108*	−0.053
	(0.242)	(0.123)	(0.102)	(0.051)	(0.047)	(0.055)
Northeast/Mid-Atlantic	0.146	0.125	0.049	−0.001	−0.055	0.004
	(0.172)	(0.103)	(0.066)	(0.039)	(0.032)	(0.035)
Northeast/New-England	0.031	−0.041	0.150	0.019	−0.117**	0.021
	(0.305)	(0.118)	(0.084)	(0.049)	(0.044)	(0.044)
Southern/Atlantic	−0.276	−0.050	0.076	−0.095**	−0.150***	0.045
	(0.182)	(0.078)	(0.057)	(0.035)	(0.028)	(0.033)
Southern/East-Coast	0.222	0.002	0.275***	−0.033	−0.253***	−0.044
	(0.217)	(0.112)	(0.081)	(0.055)	(0.055)	(0.064)
Southern/West-Coast	0.042	−0.030	0.072	−0.025	−0.099**	0.145***
	(0.161)	(0.08)	(0.058)	(0.036)	(0.03)	(0.035)
Western/Moutain	−0.346*	0.060	0.131	−0.001	−0.072*	0.004
	(0.171)	(0.089)	(0.069)	(0.04)	(0.03)	(0.039)
Western/ Northern Pacific	0.070	−0.043	0.011	−0.047	−0.084**	−0.006
	(0.173)	(0.112)	(0.086)	(0.046)	(0.026)	(0.039)

Table A5 (*continued*)

Variable	1994	1995	1996	1997	1999	2000
Prepayment constraint coverage	−0.607***	0.016	0.283*	0.105	−0.797***	−0.496***
	(0.127)	(0.083)	(0.111)	(0.088)	(0.03)	(0.032)
CMBS pool characteristics						
Weighted debt-service coverage ratio (DSCR) at deal cutoff	−0.023	−0.653	−0.256*	−0.488**	−0.889***	1.068***
	(0.217)	(0.5)	(0.118)	(0.182)	(0.162)	(0.105)
Share of multifamily loans	–	−0.512**	−2.151***	−0.866***	1.082***	2.289***
	–	(0.193)	(0.177)	(0.178)	(0.222)	(0.177)
Share of retail anchored property loans	–	0.067	−1.922***	−0.623***	0.612***	−1.511***
	–	(0.305)	(0.168)	(0.169)	(0.165)	(0.178)
Share of office loans	–	−0.489	−2.696***	0.373	1.055***	−0.997***
	–	(0.558)	(0.346)	(0.238)	(0.241)	(0.187)
Share of industrial loans	–	−0.294	−2.780***	−0.420	−2.160***	−3.376***
	–	(0.228)	(0.411)	(0.23)	(0.335)	(0.331)
Share of retail unanchored property loans	–	−0.720***	−3.797***	−0.157	0.866***	−2.821***
	–	(0.189)	(0.198)	(0.185)	(0.252)	(0.37)
Share of health care property loans	–	−3.931	−6.349***	−0.819***	−2.586***	−15.435***
	–	(2.36)	(0.595)	(0.223)	(0.558)	(1.343)
Share of full service hotel loans	–	0.878	−6.715***	−0.662	0.802*	−0.038
	–	(0.703)	(0.664)	(0.486)	(0.377)	(0.41)
Herfindahl index for loan size	–	9.275	0.468	10.555***	6.072**	−0.204
	–	(10.362)	(1.649)	(2.282)	(2.29)	(1.92)
Geographic diversification	–	–	−0.030	−0.143	−0.058	−2.122***
	–	–	(0.38)	(0.575)	(0.262)	(0.307)
Number of observation	332	1038	2118	2647	6739	3386
Adjusted R-square	0.2998	0.2451	0.3742	0.2207	0.4028	0.3299

positive share of loans q^* sold if, and only if,

$$p^* = E[Y_i | R(Y_i) \le p^*] \tag{15}$$

and

$$q(p)^* = p^* - (1-\delta)u - \frac{\underline{v}}{\overline{v} - \underline{v} + \lambda.} \tag{16}$$

Eq. (15) can be further written as

$$p^* = E[u + V_i + Z_i | (1-\delta)u + V_i + Z_i + \lambda q^*(p) \le p^*]. \tag{17}$$

Because

$$E[u + V_i + Z_i | (1-\delta)u + V_i + Z_i + \lambda q(p)^* \le p^*]$$
$$= \int_{\underline{v}}^{p^* - \lambda q(p)^* - (1-\delta)u} (u + V_i) \frac{1}{u + p^* - \lambda q(p)^* - (1-\delta)u - (u + \underline{v})} dV_i$$
$$= \frac{(1+\delta)u}{2} + \frac{p^*}{2} + \frac{\underline{v}}{2} - \frac{q(p)^*}{2}, \tag{18}$$

putting Eqs. (16) and (17) together, yields

$$q(p)^* = \frac{2\delta u}{\overline{v} - \underline{v} + 2\lambda} \tag{19}$$

and

$$p^* = u + \frac{(\overline{v} - \underline{v})\delta}{\overline{v} - \underline{v} + 2\lambda} u + \underline{v}. \qquad \square \tag{20}$$

Appendix B. Proof of Proposition 2

Because neither party knows the exact value of V_i, the seller's valuation is

$$R(Y_i) = E[(1-\delta)u + V_i + Z_i + \lambda q(p) + Z_i] = (1-\delta)u + EV_i + \lambda q(p). \tag{21}$$

The buyer knows that the seller will not distinguish good loans from bad loans and thus there is no adverse selection. His valuation of the loans is simply $\omega = E[Y_i] = u + EV_i$. Therefore, the seller's valuation $R(Y_i)$ is lower than the buyer's valuation ω for each loan. As a result, the equilibrium price is $p^* = u + EV_i = u + (\overline{v} + \underline{v})/2$ and all loans are sold, i.e., $q_* = 1$. $\square$

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