Synthetic or Real?
The Equilibrium Effects of Credit Default Swaps on Bond Markets *

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Abstract

We provide a model of non-redundant credit default swaps (CDSs), building on the observation that CDSs have lower trading costs than bonds. CDS introduction involves a trade-off: It crowds out demand for the bond, but improves the bond allocation because it allows long-term investors to become levered basis traders. CDS introduction raises bond prices only when there is a significant trading-cost difference between bond and CDS. Our framework predicts a negative CDS-bond basis, turnover and price impact patterns that are consistent with empirical evidence, and shows that a ban on naked CDSs can raise borrowing costs.

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1 Introduction

Credit Default Swap (CDS) markets have grown enormously over the last decade. However, while there is a relatively large literature on the pricing of CDSs, much less work has been done on the economic role of these markets. For example, in most pricing models, CDSs are redundant securities, such that the introduction of a CDS market has no effect on the underlying bond market. This irrelevancy feature makes a meaningful analysis of the economic role of CDS markets difficult.

In this paper, we develop a theory of non-redundant CDS markets, building on a simple, well-documented empirical observation: Trading bonds is expensive relative to trading CDSs. Based on this observation, we develop a theory of the interaction of bond and CDS markets and the economic role of CDSs. Our model provides an integrated framework that matches many of the stylized facts in bond and CDS markets: the effect of CDS markets on the price of the underlying bond (and therefore financing cost for issuers), the relative pricing of the CDS and the underlying bond (the CDS-bond basis), and trading volume in the bond and CDS markets. Our model also provides a tractable framework to assess policy interventions in CDS markets, such as the recent E.U. ban of naked CDS positions.

In our model, investors differ across two dimensions. First, investors differ in their investment horizons: Some investors are unlikely to have to sell their position in the future and are therefore similar to buy-and-hold investors, such as insurance companies. Other investors are more likely to receive liquidity shocks and therefore have shorter investment horizons. These investors can be interpreted as traders that face redemption risk (e.g., mutual funds), investors that express short-term views, or investors with frequent consumption needs. Second, investors have heterogeneous beliefs about the bond’s default probability: Optimistic investors view the default of the bond as unlikely, while pessimists think that a default is relatively more likely. If only the bond is traded, relatively optimistic investors with sufficiently long trading horizons buy the bond, whereas relatively pessimistic investors with sufficiently long trading horizons take short positions in the bond. Investors
with short investment horizons stay out of the market, because for them the transaction costs of trading the bond are too high.

The introduction of a CDS affects the underlying bond market through three effects: (1) Some investors who previously held a long position in the bond switch to selling CDS protection, putting downward pressure on the bond price. (2) Investors who previously shorted the bond switch to buying CDS protection because, in equilibrium, the relatively illiquid bond trades at a discount compared to the CDS. The resulting reduction in short selling puts upward pressure on the bond price. (3) Some investors become “negative basis traders” who hold a long position in the bond and purchase CDS protection (i.e., the model endogenously generates the negative basis trade, which has been an immensely popular trading strategy in recent years). If basis traders cannot take leverage, they do not affect the price of the underlying bond. If basis traders can take leverage—a natural assumption given that they hold hedged positions—they push up the bond price. In practice, basis trades are often highly levered and their leverage varies with financial conditions, leading to time-series variation in the strength of this third effect.

Taken together, these three effects imply that, in general, CDS introduction is associated with an ambiguous change in the price of the underlying bond. This prediction is consistent with the empirical literature, which has found no unconditional effect of CDS introduction on bond or loan spreads (Hirtle (2009), Ashcraft and Santos (2009)). More importantly, our model identifies the underlying economic trade-off that determines the effect of CDS introduction. On the one hand, CDS introduction can crowd out demand for the bond, while on the other hand it leads to an allocational improvement in the bond market, because the presence of the CDS allows long-term investors to hold more of the bond supply. The balance of this trade-off critically depends on the relative trading costs of the bond and the CDS: When trading costs of the bond and the CDS are similar in magnitude, the crowding out effect dominates and CDS introduction lowers bond prices. In contrast, when CDS trading costs are substantially lower than bond trading costs, the additional demand from levered basis traders is large, such that the introduction of the CDS tends to raise bond prices. The same logic implies that,
for firms with multiple bond issues of differing liquidity (e.g., “on-the-run” and “off-the-run” bonds), bond issues with high trading costs benefit relatively more from CDS introduction, to the extent that the price effect of CDS introduction can go in opposite directions even for bonds by the same issuer.

The endogenous emergence of leveraged basis traders highlights a novel economic role of CDS markets: The introduction of a derivative market allows buy-and-hold investors, who are efficient holders of the illiquid bond, to hedge unwanted credit risk in the more liquid CDS market. In the CDS market, the average seller of CDS protection is relatively optimistic about the bond’s default probability, but is not an efficient holder of the bond because of more frequent liquidity shocks. The role of CDS markets is therefore similar to liquidity transformation—by repackaging the bond’s default risk into a more liquid security, they allow the transfer of credit risk from efficient holders of the bond to relatively more optimistic shorter-term investors. Hence, when bonds are illiquid, a liquid CDS can improve the allocation of credit risk and thus presents an alternative to recent proposals that aim at making the corporate bond market more liquid, for example through standardization (e.g., BlackRock (2013)).

Beyond the price effects of CDS introduction, our model generates testable predictions regarding trading volume in bond and CDS markets that are consistent with recent empirical evidence. First, our model predicts that CDS turnover is higher than bond turnover, which is consistent with the evidence in Oehmke and Zawadowski (2013), who show that average monthly CDS turnover is around 50%, whereas average monthly turnover in the associated bonds is around 7.5%. Second our model predicts that CDS introduction decreases turnover in the underlying bond. However, despite this decrease in turnover, CDS introduction can reduce price impact with respect to bond supply shocks. Therefore, consistent with Das, Kalimipalli, and Nayak (2014), the effect of CDS introduction on bond market liquidity can differ depending on which particular liquidity measure (e.g., turnover or price impact) is used.

From an asset pricing perspective, the prediction that the equilibrium price of the bond is (weakly) less than the price of a synthetic bond consisting of a risk-free bond and a short position in the CDS
replicates a well-documented empirical phenomenon known as the negative CDS-bond basis (see, e.g., Bai and Collin-Dufresne (2013)). Our model generates a number of predictions regarding both the time-series and cross-sectional variation in the CDS-bond basis: The basis is more negative if the bond is more illiquid, when there is more disagreement about the bond’s default probability, and when basis traders are restricted in the amount of leverage they can take.

Finally, our model provides a framework to study regulatory interventions with respect to CDS markets. For example, a ban on naked CDS positions, as recently imposed by the European Union on sovereign bonds through EU regulation 236/2012, may, in fact, raise yields for affected issuers. If pessimistic investors cannot take naked CDS positions, some of them will short the bond instead. This exerts downward price pressure on bond prices: Owing to differences in trading costs, naked CDS positions are not equivalent to short positions in the bond because, depending on the instrument that is used, a different set of investors takes the other side. Similarly, interventions that ban CDS markets altogether, or even both CDSs and short selling of the bond, do not necessarily increase bond prices.

Our paper contributes to a growing literature on derivatives as non-redundant securities.1 In our framework, the reason that a zero-net-supply derivative is non-redundant is a difference in the trading costs of the underlying security and the derivative, combined with uninsurable liquidity shocks, which we model using the classic framework of Amihud and Mendelson (1986). Given the well-documented illiquidity of corporate bonds, this source of non-redundancy is likely to be particularly important in the context of the CDS market. The existing literature has focused on different, potentially complementary, sources of non-redundancy. Gârleanu and Pedersen (2011) explore the relative pricing of derivatives and underlying assets when derivatives have lower margin requirements and apply this framework to the CDS-bond basis. Shen, Yan, and Zhang (2013) develop a model of financial innovation based on differences in margin requirements. Neither of these two papers focuses on the consequences of derivative introduction on the underlying asset, the main focus of our paper. Banerjee and Graveline (2014) show that derivatives can relax binding short-sales constraints when the

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1Hakansson (1979) provides an early discussion of why derivatives should be studied in settings where they are not redundant.
underlying security is scarce (on “special”). In their model, the introduction of the derivative always decreases the price of the scarce asset, at least under reasonable investor preferences. Our approach does not rely on explicit short-sale constraints and, therefore, applies also in situations where the underlying asset can be shorted relatively easily. Perhaps the closest related papers are Fostel and Geanakoplos (2012) and Che and Sethi (2014). Also set in a differences-in-beliefs setup, these papers show that, in the presence of short-sale constraints, naked CDSs can facilitate negative bets that decrease the price of the underlying asset because optimists must set aside collateral to take the other side (see also Geanakoplos (2010) and Simsek (2013)). Che and Sethi (2014) also show that when only covered CDS positions are allowed, CDS introduction can increase bond prices because it allows optimists to take leverage (equivalent to collateralized borrowing). Their focus on short-sale constraints and leverage contrasts with our focus on differences in trading costs. These differences in assumptions lead to different predictions: For example, in Che and Sethi (2014), CDS introduction never raises borrowing costs if short selling is possible. In addition, our liquidity-based approach generates predictions on the CDS-bond basis and allows us to study turnover and price impact in the bond and CDS markets, as well as the effect of CDS introduction on different bonds by the same issuer.2,3

2 Model Setup

We consider a financial market with (up to) two risky assets: (i) a defaultable bond and (ii) a CDS that references the bond. The main assumption of our model is that the bond and the CDS, which

2Further sources of non-redundancy that have been analyzed include market incompleteness (Detemple and Selden (1991)), the informational effects of derivative markets (Grossman (1988), Biels and Hillion (1994), Easley, O’Hara, and Srinivas (1998), and Goldstein, Li, and Yang (2014)), the possibility that derivatives generate sunspots (Bowman and Faust (1997)), and changes in the relative bargaining power of a firm’s claimholders (Bolton and Oehmke (2011), Arping (2014)).

offer exposure to the same credit risk, differ in trading costs. This difference in trading costs makes the zero-net-supply CDS non-redundant.⁴

A number of empirical studies have documented high trading costs in the corporate bond market, which contrast with the significantly lower trading costs in CDS markets.⁵ This difference in trading costs is driven by a number of factors. First, the CDS market is much more standardized than the bond market, where an issuer’s bonds are usually fragmented into a number of different issues that differ in their coupons, maturities, covenants, embedded options, etc.⁶ Second, dealer inventory management is generally cheaper for CDS dealers than for market makers in bond markets: Because the CDS is a derivative and can be created at will, there is no need to locate a security and no ex-ante inventory has to be held. Third, a CDS investor who wants to terminate an existing position rarely sells the original CDS in the secondary market; he simply enters an offsetting CDS contract (that can be created), which is usually cheaper.

Following Amihud and Mendelson (1986), we model illiquidity by assuming that investors incur trading costs, which we interpret broadly as reflecting both bid-ask spreads and the price impact costs of executing a trade. Our main assumption, based on the evidence discussed above, is that these trading costs are lower for the CDS than the associated bond.⁷,⁸

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⁴Our liquidity-based view of CDS markets echoes Ashcraft and Santos (2009) who observe that “Liquidity in the bond market has been limited because many investors hold their bonds until maturity. [...] Under these circumstances, the development of the CDS market provided banks and investors with a new, less expensive, way to hedge or lay off their risk exposures to firms.”

⁵See, e.g., Bessembinder, Maxwell, and Venkataraman (2006), Edwards, Harris, and Piwowar (2007), and Bao, Pan, and Wang (2011). Effective trading costs for bonds include bid-ask spreads and the price impact of trading. Using the most liquid bonds in TRACE, Bao, Pan, and Wang (2011) estimate effective trading costs for corporate bonds of 74–221 basis points. Hilscher, Pollet, and Wilson (2014) report bid-ask spreads of 4-6 basis points for five-year credit default swaps on IG bonds, which thus implies trading costs of around 20-30 basis points, significantly lower than the effective bond trading costs reported by Bao, Pan, and Wang (2011). Moreover, as Randall (2013) points out, large trades ($10M+) are hard to execute in the bond market and usually have even larger transaction costs, whereas trades exceeding $10M in notional are common in CDS markets.

⁶Consistent with this argument, Oehmke and Zawadowski (2013) show that, CDS markets are more active and more likely to exist for firms whose outstanding bonds are fragmented into many separate bond issues.

⁷While we take the difference in trading costs between the bond and the CDS as given, a number of search-theoretic models have explored endogenous differences in liquidity between assets with identical payoffs (Vayanos and Wang (2007), Vayanos and Weill (2008), Weill (2008)). In this context, Praz (2014) studies the interaction between a (liquid) Walrasian and a (less liquid) OTC market, while Sambalaibat (2014) studies the effect of naked CDS trading in search markets.

⁸There are two interpretations of the trading costs in our model. One view is that trading costs are simply transfers to (competitive) dealers. Under this interpretation, trading costs simply reflect the dealers’ costs of (efficient) liquidity provision
2.1 Bond

A defaultable bond is traded in positive supply $S > 0$. We denote the bond’s equilibrium ask price by $p$. The bond matures with Poisson arrival rate $\lambda$. As will become clear below, the assumption of Poisson maturity is convenient because it guarantees stationarity. None of our results depend on this assumption. For simplicity we assume that the bond does not pay coupons. At maturity, the bond pays back its face value of $1$ with probability $1 - \pi$. With probability $\pi$, the bond defaults and pays $0$.\(^9\) We capture illiquidity of the bond market in terms of a bond trading cost $c_B$ that arises when the bond is traded. Specifically, following Amihud and Mendelson (1986), we assume that the bond can be bought at the ask price $p$ and sold (or short sold) at the bid price $p - c_B$.\(^10\)

2.2 Credit default swap

In addition to the bond, a CDS that references the bond is available in zero net supply. The CDS is an insurance contract on the bond’s default risk: It pays off $1$ if the bond defaults at maturity and zero otherwise. For simplicity we assume that the CDS matures at the same time as the bond. We denote the CDS’s equilibrium ask price by $q$.\(^11\) The (relatively low) trading cost in the CDS market is denoted by $c_{\text{CDS}}$. Hence, an investor can purchase CDS protection at the ask price $q$ and sell protection and inventory management. Alternatively, trading costs may reflect undersupply of liquidity due to market power of dealers. While the positive results in the main part of our paper do not depend on the specific interpretation, the source of trading costs matters when drawing normative conclusions (see Section 5.1).

\(^9\)This implies that default only occurs at maturity. Alternatively, one could assume that default can occur continuously with Poisson arrival rate. We chose the setup with default only at maturity because it is particularly tractable and yields the same economic insights as a model with continuous default.

\(^10\)We do not impose any additional cost on short selling beyond the trading cost $c_B$. While it would be straightforward to add this to the model, treating long and short positions symmetrically highlights that, in contrast to a number of existing papers on CDS or derivative introduction (Banerjee and Graveline (2014), Che and Sethi (2014), Fostel and Geanakoplos (2012)), our results do not require short-sale restrictions. The evidence in Asquith, Au, Covert, and Pathak (2013) suggests that, on average, shorting corporate bond is not significantly more costly than shorting stocks, which makes a framework that does not explicitly rely on significant shorting costs appealing.

\(^11\)In practice, CDS contracts have fixed maturities (also known as tenors), the most common being 1, 5 and 10 years. Our setup, where both the bond and the CDS randomly mature at the same time is comparable to a setup in which investors match maturities of finite-maturity bonds and CDSs. Moreover, CDS premia are usually paid over time (quarterly), with a potential upfront payment at inception of the contract. The CDS price $q$ should thus be interpreted as the present value of future CDS premia and the upfront payment.
at the bid $q - c_{\text{CDS}}$. Trading costs in the CDS market are lower than in the bond market, such that

$$c_B \geq c_{\text{CDS}} \geq 0. \quad (1)$$

For most of our analysis, we follow Longstaff, Mithal, and Neis (2005) in assuming, for simplicity, that the CDS market involves no transaction costs, such that $c_{\text{CDS}} = 0$. In Section 4.3.3, we extend our analysis to the case in which also the CDS is subject to trading costs, $c_{\text{CDS}} > 0$.

### 2.3 Investors

There is a mass of risk-neutral, competitive investors who can trade the bond and the CDS. For simplicity, we set the investors’ rate of time preference to zero. Investors are heterogeneous across two dimensions: (i) expected holding periods and (ii) beliefs about default probabilities.

Expected holding periods differ across investors because investors are hit by uninsurable liquidity shocks with Poisson intensity $\mu_i \in [0, \infty)$. Investors with low $\mu_i$ can be interpreted as buy-and-hold investors (for example, insurance companies or pension funds), whereas investors with high $\mu_i$ are investors subject to more frequent liquidity shocks (for example, traders that face redemption risk, express short-term views, or face frequent consumption needs investors that are expressing shorter-term views). When hit by a liquidity shock, an investor has to liquidate his position and exits the model. To preserve stationarity, we assume that a new investor with the same characteristics enters.

With respect to investor beliefs, we assume that investors agree to disagree about the bond’s default probability in the spirit of Aumann (1976). Specifically, investor $i$ believes that the bond defaults at maturity with probability $\pi_i \in [\bar{\pi} - \frac{\Delta}{2}, \bar{\pi} + \frac{\Delta}{2}]$. These differences in subjective default probabilities among investors lead to differences in valuation of the bond’s cash flows, thereby generating a motive to trade.\(^{12}\) More generally, these differences in valuation of the bond could also be generated by

\(^{12}\)The differences-in-beliefs setup we use in our model implies that investors do not learn from prices. For models that study the informational consequences of derivatives such as CDSs see Grossman (1988), Biais and Hillion (1994), Easley, O’Hara, and Srinivas (1998), and Goldstein, Li, and Yang (2014).
differences in investors' non-traded endowment risks, which would result in risk-based (rather than beliefs-based) private valuations of the bond.\textsuperscript{13}

We assume that investors’ beliefs about the bonds default probability follow a uniform distribution, with a mass one of investors at each liquidity shock intensity $\mu_i \in [0, \infty)$. This assumption implies a particularly simple conditional density function $f(\pi|\mu) = \frac{1}{\Delta}$, which allows us to calculate equilibrium prices in closed form.

Investors can take positions in the bond (the “real” asset) and the CDS (the synthetic asset), but are subject to portfolio restrictions that reflect risk management constraints.\textsuperscript{14} Specifically, we assume that each investor can hold up to one unit of credit risk. Accordingly, each investor can either go long one bond, short one bond, buy one CDS, or sell one CDS. In addition, investors can enter hedged portfolios. One such option is to take a long position in the bond and insure it by also purchasing a CDS (a so-called negative basis trade). Alternatively, investors can take a hedge position by taking a short position in the bond and selling CDS protection (a so-called positive basis trade). Because hedged positions do not involve credit risk, we allow investors to lever hedged positions to a maximum leverage of $L \geq 1$.\textsuperscript{15} Empirically, this assumption matches the stylized fact that basis traders are usually highly levered. Finally, as an outside option investors can always hold cash, which yields a zero return.

\textsuperscript{13}Under this alternative interpretation, $1 - \pi_i$ represents the risk-based valuation of the cash flows paid by the bond at maturity, based on investors $i$’s marginal utilities in the default and non-default states.

\textsuperscript{14}Given risk neutrality and differences in beliefs among investors, absent portfolio restrictions investors would take infinite positions.

\textsuperscript{15}Therefore, $L = 1$ implies that hedged investors cannot take leverage, whereas $L > 1$ implies that hedged investors can lever up their positions. Positive leverage for basis traders can be interpreted as the outcome of an (unmodeled) risk management problem: If investors start with the same economic capital, hedging their bets via the CDS allows them to take larger positions against their loss absorption capacity. The funding for this is provided by outside investors who are indifferent between holding cash and providing funding to basis traders.
3 Benchmark: No CDS Market

We first briefly consider the benchmark case in which only the bond trades. Building on this benchmark, we then turn to joint equilibrium in bond and CDS markets and the effects of CDS introduction in Section 4.

Investors maximize their utility subject to their portfolio constraints. When only the bond is trading, this means that investors choose between a long or a short position in the bond and holding cash. Investor $i$’s net payoff from a long position in the bond is given by

$$V_{\text{longBOND},i} = -p + \frac{\mu_i}{\mu_i + \lambda}(p - c_B) + \frac{\lambda}{\mu_i + \lambda}(1 - \pi_i).$$  \hfill (2)

The interpretation of this expression is as follows. The investor pays the ask price $p$ to purchase the bond. With probability $\frac{\mu_i}{\mu_i + \lambda}$ the investor has to sell the bond before maturity. Here, the stationarity property of Poisson maturity implies that a non-matured bond at some future liquidation date $t$ trades at the same price $p$ as the bond today. Hence, the investor receives the bid price $p - c_B$ when he has to sell the bond before maturity.\(^16\) If the bond matures before the investor receives a liquidity shock, the investor receives an expected payoff of $1 - \pi_i$, where $\pi_i$ is the investor’s subjective belief about the bond’s default probability. This happens with probability $\frac{\lambda}{\mu_i + \lambda}$.

Similarly, investor $i$’s net payoff from a short position in the bond is given by

$$V_{\text{shortBOND},i} = p - c_B - \frac{\mu_i}{\mu_i + \lambda}p - \frac{\lambda}{\mu_i + \lambda}(1 - \pi_i).$$  \hfill (3)

An investor who takes a short position in the bond receives the bid price $p - c_B$ today. If the investor has to cover his short position before maturity, the investor has to purchase the bond at the ask price $p$ (again using the stationarity property), whereas if the bond matures the investor has to cover his

\(^{16}\)If the bond had finite maturity or if investors updated their beliefs about the bond’s default probability over time, the above valuation equation would be more complicated because the bond would generally trade at a different price at future dates. Nevertheless, the key tradeoff would remain: For any price path $p$, investors with more frequent liquidity shocks are affected more strongly by the trading cost $c_B$. 

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short position at an expected cost of $1 - \pi_i$. The probabilities of these two events are $\frac{\mu_i}{\mu_i + \lambda}$ and $\frac{\lambda}{\mu_i + \lambda}$, respectively.

Figure 1 illustrates the resulting demand for long and short positions.\(^{17}\) Investors that are optimistic about the bonds’ default probability and have sufficiently long trading horizons purchase the bond, forming a triangle of buyers. On the boundary of the “buy” triangle, investors are indifferent between a long position in the bond and holding cash, which requires that $V_{\text{longBOND},i} = 0$. Similarly, pessimistic investors with sufficiently long trading horizons short the bond, with the boundary of the resulting “short” triangle defined by $V_{\text{shortBOND},i} = 0$. All other investors simply hold cash. The gap between the triangle of long bondholders and short sellers arises because the bond trading cost $c_B$ drives a wedge between the payoffs from long and short positions, which makes it optimal even for some investors who do not face liquidity shocks to stay out of the market.

Market clearing requires that the bond price $p$ adjusts such that the overall amount bought by long investors is equal to the amount shorted plus bond supply $S$, resulting in the following Lemma.

**Lemma 1. Benchmark: Bond market equilibrium in absence of CDS market.** When only the bond trades, the equilibrium bond price is given by

$$p_{\text{noCDS}} = 1 - \pi + \frac{c_B}{2} - \frac{c_B}{\lambda \Delta - c_B} S.$$  \hspace{1cm} (4)

Lemma 1 shows that, in the absence of the CDS, the bond price is given by the median investor’s belief about the bond’s expected payoff, $1 - \pi$, plus two additional terms that capture the effect of the bond’s trading costs and supply. The term $\frac{c_B}{2}$ captures the wedge that the bond trading cost puts between the payoff from a long and a short position, which increases the bond’s ask price by exactly half of the bond’s trading cost. The term $-\frac{c_B}{\lambda \Delta - c_B} S$ captures that, as the bond supply $S$ increases, the marginal bond investor becomes less optimistic and has shorter trading horizons, leading to a

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\(^{17}\)We focus on the case in which both long and short bond positions are taken in the absence of the CDS. This requires that the bond trading cost is not so large that it unconditionally rules out short positions, $c_B < \Delta$, and that the bond supply $S$ is not too large. We provide the exact condition on the bond supply in the appendix.
Figure 1: **Bond market equilibrium in the absence of a CDS.**

The figure illustrates the equilibrium when only the bond is trading. Investors who are sufficiently optimistic about the bond’s default probability and have sufficiently long holding horizons form a “buy bond” triangle. Investors who are pessimistic about the bond’s default probability and have sufficiently long holding horizons form a “short bond” triangle. Market clearing requires that the bond price adjust such that demand from long investors is equal to bond supply plus short positions.

A decrease in the bond price. Note that unless the bond supply is extremely small, the bond trades at a discount to the average expected payoff, and the bond price is decreasing in bond trading costs.

## 4 Introducing a CDS Market

We now introduce the CDS contract to the analysis. Analogously to before, we determine the demand for the CDS by calculating the payoffs from positions that involve the CDS: long and short CDS positions as well as hedged positions in the bond and the CDS. Combining these payoffs with the payoffs to going long or short in the bond, derived in equations (2) and (3), we then solve for joint equilibrium in the bond and the CDS market.

The net payoff to investor $i$ of purchasing a CDS on the bond is given by

$$V_{buyCDS,i} = -q + \frac{\mu_i}{\mu_i + \lambda} (q - c_{CDS}) + \frac{\lambda}{\mu_i + \lambda} \pi_i.$$  

(5)
This expression reflects the purchase price $q$ of the CDS, the payoff $q - c_{\text{CDS}}$ from early liquidation at the bid with probability $\frac{\mu_i}{\mu_i + \lambda}$ (using stationarity) and the expected CDS payoff of $\pi_i$ in the case of default at maturity, which happens with probability $\frac{\lambda}{\mu_i + \lambda}$. Analogously, the payoff to investor $i$ of selling a CDS on the bond is given by

$$V_{\text{sellCDS},i} = q - c_{\text{CDS}} - \frac{\mu_i}{\mu_i + \lambda} q - \frac{\lambda}{\mu_i + \lambda} \pi_i.$$  \hspace{1cm} (6)

In addition to taking directional positions in the bond or the CDS, investors can enter hedged “basis trade” positions. Because hedged positions can be levered $L$ times, these hedged portfolios pay off $L \cdot (V_{\text{buyCDS},i} + V_{\text{longBOND},i})$ in the case of a negative basis trade and $L \cdot (V_{\text{sellCDS},i} + V_{\text{shortBOND},i})$ for a positive basis trade. Finally, investors can still hold cash as an outside option with zero return.

Solving for equilibrium in the bond and CDS market requires calculating the demand for bond and CDS positions from the above payoffs and then imposing market clearing to determine the equilibrium prices of the bond and the CDS. In our main analysis, we will focus on the case in which the CDS market is frictionless ($c_{\text{CDS}} = 0$).

4.1 The effect of CDS introduction on prices and trading in the bond market

The advantage of assuming that CDS markets are frictionless is that the equilibrium in the CDS market becomes particularly simple: When $c_{\text{CDS}} = 0$, equations (5) and (6) imply that all investors with beliefs $\pi_i < q$ are willing to sell CDS protection ($V_{\text{sellCDS},i} > 0$), while all investors with $\pi_i > q$ are ready to purchase CDS protection ($V_{\text{buyCDS},i} > 0$). Given the infinite support of $\mu_i$, the bond market is then vanishingly small relative to the CDS market, such that the CDS market clears at a price equal to the average investor belief about the bond’s default probability, irrespective of positions in the bond market.\(^\text{18}\)

$$q = \bar{\pi}. \hspace{1cm} (7)$$

\(^{18}\)Strictly speaking, this is a limit argument: Consider an upper bound $\overline{\rho}$ for the frequency of the liquidity shock and then take the limit $\overline{\rho} \to \infty$. As the mass of traders in the CDS market grows, the CDS price $q$ converges to $\overline{\pi}$. 

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To determine the equilibrium bond price, it therefore suffices to investigate how the availability of the CDS priced at \( q = \pi \) affects investors’ incentives to take long or short positions in the bond. In other words, we can clear markets sequentially rather than having to solve simultaneously for equilibrium in the bond and CDS market.

\[
\frac{\lambda}{c_B} \left( 1 - p - \left( \frac{\pi - \Delta}{2} \right) \right)
\]

\[
\frac{\lambda}{c_B} (1 - p - q)
\]

\[
0 \quad \frac{-\pi - \Delta}{2} \quad \frac{-\pi}{q} \quad 1 - p \quad \frac{-\pi + \Delta}{2}
\]

**Figure 2: CDS Introduction (basis traders cannot take leverage)**

This figure illustrates the change in investor strategies that results from CDS introduction when basis traders cannot trade leverage \( L = 1 \), holding constant the price of the bond. The dashed lines illustrate the long and short triangles in the absence of the CDS. The introduction of the CDS has three effects: (i) Some investors who absent the CDS would purchase the bond now choose to sell CDS protection, cutting off the top of the bond buying triangle. (ii) Because the bond trades at a discount relative to the CDS, all former short sellers prefer to purchase CDS protection, which eliminates the shorting triangle. (iii) Investors who formerly bought the bond but whose beliefs about the bond’s default probability are below the median belief \( \bar{\pi} \) become basis traders who purchase the bond and buy CDS protection.

Consider first the case in which basis traders cannot take leverage \( (L = 1) \), depicted in Figure 2. The figure shows that the introduction of the CDS has three effects on the equilibrium in the bond market. First, when the CDS is available, investors with relatively short trading horizons who in absence of the CDS used to purchase the bond now prefer to sell CDS protection. This can be seen in Figure 2 by observing that the triangle of long bondholders has been cut off at the top (for ease of comparison, the triangle of long bond positions in the absence of the CDS is depicted by the dashed
This crowding out of long bond investors leads to a reduction in demand for the bond, exerting downward pressure on the bond price.

Second, the introduction of the CDS eliminates short selling in the bond. In the figure, the triangle of investors that formerly shorted the bond (depicted by the dotted line on the right) vanishes, because those investors now prefer to purchase CDS protection instead of shorting the bond. The reason why investors prefer to use the CDS market to take bearish bets works through the equilibrium price: Because of its trading costs, in equilibrium the bond trades at a discount relative to the CDS. Hence, investors that wish to take a bearish bet on the bond prefer to do this in the CDS market rather than via a short position in the bond. By eliminating short sellers, the introduction of the CDS exerts upward pressure on the bond price.

Third, the introduction of the CDS generates a new class of investors: hedged basis traders. Specifically, when $L = 1$ we see that investors who in the absence of the CDS would have taken a long position in the bond but whose beliefs about the bond’s default probability is less optimistic than the median belief $\pi$ now find it optimal to purchase both the bond and the CDS. These investors thus become negative basis traders: They hold a hedged position in the bond and the CDS, thereby locking in the equilibrium price differential between the underlying bond and the derivative. Rather than taking bets on credit risk, these investors act as arbitrageurs.

When basis traders cannot take leverage ($L = 1$), as assumed in Figure 2, their presence does not affect the bond price. The reason is that the investors in the basis trade triangle would have purchased the bond anyway, even in absence of the CDS. When basis traders can take leverage ($L > 1$), on the other hand, the ability to hedge with the CDS allows basis traders to demand more of the bond, such that they exert upward pressure on the bond price. This is illustrated in Figure 3. More specifically, the figure shows that the ability of basis traders to take leverage raises the equilibrium bond price in two ways. First, holding constant the number of basis traders (i.e., keeping the size of the basis trader triangle as in Figure 2), the ability to take leverage increases the demand for the bond from this given set of basis traders, thereby putting upward pressure on the bond price. Second, the ability to take
leverage makes the basis trade more profitable and thereby increases the number of basis traders: As illustrated in Figure 3, the basis trader triangle expands. In fact, when basis traders can take leverage, even some investors to the left of $\pi$ become basis traders. Even though for these investors the CDS priced at $q = \pi$ has a negative payoff when seen in isolation, they purchase the CDS because it allows them to lever up their position in the bond.

Figure 3: Bond and CDS market equilibrium (basis traders can take leverage)
The figure illustrates the equilibrium when both the bond and the CDS are trading and basis traders can take leverage ($L > 1$). The ability to take leverage makes the basis trade more attractive, such that the basis trade triangle expands compared to Figure 2. Because of the increased demand from basis traders, more of the bond can be held by investors with long trading horizons, improving the allocation in the bond market. For ease of comparison, the dashed line illustrates the rectangle of investors who purchase the bond when basis traders cannot take leverage ($L = 1$).

The endogenous emergence of leveraged basis traders highlights the key economic role of CDS markets in our model: The introduction of the CDS allows buy-and-hold investors, who are efficient holders of the illiquid bond, to hold a larger share of the bond supply and hedge unwanted credit risk.

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19When the bond supply or basis trader leverage are large, it is possible for the basis trade region to extend all the way to $\pi_i = \pi + \Delta/2$, thereby becoming a trapezoid. While this would affect some of the analytic expressions calculated below, it would not affect any of the economic predictions of our model. For brevity, we therefore rule out this case. We provide the exact condition in the appendix.
in the more liquid CDS market. In the CDS market, the average seller of CDS protection is relatively optimistic about the bond’s default probability, but is not an efficient holder of the bond because of more frequent liquidity shocks. The role of CDS markets is thus similar to liquidity transformation—by repackaging the bond’s default risk into a more liquid security, they allow the transfer of credit risk from efficient holders of the bond to relatively more optimistic shorter-term investors, improving the allocation in the bond market.\(^{20}\) This liquidity-based view of CDS markets differs from the traditional view that CDSs simply allow the separation of credit risk from interest rate risk (e.g., JPMorgan (2006)). In particular, separation of credit risk from interest rate risk is possible with an interest rate swap and does not require a CDS. In contrast, the allocational improvement through levered basis traders is only possible via a (liquid) CDS contract.

Given the discussion above, we now solve for the equilibrium bond price. Market clearing in the bond market requires that the demand from investors with a long position in the bond and the demand from basis traders add up to the bond supply \(S\), given that the CDS market clears at \(q = \pi\). Solving for the bond price \(p\) that satisfies this market clearing condition yields the following Lemma.

**Lemma 2. Bond price in presence of frictionless CDS market.** When both the bond and a frictionless CDS are traded, the CDS price is given by \(q = \pi\) and the equilibrium bond price is equal to

\[
p_{\text{with CDS}} = 1 - \pi - \frac{\Delta}{2} \frac{\sqrt{1 + 8\Phi \frac{\pi S}{\Delta}} - 1}{\Phi},
\]

where we define \(\Phi \equiv 1 + 2L(L - 1)\).

Similar to Lemma 1, the bond price in the presence of the CDS is equal to the average expected payoff \(1 - \pi\) and an adjustment that captures the bond’s trading cost and supply. Note, however, that in the presence of the CDS, this adjustment depends on the amount of leverage basis traders can take.

In addition, the ability to (synthetically) short the bond via the CDS without incurring a trading cost

\(^{20}\)When trading costs have a deadweight component, this is an allocational improvement from a welfare perspective. When trading costs are transfers to market makers, then the term “allocational improvement” should be interpreted from the investor’s perspective (i.e., investors incur fewer trading costs).
eliminates the wedge between long and short positions and therefore the half spread \( c_B/2 \) that was present when no CDS is available.

Based on Lemmas 1 and 2, we are now in a position to characterize the effect of CDS introduction on the price of the underlying bond.

**Proposition 1. The effect of CDS introduction on the bond price.** The change in the bond price due to CDS introduction is given by

\[
dp = p_{\text{withCDS}} - p_{\text{noCDS}} = -\frac{c_B}{2} + \frac{c_B}{\lambda} \frac{\Delta}{\Delta - c_B} S - \frac{\Delta}{2} \sqrt{1 + 8\Phi \frac{c_B S}{\lambda \Delta} - 1}.
\]  

(i) The price effect of CDS introduction on the underlying bond is ambiguous.

(ii) The CDS is redundant when \( c_B = 0 \).

(iii) For CDS introduction to raise the bond price, it is necessary that the bond trading cost \( c_B \) and basis trader leverage \( L \) are sufficiently high.

(iv) CDS introduction is more likely to raise the bond price when disagreement about the default probability \( \Delta \) is small.

Proposition 1 shows that the price effect of CDS introduction is generally ambiguous and depends on the bond trading cost on basis trader leverage. Setting \( c_B = 0 \), we see that the CDS is redundant when the bond is perfectly liquid. In this case, the CDS has no liquidity advantage over the bond and therefore does not affect the bond price, such that \( p_{\text{withCDS}} - p_{\text{noCDS}} = 0 \).

When \( c_B > 0 \), on the other hand, CDS introduction affects the bond price. When the bond trading cost \( c_B \) is close to zero, CDS introduction unambiguously reduces the bond price. The intuition for this result is that the discontinuous change in strategies of investors that move from the bond market to the CDS market crowds out a strictly positive amount of demand for the bond, even when the difference in trading costs between the bond and the CDS is very small. The basis trader effect, on the other hand, is continuous and becomes arbitrarily small: For small differences in trading costs, the
CDS-bond basis approaches zero and there is essentially no demand from basis traders, irrespective of their ability to take leverage. In contrast, when $c_B$ is sufficiently large, CDS introduction can increase the bond price: To see this, note that when basis traders cannot take leverage ($L = 1$), only the crowding out effect is present and the bond price decreases when the CDS is introduced. When $L > 1$, on the other hand, the introduction of the CDS can increase the bond price because demand from basis traders can outweigh the crowding out effect.\footnote{While in Proposition 1 we keep the CDS trading cost $c_{CDS}$ fixed at 0 and vary the bond trading cost $c_B$, these results continue to hold when both the bond and the CDS are subject to strictly positive trading costs (see Section 4.3.3).}

The above discussion highlights the main economic trade-off that arises when the CDS is introduced. On one hand, CDS introduction crowds out demand for the bond which puts downward pressure on the equilibrium bond price. On the other hand, CDS introduction improves the allocation in the bond market because it allows investors with long horizons to hold more of the illiquid bond, which puts upward pressure on the equilibrium bond price. As shown above, for CDS introduction to increase the bond price, the liquidity differential between the bond and the CDS has to be sufficiently large and basis traders must be able to take sufficient leverage.\footnote{Even though we have focused on the uniform investor distribution in characterizing the trade-off between the crowding out effect and the allocational improvement that is possible in the presence of the CDS, the underlying economic insight is not distribution-specific. What is distribution specific, is the result that CDS introduction always reduces the bond price when $L = 1$: There are distributions for which the reduction in short selling outweighs the crowding out of long positions, such that CDS introduction raises the bond price even for $L = 1$. This requires that the mass of traders in the shorting triangle is larger than to mass of long bond investors crowded out by CDS introduction (see Figure 2).}

The final result in Proposition 1 is that CDS introduction is more likely to increase the bond price when there is little disagreement about the bond’s default probability. The intuition for this result is that the positive price effect of CDS introduction is driven by investors with moderate beliefs, who, after CDS introduction, become levered basis traders. An increase in disagreement reduces the mass of basis traders who can take leverage.

\footnote{One way to isolate the forces at work is consider the extreme cases in which only one of the two dimensions of heterogeneity is present. If investors only differ in their trading frequencies but there is not disagreement about default probabilities, then only the basis trader effect is present: Investors with infrequent trading needs hold levered basis positions, purchasing CDS protection from investors with more frequent liquidity shocks. The bond price is higher than in the no-CDS case. When there is only disagreement about the default probability, on the other hand, no basis traders emerge and only the crowding-out effect is present: Relatively optimistic investors are indifferent between holding the bond and selling CDS protection, whereas pessimistic investors purchase CDS protection. The bond price is lower than in the no-CDS case.}
of investors with moderate beliefs and therefore weakens the increase in bond demand from basis traders.

The main empirical prediction of Proposition 1 is that the price effect of CDS introduction on bond prices is generally ambiguous and depends on bond and firm characteristics. This is consistent with the emerging empirical literature on the effect of CDSs on the cost of financing for firms. Moreover, the specific empirical patterns regarding which types of borrowers benefit from CDS introduction are in line with the predictions of our model: Ashcraft and Santos (2009) and Shim and Zhu (2014) provide evidence that CDS introduction tends to reduce funding costs when bond and CDS differ sufficiently in liquidity. Similarly, Nashikkar, Subrahmanyam, and Mahanti (2011) show that controlling for bond liquidity (measured by their “latent liquidity” measure), bonds of issuers with more liquid CDS contracts (in terms of bid-ask spreads) tend to have lower yields. Consistent with the prediction that CDS introduction is less likely to raise bond prices when there is substantial disagreement, Ashcraft and Santos (2009) find that firms with high earnings forecast dispersion face increased funding costs once a CDS is introduced. Finally, Jiang and Zhu (2015) provide direct evidence for the investor holding patterns predicted by our model: Mutual funds with more frequent liquidity needs (proxied by fund flow volatility and portfolio turnover) are more likely to substitute long bond positions with short positions in the CDS.

In addition to the result on the effects of CDS introduction on the bond price, our model generates predictions regarding turnover and price impact in the bond and the CDS market. We define turnover in the bond market as bond trading volume divided by the supply of the bond, and CDS turnover as CDS trading volume divided by the notional amount (open interest) of outstanding CDSs.

**Proposition 2. Turnover in the bond and CDS markets.**

(i) *Turnover in the CDS market is higher than turnover in the bond market.*

(ii) *Turnover in the underlying bond decreases when the CDS is introduced.*

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24 Ashcraft and Santos (2009) proxy for CDS liquidity using the number of daily quotes, whereas Shim and Zhu (2014) use the standard deviation of CDS quotes.
The predictions in Proposition 2 follow relatively directly from the differences in trading costs between the bond and the CDS, and the resulting clientele effect that arises as investors sort themselves into the two markets depending on the frequency of their liquidity shocks. Nevertheless, these predictions are useful because they offer additional dimensions along which we can link our model to empirical evidence: Consistent with the first prediction in Proposition 2, Oehmke and Zawadowski (2013) document that average monthly CDS turnover is 50.8% per month, whereas average turnover in the underlying bonds is around 7.5% per month. Consistent with the second prediction, Das, Kalimipalli, and Nayak (2014) show that CDS introduction is indeed associated with a decrease in turnover in the underlying bond.

However, even though CDS introduction unambiguously lowers turnover in the bond market, this does not necessarily imply that the bond market becomes less liquid in terms of the price impact of bond supply shocks. In fact, CDS introduction can reduce the price impact of bond supply shocks, despite lower bond turnover:

**Proposition 3. The effect of CDS introduction on price impact in the bond market.** CDS introduction reduces price impact in response to bond supply shocks, \( \left| \frac{dp}{dS} \right| \), when

(i) basis trader leverage \( L \) is sufficiently high,

(ii) bond trading costs \( c_B \) are sufficiently high,

(iii) disagreement about the bond’s default probability \( \Delta \) is sufficiently low.

Proposition 3 shows that, depending on basis trader leverage, trading costs, and disagreement, the sensitivity of the bond price with respect to bond supply shocks, \( \left| \frac{dp}{dS} \right| \), decreases when the CDS is introduced. This effect is driven by the presence of basis traders: When basis trader leverage is high or when the basis trade is particularly profitable, levered basis traders cushion the price effect of bond supply shocks. Accordingly, the effect of CDS introduction on bond “liquidity” can differ depending on the specific liquidity measure that is used (e.g., turnover or price impact). Proposition 3 therefore provides a potential explanation for the empirical results of Das, Kalimipalli, and Nayak (2014), who
find that, even though CDS introduction reduces bond turnover, there is no clear directional effect when investigating the effect of CDS introduction on the Amihud (2002) price impact measure.

4.2 The CDS-bond basis

In this section, we investigate the relative pricing of the bond and the CDS once both instruments trade. The relative pricing of bonds and CDSs is captured by the CDS-bond basis, which has attracted considerable attention in the wake of the financial crisis of 2007-2009. The CDS-bond basis is defined as the difference between the spread of a synthetic bond (composed of a long position in a risk-free bond of the same maturity and coupon as the risky bond and a short position in the CDS) and the spread of the actual risky bond. Intuitively speaking, when the CDS-bond basis is negative, the bond spread is larger than the CDS spread, which means that the physical bond is cheaper than the payoff-equivalent synthetic bond.

Absent frictions, the CDS-bond basis should be approximately zero. The reason is that a portfolio consisting of a long bond position and a CDS that insures the default risk of the bond should yield the risk-free rate. Since the financial crisis, the CDS-bond basis has been consistently negative for most reference entities.

In our framework, a negative basis between bonds and CDSs arises endogenously from the difference in trading costs of the bond and the CDS. To calculate the basis, note that in our setting a risk-free bond with the same maturity as the risky bond trades at a price of one (since there is no discounting). We can then calculate the spread of the risky bond above the risk-free rate by calculating the price difference between the risk-free and the risky bond and dividing it by the expected time to maturity $1/\lambda$, which yields a bond spread of $\lambda(1 - p)$. Analogously, given the CDS price $q$ we can calculate the

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25 See Duffie (1999) for conditions under which this arbitrage relationship holds exactly.

26 See, e.g., Bai and Collin-Dufresne (2013). Note, however, that positive bases do occur in some instances and are usually attributed to frictions that are outside of our model, such as short-selling constraints that arise from imperfections in the repo market, the cheapest-to-deliver option, and control rights associated with the underlying bond (see JPMorgan (2006)).
CDS spread (the flow cost of CDS protection) as \( \lambda q \). The CDS-bond basis is then given by

\[
\text{basis} = \text{spread}_{\text{CDS}} - \text{spread}_{\text{bond}} = -\lambda (1 - p - q).
\] (10)

Based on the bond and CDS market equilibrium derived above, the CDS-bond basis then satisfies the following properties.

**Proposition 4. The CDS-bond basis.** The CDS-bond basis in the presence of frictionless CDS markets \( (c_{\text{CDS}} = 0) \) is given by

\[
\text{basis} = -\frac{\lambda \Delta}{2} \sqrt{1 + \frac{8\Phi c_{\text{B}} S}{\Delta} - 1} \leq 0,
\] (11)

where \( \Phi \equiv 1 + 2L(L - 1) \). The CDS-bond basis is more negative when

(i) bond supply \( S \) is large,

(ii) bond trading costs \( c_{\text{B}} \) are high,

(iii) basis traders can take less leverage (small \( L \)),

(iv) disagreement about the bond’s default probability \( \Delta \) is high.

The source of the negative basis in our model is straightforward. Because trading costs for the bond are higher than those of the CDS, the bond trades at a discount relative to the CDS. The resulting CDS-bond basis is larger when basis traders find it harder to trade against the basis (small \( L \)) and when the supply of the bond is large.

Proposition 4 generates a number of time-series and cross-sectional predictions on the CDS-bond basis. First, the basis becomes more negative in response to supply shocks in the bond market, consistent with evidence in Ellul, Jotikasthira, and Lundblad (2011). Second, bonds with high trading costs (relative to trading costs in the associated CDS) are predicted to have more negative CDS-bond bases, consistent with the evidence in Bai and Collin-Dufresne (2013), who find that higher bond
bid-ask spreads are associated with a more negative CDS-bond basis. Third, higher basis trader leverage compresses the negative basis. Therefore, at times when basis traders can take substantial leverage, the basis should be close to zero. In contrast, during times of tough funding conditions, the equilibrium basis becomes more negative, consistent with the evidence in Gárleanu and Pedersen (2011), Fontana (2012), and Mitchell and Pulvino (2012). Choi and Shachar (2014) provide evidence that the unwinding of CDS-bond basis arbitrage trades was a main cause of the large negative basis in 2008. Fourth, bonds characterized by substantial disagreement about default probabilities have more negative bases. In practice, high-yield bonds tend to be have high levels of disagreement and high trading costs. Consistent with our model, they also tend to have more negative CDS-bond bases (Gárleanu and Pedersen (2011) and Bai and Collin-Dufresne (2013)).

In addition to characterizing the determinants of the CDS-bond basis, our model also makes predictions on the size of the basis trade.

**Corollary 1. The size of the basis trade.** The amount of bonds held by basis traders in equilibrium is given by

\[
\text{size of the basis trade} = \frac{L \cdot \left(L - \frac{1}{2}\right)}{\Delta \cdot \lambda \cdot c_B} \cdot \text{basis}^2, \tag{12}
\]

where basis is the equilibrium basis given in (11). In equilibrium, basis trade positions are increasing in bond supply \(S\), bond trading costs \(c_B\), and basis trader leverage \(L\), and decreasing in disagreement \(\Delta\).

The main prediction of Corollary 1 is that the joint dynamics of the CDS-bond basis and the size of the basis trade depend on the type of shock that moves the basis. When the basis becomes more negative because of bond supply shocks or higher bond trading costs, this also makes the basis trade more profitable, drawing more investors into the basis trade. In these cases, a larger negative basis is associated with larger basis trader positions. In contrast, lower basis trader leverage and higher disagreement make the basis more negative because they reduce the supply of basis trader capital, such that a larger negative basis is associated with smaller basis trader positions. Consistent
with these predictions, Oehmke and Zawadowski (2013) document a positive cross-sectional relation between CDSs positions (a proxy for CDS demand by basis traders) and bond trading costs. They also show that as funding conditions worsen (i.e., basis trader leverage $L$ decreases), the correlation between the CDS positions and the negative basis weakens.

4.3 Extensions

In this section we discuss how our framework can be extended to allow for multiple bond issues, endogenous trading costs, and positive trading costs in the CDS market.

4.3.1 Two bond issues

In this subsection, we briefly discuss an extension of our model to a setting where an issuer has multiple bond issues outstanding: a more liquid and a less liquid issue. One interpretation of this setting is that the liquid issue is a recently issued “on-the-run” bond, while the less liquid issue is an older “off-the-run” bond. Alternatively, the liquid bond may be a relatively standard bond, whereas the illiquid bond is more custom-tailored for a particular investor clientele. Because the liquid and illiquid bond are held by different investors, CDS introduction affects the prices of the two bonds differentially. The liquid bond is held by investors with relatively frequent liquidity shocks and is therefore affected disproportionately by the crowding-out effect of CDS introduction. The illiquid bond, on the other hand, benefits disproportionately from the increased demand from basis traders. This implies that illiquid bonds generally benefit more from CDS introduction than liquid bonds. In fact, it is possible that the price of the illiquid bond increases while the price of the liquid bond decreases in response to CDS introduction (see online appendix B.1 for further details).

Given that illiquid bonds benefit disproportionately from CDS introduction, firms with CDSs may issue more of these types of bonds. For example, when a CDS is available firms may issue more customized bonds that cater to specific investors (e.g., pension funds or insurance companies), given that the CDS allows these investors to take levered hedged positions. To the extent that long-term
bonds are more illiquid than short-term bonds, CDS introduction may also induce firms to issue more long-term bonds, consistent with the evidence in Saretto and Tookes (2013).

4.3.2 Endogenous trading costs

One important assumption of our analysis is that the trading costs $c_B$ and $c_{CDS}$ are exogenous, and that the bond trading cost $c_B$ is not affected by CDS introduction. While fully endogenizing trading costs would go beyond the scope of this paper, the results on turnover presented in Proposition 2 allow us to consider endogenous trading costs in reduced form. In search models (e.g., Duffie, Gârleanu, and Pedersen (2005)), a reduction in trading activity is usually associated with higher trading costs in the form of larger bid-ask spreads. We can allow for this possibility through a slight adjustment in equation (9): In the third term of the expression, $c_B$ would now be replaced by $\tilde{c}_B > c_B$ to reflect higher bond trading costs post CDS introduction. The increase in bond trading costs would therefore put negative pressure on the bond price, partially offsetting the potential bond price increase resulting from CDS introduction.

4.3.3 CDS market with frictions

Up to now, we have focused on the particularly tractable case in which CDSs involve no trading costs ($c_{CDS} = 0$). This assumption made solving for the equilibrium in the CDS market particularly easy because it ensured that $q = \pi$, which allowed us to solve sequentially for equilibrium prices of the CDS and the bond. When $c_{CDS} > 0$, this is no longer possible and one has to jointly solve for bond and CDS prices. Because also the CDS price now reflects trading frictions, it is generally the case that $q \neq \pi$. While closed-form solutions are not available for this case, this section shows that the main economic results derived above continue to hold (see online appendix B.2 for further details).

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More formally, if CDS introduction reduces the intensity with which bond traders meet trading partners, this would result in lower trading activity and higher bid-ask spreads.

More generally, in such an extension the trading costs in the bond and CDS markets would be given by fixed points, where each trading cost must be consistent with the amount of trading activity in the respective market. Note that such a fixed-point argument may make the trading cost difference between the bond and the CDS self-sustaining, similar in spirit to the results of Vayanos and Wang (2007).
Figure 4 illustrates the equilibrium when there are trading costs also in the CDS market. In contrast to the frictionless CDS case, investors with sufficiently frequent liquidity shocks now stay out of the market altogether and hold cash. Despite this difference, the main results derived in the frictionless CDS setting remain valid. In particular, the introduction of a CDS affects the bond market through three effects: (i) the CDS crowds out some long bondholders, (ii) the CDS eliminates short sellers, and (iii) the CDS leads to the emergence of hedged basis traders. As in the frictionless model, basis traders are price neutral when $L = 1$, whereas basis traders exert upward pressure on the bond price when they can take leverage $L > 1$.

![Diagram](image)

**Figure 4: Bond and CDS market equilibrium when $c_{\text{CDS}} > 0$ and $L > 1$**

The figure illustrates the equilibrium when also the CDS is subject to trading costs ($c_{\text{CDS}} > 0$) and basis traders can take leverage ($L > 1$). Compared to Figure 3 (where $c_{\text{CDS}} = 0$) the “sell CDS” and “buy CDS” regions are now triangles, reflecting higher expected CDS trading costs for investors with more frequent trading needs (higher $\mu$). As in the case with frictionless CDS, the introduction of the CDS has three effects: (i) Some investors who absent the CDS would purchase the bond now choose to sell CDS protection, cutting off the top of the bond-buying triangle. (ii) Because of the negative CDS-bond basis, all former short sellers prefer to purchase the CDS, which eliminates the shorting triangle. (iii) Basis traders (who take a levered hedged position in the bond and the CDS) emerge, putting upward pressure on the bond price.
Proposition 5. **CDS introduction when also the CDS market is subject to trading costs.**

When also the CDS market is subject to trading costs, $0 < c_{CDS} \leq c_B$, then:

(i) The price effect of CDS introduction on the underlying bond is ambiguous.

(ii) The CDS is redundant when $c_B = c_{CDS}$.

(iii) For CDS introduction to raise the bond price, it is necessary that both the trading cost advantage of the CDS, $c_B - c_{CDS}$, and basis trader leverage $L$ are sufficiently high.

Proposition 5 shows that the main economic trade-off between a crowding-out effect and an improvement in the bond market allocation continues to hold when $c_{CDS} > 0$. In particular, the bond price increases in response to CDS introduction only if the bond and the CDS differ sufficiently in their trading costs and when basis traders can take sufficient leverage.

5 Discussion and Policy Implications

5.1 Welfare

Our analysis up to now has focused on positive results, e.g., how does CDS introduction affect the price of the underlying bond? In this section, we discuss the extent to which our framework allows us to draw normative conclusions: Does the introduction of a CDS improve welfare?

Welfare effects depend on the interpretation of the differences in valuations that generate trading motives in our model. We first consider the case in which differences in the valuations of the cash flows paid by the bond and the CDS arise because of risk-based private valuations. We then discuss how welfare conclusions change if trading motives are generated by differences in beliefs, and not by endowment risk. Throughout, we focus on total (utilitarian) welfare, and we assume that trading costs are at least partially deadweight, for example, because they reflect market power of dealers.\(^{29}\)

\(^{29}\)If, instead, trading costs are interpreted as transfers, a similar line of argument to the one below applies, with the exception that changes in incurred trading costs would not be relevant for welfare purposes.
The key to assessing welfare is the observation that, holding fixed the issuer’s investment decision, price changes due to CDS introduction cancel out: They are transfers, either between long and short investors, or between long bondholders and the issuer. What matters for welfare is the ability of investors to share risk, the trading costs incurred to do so, and the issuer’s investment decision. Under risk-based private valuations, our model therefore highlights three positive welfare effects of CDS introduction. First, the migration of offsetting long-short bond positions to the CDS market is welfare improving because it lowers the incidence of transaction costs that agents pay to share risk (the price at which this risk is shared changes, but this constitutes a transfer). Second, the availability of the CDS improves risk sharing because it allows investors who were previously sidelined by the bond’s high trading cost to share risk via the CDS. Finally, the emergence of levered basis traders reduces the incidence of trading costs among investors who continue to hold the bond after CDS introduction, resulting in a positive welfare effect. Changes in the bond price in response to CDS introduction lead to a transfer between bondholders and the firm when investment is held fixed, but a price increase resulting from CDS introduction increases welfare if it allows the firm to increase positive NPV investment. Note that, taken together, these findings imply that a bond price increase (our focus in the main part of the paper) is a sufficient condition for an increase in welfare if it allows the firm to increase positive NPV investment.

The welfare implications of CDS introduction are somewhat more complicated when trading motives arise due to differences in beliefs. However, our framework continues to highlight the relevant effects. The main difference is that, under a strict differences-in-beliefs interpretation, offsetting positions are simply bets and do not generate risk sharing benefits. However, the welfare criterion for distorted beliefs proposed by Brunnermeier, Simsek, and Xiong (2014) implies that all offsetting long-short bets (in the bond or the CDS) matter for welfare only to the extent that they lead to the incidence of deadweight transaction costs.\footnote{Intuitively, deadweight transaction costs are the equivalent of the destruction of the pillow in the main example of Brunnermeier, Simsek, and Xiong (2014).} Therefore, as before the migration of long-short bets from the bond to the CDS market is welfare improving because it lowers the incidence of transaction
costs that agents pay to make these bets. However, if there is a trading cost also in the CDS market, the gain from moving existing long-short bets in the bond to the CDS market has to be traded off against the trading costs incurred through additional speculative bets that emerge in the CDS market (in contrast to the risk-based private valuation case, these additional bets no longer generate any risk sharing benefits). Finally, while the price change in the bond still constitutes a welfare-neutral transfer between the firm and long bondholders, the welfare consequences of a change in investment are now more difficult to assess: Unless one imposes the restrictive assumption that the change in investment is desirable under any reasonable probability belief, no clear statements can be made.

In addition to assessing overall welfare effects, the above discussion highlights that CDS introduction has distributional consequences. For example, when CDS introduction leads to higher bond prices, some long bondholders are worse off (from an ex-ante perspective) when the CDS is available.

5.2 Bond standardization

The prediction that CDS markets allow buy-and-hold investors to absorb more of the bond supply provides an interesting angle on the recent discussion on standardization in the bond market. For example, in a recent proposal, BlackRock (2013) argues for more standardized corporate bonds, in an attempt to improve secondary market liquidity (i.e., lowering $c_B$). However, as some market participants have pointed out, for issuers standardization may come at the expense of being able to tailor bonds to particular clienteles: A bond that is tailored to a particular investor may fetch a higher at-issue price, despite higher trading costs in the secondary market. Our results suggest that the presence of a CDS allows such issues to be held predominantly by buy-and-hold investors, which reduces the incidence of higher secondary-market trading costs that come with customization. Therefore, the introduction of the CDS can be viewed as a “backdoor” way to achieve some of the benefits of bond standardization, while still allowing issuers to cater their bonds to specific investors.

Our model also highlights that bond standardization, like CDS introduction, has distributional consequences. Proposals to standardize the bond market in order to improve secondary market liq-
uidity are therefore unlikely to be supported by all market participants. Clearly, dealers may oppose moves towards bond standardization if the resulting reduction in trading costs reduces dealer profits. But also bond market participants may be opposed: In particular, long-term bond investors are negatively affected (in an ex-ante sense) because for them the bond price increase outweighs the reduction in bond trading costs that they incur. This is easiest to see for the extreme case of pure buy-and-hold investors \( (\mu_i = 0) \), who pay a higher price for the bond but do not benefit from lower trading costs. Note that, generally speaking, the set of investors that loses from bond standardization is the same set of investors that is negatively affected by CDS introduction that raises the bond price: In both cases, buy-and-hold investors lose out, whereas investors with more frequent trading needs are more likely to gain.

5.3 Naked (and other) CDS bans

In this section, we apply our framework to analyze a number of policy interventions in the CDS market. Specifically, we briefly consider the effects of (i) banning naked CDS positions (as recently implemented by the European Union with respect to sovereign bonds), (ii) banning CDS markets altogether, and (iii) banning both CDSs and short positions in bonds. The motivation for such interventions is usually to achieve a reduction in bond yields (and thereby borrowing costs) for issuers.  

EU regulation No 236/2012, in effect since November 1, 2012, allows market participants to purchase CDS protection only if they own the underlying bond or have other significant exposure to the sovereign, thereby restricting so-called naked CDS positions. Short selling of the bond is allowed under this regulation as long as the short seller is able to borrow the bond.

The crucial question in assessing the effect of a naked CDS ban is what investors who were previously holding naked CDS protection choose to do instead. Our framework highlights three effects,

\[ \text{31} \]

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\[ \text{31} \]Clearly, the simple framework proposed here is not rich enough to yield detailed policy prescriptions. Moreover, some of the policies that we discuss in the following subsections may be driven by considerations that are outside of our model. For example, our model does not capture so-called bear raids, which are sometimes cited as a justification for the naked CDS ban in Europe. Nevertheless, even in the context of our simple framework the effects of CDS market interventions on bond yields are subtle and can potentially go in the “wrong” direction (i.e., contrary to the policymaker’s probable objective, such interventions can, in fact, increase borrowing costs for issuers).
which are illustrated in Figure 5: First, some of these investors switch from a naked CDS position to a short position in the bond. Hence, as a result of a ban on naked CDSs, short sellers reappear, putting downward pressure on the bond price. Second, some investors who formerly held a naked CDS position become basis traders and hold the bond and the CDS, up to the maximum leverage $L$. This second effect increases demand for the bond, resulting in upward pressure on the bond price. Third, some investors that previously held naked CDS protection switch to simply holding cash. The effect of banning naked CDS positions on the cost of borrowing therefore depends on the relative size of these effects and, in the absence of restrictions on the investor distribution, can go in either direction.

![Figure 5: Banning naked CDS when $c_{\text{CDS}} > 0$ and $L > 1$](image)

Figure 5: Banning naked CDS when $c_{\text{CDS}} > 0$ and $L > 1$

The figure illustrates the change in investor strategies when naked CDS positions are banned, holding constant the price of the bond. The dashed line shows the position of CDS buyers and basis traders before the ban. Compared to Figure 4, which depicts the same setup except that naked CDS positions are allowed, there are two major changes. Some investors who used to purchase naked CDS protection now choose to short the bond, exerting downward pressure on the bond price. Some investors who used to purchase naked CDS protection now become basis traders, which exerts upward pressure on the bond price.

In fact, it is possible that bond and CDS spreads move in opposite directions in response to a naked CDS ban, such that borrowing costs for issuers may rise, even though the ban naked CDSs
lowers CDS spreads. Consistent with this prediction, a recent report by the European Securities and Markets Authority on the naked CDS ban in Europe (ESMA (2013)) documents a modest 26 basis point reduction in CDS spreads, but finds no evidence that EU sovereign bond yields dropped as a result of the naked CDS ban. Our model identifies the channel that can render a naked CDS ban ineffective in lowering bond yields: the re-emergence of short sellers. Hence, in order to guarantee a reduction in borrowing costs, a ban on naked short selling needs to be combined with restrictions on short selling.

Second, we briefly consider an outright ban of the CDS market. This amounts to a comparison of the equilibrium with a CDS market to the equilibrium without CDS. From Proposition 1, we know that the effect of CDS introduction on the bond yield is ambiguous. Therefore, banning CDS markets altogether may either increase or decrease borrowing costs for issuers, depending on parameters. Accordingly, a ban on CDSs is more likely to lead to a reduction in funding costs if trading costs in the bond and the CDS market are similar, and when basis traders are restricted in the amount of leverage they can take.

Finally, let us consider the effect of banning both the CDS market and short positions in the bond. This intervention amounts to a comparison of the bond and CDS market equilibrium market described in Proposition 1 to a setting where only long positions in the bond are allowed and no CDS is available. Perhaps surprisingly even this intervention is not guaranteed to lower bond yields for issuers. While restricting short positions prevents the reemergence of short sellers in response to a ban on CDS positions, a trade-off now emerges from the countervailing effects of (i) increased demand for the bond from investors who formerly sold the CDS but now purchase the bond and (ii) the reduction in demand for the bond that results from the elimination of basis traders. Because basis traders are price neutral when they cannot take leverage \((L = 1)\), in this case a joint ban on CDSs and short

\[\text{32}\text{This long-only case can be solved analogously to the no-CDS case in Lemma 1. The main difference is that the shorting triangle in Figure 1 would disappear. Market clearing then requires that demand from the buying triangle equals bond supply.}\]
selling leads to an unambiguous decrease in the bond yield. When basis traders can take leverage, on
the other hand, bond yields may increase or decrease, depending on the relative size of the two effects.

6 Conclusion

This paper provides a liquidity-based model of CDS markets, bond markets and their interaction. In
our framework, CDSs are non-redundant because they have lower trading costs than the underlying
bonds. Our model identifies a fundamental trade-off between a crowding-out effect (the CDS crowds
out demand for the bond) and an improvement in the allocation in the bond market (the CDS leads
to the emergence of levered basis traders, which allows long-term investors to hold more of the illiquid
bond).

CDS introduction is more likely to raise the price of the underlying bond when there is a significant
trading-cost difference between the bond and the CDS, and when hedged basis traders can take sub-
stantial leverage. For firms with multiple bond issues, more illiquid bonds (such as off-the-run bonds
or custom-tailored issues) are more likely to benefit from CDS introduction. Beyond characterizing
the impact of CDS introduction on the pricing of the underlying bond, the model also generates em-
pirical predictions regarding trading volume in bond and CDS markets, as well as the cross-sectional
and time-series properties of the CDS-bond basis. It therefore provides an integrated framework that
matches many of the stylized facts in bond and CDS markets. Finally, our framework can be used
to assess a number of policy measures related to CDS markets, such as the recent E.U. ban on naked
CDS positions.

Finally, it is worthwhile pointing out that our framework and therefore its main insights apply to
any derivative that can be traded at a lower cost than the underlying asset. Beyond CDSs, examples
of such assets may include index futures, bond futures, and ETFs.
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A  Proofs

Parametric assumptions for closed-form solutions. We make three main parametric assumptions in order to simplify the analysis. Our qualitative results do not depend on these assumptions, but relaxing these assumptions would lead to slightly different expressions. Assumptions 1 and 2 ensure that both long and short bond positions are present before CDS introduction (and, hence, the region of long bond investors is a triangle):

Assumption 1. $\Delta > c_B$.

Assumption 2. $S < \frac{\lambda}{2} \cdot \frac{(\Delta - c_B)^2}{\Delta - c_B}$.

Assumption 3 ensures that the region of basis traders forms a triangle, which requires that basis trader leverage is not too high:

Assumption 3. $S < \frac{\lambda}{2} \cdot \frac{\Delta}{c_B} \cdot \frac{2L^2 + 1}{4L^2}$.

Proof of Lemma 1. It follows from Assumptions 1 and 2 that both long and short bond positions emerge. Moreover, the regions of long and short investors are triangles, as depicted in Figure 1. Evaluating the zero-valuation line of a long bond position, $V_{\text{longBOND},i} = 0$, at $\mu_i = 0$ and at $\pi_i = \pi - \frac{\Delta}{2}$ yields a right-angled “buy” triangle with base $1 - p - (\pi - \frac{\Delta}{2})$ and height $\frac{\Delta}{c_B} \left[ 1 - p - (\pi - \frac{\Delta}{2}) \right]$. Similarly, evaluating the zero-valuation line of a short bond position, $V_{\text{shortBOND},i} = 0$, at $\mu_i = 0$ and at $\pi_i = \pi + \frac{\Delta}{2}$ yields a right-angled “short” triangle with base $\pi - \frac{\Delta}{2} - (1 - p + c_B)$ and height $\frac{\Delta}{c_B} \left[ \pi - \frac{\Delta}{2} - (1 - p + c_B) \right]$. Given the uniform conditional density of investors, $f(\pi|\mu) = \frac{1}{\Delta}$, market clearing then requires that

$$\frac{1}{\Delta} \left[ \frac{1}{2} \cdot \frac{\lambda}{c_B} \left( 1 - p_{\text{noCDS}} - \left( \pi - \frac{\Delta}{2} \right) \right)^2 - \frac{1}{2} \cdot \frac{\lambda}{c_B} \left( \pi - \frac{\Delta}{2} - (1 - p_{\text{noCDS}} + c_B) \right)^2 \right] = S, \quad (A1)$$

which yields

$$p_{\text{noCDS}} = 1 - \frac{\pi + c_B}{2} - \frac{c_B}{\lambda} \frac{\Delta}{\Delta - c_B} S. \quad (A2)$$

Proof of Lemma 2. We first show that the equilibrium CDS price is given by $q = \pi$, irrespective of positions taken in the bond market. This result allows us to solve sequentially for price of the CDS and the bond. Formally, the pricing of the CDS follows from a limit argument. Let $\overline{\pi}$ denote the maximum value of the support of the liquidity shock intensity and the associated CDS price $q(\overline{\pi})$. Because of the presence of long bondholders, market clearing in the CDS market requires that, for any finite $\overline{\pi}$, $q(\overline{\pi}) > \pi$. Intuitively, because
long positions take away from potential CDS sellers, the CDS price has to be slightly more attractive than the average default probability for markets to clear. However, in the limit $\mu \rightarrow \infty$, bond positions become negligibly small relative to positions in the CDS market, which implies that the price of the CDS converges to the average default probability, $\lim_{\mu \rightarrow \infty} q = \pi$.

When a CDS priced at $q = \pi$ is available, solving $V_{\text{sellCDS},i} > V_{\text{longBOND},i}$ for $\mu_i$ yields that any investor with liquidity shock intensity $\mu_i > \frac{\lambda}{c_B} (1 - p - q)$ strictly prefers selling a CDS to taking a long position in the bond. Because of its trading costs, the bond must trade at a price below $1 - \pi$. Therefore, given availability of the CDS priced at $q = \pi$, no investors will short the bond and, by the same observation, the positive basis trade is not profitable. Comparing the payoff from a negative basis trade, $L \cdot (V_{\text{sellCDS},i} + V_{\text{shortBOND},i})$, to $V_{\text{longBOND},i}$ and $V_{\text{buyCDS},i}$ yields a right-angled basis trade triangle with base $(2L - 1)(1 - p - q)$ and height $\frac{\lambda}{c_B} (1 - p - q)$. Assumption 3 guarantees that this basis trader region is indeed a triangle.

Market clearing in the bond market requires that the demand from long bond investors (the “buy bond” trapezoid) and basis traders (the “basis trader triangle”) equals the supply of the bond:

$$\frac{1}{2} \left\{ q - \left( \pi - \frac{\Delta}{2} \right) + q - (L - 1)(1 - p - q) - \left( \pi - \frac{\Delta}{2} \right) \left( \frac{\lambda}{c_B} (1 - p - q) \right) + \frac{1}{2} \frac{\lambda}{c_B} (2L - 1)(1 - p - q)^2 \right\} = S,$$  \hspace{1cm} (A3)

which, defining $\Phi \equiv 1 + 2L(L - 1)$, yields

$$p_{\text{withCDS}} = 1 - \pi - \frac{\Delta}{2} \sqrt{1 + 8 \Phi \frac{\lambda}{c_B} \frac{\Delta}{\lambda} - 1}. \hspace{1cm} (A4)$$

**Proof of Proposition 1.** The bond price change in response to CDS introduction can be calculated directly from Lemmas 1 and 2:

$$dp = p_{\text{withCDS}} - p_{\text{noCDS}} = -\frac{c_B}{2} + \frac{c_B}{\lambda} \frac{\Delta}{\Delta - c_B} S - \frac{\Delta}{2} \sqrt{1 + 8 \Phi \frac{\lambda}{c_B} \frac{\Delta}{\lambda} - 1}. \hspace{1cm} (A5)$$

Part (i) follows from the observation that (A5) cannot be signed unless we impose further restrictions on parameters (in the proof of part (iii), we provide specific examples of both increases and decreases in the bond price in response to CDS introduction). Part (ii) follows directly from setting $c_B = 0$ in (A5), which yields $dp = 0$. To show part (iii), we first show that, for a given level of basis trader leverage $L$, the bond price
decreases in response to CDS introduction when \(c_B\) is sufficiently small. This can be seen by differentiating equation (A5) with respect to the bond trading cost and evaluating the resulting expression at \(c_B = 0\), which yields \(-\frac{1}{2} - \frac{S}{\lambda} < 0\). Given that the bond price is not affected by CDS introduction when \(c_B = 0\), this implies that for bond trading costs close to zero CDS introduction reduces the bond price. To show that the bond price can only increase if basis trader leverage is sufficiently high, we observe from (A5) that

\[
\frac{d(p_{\text{withCDS}} - p_{\text{noCDS}})}{dL} = \frac{-4(2L^2 - 2L + 1)Sc_B - \Delta\lambda}{\sqrt{\Delta\lambda(8(2L^2 - 2L + 1)Sc_B + \Delta\lambda)}} + \frac{\sqrt{\lambda} + Sc_B^2}{\lambda(\Delta - c_B)^2} < 0.
\]  

(A6)

From Lemma 2 we see that \(p_{\text{withCDS}}|_{L \to \infty} = 1 - \pi\). Therefore, if \(p_{\text{noCDS}} < 1 - \pi\), CDS introduction raises the bond price when \(L\) is sufficiently high. This is the case whenever \(S > \frac{\lambda - c_B}{2\Delta}\), which is not ruled out by either Assumption 2 or 3. To show (iv), we note that

\[
\frac{d(p_{\text{withCDS}} - p_{\text{noCDS}})}{d\Delta} = \frac{-4(2L^2 - 2L + 1)Sc_B - \Delta\lambda}{\sqrt{\Delta(8(2L^2 - 2L + 1)Sc_B + \Delta\lambda)}} + \frac{\sqrt{\lambda}}{2\sqrt{\lambda(2L^2 - 2L + 1)}} - \frac{Sc_B^2}{\lambda(\Delta - c_B)^2} < 0.
\]  

(A7)

The above condition holds if and only if

\[
\sqrt{\Delta\lambda(8(2L^2 - 2L + 1)Sc_B + \Delta\lambda)} [\lambda(\Delta - c_B)^2 - 2(2L^2 - 2L + 1)Sc_B^2] < \lambda(\Delta - c_B)^2 [4(2L^2 - 2L + 1)Sc_B + \Delta\lambda],
\]  

(A8)

which can be shown to hold by bounding the left hand side from above by dropping the negative term \(-2(2L^2 - 2L + 1)Sc_B^2\). □

**Proof of Proposition 2.** To prove (i), we note that trading frequency of all investors selling the CDS is higher than the trading frequency of any investor buying the bond either through a long only trade or a basis trade (see Figure 2). This implies that turnover generated by CDS sellers (their average trading frequency) is higher than turnover in the bond market (the average trading frequency of investors who hold the bond). Note that this argument even ignores additional CDS turnover generated by CDS buyers (i.e., the turnover generated by CDS sellers strictly underestimates overall CDS turnover).
To prove (ii), we observe that CDS introduction changes the bond holding regions in two ways, both of which lead to lower bond turnover (see Figure 2). First, the elimination of the shorting triangle unambiguously decreases bond trading. Since the amount of bonds outstanding $S$ is unchanged, this decreases bond turnover. Second, of the remaining bond buyers (including basis traders) even those with the highest trading frequency have a lower trading frequency than the bond buyers that have been eliminated through introduction of the CDS. Because the overall required number of bond buyers decreases (the CDS eliminates short selling), the mass of low turnover investors added to the bond buyers (if any), is smaller than the mass of former bond buyers who are crowded out into the CDS market. Since these new bond buyers all have a lower trading frequency than the bond investors crowded out by the CDS market, the amount of equilibrium trading diminishes. Given that the bond supply $S$ is unchanged, turnover in the bond market decreases. □

**Proof of Proposition 3.** To compare price impact with and without the CDS, we can use the expressions in Lemmas 1 and 2 to calculate

$$\left| \frac{dp_{noCDS}}{dS} \right| = \frac{c_B \Delta}{\lambda (\Delta - c_B)}, \quad (A9)$$

$$\left| \frac{dp_{withCDS}}{dS} \right| = \frac{c_B}{\lambda} \frac{2}{\sqrt{1 + 8\Phi \frac{c_B}{\lambda} S}}, \quad (A10)$$

This implies that price impact is lower in the presence of the CDS if

$$\frac{\Delta}{\Delta - c_B} > \frac{2}{\sqrt{1 + 8\Phi \frac{c_B}{\lambda} S}}, \quad (A11)$$

where, as before, $\Phi \equiv 1 + 2L(L-1)$. The results in the proposition then follow directly from (A11): First, note that the right hand side goes to zero as $L \to \infty$, whereas and the left hand side is positive and independent of $L$. Hence, (A11) is satisfied if basis trader leverage $L$ is sufficiently high, proving (i). Second, as $c_B$ increases towards its upper bound $\Delta$, the left hand side diverges to $+\infty$, while the right hand side decreases, proving (ii). Third, as $\Delta$ decreases towards its lower bound $c_B$, the left hand side diverges to $+\infty$, while the right hand side stays bounded from above, proving (iii). □
Proof of Proposition 4. As discussed in the main text, the CDS-bond basis is given by \(- \lambda (1 - p - q)\). Inserting \(p = p_{\text{withCDS}}\) and \(q = \pi\) yields

\[
\text{basis} = -\lambda \frac{\Delta}{2} \sqrt{1 + 8\Phi \frac{S}{\Delta} - 1} \leq 0, \quad (A12)
\]

where, as before, \(\Phi \equiv 1 + 2L(L - 1)\). The comparative statics follow directly from differentiating the basis with respect to \(S\), \(c_B\), \(L\), and \(\Delta\) and are omitted for brevity.

Proof of Corollary 1. The size of the basis trade is defined as the amount of bonds (and, equivalently, CDSs) that basis traders own in equilibrium, which can be calculated as the mass of traders in the basis trader triangle multiplied by their leverage \(L\). This yields:

\[
\text{size of the basis trade} = \frac{L(2L - 1) \left[\sqrt{\Delta (8(2L^2 - 2L + 1)S c_B + \Delta \lambda) - \Delta \sqrt{\lambda}}\right]^2}{8\Delta (2L^2 - 2L + 1)^2 c_B}, \quad (A13)
\]

which can be rearranged to yield the expression in the proposition. The comparative statics for \(S\), \(c_B\), and \(\Delta\) follow directly from differentiating this expression with respect to the relevant parameters. The comparative statics for \(L\) are slightly more complicated: The size of the basis trade is increasing in \(L\) if and only if

\[
(4L^4 - 12L^3 + 12L^2 - 6L + 1) \frac{8S c_B}{\Delta \lambda} < (8L^3 - 6L^2 - 2L + 1) \left(1 + (2L^2 - 2L + 1) \frac{8S c_B}{\Delta \lambda} - 1\right). \quad (A14)
\]

For \(L \geq 1\) this can be shown to hold if \(\frac{S c_B}{\Delta \lambda} < 1\), which is true by Assumption 3.

Proof of Proposition 5. When \(c_{\text{CDS}} > 0\), closed-form solutions for the equilibrium prices are only available in special cases. Part (i) follows because in the absence on further restrictions on parameters, the price effect of CDS introduction can go either way (in the proof of part (iii), we provide specific examples of both increases and decreases in the bond price in response to CDS introduction). To show part (ii), we first note that, when \(c_{\text{CDS}}\) is sufficiently close to \(c_B\), there are no basis traders (the negative basis is smaller than the trading cost to set up the basis trade). Given that there are no basis traders in this case, we can then solve for the equilibrium prices in closed form:

\[
p_{\text{withCDS}} = 1 - \bar{\pi} + \frac{\Delta}{2} + \frac{c_{\text{CDS}} (\Delta - c_{\text{CDS}})}{4 (c_B - c_{\text{CDS}})} - \frac{2c_B - c_{\text{CDS}}}{4 (c_B - c_{\text{CDS}})} \sqrt{\left(\Delta - c_{\text{CDS}}\right)^2 + 8\Delta \frac{S}{\lambda} (c_B - c_{\text{CDS}})} \quad (A15)
\]

\[
q = \bar{\pi} + \frac{c_{\text{CDS}}}{2} - \frac{c_{\text{CDS}} (\Delta - c_{\text{CDS}})}{4 (c_B - c_{\text{CDS}})} + \frac{c_{\text{CDS}}}{4 (c_B - c_{\text{CDS}})} \sqrt{\left(\Delta - c_{\text{CDS}}\right)^2 + 8\Delta \frac{S}{\lambda} (c_B - c_{\text{CDS}})} \quad (A16)
\]

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Note that taking the limit of (A15) as $c_{\text{CDS}} \to c_B$, we recover equation (4). This shows that the CDS is redundant when CDS and bond trading costs are equal, establishing (ii). Holding fixed $L$ and differentiating (A15) with respect to $c_{\text{CDS}}$ and evaluating the derivative at $c_{\text{CDS}} = c_B$ yields

$$\frac{dp_{\text{with CDS}}}{dc_{\text{CDS}}} \bigg|_{c_{\text{CDS}}=c_B} > 0,$$

which establishes that a small reduction of CDS trading costs starting from $c_{\text{CDS}} = c_B$ always reduces the bond price, establishing the first part of (iii). Finally, it follows from the observation that basis traders are price-neutral when they cannot take leverage, that basis trader leverage $L$ must be sufficiently high for CDS introduction to increase the bond price. Closed-form solutions are available when $L \to \infty$. In this case, the basis trader region shrinks to a point, demanding a finite amount of the bond and an equal amount of the CDS. The CDS-bond basis is zero ($p_{\text{with CDS}} = 1 - q$), but, because of trading costs in the CDS, $q \neq \pi$. From the equilibrium prices (omitted for brevity), one then finds that CDS introduction raises the bond price whenever

$$S > \frac{1}{2} \frac{\Delta-c_B}{\Delta} \frac{\Delta(c_B^2-c_{\text{CDS}}^2)-cc_{\text{CDS}}^2}{\Delta(c_B-c_{\text{CDS}})^2},$$

which converges to the condition given in Proposition 1 when $c_{\text{CDS}} \to 0$. \qed
B Online Appendix (not for publication)

B.1 Two bond issues

In this section, we provide a more detailed analysis of the two-bond extension discussed in Section 4.3.1 of the main paper. We consider an issuer with two bond issues: a “liquid” issue with lower trading costs and a “less liquid” issue with higher trading costs. One interpretation of this setting is that the liquid issue is a recently issued “on-the-run” bond, while the less liquid issue is an older “off-the-run” bond. Alternatively, the liquid bond may be a relatively standard bond issue, whereas the illiquid bond represents a bond that is more custom-tailored towards a particular clientele and therefore less liquid. Finally, based on empirical evidence that longer-term bonds are less liquid, the illiquid bond could be interpreted as a longer-term bond.

As in the main part of the paper, we assume that the CDS is frictionless ($c_{CDS} = 0$) and is therefore more liquid than either of the two bonds, which have strictly positive trading costs of $c^L_B$ (low trading cost) for the liquid bond and $c^H_B > c^L_B$ (high trading cost) for the illiquid bond. Figures 6 and 7 illustrate the holding regions, which can be derived in analogous fashion to the one-bond case. The illiquid bond is held by investors with longer trading horizons. Moreover, in equilibrium the less liquid bond has a larger illiquidity discount and therefore a more negative CDS-bond basis.

Because of the difference in ownership patterns for the two bonds, CDS introduction affects the prices of the two bonds differently. The liquid bond and the CDS are relatively close substitutes (in terms of liquidity), which means that the liquid bond is affected disproportionately by the crowding-out effect of CDS introduction. The illiquid bond and the CDS, on the other hand, are less close substitutes, which implies that the illiquid bond benefits disproportionately from the increased demand from basis traders. Hence, the illiquid bond generally benefits more from CDS introduction (in a relative sense). Moreover, as we illustrate below, it is possible that the price effect of CDS introduction goes in opposite directions for the liquid and the illiquid bonds.

Figure 8 illustrates the price effect of CDS introduction on two bonds of differing liquidity for specific parameter values. When basis trader leverage is sufficiently small ($L < L^*$), CDS introduction reduces the price of both the liquid and the illiquid bond. However, because the liquid bond is affected more strongly by the crowding out effect of the CDS, the price of the liquid bond drops by more than the price of the illiquid

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33To reduce the number of cases discussed in this extension, we assume that $c^L_B$ is not too small. This simplifies the analysis because it ensures that absent the CDS investors do not take long-short positions (similar to on-the-run/off-the-run strategies) in the two bonds. However, this could be incorporated without affecting the main insights of this section.
Figure 6: Equilibrium with two bonds before CDS introduction.

The figure illustrates the equilibrium when two bonds with different trading costs are traded. Optimistic investors with sufficiently long trading horizons purchase the illiquid bond, whereas optimistic investors with shorter trading horizons purchase the liquid bond. Investors who are pessimistic about the bond’s default probability and have sufficiently long trading horizons short the liquid bond. There are no short positions in the illiquid bond. Market clearing requires that the bond prices adjust such that for each bond demand from long investors is equal to bond supply plus (in the case of the liquid bond) short positions.

Bond. For an intermediary range of basis trader leverage \((L^* < L < L^{**})\), the prices of the two bonds move in opposite directions when the CDS is introduced—the illiquid bond benefits from CDS introduction, while the price of the liquid bond decreases. Finally, when basis trader leverage is sufficiently high \((L > L^{**})\), the prices of both bonds increase in response to CDS introduction, but the price of the illiquid bond increases by more than the price of the liquid bond.

Formally, we can summarize the results on CDS introduction in the presence of two bonds in the following proposition.

**Proposition 6. The effect of CDS introduction on liquid and illiquid bonds of the same issuer.**

Assume an issuer has a liquid and an illiquid bond outstanding, with trading costs \(c_B^L\) and \(c_B^H\), respectively.

The price change from CDS introduction is larger for the illiquid bond than for the liquid bond,

\[
p_H^{\text{withCDS}} - p_H^{\text{noCDS}} > p_L^{\text{withCDS}} - p_L^{\text{noCDS}}.
\]  

\(\text{(B1)}\)
Figure 7: Bond and CDS market equilibrium with two bonds of different liquidity.

The figure illustrates the equilibrium when two bonds of different liquidity and a (more liquid) CDS are traded. Relative to the liquid bond, the illiquid bond is held by investors and basis traders with longer trading horizons. Because the two bonds are held by different investor clienteles, they are affected differently by CDS introduction. The liquid bond is disproportionately affected by the crowding out effect of the CDS market, the illiquid bond benefits disproportionately from the emergence of basis traders. The illiquid bond therefore benefits more from CDS introduction.

Hence, the illiquid bond is more likely to benefit from CDS introduction than the liquid bond.

Proof of Proposition 6. The first part of the proof is based on a geometric argument using Figure 6, which illustrates the equilibrium with two bonds before the CDS is introduced. The strategy of the proof is to consider how the equilibrium allocation and equilibrium prices have to change once the CDS is introduced.

Assume for now that basis traders cannot take leverage (L=1) and consider the effect of CDS introduction. Under the uniform investor distribution and $L = 1$, the crowding out effect of CDS introduction dominates the elimination of short sellers. Hence, at pre-CDS prices there is insufficient demand for the liquid bond once the CDS is available. Now consider lowering the price of the liquid bond $p^L$ holding constant the price differential between the two bonds, $p^L - p^H$. We now lower $p^L$ (and thus also $p^H$) in this fashion until the liquid bond market clears. However, now the market for the illiquid bond cannot clear. Because we held $p^L - p^H$ fixed when lowering the price of the liquid bond, we also lowered the price of the illiquid bond, shifting to the right the boundary of the illiquid bond trapezoid. For the illiquid bond market to clear, we now move the liquid bond
Figure 8: Price change of liquid and illiquid bond due to CDS introduction

This figure illustrates the price change for a liquid and an illiquid bond in response to CDS introduction, as a function of basis trader leverage $L$. For low levels of basis trader leverage, both bond prices drop in response to CDS introduction, but the price of the illiquid bond drops by less. For an intermediary range of basis trader leverage, the price of the illiquid bond increases but the price of the liquid bond decreases in response to CDS introduction. When basis trader leverage is sufficiently high, both bond prices increase, but the price of the illiquid bond increases by more when the CDS is introduced. Parameters: $S_H^H = 0.2$, $S_L^L = 0$, $c_H^H = 0.02$, $c_L^L = 0.01$, $\bar{\pi} = 0.1$, $\Delta = 0.1$, $\lambda = 0.2$. Note that the supply of the liquid bond is set to zero simply because it allows for a particularly tractable way to solve for bond prices when two bonds are trading.

Having shown that when $L = 1$, the illiquid bond price drops less when the CDS is introduced, we now show that the illiquid bond increases faster in basis trader leverage than the price of the liquid bond. To do this, we solve for the equilibrium prices of the two bonds under the uniform investor distribution in the presence of a frictionless CDS, allowing for $L \geq 1$. Following a similar procedure as before, the equilibrium bond prices are given by

$$p_H^{with\text{CDS}} = 1 - \bar{\pi} - \frac{\Delta}{2} \sqrt{\frac{1 + 8\Phi \frac{S_H^c + S_L^c}{\lambda} - 1}{\Phi}}$$

(B2)
and
\[
p^L_{\text{withCDS}} = 1 - \bar{p} - \frac{c^L_{\text{B}}}{c^L_{\text{H}}} \sqrt{1 + \Phi \frac{S^H \Phi + S^L c^L_{\text{H}}}{\lambda \Delta}} + \left(1 - \frac{c^L_{\text{H}}}{c^L_{\text{B}}} \right) \sqrt{1 + \Phi \frac{S^L c^L_{\text{B}}}{\lambda \Delta}} - 1
\]  
(B3)

where we define \( \Phi \equiv 1 + 2L(L - 1) \). Differentiating these expressions with respect to \( L \), we see that the illiquid bond profits more from basis trader leverage:

\[
\frac{\partial p^H_{\text{withCDS}}}{\partial L} > \frac{\partial p^L_{\text{withCDS}}}{\partial L} > 0. \tag{B4}
\]

**B.2 CDS market with frictions (c_{CDS} > 0): A numerical example**

In this section, we provide a brief numerical example that shows the effect of CDS introduction on the bond price and the equilibrium CDS-bond basis when trading costs are present both in the bond and the CDS market (i.e., \( c_{\text{B}} \geq c_{\text{CDS}} > 0 \)). This numerical example illustrates the main insights of Proposition 5 in Section 4.3.3 of the main paper.

The left panel of Figure 9 plots the effect of CDS introduction on the bond price as a function of the CDS trading cost \( c_{\text{CDS}} \). Each of the three lines in the plot corresponds to different levels of basis trader leverage \( L \). When the CDS has the same trading cost as the bond (\( c_{\text{CDS}} = 0.02 \)), the CDS is redundant and CDS introduction has no effect on the price of the bond. (More generally, the CDS is redundant in our framework whenever CDS trading costs are weakly larger than trading costs in the bond.) When \( c_{\text{CDS}} \) is slightly smaller than the bond trading cost, the crowding-out effect of the CDS dominates and CDS introduction leads to a decrease in the bond price, independent of the amount of leverage that basis traders can take. However, as the liquidity differential between the bond and the CDS widens, basis traders emerge in equilibrium. When basis traders can take leverage (the figure depicts \( L = 3 \) and \( L = 20 \)), they improve the allocation in the bond market and put upward pressure on the bond price. For the parameter values in this example, basis trader leverage of \( L = 3 \) is not sufficient to generate an increase in the bond price, even as \( c_{\text{CDS}} \) approaches 0. When \( L = 20 \), on the other hand, CDS introduction increases the bond price when the CDS trading cost \( c_{\text{CDS}} \) is sufficiently small.

The right panel of Figure 9 illustrates the equilibrium CDS-bond basis. We calculate the CDS-bond basis at ask prices because this most accurately reflects the implementable trading strategy of a negative basis trader who has to purchase both the bond and the CDS at ask prices. As the figure shows, the CDS-bond basis is
Figure 9: Price effect of CDS introduction and CDS-bond basis when $c_{\text{CDS}} > 0$

The left panel shows the bond price change in response to CDS introduction as a function of the CDS trading cost $c_{\text{CDS}}$. The CDS is redundant when $c_{\text{CDS}} = c_B$ and reduces the bond price when the bond and the CDS have similar liquidity. When the CDS is sufficiently more liquid than the bond, CDS introduction can increase the bond price if basis traders can take sufficient leverage. The right panel illustrates the CDS-bond basis. When the CDS trading cost $c_{\text{CDS}}$ is close to the bond trading cost $c_B$, the basis (calculated at ask prices) is slightly positive, but no basis traders are active. When the CDS is sufficiently more liquid than the bond, the basis becomes negative and basis traders become active and lean against the basis. Parameters: $S = 0.2$, $c_B = 0.02$, $\bar{\pi} = 0.1$, $\Delta = 0.12$, $\lambda = 0.2$, uniform investor distribution.

Note that the basis is positive using bond and CDS ask prices, but remains negative at bond and CDS mid prices. Finally, comparing the lines for $L = 1$, $L = 3$, and $L = 20$ show that more leverage allows basis traders to trade more aggressively against the negative CDS-bond basis, compressing it towards zero.