Real Effects of Corporate Bond ETF Ownership*

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Abstract

Corporate bond ETFs provide stable funding to US companies, with real and pricing effects. Exogenous ETF rule changes establish a causal positive link between bond ETF ownership and R&D spending, with the effect being largest for speculative-grade issuers. The stable and passive features of ETF ownership translate into a pervasive and persistent reduction in firms' cost of debt, which enables especially financially constrained firms to further exploit their internal growth opportunities. A theoretical model incorporating institutional features of bond ETFs shows that sufficiently productive firms will optimally issue extra debt to ensure their bonds are ETF-eligible.

Keywords: ETF ownership, corporate bonds, R&D investments.

JEL: G11, G12, G31.

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1 Introduction

A stable supply of debt capital is of paramount importance to financial managers. Most research on this topic has focused on the composition of the bond investor base, particularly on its partition between mutual funds and insurance companies, with the latter group thought to provide a more stable supply of capital (Massa et al., 2013; Coppola, 2021). With assets under management in excess of $1 trillion as of 2020 (Todorov, 2021), corporate bond exchange-traded funds (ETFs) have become an important vehicle of passive and potentially stable debt capital. Our calculations show that conditional on bond ownership today, the probability of continued ETF ownership over the next nine years is about 70%. In this paper, we study whether this stability encourages firms to undertake risky, long-term investments such as in research and development (R&D).

Recent evidence by Antoniou et al. (2022) based on equity ETFs reveals that ETF ownership increases firms' investment sensitivities to their stock prices. The driving idea is that ETFs improve the informational efficiency of the stocks that they cover, thus making their prices an effective tool for managerial decisions (Chen et al., 2007). We complement this evidence by focusing on the stability of debt capital that bond ETF funds create. Unlike equity, debt has a finite maturity and is subject to rollover risk, so considering bond ETFs provides a more fruitful avenue for studying the real effects of capital stability.

We conjecture that the economic benefits of bond ETF ownership will accrue mainly to firms that face higher financial constraints and rollover risk, and will allow these firms to undertake more risky, long-term investments once these constraints bind less. Consistent with this conjecture, we find that issuers of speculative-grade bonds increase their R&D

investments once they have secured a more stable source of capital. On the other hand, we find that investment-grade issuers do not change their investment strategy significantly.

To establish a causal link between investment and ETF ownership, we exploit two quasi-natural experiments that exogenously alter firms' ETF ownership. These experiments allow us to use a difference-in-differences (DID) analysis in which treated firms experience an exogenous increase in ETF bond ownership. The first experiment is based on Dannhauser (2017), and we define the treatment group to be the firms with at least one bond newly added to the iShares iBoxx USD High Yield Corporate Bond ETF (HYG) between July 2009 and July 2010. We propose two control groups: firms with pre-existing bonds in HYG and a matched sample of firms with similar characteristics to the treated group. The second experiment focuses on the iShares iBoxx USD Investment Grade Corporate Bond ETF (LQD). On April 30, 2012, LQD changed its inclusion rule by decreasing the minimum issuer amount outstanding from $3 billion to $2 billion. As a result of this rule change, about 200 bonds were newly added to LQD between April and July 2012. In this experiment, treated firms are those with at least one bond added to LQD in 2012. Similar to the HYG experiment, we also consider two control groups: firms whose bonds were held by LQD before the rule change and firms that are matched to treated firms.

Our DID analysis reveals that ETFs' inelastic supply of debt capital contributes significantly to an increase in R&D, but not in CAPX. Firms issuing speculative-grade bonds exploit the cheaper and more stable long-term debt supply to redirect resources toward innovation and internal growth opportunities (R&D). Depending on the control group, R&D spending as a percentage of firms' lagged assets increases by approximately 0.1 percentage points for original constituents controls and 0.5 percentage points for matched controls. Economically, these increases account for 5.6% and 28.5% of the average R&D rate. ETF ownership, however, does not affect CAPX since CAPX is more tangible and easier to redeploy in case of bankruptcy and the firms may already have debt clienteles willing to finance the expenditures.

Having established a positive relation between ETF ownership and investment in R&D, we devote the rest of our study to exploring both empirically and theoretically the likely sources of the relation. The pricing channel is the first place we look. Specifically, we consider the effect of bond ETF eligibility and inclusion using the experiments already introduced above. We extend the HYG inclusion rule change experiment of Dannhauser (2017) by considering a larger set of bonds. While Dannhauser (2017) focuses on bonds directly experiencing HYG inclusion, we consider the set of all bonds issued by firms experiencing HYG inclusion (aggregate effect), and, of this larger set, we also consider the subset of bonds not included to identify any potential spillover effect of HYG inclusion. Our results show that, in aggregate, bonds experience a substantial average yield spread reduction of approximately 126 basis points. For the spillover effect, and we find an average yield spread reduction of 136 basis points.

The second experiment testing the pricing effect focuses on investment-grade bonds' eligibility for LQD. As a result of this rule change, about 200 bonds were added to LQD between April and July 2012. In this experiment, treated bonds are those meeting the new inclusion criteria in April 2012, while the control group is constructed using bonds that barely fall short of the revised $2 billion threshold. We find that the average yield spread of treated bonds decreases by 10 basis points following the rule change, which is about 5% reduction in yield spread.

Based on the pricing effect that ETF ownership has on all bonds, and not merely the bonds directly selected by the ETF, we can conclude that ETF ownership results in a pervasive reduction in the cost of debt capital for both high-yield and investment-grade bonds. If only the direct effect held, the reduction in yield would be a bond-specific phenomenon likely related to its liquidity.

The final step in our analysis is to propose a theory to gain deeper insights and draw further implications based on a stable source of financing provided by ETF and the positive effect of ETF ownership on the cost of capital. We build a three-period model of deb choice and investment. The model considers several institutional features of bond ETFs, such as the eligibility requirement and probabilistic inclusion. The decision to own a bond rests with the ETF sponsor, but the firm controls the bond issue size, which is the main dimension of ETF inclusion.

In the model, each firm fully finances R&D expenditures by issuing one-period debt in the first period, with production in the last period. A firm's total debt issuance needs to meet a minimum threshold in order for a portion of its bonds to be included in an ETF with some probability, with the rest still being held by active bond investors. In the second period, each firm faces debt rollover risk, where active debt holders demand full repayment, prompting the firm to issue new debt in order to avoid default. ETF investors will always allow rollover at no additional cost, thus lowering the total issuance cost.

A key tension in this model is that when a firm issues extra debt to meet the ETF inclusion criterion, the firm may be ex-post worse off if the ETF fails to include its bonds. In such a case, the firm would have preferred not to issue excess debt. Therefore, in equilibrium, each firm's debt issuance, or equivalently R&D expense, is a choice that must weigh the benefit of ETF inclusion against the potential cost of excessive issuance.

The model shows that a firm's R&D investment as well as its equity value increase when the firm has met the ETF inclusion criterion relative to an economy without an ETF. For a firm that chooses to issue extra debt for ETF inclusion, it will only issue up to the inclusion threshold level, and the firm's ex-ante equity value becomes larger than when it does not issue extra debt.

This paper contributes to two strands of the literature. The first contribution relates to studies on how ETFs affect corporate policies. Antoniou et al. (2022) find that higher equity ETF ownership increases price informativeness about systematic shocks, hence increasing the sensitivity of real investment to Tobin's q. Gibbons (2019) studies how passive ownership (mutual funds) of corporate bonds affects firms' financing. The paper finds that higher passive debt ownership increases payouts to shareholders and reduces aggregate ex-ante and ex-post monitoring. Dathan and Davydenko (2020) construct an aggregate passive debt ownership time series and bond-level passive debt ownership. They find that higher aggregate passive debt demand increases firms' propensity to issue bonds and results in larger bonds, lower spreads, longer maturities, and fewer covenants. To the best of our knowledge, our paper is the first to study how the stability connected to bond ETF ownership affects firms' investment decisions.

The paper also contributes to the growing literature on the impact of ETFs on the bond market. Pan and Zeng (2019) show that bond ETFs engage in both index tracking and liquidity transformation, and the former objective may be limited by bond market illiquidity. Koont et al. (2022) and Holden and Nam (2022) find that bond liquidity improves after being included in an ETF basket. We expand Dannhauser (2017)'s result that corporate bond ETFs have a positive valuation effect on their constituents by showing that the benefits extend all bonds backed by firms represented in an ETF, not just the ETF constituents.

The rest of the paper is organized as follows. Section 2 describes data. Section 3 shows how bond ETF ownership affects real investments. Section 4 explores explanations of the real effects of bond ETF ownership by studying the cost of debt. Section 5 provides a model of optimal debt issuance and investment. Section 6 concludes.

2 Data

The Center for Research in Security Prices (CRSP) Survivor-Bias-Free US Mutual Fund Database is used to identify corporate bond ETFs. We identify corporate bond ETFs based on *et_flag* and *crsp_obj_cd*.[1] Furthermore, the fund name must contain "Bond" and any of "ETF", "Exchange Traded", and "Exchange-Traded". After removing all bond funds that do not hold U.S. corporate bonds (i.e., those that specialize in government, municipal, and foreign bonds only), we are left with 193 corporate bond ETFs. Our sample ranges from 2006 to 2019. For each ETF, we obtain monthly data on fund portfolio holdings from CRSP.

We obtain bond characteristics such as amount outstanding, face value, maturity, and

[1] *et_flag* identifies if a fund is an ETF or an ETN. *crsp_obj_cd* is the CRSP objective code that identifies fund style and objectives.

coupon rate from the Fixed Income Securities Database (FISD). We then link ETF holdings and bond characteristics data using eight-digit CUSIP codes and the Bond CRSP Link table on WRDS.

2.1 Bond data

The corporate bond transaction data is obtained from TRACE, which contains data for over 99% of the transactions in the US corporate bond market. Using these characteristics, we exclude convertible, perpetual, foreign currency, zero coupon, floating rate, preferred security, and Rule 144A bonds. We only keep the bonds with at least one year to maturity and offering amount greater than 100 million USD. We calculate bond ratings using the median numerical versions of Standard & Poor's (S&P), Moody's, and Fitch ratings, and we obtain an index ranging from 1 (AAA) to 21 (C). We also filter out possible erroneous trades using the method of Dick-Nielsen (2009). We construct monthly yield spreads of a bond by considering all transactions from the last five business days of each month and then computing the volume-weighted average yield of the bond in that month over the maturity-matched swap rate. We also obtain quarterly firm-level characteristics from Compustat.

Table 1 shows the summary statistics for 805,004 bond-month observations during the sample period from January 2006 to December 2019. ETF bonds are bond-month observations that have positive ETF ownership. Investment-grade bonds have ratings below or equal to 10, and high-yield bonds have ratings above 10. Comparing the summary statistics, we find that the yield spreads of bonds in the ETF sample are generally lower than non-ETF bonds. For example, the average yield spread of non-ETF, high-yield bonds is 5.31%, whereas that of the ETF sample is 4.22%. Table 1 also shows that the issue amount for the ETF sample is generally larger than that of non-ETF bonds. For example, in the market of speculative bonds, the average (median) issue amount is about 723 (550) million for ETF bonds and 421 (300) million for non-ETF bonds.

2.2 Corporate bond ETF ownership data

We calculate firm-year level corporate bond ETF ownership according to the following formula:

$$\text{ETF}_{j,t} = \frac{\sum_{i=1}^{I_j} \sum_{k=1}^{K_i} \text{Par Value Held}_{i,j,k,t}}{\text{Amount Outstanding}_{j,t}}, \tag{1}$$

where Par Value $\text{Held}_{i,j,k,t}$ is the face value of bond i issued by firm j and held by ETF k in month t, and Amount $\text{Outstanding}_{j,t}$ is the amount outstanding of all bonds at time t issued by firm j. Each firm j issues I_j number of bonds, and each bond i is held by K_i ETFs.

We use the bond ETF ownership (1) of the last month of each year to represent yearly ETF ownership. Following Dannhauser (2017), we make a critical change to the data. CRSP Mutual Fund Database began reporting information on ETFs not affiliated with mutual funds in 2010, and hence we encounter the issue of missing data prior to 2010. As iShares represented a large number of shares in the corporate bond ETF market before 2010, we thus replace the iShares data before 2010 from the CRSP holding database with the complete time series of month-end holdings from iShares' website.

Data on corporate bond ETF ownership is merged with firm characteristics from Compustat. We exclude financial firms (SIC codes 6000-6999) and utility firms (SIC codes 4900-4949). We also exclude motor vehicle firms (SIC codes 3711) as the US government intervened heavily with loans and bailouts in the automotive sector during the Great Recession,[2] which could have distorted firms' investment decisions in this industry. To make sure we focus on firms with public bonds outstanding, we only include firms with bond transactions in the Trade Reporting and Compliance Engine (TRACE). We also exclude firms with total assets of less than 1 million and replace missing values of investments with zero. We winsorize all control variables at 1% and 99% levels. In addition, we trim the data for the dependent variables, R&D and CAPX, at the 99th percentile to exclude outliers and maintain the original data distribution. Our final sample has $15,233$ firm-year observations. Among those, $6,763$ firm-year observations have positive corporate bond ETF ownership. Details about the financial variables are given in Appendix A.

For control variables, we include tangibility, defined as the net property, plant, and equipment divided by the book value of assets. Firms with more tangible assets should find asset substitution (risk shifting) more difficult, which lowers debt agency costs and thus raises optimal leverage (Williamson, 1988). The liquidation value of companies with more tangible assets will be higher, reducing the cost of inefficient liquidation and increasing optimal leverage. Second, we control for equity ETF ownership to focus on the extra effect that corporate bond ETF has. Finally, we follow previous literature to include firm size, cash, ROA, cash flow, Tobin's q, market leverage, tangibility, and lagged size as controls.

Table 2 shows the summary statistics at the firm-level variables. Firms in the ETF sam-

[2] https://www.npr.org/2008/12/19/98498125/bush-sets-17-4-billion-in-loans-for-automakers

ple have higher asset, CAPX, and R&D levels. For the total sample, the average corporate bond ETF ownership is 0.95% with a standard deviation 1.45%, whereas for the sample with only positive ETF ownership, the average is 2.15% with 1.47% standard deviation. For an average firm, the total investment rate is about 8.63% of its total assets. Among that, the capital investment accounts for about 6.43% of the total asset, and the R&D expenditure is around 2.20%.

2.3 ETF as a stable source of capital

We conclude the description of the data by showing evidence that corporate bond ETFs provide their portfolio firms with a long-term and stable capital of debt financing. Table 3 shows the conditional empirical probability of positive ETF ownership in the future

$$\mathbb{P}\left[\text{ETF\%}_{t+k} > 0, \forall k \mid \text{ETF\%}_t > 0\right]. \tag{2}$$

The first row shows that among firms with positive ETF ownership in 2007, 71% of them also had positive ETF ownership during each of the next 9 years. On average, nearly 70% of firms have positive ETF ownership over the next 9 years. Once a bond is owned by a corporate bond ETF, the issuer is highly likely to have a certain fraction of bonds held by ETFs in the future. This stable debt capital demand is the main driver for firms to consider increasing investments in long-term and riskier projects such as R&D. Although the average corporate bond ETF ownership for ETF portfolio firms is just about 2.15%, being included in ETFs can also induce other institutional investors in the bond market to hold more shares of that bond (Dannhauser, 2017).

3 Real Effect: Investment

In this section, we analyze the real effects of corporate bond ETF ownership on firms' investments by exploiting the two quasi-natural experiments of changes in ETF inclusion rules.

3.1 HYG inclusion and investments

We leverage the quasi-natural experiment for HYG to explore whether an exogenous increase in ETF ownership affects firms' R&D and CAPX rates. The iShares iBoxx USD High Yield Corporate Bond ETF (HYG) started trading on April 4, 2007, and it is one of the largest high-yield bond ETFs based on assets under management. HYG tracks an equal-weighted 50-bond index managed by the Markit Group. The eligibility criteria for the iBoxx Liquid High Yield Index were modified by imposing a 3-percent cap on the constituent bonds, effective June 30, 2009. As a result of this rule change, about 250 bonds were added to HYG from June to December 2009.Figure 1 shows that before the rule change, only around 50 bonds were held by HYG, and after the rule change, the number of holdings had increased substantially.

The treatment group contains firms that have bonds added to HYG between July 2009 and July 2010.[3] We form two different control groups. The first set consists of firms whose bonds were among the HYG original constituents between January and May 2009. The second control group contains firms that are matched with the treatment group by the following requirements: same three-digit SIC industry codes with treated firms, similar size

[3]We have expanded the inclusion time period for the treatment group in order to obtain more treated firms.

and leverage in 2009, high-yield issuers, having bonds outstanding, and not having bonds in HYG (either original or newly added). Each treated firm is matched with 5 such control firms. We include 8 years of observations (4 years before and 4 years after the exogenous shock) in the analysis.

We first study the dynamic response of firms' R&D and CAPX investment rates using the following specification,

$$\text{R\&D}_{i,t}\ (\text{CAPX}_{i,t}) = \alpha_i + \lambda_t + \sum_{\tau} \beta_\tau \times \text{Treated}_i \times \mathbb{1}_{\tau=t} + \boldsymbol{\delta}\mathbf{X}_{i,t} + \epsilon_{i,t}, \tag{3}$$

where we include various firm-level controls $\mathbf{X}_{i,t}$. To mitigate the concern that firms' investments may depend on size, we control for size and lagged size. Since the stocks of these firms may be included in equity ETFs that in turn can affect the investment opportunities (Antoniou et al., 2022), we control for firms' equity ETF ownership, which is the proportion of a firm's equity market value held by ETFs. To further control for investment opportunities, we include Tobin's q in the regression. We also include cash flow to control for potential investment sensitivity to cash flow. As we study R&D investment, we control for firms' tangibility. Finally, we control for leverage, ROA, and cash holding.

Using specification (3), we plot the coefficients β_τ as well as their 90% confidence intervals in Figure 2 to show the dynamic differences of investments between the treatment and control groups for speculative firms. In panels (a) and (c), R&D expenditure rates for the treatment and control groups are not statistically different before the rule change. After the rule change, firms in the treatment group spend more on R&D than those in the control group. The results support the parallel trend assumption for difference-in-differences analysis. The estimates of β_τ are reported in Table 4. Panels (b) and (d) show the response of CAPX to the rule change, and we do not find a significant effect.

Furthermore, we conduct the difference-in-differences regression,

$$\text{R\&D}_{i,t}\ (\text{CAPX}_{i,t}) = \alpha_i + \lambda_t + \beta_1 \text{Treated}_i \times \text{Post}_t + \boldsymbol{\delta}\mathbf{X}_{i,t}, \tag{4}$$

by including the same set of firm-level controls as in (3). We require that each firm have non-missing observations for dependent variables in each year of the study to ensure that the same firms are included in the pre-and post-periods samples. We find that treatment firms spend more on R&D than control firms after the shock. The results are reported in Table 4.

Depending on the control group, the R&D spending as a fraction of firms' lagged assets increases by approximately 0.1 percentage points for original constituents controls and 0.5 percentage points for matched controls. Economically, these increases account for 5.6% and 28.5% of the average R&D rate among our sample. However, changes in ETF ownership do not have a statistically significant effect on CAPX. This last result suggests that speculative-grade bond issuers were already able to raise debt to finance projects with a high degree of tangibility, given that the assets underlying such projects are easy to recover in the case of default.

The above results on the R&D spending of speculative-grade bond issuers are economically and statistically significant. There is a concern that firms in the treated group may already have bonds included in other ETFs so that the increase in R&D spending is not due to the HYG rule change per se. To alleviate this issue, in Figure 3 we plot the firm-level bond ETF ownership (1) around the HYG inclusion rule change in June 2009. The figure shows that the bond ETF ownership of the treated firms was little prior to the rule change and experienced a large increase afterward, suggesting that HYG was the major ETF holder of these firms' bonds.

3.2 LQD inclusion and investments

In this section, we study the real effects of bond ETF ownership on investment-grade issuers. iShares iBoxx USD Investment Grade Corporate Bond ETF (LQD) started tracking the Liquid Investment Grade Index on July 22, 2002. The new eligibility guidelines for the index were implemented by the Markit Group on April 30, 2012. Before this rule change, the index required the issuer amount outstanding to be at least $3 billion. The new rule reduced the threshold to $2 billion, thus expanding the set of investment-grade bonds admissible in LQD. The details of eligibility requirements are given in Appendix B.1.

To show the addition of bonds after the rule change, we provide the time series plot of the number of bonds held by LQD in Figure 4. At the end of March 2012, there were 769 bonds held by LQD, and nearly 200 additional bonds were added to LQD between April and July 2012. The figure also shows that the three-month moving average of the growth rate of LQD holdings was around 2% before April 2012 and spiked to 8% in June.

The treatment group contains firms with at least one bond newly added to LQD within 2012 after the rule change in April 2012. Similar to the experiment of HYG, we consider two control groups, where the first group consists of firms that have bonds pre-existing in LQD, and the second one contains firms that are matched with the treated firms.

In a similar vein to HYG, we examine the effect of bond ETF ownership on investment-grade issuers' R&D and CAPX investments using both the dynamic response (3) and difference-in-differences regression (4). We find that neither R&D investments nor capital expenditures are significantly affected by ETF ownership. As shown in Figure 5 and Table 5, the positive effect of ETF inclusion is mild and barely statistically significant. The idea is that investment-grade issuers, while enjoying a lower cost of debt following ETF inclusion, were not facing binding borrowing constraints.

4 Pricing Effect: Cost of Debt

Having established the positive causal effect of bond ETF ownership on R&D investments by speculative-grade issuers, we now explore the channel for this effect. In particular, we continue to exploit the two quasi-natural experiments introduced in Section 3.

4.1 HYG rule change

We define two treatment groups. The first treatment group contains all bonds issued by firms that have bonds newly added to HYG in June and July 2009. The second treatment (peer) group consists of only the bonds from the same issuer as the first treatment group but not included in HYG. The control group consists of bonds held by HYG from January to May 2009.[4] Table 6 summarizes the characteristics of bonds newly added to HYG and

[4] We exclude bonds whose issuers have bonds in both treated and control groups.

those in the peer and control groups. 43 bonds issued by 34 firms were added to HYG in June and July 2009. Among the 34 firms, 25 of them have a total of 85 bonds that were not included in HYG. 29 bonds issued by 29 firms are in the control group.[5] Bonds in all three categories have similar ratings, while the peer bonds have a slightly lower time to maturity.

By comparing the first treatment group (newly added and peer bonds) and the control group, we obtain the aggregate effect of ETF inclusion on yield spreads of all bonds issued by a firm with at least a bond entering the ETF. By comparing the second treatment (peer) group and the control group, we identify the spillover effect of ETF inclusion on the other bonds issued by the same firm but not held by any ETF.

In principle, bonds in treated and control groups can be simultaneously held by many ETFs other than HYG. To confirm that the HYG rule change does satisfy the relevance criteria, i.e., the reduction in yield spread is due to the inclusion into HYG, not because of the bonds being pre-existing in other ETFs, we plot the average ETF ownership and HYG ownership for bonds in treated and control groups in Figure 6. We observe that, by construction, bonds in the peer group have zero ownership before and after the HYG inclusion event across all ETFs, including HYG. Importantly, bonds newly added to HYG in our first treatment group had no ownership in any ETF before the HYG inclusion event, after which the ETF ownership of these bonds starts to increase. Moreover, the total ETF ownership of these bonds is very close to their HYG ownership, indicating that HYG is the major holder of these bonds. For bonds in the control group, by construction, the ETF ownership is always positive, and the majority of their ETF ownership is also from HYG.

[5] We remove bonds (treated and control) with missing characteristics such as amount outstanding, issuer amount outstanding, time to maturity, and rating in our sample.

In Figure 7, we report the average yield spreads of the control group and the two treatment groups. Before the rule change, the yield spreads of both treatment groups were either higher or similar to the control group. After the rule change, the average yield spreads of both treatment groups became lower than the control group.

To further examine causality, we use the following difference-in-differences specification to analyze the causal effect of ETF inclusion on bond yield spread:

$$\text{Yield spread}_{i,t} = \alpha_i + \lambda_t + \beta_1 \text{Treatment}_i \times \text{Post}_t + \boldsymbol{\delta} \mathbf{X}_{i,t} + \epsilon_{i,t}, \tag{5}$$

where $\mathbf{X}_{i,t}$ are control variables that include the median of a numerical version of Standard & Poor's, Moody's, and Fitch ratings ($\text{Rating}_{i,t}$), market leverage ($\text{Leverage}_{i,t}$), operating income to sales ($\text{Operating}_{i,t}$), the ratio of long term debt to assets ($\text{Long term debt}_{i,t}$), and the issuer's equity volatility ($\text{Equity volatility}_{i,t}$). Our sample period contains 12 months before and after the rule change. Post_t equals one starting from July 2009 and zero otherwise.

Table 7 shows the regression results. In columns (1) and (2), we focus on the aggregate effect of bond ETF inclusion on yield spread by using all bonds from firms with at least one bond newly added to HYG due to the rule change. The negative coefficients β_1 indicate that bond ETF inclusion lowers the yield spreads of all treatment bonds by over 126 basis points (the aggregate effect). Economically, this change is about a 23.7% reduction in the yield spread for the average bond of the non-ETF sample. In columns (3) and (4), we compare the same-issuer, non-HYG bonds with the original HYG constituents. The results show that ETF inclusion also reduces the yield spread of the treated, non-HYG bonds by about 137 basis points (spillover effect), roughly a 25.8% decrease in the yield spread for the average bond within the non-ETF sample.

There are several potential reasons for the spillover effect. First, ETF inclusion of a bond may increase the probability of the firm's non-ETF bonds to be included in the future. By including bonds issued by a particular firm, the ETF manager may pay more attention to the firm's overall profile and thus may become familiar with the characteristics of the firm's other non-ETF bonds. Consequently, when the ETF manager has to include new bonds in the portfolio due to creation activities, the chance of including the non-ETF bonds from the same firm is likely to be higher than other firms that have no prior relation with the ETF. Second, having bonds included in an ETF could increase the firm's visibility. As a result, the firm may attract more investors to trade its bonds, thus improving the liquidity of its bonds and lowering the liquidity premium. Third, Dannhauser (2017) argues that bond yield reduction is due to an increased portion of informed traders. In other words, it is the change in the composition of the investor base that induces yield reduction, and bonds from the same issuers probably share a similar investor base.

4.2 LQD rule change

The previous section highlights an important consequence of bond ETF inclusion, such that if a firm has a bond added to ETF, both the overall yield spread of the firm and the yield spread of the firm's non-ETF bonds decrease. However, there may be a concern of selection bias: ETF managers deliberately choose the firms that are likely to have better credit qualities in the near future so that the yield spreads will decrease.

To mitigate this concern, in this section, we focus on the pricing implication of ETF eligibility. In particular, we revisit the rule change to LQD and test the pricing effect on investment-grade bonds. Bonds from issuers that have a total face value outstanding of at least $2 billion but less than $3 billion during any month between February and April 2012 are considered the treatment group. Therefore, the LQD rule change creates a narrow range of eligible firms, and consequently we are able to identify a subset of bonds meeting the eligibility requirements, a feature missing in the HYG experiment. The control group consists of bonds from issuers that have face value outstanding greater than or equal to $1 billion but less than $2 billion, so below the inclusion threshold.[6]

We also impose an additional index requirement that both treatment and control groups are investment-grade bonds with a bond-level amount outstanding of at least $750 million. The difference in issuer amount outstanding can be observed in Table 8. It is important to note that bonds in the treatment group are simply eligible for LQD inclusion after the rule change, and they may or may not be added to LQD eventually.

Ex-ante, issuers belonging to these two groups are randomly assigned to the treatment and control groups, and we have no reason to believe they differ substantially on key financial dimensions. Table 8 also compares other characteristics of the treatment and control groups. In our sample, there are 61 bonds from 39 issuers in the treatment group and 55 bonds from 52 issuers in the control group. Bonds in both groups have similar ratings and bond amount outstanding, while the time to maturity of treated bonds is slightly longer.

[6]Similar to HYG pricing effect, we exclude bonds whose issuers have bonds in both treated and control groups, and we also remove bonds (treated and control) with missing characteristics such as amount outstanding, issuer amount outstanding, time to maturity, and rating.

In Figure 8, we report the monthly volume-weighted average yield spreads for both treated and control bonds. It shows that before the rule change, the average yield spread of treated bonds was close to that of control bonds. After April 2012, the yield spread of treated bonds declines significantly, and the gap between treatment and control bonds becomes larger.

We adopt the same difference-in-differences specification as in equation (5). We include observations from April 2011 to January 2013. Post_t equals one starting from April 2012 and zero otherwise, and α_i and λ_t are bond and month fixed effects, respectively. Control variables are the same set of bond and firm characteristics as in Table 7. Table 9 shows the difference-in-difference regression results of the eligibility effects. Being eligible for an ETF reduces yield spread by 10 basis points following the rule change, which accounts for 5.5% reduction as the average yield spread for investment-grade, non-ETF bonds is 1.83%. Thus, these results provide evidence that ETF eligibility and potential inclusion reduce bond yield spreads substantially.

To summarize, we have shown that ETF ownership reduces the cost of debt and ETFs as passive investors provide long-term and stable debt financing, which jointly encourage firms to be more patient and invest more in long-term and high-risk projects, i.e., innovation.

5 A Model of Debt Choice and Firm Investment

In this section, we provide a parsimonious three-period theoretical model to illustrate our main empirical finding that firms with some bonds included in ETFs have better incentive to spend more on long-term R&D investments. In addition, we provide cross-sectional results on firms' ETF participation and debt issuance decisions.

The model is based on Dathan and Davydenko (2020), in which firms choose the amount of debt to issue. In particular, a firm's debt issue size needs to pass a minimal threshold in order to be included in an ETF with some probability. We further follow Hoffmann (2019) and assume that the outcome of each firm's R&D investment is materialized in the last period and depends on the firm-specific innovation efficiency determined before any decision is made.

One of the driving forces behind a firm's R&D expenditure and debt issuance decisions is the bond rollover risk in the second period. When the active bond holders are hit by a liquidity shock, they demand full repayment and refuse to roll over the existing debt. The firm has to search for new creditors to fulfill the debt obligation, thus incurring an extra cost. By contrast, bonds held by passive investors (i.e., ETFs) are not subject to this risk. Therefore, meeting the ETF eligibility can lower the firm's expected cost of debt reissuance.

A counteracting tension to the aforementioned benefit is that firms may be ex-post worse off if they issue a sufficient amount of debt, hoping to meet the eligibility criterion but failing to be included in an ETF, in which case the debt becomes excessive. The firm's equity value would have been higher had the firm not chosen to issue extra debt. Hence, each firm will strike a balance between the benefit of ETF inclusion and the cost of excessive debt if ex-post its bond is not included in an ETF.

5.1 Model setup

There are three periods, $t = 1, 2, 3$, and a continuum of firms of unit measure, $i \in [0, 1]$. To focus on the role of ETF on firms' investments, we do not allow entry or exit of firms. Firms make R&D investment decisions at $t = 1$. The R&D expenditures at $t = 1$ are fully financed by issuing one-period bonds, and firms cannot issue equity at any point in time.

An ETF market opens up at the beginning of $t = 2$. Once a firm has met the inclusion requirement of the ETF, there is an exogenous probability of its bonds being included in the ETF. Regardless of ETF inclusion, all firms face a rollover risk at the end of $t = 2$, in which active investors demand full repayment of their lending. If such an event occurs, firms have to borrow new debt to fulfill the obligation. To abstract away from output risks and to focus on the implications of ETF inclusion, we do not impose output related risks.

Production takes place at $t = 3$. There is no intermediate output at $t = 2$, so the R&D investment is long-term. Finally, all firms pay off their (remaining) debt obligations. Figure 9 describes the timeline and decisions that firms make.

5.1.1 Innovation efficiency

As in Kogan and Papanikolaou (2019) and Hoffmann (2019), firms' R&D expenditures and thus production outcomes are subject to an exogenous innovation efficiency ξ. Each firm i is endowed with an idea or innovation efficiency $\xi_i > 0$ at the beginning of $t = 1$ before making R&D investment decision.

5.1.2 Bond ETF market

There is a bond ETF market. In order for a firm's bonds to be included in an ETF, the firm must issue at least $\underline{D}$ units of bonds in terms of money borrowed. Once a firm is eligible, there is a probability p that P units of the firm's bonds are eventually included in an ETF and held by passive investors. The benefit of ETF inclusion is that P units of the total borrowing are always rolled over at $t = 2$. That is, the passive investors are always willing to hold the bonds. If the bonds are held by active investors, then there is a probability λ that the active investors experience a liquidity shock and demand full repayment of their lending. In such a case, the firm needs to raise additional debt with new active investors, which incurs an adjustment cost $\Phi(\cdot)$ that is increasing in the proceeds. For simplicity, we assume that there is no such cost when firms initially raise funding at $t = 1$.

Moreover, rather than solving bond yield endogenously, we follow Dathan and Davydenko (2020) and assume that the yield of a firm's bonds is increasing in the bonds held by active investors, i.e., the yield $s(A)$ is increasing in A, where $A = D - P$. The intuition of formulation is as follows. Suppose each active investor can only hold one unit of bond. Then, A represents the number of active investors for the firm. A larger debt issuance induces the firm to secure a larger pool of active investors. Relative to a smaller pool, a larger pool may contain more pessimistic investors who require a higher yield spread. For convenience, we use continuously compounded interest rate.

5.1.3 Production

Let D_i be the R&D expenditure made by firm i at $t = 1$. Each firm has an initial innovation capital of 1. Following Hoffmann (2019), the innovation capital at $t = 3$ as an outcome of R&D is

$$\xi_{i,3} = \xi_i {D_i}^{\gamma}, \tag{6}$$

where $\gamma \in (0, 1)$. The output at $t = 3$ is based on a combination of innovation capital $\xi_{i,3}$ and physical capital k_i

$$y_i = z\xi_{i,3}k_i, \tag{7}$$

where z is a constant, i.e., there is no output risk in this model, and k_i is fixed for firm i.

5.2 Model solution

We make the following assumptions on the functional forms of $s(\cdot)$ and $\Phi(\cdot)$.

Assumptions 1. *We assume a linear bond yield and a quadratic debt issuance cost. That is, $s(A)$ and $\Phi(D)$ satisfy $s(A) = \alpha A$ and $\Phi(D) = \phi D^2$, where A is the debt held by active investors and D is the newly issued debt at $t = 2$.*

Assumptions 2. *To make the new issuance more costly than rolling over the debt at $t = 2$, we assume $\phi > \alpha$.*

5.2.1 Firms' problems

Consider firm i's optimal R&D expenditure, or equivalently the debt issuance, without passive investors. The firm solves the following problem:

$$E_i^A = \max_{D_i} \underbrace{z\xi_i D_i^\gamma k_i}_{\text{output (dividend)}} - \underbrace{(1-\lambda)e^{2s(D_i)}D_i}_{\substack{\text{debt repayment} \\ \text{without liq. shock}}} - \underbrace{\lambda\left(\Phi(e^{s(D_i)}D_i) + e^{2s(D_i)}D_i\right)}_{\substack{\text{debt repayment and} \\ \text{expected reissuance cost} \\ \text{with liq. shock}}}, \tag{8}$$

where E_i^A denotes the optimal equity value at $t = 1$ with only active investors. The first term on the right-hand side of (8) is the equity value when active investors do not experience the liquidity shock, and the second term is the equity value when the liquidity shock hits. The debt issuance cost takes into account the accrued interest payment at $t = 2$. Firm i chooses R&D investment D_i to maximize its equity value at $t = 1$ as long as $E_i^A > 0$; otherwise, the firm will not invest in the R&D project.

If the passive investors are present, firm i will solve the following problem and check whether the optimal issue size is indeed larger than $\underline{D}$.[7]

$$\begin{aligned} E_i^P = \max_{D_i} & \underbrace{z\xi_i D_i^\gamma k_i}_{\text{output (dividend)}} - (1-p)\Big[\underbrace{(1-\lambda)e^{2s(D_i)}D_i + \lambda\left(\Phi(e^{s(D_i)}D_i) + e^{2s(D_i)}D_i\right)}_{\text{expected financing cost without ETF inclusion}}\Big] \\ & - p\Big[\underbrace{(1-\lambda)\left(e^{2s(D_i-P)}D_i\right)}_{\substack{\text{benefit of ETF: lower yield} \\ \text{without liq. shock}}} + \lambda\Big(\underbrace{\Phi(e^{s(D_i-P)}(D_i-P)) + e^{2s(D_i-P)}(D_i-P)}_{\substack{\text{benefit of ETF: lower yield,} \\ \text{lower expected reissuance cost, with liq. shock}}} + \underbrace{e^{2s(D_i-P)}P}_{\substack{\text{benefit of ETF:} \\ \text{lower yield}}}\Big)\Big], \end{aligned} \tag{9}$$

where E_i^P is the optimal equity value at $t = 1$ with a mixture of active and passive investors.

[7]The optimal debt issuance size must also exceed P.

With probability $1 - p$, firm i's bonds are not included in ETF, so the expression of equity value under this scenario is identical to the one with only active investors. With probability p, P units of firm i's bonds are held by passive investors, so the yield lowers. Consequently, if the liquidity shock hits, the size of newly issued bond will be lower as well, leading to a reduction in issuance cost.

5.2.2 Effect of ETF on R&D investment

To examine how the presence of passive investors affects a firm's optimal R&D investment, we obtain the following result.

Proposition 1. *If there were no restriction $\underline{D}$ on the issue size, a firm's R&D expenditure with only active investors is smaller than when passive investors are present.*

This proposition shows that absent the ETF inclusion criterion, a firm's R&D investment and thus debt issuance face an upward jump relative to the no ETF case, regardless of the firm's innovation efficiency. This is because ETF reduces the expected cost of financing and enables the firm to borrow more. Furthermore, given a sufficiently high cost of rollover risk (Assumption 2), being included in ETF can potentially lower the expected cost of rollover, which may induce the firm to spend more on the long-term R&D project.

A corollary of Proposition 1 is that if a firm's issue size is larger than $\underline{D}$ when only active investors are present, then the firm will be eligible for ETF if the ETF market opens up. In principle, a firm's preference for possible ETF inclusion depends on whether it can result in a higher equity value at $t = 1$. The next result shows that firms will always prefer ETF inclusion once they meet the requirement.

Lemma 1. *A firm's optimal time-1 equity value is always higher when its bonds are held by both active and passive investors than held by active investors only. In particular, given its debt issue size larger than $\underline{D}$, the firm has a higher equity value in an economy with ETF than in one without.*

Moreover, a firm can only enjoy the benefits of ETF when some of its bonds are actually included in ETF. Consequently, the higher the probability p of ETF inclusion is, the lower the expected costs of financing and rollover the firm will face, resulting in a larger debt issuance size or R&D expenditure.

Lemma 2. *If there were no restriction $\underline{D}$ on the issue size, a firm's issue size when passive investors are present is increasing in the probability p of being included in ETF.*

Another implication of Proposition 1 is that when the optimal R&D investment D_i with only active investors is less than $\underline{D}$, it is possible to have the optimal issuance size larger than $\underline{D}$ with a mixture of active and passive investors. This means that there is a discontinuity at $\underline{D}$ in the cross-sectional debt issuance or, equivalently, R&D investments.

Corollary 1. *It is possible that a firm's optimal debt issuance size is less than the threshold $\underline{D}$ with only active investors but becomes larger than $\underline{D}$ when passive investors are present.*

5.2.3 Effect of innovation efficiency on ETF inclusion

The optimization problems (8) and (9) imply that each firm's own innovation efficiency ξ_i affects the optimal R&D expenditure or debt issuance size. Intuitively, a higher innovation efficiency offers a larger marginal benefit of R&D investment, which incentivizes the firms to spend more on R&D and grow. The following proposition formally shows such a relationship between ξ_i and D_i.

Proposition 2. *Without the restriction $\underline{D}$ on issuance size, a firm's R&D investment or debt issuance size is increasing in its innovation efficiency regardless of whether passive investors are present.*

The above result implies that firms with sufficiently high innovation efficiency will optimally issue more than $\underline{D}$ units of debt, which makes these firms eligible for ETF inclusion. Moreover, as the criterion $\underline{D}$ is loosened, the minimal required innovation efficiency for ETF inclusion becomes lower. Thus, more firms will be eligible for ETF.

Corollary 2. *There exists a threshold of innovation efficiency, $\widehat{\xi}$, such that the optimal interior debt issuance for firms with $\xi_i > \widehat{\xi}$ in the presence of passive investors exceeds the threshold $\underline{D}$. Furthermore, as the threshold $\underline{D}$ decreases, the innovation efficiency threshold $\widehat{\xi}$ for meeting the ETF criterion also decreases. Consequently, more firms become eligible for ETF inclusion.*

5.2.4 Excess debt issuance

So far, we have examined interior debt issuance made by firms. Suppose firm i's optimal interior issuance $\hat{D}_i$ is close to $\underline{D}$ from below when the passive investors are present and when there were no ETF criterion. It is natural for the firm to consider issuing extra debt to meet the threshold $\underline{D}$. Even though the excess issuance deviates from the firm's optimal interior R&D expenditure, the equity value may still become larger due to the benefits of lower yield and smaller refinancing costs when some of the bonds are held by ETF. If the firm decides to issue extra, it will issue exactly $\underline{D}$ units of bonds as the equity value (9) is concave in debt issuance.

Proposition 3. *Suppose a firm's optimal interior debt issuance is less than $\underline{D}$ when the passive investors are present and when there were no ETF criterion. If the firm chooses to issue excess debt to meet the ETF inclusion criterion, its total debt will be exactly $\underline{D}$.*

However, not every firm with $\hat{D}_i < \underline{D}$ finds it optimal to issue $\underline{D}$ for possible ETF inclusion. According to Proposition 2, there is a one-to-one relationship between optimal debt issuance and innovation efficiency. Hence, if a firm has a low innovation efficiency, issuing a large amount of excess debt may make the firm worse off because the total debt obligation and refinancing costs are high, even though the per unit cost is low. For example, firms with very low innovation efficiency may default at $t = 3$ due to a sufficiently low output level if they choose to issue extra debt.

Proposition 4. *Suppose a firm's optimal interior debt issuance is less than $\underline{D}$ when the passive investors are present and when there were no ETF criterion. There is a unique level of innovation efficiency $\underline{\xi}$, below which the firm will not find it optimal to issue excess debt.*

5.3 Numerical results

We present a series of numerical results. To focus solely on innovation, we assume that the physical capital is identical for every firm, i.e., $k_i = 1$ for all i. The baseline parameters are given in Table 10.

For each level of innovation efficiency ξ, we solve the firm's problems (8) and (9). The results are presented in Figure 10. Panel (a) illustrates Proposition 1 that, absent the ETF inclusion criterion $\underline{D}$, for any level of innovation efficiency, the R&D expenditures are higher when both active and passive investors hold bonds than active investors alone. We also observe that the R&D investment or debt issuance size is increasing in innovation efficiency as mentioned in Proposition 2.

Panel (b) considers the ETF inclusion criterion $\underline{D}$. According to Lemma 1, a firm is better off when passive investors hold a fraction of its debt, if the optimal debt issuance is more than $\underline{D}$. Hence, there exists a discontinuity in the cross-sectional R&D expenditures at $\widehat{\xi} \approx 1.75$, beyond which the debt issuance is more that $\underline{D}$, a result given in Corollary 2.

Finally, Figure 11 plots the R&D investments when firms can issue extra debt to meet the ETF inclusion criterion. The figure shows two important cutoffs of innovation efficiency. The first one, $\underline{\xi}$, represents the threshold below which firms will not find it optimal to issue extra debt. The second cutoff, $\widehat{\xi}$, is where a firm's optimal issuance starts to be larger than $\underline{D}$ when passive investors are also present. For firms with $\xi_i \in (\underline{\xi}, \widehat{\xi})$, they will find it optimal to issue extra debt to gain the benefits of possible ETF inclusion. As a result, there is a cluster of debt issuance at $\underline{D}$ (Dathan and Davydenko, 2020).

6 Conclusion

We examine the effect of corporate bond ETF ownership on firms' investment behavior. Using two quasi-natural experiments, we show that bond ETF ownership has causal and real effects on firms' investments by significantly increasing firms' R&D spending, especially for speculative-grade bond issuers. We further show that corporate bond ETF ownership has a pervasive and persistent positive valuation effect. With a stable and cheaper supply of debt capital, risky issuers become less financially constrained and invest more in long-term, riskier projects such as R&D.

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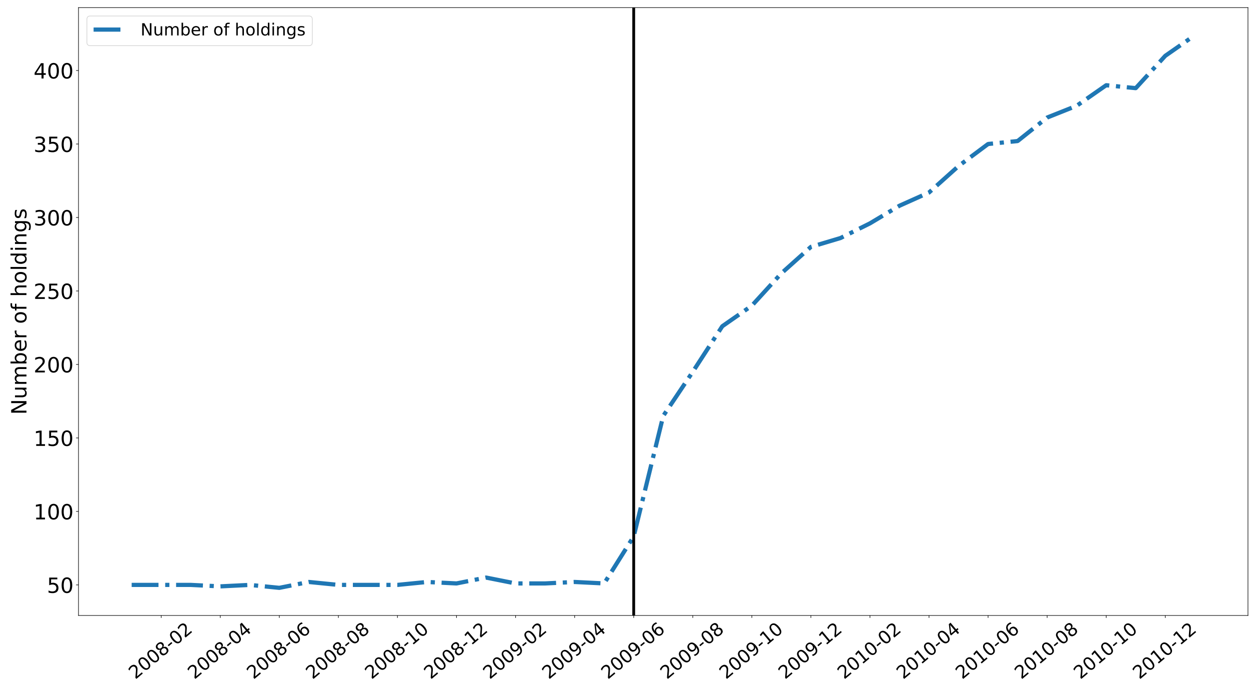
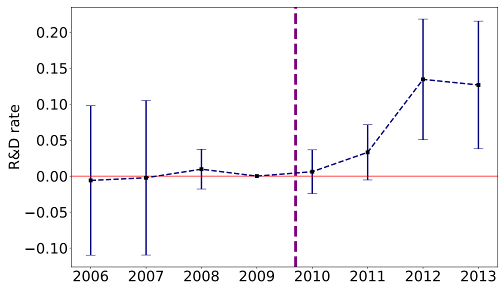
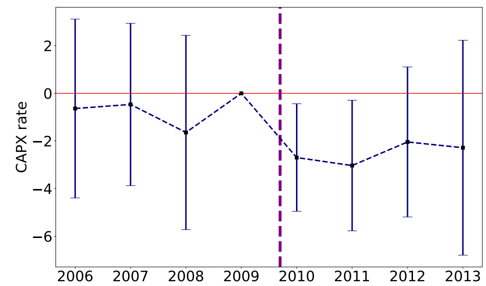


Figure 1: The growth in HYG holdings around the rule change

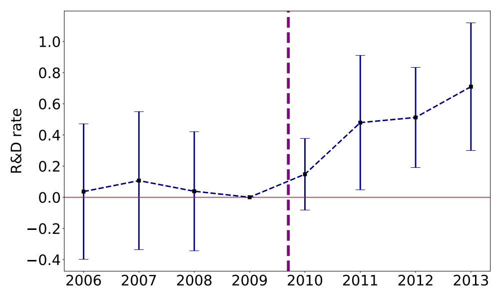
This figure plots the number of holdings by the iShares iBoxx USD High Yield Corporate Bond ETF (HYG). The vertical line shows the date, June 22, 2009, when the index administrator, Markit, removed the cap on the number of constituents for the index followed by HYG. The treatment group contains bonds added in July 2009. The control group contains the original bonds held by the ETF in May 2009.



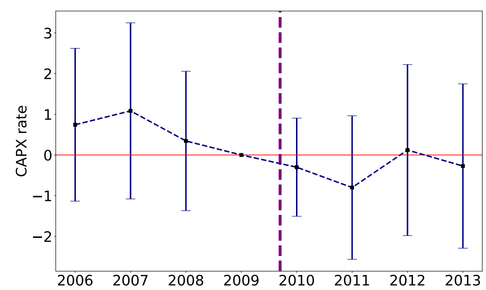
(a) R&D: original constituents



(b) CAPX: original constituents



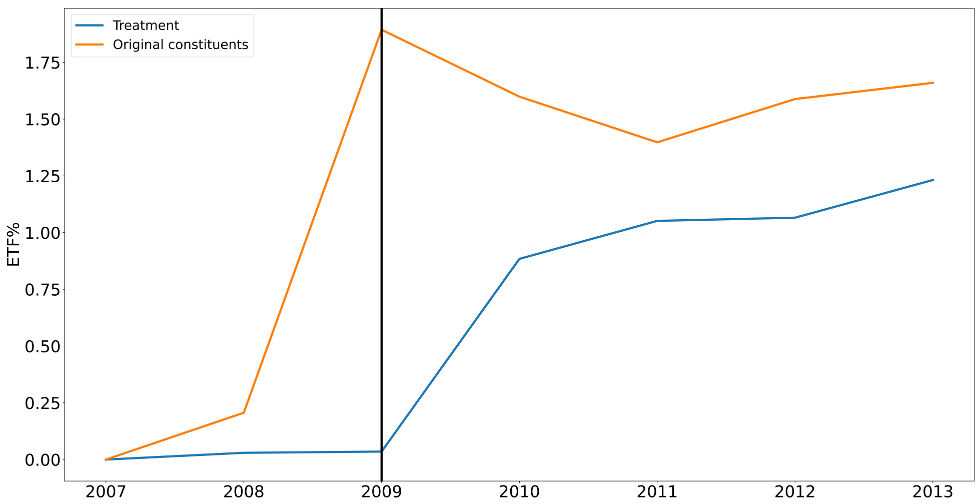
(c) R&D: matched control



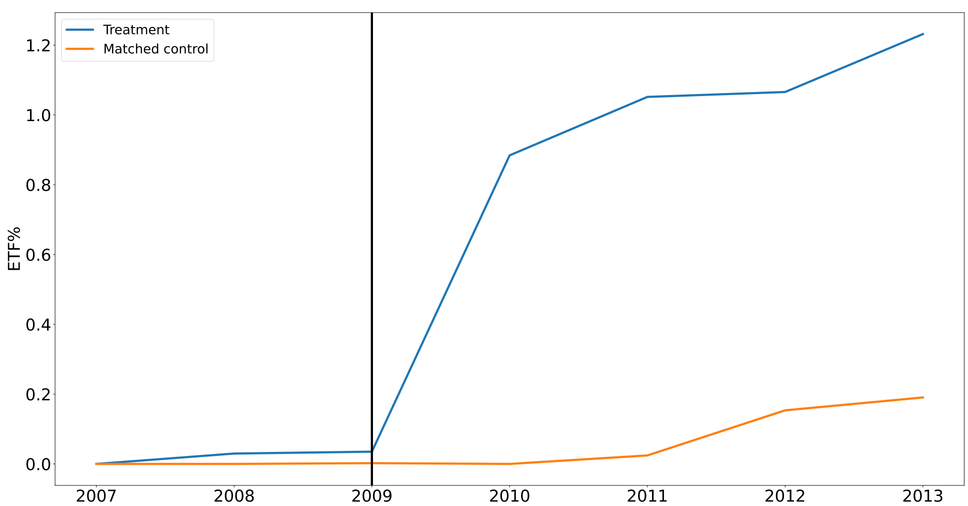
(d) CAPX: matched control

Figure 2: HYG rule change: real effects

This figure plots the effect of corporate bond ETF inclusion on firms' R&D and CAPX rates. On June 30, 2009, HYG removed the 50-bond limit. The treatment group contains firms with at least one bond newly added to HYG within one year after the rule change. We form two control groups: the first control group (panels (a) and (b)) contains firms whose bonds were HYG's original constituents. The second control group (panels (c) and (d)) includes firms that are matched with the treatment firms by the following requirements: same three-digit SIC industry codes with treated firms, similar size and leverage in 2009, high-yield issuers, having bonds outstanding, and not having bonds in HYG (either original or newly added). Each treated firm is matched with 5 such control firms. We include 9 years of observations (four years before and five years after 2009) in the analysis. To estimate the effect of ETF inclusion on firms' investments, we use the panel regression specification with firm fixed effects and year fixed effects as follows: $R\&D_{i,t}(CAPX_{i,t}) = \alpha_i + \lambda_t + \sum_\tau \beta_\tau \times \text{Treatment}_i \times \mathbb{1}_{\tau=t} + \boldsymbol{\delta}\mathbf{X}_{i,t} + \epsilon_{i,t}$. The coefficients quantify differences in R&D and CAPX rates between the treated and control firms over the years. We impose $\beta_{2009} = 0$ to avoid collinearity, and by doing this, we set the year 2009 as the benchmark. We plot the estimated coefficients β_τ as well as their 90% confidence intervals with standard errors clustered at the firm level. The vertical dashed line represents the year when the ETF inclusion rule changed.



(a) Original constituents



(b) Matched control

Figure 3: Firm-level bond ETF ownership

This figure plots the firm-level bond ETF ownership around the HYG rule change in June 2009. The treatment group contains firms with at least one bond newly added to HYG within one year after the rule change. The original control group (panel (a)) contains firms whose bonds were HYG's original constituents. The matched control group (panel (b)) includes firms that are matched with the treatment firms by the following requirements: same three-digit SIC industry codes with treated firms, similar size and leverage in 2009, high-yield issuers, having bonds outstanding, and not having bonds in HYG (either original or newly added). A firm's bond ETF ownership is calculated by the ratio of total face value of bonds held by ETFs to the total amount outstanding of all bonds issued by the firm.

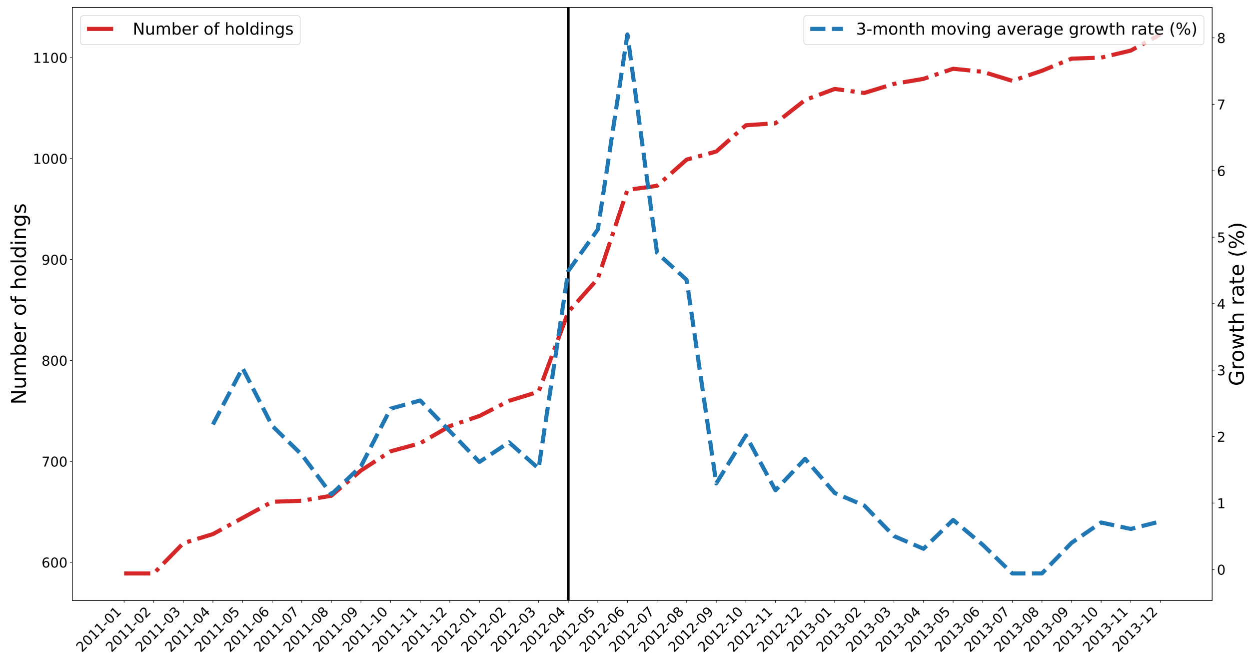
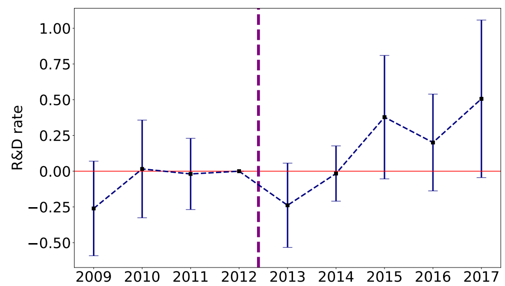
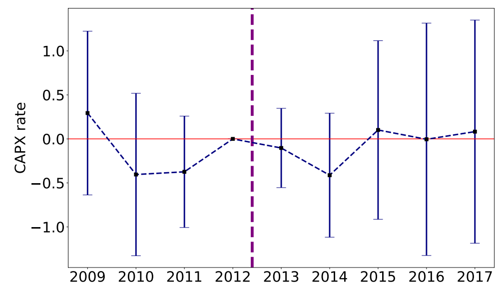


Figure 4: The growth in LQD holdings around the 2012 rule change

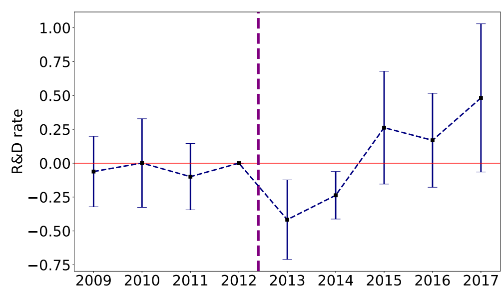
This figure plots the number of holdings by the iShares iBoxx USD Investment Grade Corporate Bond ETF (LQD) in the red dash-dotted line. The vertical line shows the date, April 30, 2012, when the index administrator, Markit, changed the inclusion criteria — reduction in the requirement of issuer's total face value outstanding from \$3 billion to \$2 billion. The blue dashed line is the 3-month moving average growth rate of LQD holdings.



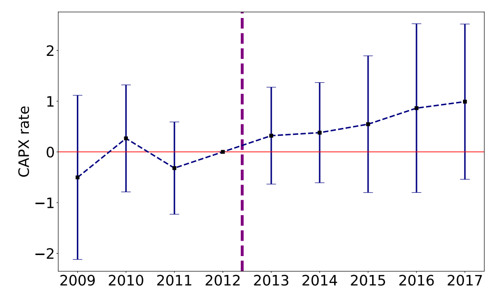
(a) R&D: original constituents



(b) CAPX: original constituents



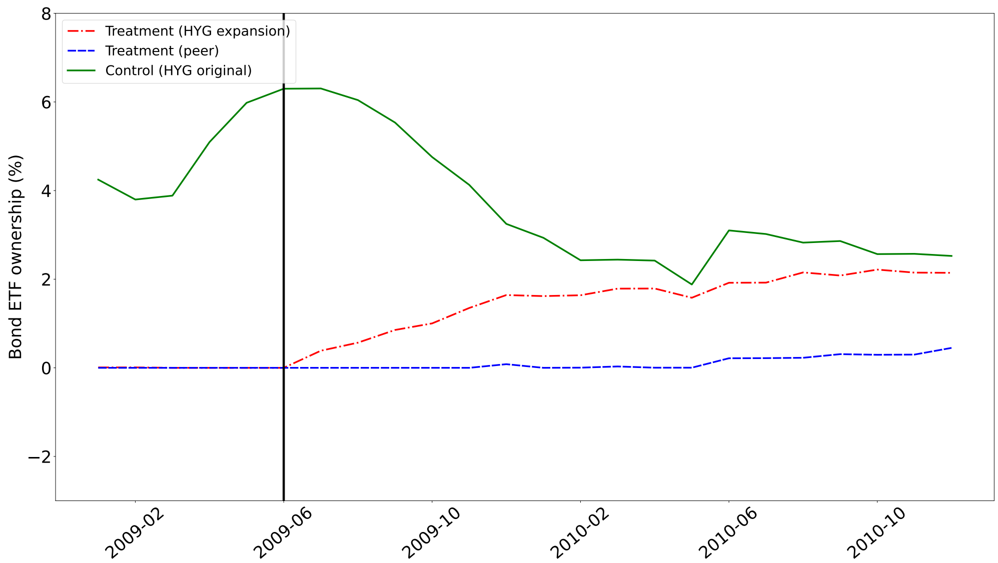
(c) R&D: matched controls



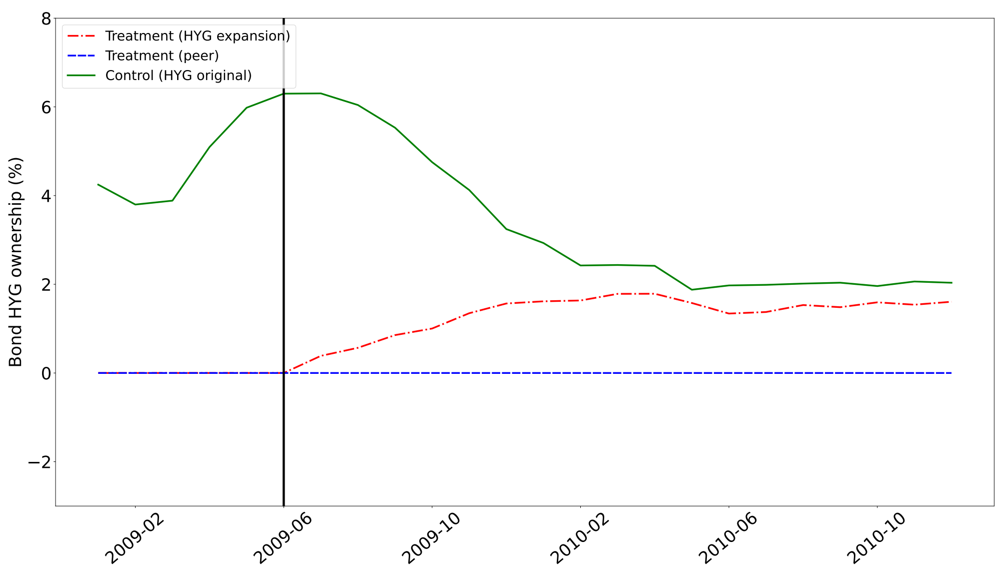
(d) CAPX: matched controls

Figure 5: LQD rule change: real effects

This figure plots the effect of corporate bond ETF inclusion on firms' R&D and CAPX rates. On April 30, 2012, LQD lowered the minimum issuer's face value outstanding decreased from \$3 billion to \$2 billion. The treatment group contains firms with at least one bond newly added to LQD within 2012 after the rule change. The first control group (panels (a) and (b)) contains firms whose bonds were LQD's original constituents. The second control group (panels (c) and (d)) includes firms that are matched with the treatment firms by the following requirements: same three-digit SIC industry codes with treated firms, similar size and leverage in 2012, investment-grade issuers, having bonds outstanding, and not having bonds in LQD (either original or newly added). Each treated firm is matched with 5 such control firms. We include 9 years of observations (four years before and five years after 2012) in the analysis. To estimate the effect of ETF inclusion on firms' investments, we use the panel regression specification with firm fixed effects and year fixed effects as follows: $R\&D_{i,t}(CAPX_{i,t}) = \alpha_i + \lambda_t + \sum_{\tau} \beta_{\tau} \times \text{Treatment}_i \times \mathbb{1}_{\tau=t} + \boldsymbol{\delta}\mathbf{X}_{i,t} + \epsilon_{i,t}$. The coefficients quantify differences in R&D and CAPX rates between the treated and control firms over the years. We impose $\beta_{2012} = 0$ to avoid collinearity, and by doing this, we set the year 2012 as the benchmark. We plot the estimated coefficients β_{τ} as well as their 90% confidence intervals with standard errors clustered at the firm level. The vertical dashed line represents the year when the ETF inclusion rule changed.



(a) Ownership by all ETFs



(b) Ownership by HYG

Figure 6: Bond-level ETF ownership

This figure shows the monthly average bond ETF ownership by all ETFs in panel (a) and by HYG in panel (b) around the HYG rule change in June 2009. Original bonds (green solid line) are those that were held by HYG in the month before the 50-bond constituent cap was removed. The HYG expansion bonds (red dash-dotted line) are those added to HYG in July 2009. We also include bonds (blue dashed line) that were issued from the same issuers as the HYG expansion bonds but were not added to HYG.

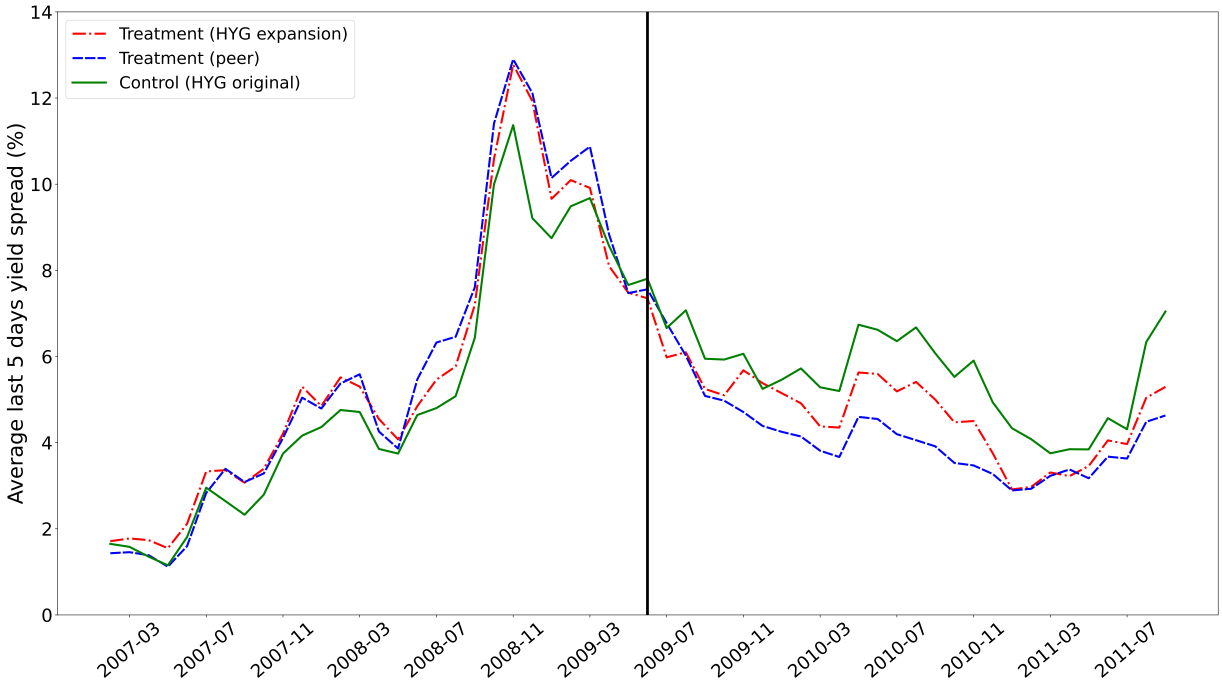


Figure 7: HYG rule change: pricing effects

This figure plots the monthly volume-weighted average yield spreads over the swap rate around the HYG rule change in June 2009. Original bonds (green solid line) are those that were held by HYG in the month before the 50-bond constituent cap was removed. The HYG expansion bonds (red dash-dotted line) are those added to HYG in July 2009. We also include bonds (blue dashed line) that were issued from the same issuers as the HYG expansion bonds but were not added to HYG.

Figure 8: Yield spreads of bonds around the 2012 rule change

This figure presents the monthly volume-weighted average yield spreads over the swap rate for bonds impacted by the index rule change in April 2012. On April 30th, 2012, LQD changed its requirement for the outstanding face value of bonds from the issuer from $3 billion to $2 billion. The treatment group contains bonds from issuers who have outstanding face value of bonds between $2 billion and less than $3 billion. The control group includes bonds from issuers with outstanding face value of bonds between $1 billion and less than $2 billion.

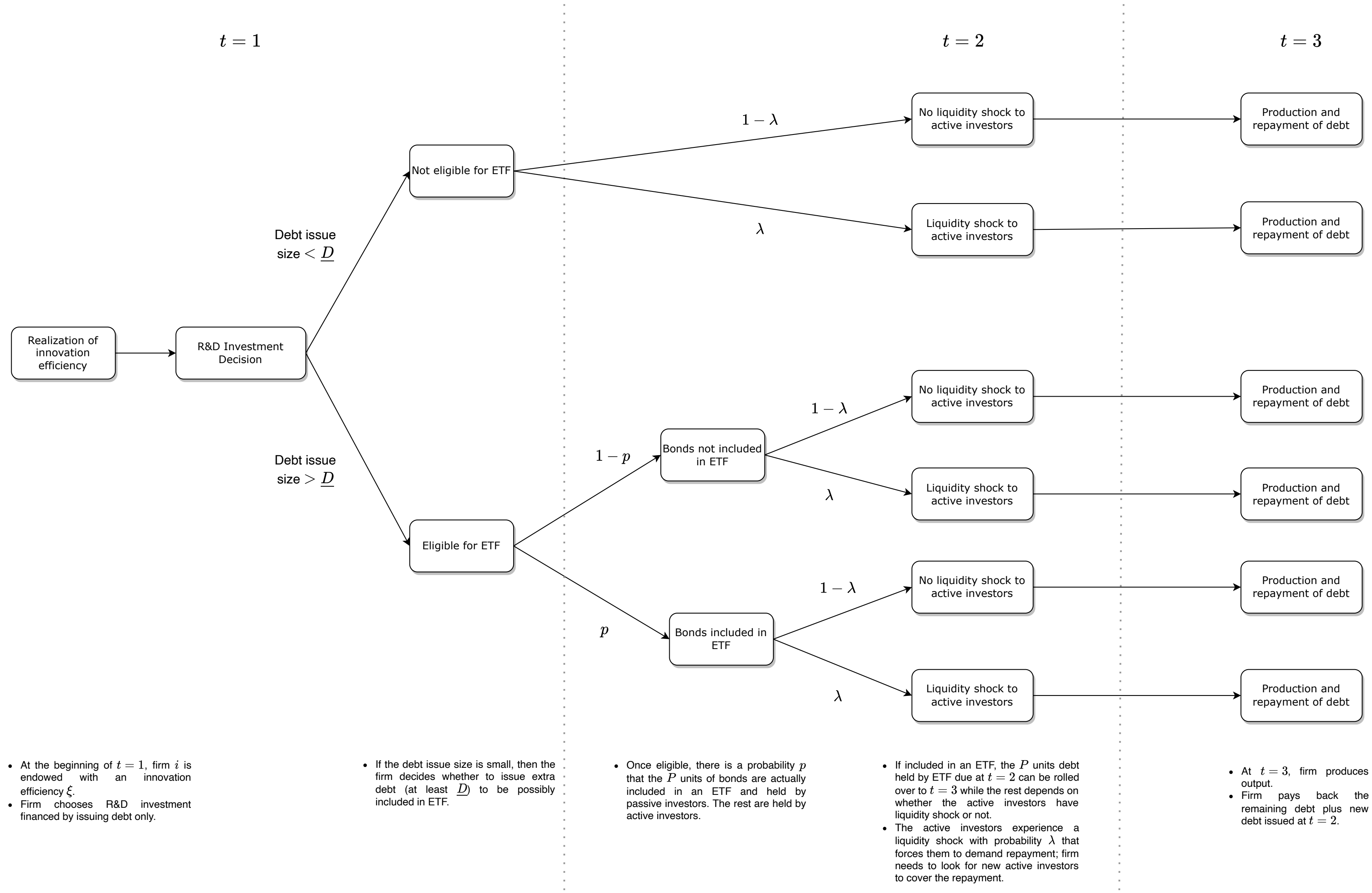
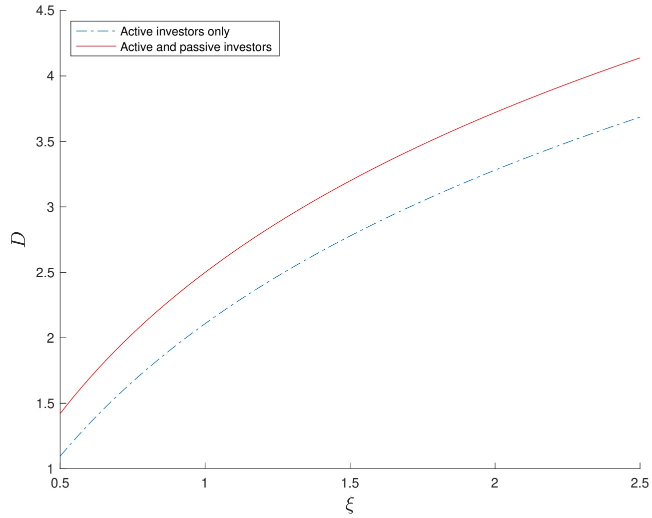
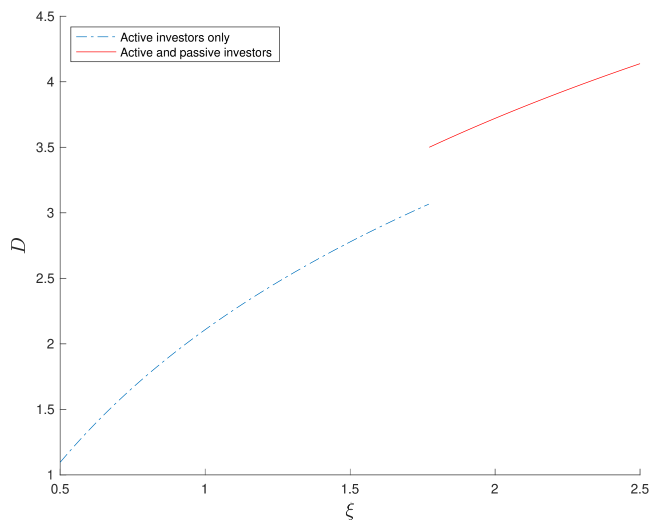


Figure 9: Timeline of the model.

This figure shows the evolution of events and the decisions made by a firm. There is only one equilibrium path for each firm, which is jointly determined by the firm's debt issuance size, ETF inclusion probability, and rollover risk.



(a) R&D investment without ETF inclusion criterion



(b) R&D investment with ETF inclusion criterion

Figure 10: Optimal R&D investment.

This figure plots the optimal R&D investments of firms with different levels of innovation efficiency ξ. The blue dash-dotted curves represent R&D investments with active bond investors only, and the red solid curves plot these values when passive investors are also present. Panel (a) plots optimal R&D investments without accounting for the ETF inclusion requirement $\underline{D}$. Panel (b) plots R&D investment when the ETF inclusion criterion is imposed.

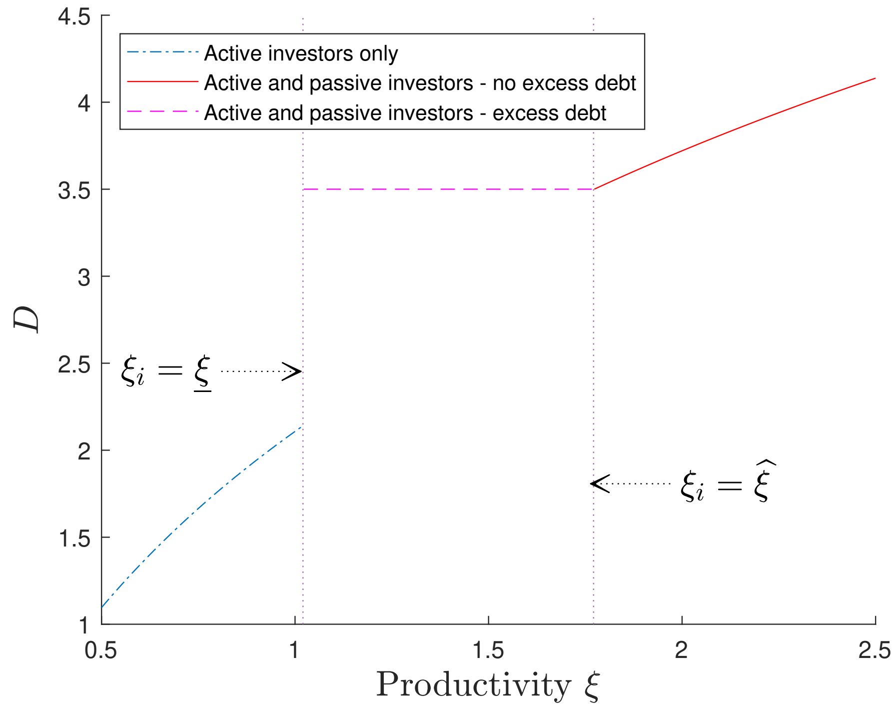


Figure 11: R&D investment with excess debt issuance.

This figure plots the optimal R&D investments for firms with different levels of innovation efficiency ξ_i when they can issue extra debt. Firms with innovation efficiency below $\underline{\xi}$ choose not to issue extra debt. Firms with ξ_i above $\widehat{\xi}$ have optimal interior R&D investment exceeding $\underline{D}$. Firms in between $\underline{\xi}$ and $\widehat{\xi}$ issue exactly $\underline{D}$ units of debt.

Table 1: Descriptive statistics of bond characteristics

This table reports the summary statistics of bonds. ETF samples are bond-month observations that have positive corporate bond ETF ownership. Non-ETF samples are bond-month observations that have zero corporate bond ETF ownership. The data consists of 805,004 bond-month observations for the sample period from January 2006 to December 2019.

Panel A: ETF sample (investment-grade bonds)

	N	Mean	S.D.	25%	50%	75%
Yield spread	474143	1.39	1.06	0.70	1.19	1.81
Coupon	474143	4.55	1.66	3.35	4.50	5.75
Bond ETF%	474143	2.43	2.02	0.70	1.99	3.72
Rating	474143	7.26	1.99	6.00	8.00	9.00
Time-to-maturity (year)	474143	10.27	9.39	3.50	6.62	15.34
Age (year)	474143	3.99	3.66	1.39	3.02	5.58
Issue amount (millions)	474143	846.65	715.12	400.00	600.00	1,000.00
Issuer amount (millions)	474143	12,802.78	18,267.05	2,750.00	6,300.00	13,974.90
Equity volatility	467229	0.25	0.14	0.18	0.22	0.28

Panel B: Non-ETF smaple (investment-grade bonds)

	N	Mean	S.D.	25%	50%	75%
Yield spread	100855	1.83	1.85	0.69	1.38	2.30
Coupon	100855	5.95	1.27	5.20	5.90	6.75
Bond ETF%	100855	0.00	0.00	0.00	0.00	0.00
Rating	100855	7.10	2.09	6.00	7.00	9.00
Time-to-maturity (year)	100855	11.48	10.15	4.62	7.71	17.54
Age (year)	100855	5.02	4.71	1.60	3.78	6.67
Issue amount (millions)	100855	540.64	481.95	300.00	400.00	600.00
Issuer amount (millions)	100855	6,875.77	11,664.51	1,450.00	3,225.00	6,975.00
Equity volatility	98930	0.34	0.26	0.19	0.26	0.38

Panel C: ETF sample (High-yield bonds)

	N	Mean	S.D.	25%	50%	75%
Yield spread	82205	4.22	3.18	2.29	3.30	4.96
Coupon	82205	6.63	1.62	5.50	6.50	7.62
Bond ETF%	82205	2.58	1.91	0.96	2.42	3.79
Rating	82205	13.41	2.06	12.00	13.00	15.00
Time-to-maturity (year)	82205	6.46	5.54	3.96	5.62	7.46
Age (year)	82205	3.55	3.50	1.37	2.71	4.50
Issue amount (millions)	82205	722.87	523.82	400.00	550.00	899.98
Issuer amount (millions)	82205	3,780.21	4,755.85	1,000.00	2,065.00	4,404.71
Equity volatility	78601	0.40	0.20	0.27	0.35	0.48

Panel D: Non-ETF sample (High-yield bonds)

	N	Mean	S.D.	25%	50%	75%
Yield spread	31355	5.31	3.38	3.10	4.46	6.39
Coupon	31355	7.34	1.41	6.50	7.25	8.00
Bond ETF%	31355	0.00	0.00	0.00	0.00	0.00
Rating	31355	13.67	2.24	12.00	13.00	15.00
Time-to-maturity (year)	31355	8.90	7.39	5.12	6.92	9.34
Age (year)	31355	4.54	4.68	1.20	2.80	6.22
Issue amount (millions)	31355	421.07	366.59	250.00	300.00	470.00
Issuer amount (millions)	31355	2,216.20	3,221.53	531.80	1,200.00	2,515.00
Equity volatility	29923	0.49	0.31	0.29	0.40	0.58

Table 2: Descriptive statistics of firm characteristics

This table reports the summary statistics of firm characteristics. Variable definitions are given in Appendix A. The data consists of 15,233 firm-year observations for the sample period from January 2006 to December 2019. Panel A shows statistics based on the whole sample data. Panel B shows statistics of firms with positive corporate bond ETF ownership.

Panel A: Full sample

	N	Mean	S.D.	25%	50%	75%
Asset (millions)	15233	15,606.83	40,130.39	1,607.65	4,170.07	12,571.90
CAPX (millions)	15233	823.91	2,367.62	48.20	155.00	564.14
R&D (millions)	15233	270.17	1,145.81	0.00	0.00	69.00
Size	15233	8.37	1.56	7.38	8.34	9.44
CAPX	15233	6.43	8.46	2.03	3.81	7.23
R&D	15233	2.20	5.94	0.00	0.00	1.70
Bond ETF%	15233	0.95	1.45	0.00	0.00	1.68
Equity ETF%	15233	1.31	3.37	0.00	0.00	0.00
Cash	15231	0.13	0.19	0.03	0.07	0.15
Tobin's q	13957	1.73	1.12	1.10	1.42	1.98
ROA	15229	0.02	0.17	0.00	0.04	0.08
Tangibility	15233	0.33	0.26	0.11	0.25	0.50
Market leverage	14792	0.32	0.23	0.14	0.27	0.46

Panel B: ETF sample

	N	Mean	S.D.	25%	50%	75%
Asset (millions)	6763	27,432.28	55,482.49	4,481.22	9,860.94	26,228.04
CAPX (millions)	6763	1,424.69	3,216.10	136.89	386.88	1,195.39
R&D (millions)	6763	475.28	1,608.24	0.00	0.00	189.27
Size	6763	9.26	1.24	8.41	9.20	10.17
CAPX	6763	6.05	7.19	2.07	3.85	7.16
R&D	6763	1.77	4.13	0.00	0.00	1.73
Bond ETF%	6763	2.15	1.47	0.97	1.93	3.15
Equity ETF%	6763	1.47	3.70	0.00	0.00	0.00
Cash	6763	0.11	0.13	0.03	0.07	0.13
Tobin's q	6328	1.76	1.02	1.13	1.48	2.04
ROA	6759	0.03	0.14	0.01	0.05	0.08
Tangibility	6763	0.34	0.26	0.11	0.26	0.54
Market leverage	6755	0.32	0.21	0.16	0.26	0.43

Table 3: Stable and long-term corporate bond ETF ownership

This table shows the average fraction of firms that have positive ETF ownership over the entire next 1 to 9 years conditional on positive ETF ownership in year t. For example, among firms with positive corporate bond ETF ownership in 2007, 71% of them also have positive ETF ownership in each year from 2008 to 2016.

t	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$	$t+6$	$t+7$	$t+8$	$t+9$
2007	93.27	88.40	84.69	81.21	79.81	77.03	74.25	72.62	71.00
2008	94.09	90.37	86.87	85.12	82.28	79.21	77.68	75.27	71.33
2009	95.91	90.52	88.10	85.32	81.41	79.55	76.58	71.93	69.33
2010	91.51	88.23	85.54	80.63	77.94	74.07	68.85	65.57	62.30
2011	96.11	92.36	86.31	82.85	78.67	72.62	69.31	65.56	
2012	94.04	87.37	83.16	78.25	71.35	67.95	63.86		
2013	92.33	88.01	82.07	73.97	70.30	65.98			
2014	94.10	85.74	76.50	72.37	66.86				
2015	90.92	79.96	74.63	69.10					
2016	88.20	82.21	75.73						
2017	92.99	85.26							
2018	91.77								
Mean	92.94	87.13	82.36	78.76	76.08	73.77	71.75	70.19	68.49

Table 4: HYG rule change: real effects

This table presents results from estimating the difference-in-differences model of R&D and CAPX around the high-yield bond index rule change. The treatment group contains firms with bonds added to HYG from July 2009 to July 2010. The control group contains firms that are matched with the treated firms (Columns (1)-(4)) or those whose bonds were original constituents of HYG (Columns (5)-(8)). We include 9 years of observations (i.e., four years before and five years after 2009). Post = 1 after 2010 and otherwise zero. Control variables contain size, lagged size, market leverage, equity ETF ownership, ROA, tangibility, cash, Tobin's q, and cash flow. t-statistics based on standard errors clustered at the firm level are reported below the coefficients. * indicates significance at the 10% level; **, at the 5% level; and ***, at the 1% level.

	(1) $R\&D_t$	(2) $CAPX_t$	(3) $R\&D_t$	(4) $CAPX_t$	(5) $R\&D_t$	(6) $CAPX_t$	(7) $R\&D_t$	(8) $CAPX_t$
Post × Treated	0.499**	-0.692			0.097**	-1.351		
	(2.49)	(-0.78)			(2.39)	(-0.93)		
Treated × $Year_{2006}$			0.036	0.743			-0.006	-0.638
			(0.14)	(0.65)			(-0.10)	(-0.28)
Treated × $Year_{2007}$			0.107	1.083			-0.002	-0.467
			(0.40)	(0.83)			(-0.04)	(-0.23)
Treated × $Year_{2008}$			0.038	0.345			0.010	-1.643
			(0.17)	(0.33)			(0.58)	(-0.67)
Treated × $Year_{2010}$			0.148	-0.301			0.006	-2.698*
			(1.06)	(-0.41)			(0.34)	(-1.99)
Treated × $Year_{2011}$			0.479*	-0.800			0.033	-3.033*
			(1.84)	(-0.75)			(1.43)	(-1.84)
Treated × $Year_{2012}$			0.512***	0.121			0.134***	-2.043
			(2.64)	(0.10)			(2.67)	(-1.08)
Treated × $Year_{2013}$			0.710***	-0.272			0.127**	-2.284
			(2.87)	(-0.22)			(2.38)	(-0.84)
Size	0.497*	6.274***	0.496*	6.267***	0.108*	8.473***	0.108*	8.551***
	(1.80)	(5.41)	(1.80)	(5.46)	(1.97)	(4.89)	(1.87)	(4.95)
Lagged size	-0.258	-7.675***	-0.252	-7.645***	-0.174*	-7.736***	-0.173*	-7.790***
	(-0.85)	(-6.20)	(-0.83)	(-6.09)	(-1.85)	(-4.22)	(-1.78)	(-4.15)
Leverage	-3.268**	-1.635	-3.277**	-1.542	-0.124	-11.635**	-0.127	-11.681**
	(-2.12)	(-0.90)	(-2.10)	(-0.88)	(-1.54)	(-2.20)	(-1.60)	(-2.21)
Equity ETF%	-0.027	-0.103	-0.027	-0.102	0.001	-0.188	0.002	-0.188
	(-0.56)	(-0.64)	(-0.56)	(-0.64)	(0.10)	(-0.51)	(0.12)	(-0.52)
ROA	1.391	-2.646	1.373	-2.470	0.131	-4.003	0.141	-4.053
	(0.59)	(-1.13)	(0.57)	(-1.04)	(0.51)	(-1.22)	(0.53)	(-1.27)
Tangibility	4.567***	14.239***	4.590***	14.338***	0.266	16.673**	0.282	16.928**
	(2.64)	(3.85)	(2.65)	(3.85)	(1.18)	(2.24)	(1.21)	(2.17)
Cash	4.144***	-4.070***	4.145***	-4.138***	0.298*	8.710	0.311*	8.937
	(2.62)	(-2.75)	(2.63)	(-2.80)	(1.69)	(1.00)	(1.69)	(1.06)
Tobin's q	0.775***	0.713**	0.777***	0.715**	0.089***	2.865**	0.088***	2.877**
	(2.61)	(2.40)	(2.61)	(2.42)	(2.67)	(2.34)	(2.70)	(2.39)
Cash flow	-4.700	4.293**	-4.681	4.170**	-0.537	4.444	-0.539	4.352
	(-1.42)	(2.28)	(-1.41)	(2.18)	(-1.44)	(1.56)	(-1.43)	(1.45)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.945	0.783	0.945	0.783	0.900	0.848	0.901	0.849
Observations	1298	1298	1298	1298	553	553	553	553

Table 5: LQD rule change: real effects

This table presents results from estimating the difference-in-differences model of R&D and CAPX around the investment bond index rule change. The treatment group contains firms with bonds added to LQD from April 2012 to March 2013. The control group contains firms that are matched with the treated firms (Columns (1)-(4)) or those whose bonds were original constituents of LQD (Columns (5)-(8)). We include 9 years of observations (i.e., four years before and five years after 2012). Post = 1 if years after 2013 and otherwise zero. Control variables contain size, lagged size, market leverage, equity ETF ownership, ROA, tangibility, cash, Tobin's q, and cash flow. t-statistics based on standard errors clustered at the firm level are reported below the coefficients. * indicates significance at the 10% level; **, at the 5% level; and ***, at the 1% level.

	(1) $R\&D_t$	(2) $CAPX_t$	(3) $R\&D_t$	(4) $CAPX_t$	(5) $R\&D_t$	(6) $CAPX_t$	(7) $R\&D_t$	(8) $CAPX_t$
Post × Treated	0.288	0.733			0.371*	0.059		
	(1.47)	(1.55)			(1.78)	(0.14)		
Treated × $Year_{2009}$			-0.062	-0.503			-0.261	0.294
			(-0.39)	(-0.52)			(-1.31)	(0.52)
Treated × $Year_{2010}$			0.001	0.266			0.016	-0.405
			(0.01)	(0.42)			(0.08)	(-0.73)
Treated × $Year_{2011}$			-0.099	-0.319			-0.019	-0.374
			(-0.67)	(-0.58)			(-0.13)	(-0.98)
Treated × $Year_{2013}$			-0.417**	0.320			-0.239	-0.103
			(-2.36)	(0.56)			(-1.34)	(-0.38)
Treated × $Year_{2014}$			-0.237**	0.380			-0.016	-0.412
			(-2.24)	(0.64)			(-0.14)	(-0.97)
Treated × $Year_{2006}$			0.262	0.546			0.378	0.101
			(1.04)	(0.67)			(1.45)	(0.17)
Treated × $Year_{2007}$			0.169	0.863			0.201	-0.004
			(0.81)	(0.86)			(0.98)	(-0.01)
Treated × $Year_{2008}$			0.482	0.990			0.506	0.083
			(1.46)	(1.07)			(1.52)	(0.11)
Size	0.492***	5.215***	0.478***	5.249***	0.571**	3.457***	0.568**	3.430***
	(2.87)	(3.62)	(2.71)	(3.63)	(2.37)	(3.66)	(2.26)	(3.64)
Lagged size	-0.838***	-5.067***	-0.829***	-5.125***	-0.790**	-2.702***	-0.788**	-2.691***
	(-3.44)	(-3.44)	(-3.37)	(-3.43)	(-2.38)	(-3.50)	(-2.34)	(-3.49)
Leverage	-0.194	0.948	-0.197	0.927	0.516	1.022	0.526	0.975
	(-0.51)	(0.84)	(-0.51)	(0.81)	(0.85)	(0.92)	(0.86)	(0.88)
Equity ETF%	-0.026	-0.001	-0.026	0.004	0.021	0.272**	0.018	0.270**
	(-0.68)	(-0.01)	(-0.70)	(0.04)	(0.32)	(2.07)	(0.25)	(2.06)
ROA	-1.038**	-3.482*	-1.181***	-3.620*	-1.685***	-4.145***	-1.755***	-4.305***
	(-2.33)	(-1.70)	(-2.70)	(-1.77)	(-3.08)	(-2.98)	(-3.31)	(-2.96)
Tangibility	2.307***	7.737*	2.370***	7.785*	3.256***	8.109***	3.269***	8.097***
	(3.20)	(1.95)	(3.35)	(1.95)	(3.46)	(3.29)	(3.50)	(3.27)
Cash	0.370	-3.816	0.407	-3.806	-0.025	-3.869**	-0.006	-3.918**
	(0.61)	(-1.50)	(0.66)	(-1.49)	(-0.03)	(-2.18)	(-0.01)	(-2.18)
Tobin's q	0.045	0.879*	0.046	0.867*	0.145	0.294	0.150	0.294
	(0.33)	(1.95)	(0.34)	(1.93)	(1.08)	(0.94)	(1.11)	(0.93)
Cash flow	1.079	8.619*	1.243	8.715*	2.862**	17.379***	2.847**	17.562***
	(1.22)	(1.94)	(1.42)	(1.97)	(2.46)	(4.21)	(2.45)	(4.18)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.971	0.715	0.971	0.715	0.971	0.841	0.971	0.842
Observations	939	939	939	939	1052	1052	1052	1052

Table 6: Characteristics of HYG bonds and peer bonds

This table compares the characteristics of bonds that were added to HYG in June and July 2009 (New inclusion), bonds that were not added to HYG but issued by the same issuers of newly included bonds (Peer), and bonds that were present in HYG from January to May 2009 (Control).

	Newly added	Peer	Controls
Number of bonds	43	85	29
Number of firms	34	25	29
Rating	13.32	12.99	13.85
Time to maturity (year)	6.56	5.40	6.54
Issuer amount (millions)	3,217.10	5,397.40	3,940.86
Bond amount (millions)	705.29	584.44	1,236.89

Table 7: HYG rule change: pricing effect

This table reports the results of difference-in-differences regressions estimating the effect of ETF inclusion on all bonds issued by a firm with a bond added in HYG and non-ETF bonds from the same issuers using the specification Yield spread$_{i,t}$ = $\alpha_i + \lambda_t + \beta_1(\text{Treatment}_i \times \text{Post}_t) + \boldsymbol{\delta}\mathbf{X}_{i,t} + \epsilon_{i,t}$. To construct Yield spread$_{i,t}$, we consider all transactions from the last five days of the month and compute the volume-weighted average yield of the bond in that month over the maturity-matched swap rate. $\mathbf{X}_{i,t}$ are covariates including Rating$_{i,t}$, the median of numerical version of Standard & Poor's, Moody's, and Fitch ratings, Leverage$_{i,t}$, the market value of firm leverage, Operating$_{i,t}$, operating income from sales, Long term debt$_t$, the ratio of long-term debt to assets, and Equity volatility$_{i,t}$, the volatility of equity from Campbell and Taksler (2003). In columns (1) and (2), treatment bonds are all bonds issued by a firm with a bond added to HYG. In columns (3) and (4), treatment bonds are those that were not added to HYG but issued by the same issuers of bonds added to HYG in June and July 2009. In all columns, controls are bonds that were present in HYG from January to May 2009. Post$_t$ equals one from July to December 2009 to account for the six-month transition from the original index to the expanded index and equals zero from January to June. α_i and λ_t are bond and time fixed effects, respectively. t-statistics based on robust standard errors are reported below the coefficients. * indicates significance at the 10% level; **, at the 5% level; and ***, at the 1% level.

	(1) Aggregate effect	(2) Aggregate effect	(3) Aggregate effect	(4) Aggregate effect
Treated*Post	-1.410***	-1.257***	-1.644***	-1.367***
	(-9.58)	(-8.63)	(-10.09)	(-8.41)
Rating		-0.013		-0.014
		(-0.16)		(-0.14)
Leverage		5.936***		7.690***
		(10.40)		(9.98)
Operating		0.065***		0.056***
		(4.75)		(5.08)
Long term debt		3.663***		3.291**
		(3.03)		(2.37)
Equity volatility		3.098***		3.033***
		(10.13)		(8.79)
Bond FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
R-squared	0.853	0.873	0.853	0.880
Observations	2634	2079	1865	1489

Table 8: Bonds on both sides of the new LQD inclusion threshold

This table compares the characteristics of bonds just above the LQD inclusion criteria (Treatment) and bonds just below the inclusion criteria (Control). On April 30, 2012, the Markit iBoxx USD Liquid Investment Grade Index announced a new inclusion criterion: the minimum issuer's total face value outstanding decreased from $3 billion to $2 billion. For both treatment and control groups, bonds are required to be investment-grade, and the bond level amount outstanding is greater than $750 million. The treatment group has issuer's amount outstanding bonds between $2 billion and less than $3 billion, whereas for the control group, it is at least $1 billion and less than $2 billion.

	Treatment	Control
Number of bonds	61.00	55.00
Number of firms	39.00	52.00
Rating	6.90	6.88
Time to maturity (year)	9.53	8.01
Issuer amount (millions)	2,539.18	1,394.98
Bond amount (millions)	1,016.11	965.18

Table 9: LQD rule change: pricing effect

On April 30, 2012, the Markit iBoxx USD Liquid Investment Grade Index announced a new inclusion criterion: the outstanding face value of all bonds from the issuer must be at least $2 billion. This table reports the results of difference-in-differences regressions estimating the effect of exchange-traded fund (ETF) eligibility on bond yield spreads using the specification: $\text{Yield spread}_{i,t} = \alpha_i + \lambda_t + \beta_1(\text{Treatment}_i \times \text{Post}_t) + \boldsymbol{\delta}\mathbf{X}_{i,t} + \epsilon_{i,t}$. To construct $\text{Yield spread}_{i,t}$, we consider all transactions from the last five business days of the month and compute the volume-weighted average yield of the bond in that month over the maturity-matched swap rate. $\mathbf{X}_{i,t}$ are covariates including $\text{Rating}_{i,t}$, the median of numerical version of Standard & Poor's, Moody's, and Fitch ratings, $\text{Leverage}_{i,t}$, the market value of firm leverage, $\text{Operating}_{i,t}$, operating income from sales, Long term $\text{debt}_{i,t}$, the ratio of long-term debt to assets, and Equity $\text{volatility}_{i,t}$, the volatility of equity from Campbell and Taksler (2003). The treatment group contains bonds from issuers with total face value outstanding bonds greater or equal to $2 billion and less than $3 billion during any month of February 2012 to April 2012. The control group contains bonds from issuers with face value outstanding bonds greater than or equal to $1 billion but less than $2 billion. Post_t equals one after April 2012 and equals zero otherwise. α_i and λ_t are bond and month fixed effects, respectively. t-statistics based on robust standard errors are reported below the coefficients. * indicates significance at the 10% level; **, at the 5% level; and ***, at the 1% level.

	(1) LQD	(2) LQD
Treated*Post	-0.145***	-0.095**
	(-3.90)	(-2.44)
Rating		0.456***
		(5.96)
Leverage		2.840***
		(4.35)
Operating		0.131***
		(3.64)
Long term debt		-1.645***
		(-4.52)
Equity volatility		1.469***
		(3.13)
Bond FE	Yes	Yes
Month FE	Yes	Yes
R-squared	0.872	0.910
Observations	2190	1443

Table 10: Baseline parameters.

This table reports the baseline parameters used in the numerical results in Section 5.3.

Description	Parameter	Value
Productivity	z	5
Physical capital	k	1
Output elasticity	γ	0.8
Units of bonds held by passive investors	P	1
Minimal debt issuance size for ETF	$\underline{D}$	3.5
Probability of ETF inclusion for eligible firms	p	0.7
Probability of liquidity shocks to active investors	λ	0.2
Yield parameter	α	0.15
Issuance cost parameter	ϕ	0.3

Appendices

A Variable Definition

Variable	Definition
Size	The natural logarithm of the firm's book asset at the end of the fiscal year.
CAPX	Capital expenditures at the end of the fiscal year divided by total assets at the beginning of the year. Missing values are set to zero.
R&D	R&D expenses at the end of fiscal year divided by total assets at the beginning of the year. Missing values are set to zero.
Lev	Book leverage. The sum of long-term and current liabilities, scaled by total assets.
Market leverage	(Long-term debt + short-term debt) divided by (market equity value + long-term debt + short-term debt).
ROA	Income before extraordinary items scaled by total assets.
Operating income	The ratio of operating income to sales.
Tobin's q	Sum of market value of equity and the book value of assets minus the book value of equity, scaled by total assets.
Cash	The ratio of cash and cash equivalent to lagged total assets.
Cash flow	Net income before extraordinary items plus depreciation and amortization expenses, scaled by lagged total assets.
Tangibility	Property, plant and equipment (net), scaled by total assets.

Equity ETF %	The fraction of market value of a given firm held by equity ETFs at a given year scaled by the firm's total number of shares outstanding.
Equity volatility	The equity volatility for the previous 180 days of daily stock returns.

B Bond ETF Inclusion Rule Changes

B.1 Markit iBoxx USD Liquid Investment Grade Index

- Inclusion criteria prior to April 30, 2012
  - Callable and puttable bonds are not candidates for inclusion.
  - The outstanding face value of all USD denominated bonds in the broader Markit iBoxx USD Investment Grade Corporate Index (including Yankee bonds and Eurobonds and excluding fixed-to-floater, callable, puttable, and perpetual bonds) from the issuer must be greater than or equal to $3 billion as of the Bond Selection Cut-off Date.
- Inclusion criteria after April 30, 2012
  - Callable and puttable bonds are eligible for inclusion.
  - The outstanding face value of all bonds denominated in USD from the issuer in the broader Markit iBoxx USD Investment Grade Corporate Index (excluding

fixed-to-floater and perpetual bonds) must be greater than or equal to $2 billion as of the Bond Selection Cut-off Date.

B.2 Markit iBoxx USD Liquid High Yield Index

- Inclusion criteria prior to June 30, 2009
  - Minimum issue amount outstanding of $200 million.
  - The highest rating below investment grade.
  - Time-to-maturity between three and fifteen years.
  - equal-weighted index of 50 bonds.
- Inclusion criteria after June 30, 2009
  - A minimum issue amount outstanding of $400 million.
  - Greater than $1 billion in issuer amount outstanding.
  - Average rating below investment grade.
  - Time-to-maturity between three and fifteen years.
  - 3% capped market-value-weighted index of an unlimited number of bonds.

C Proofs

Proof of Proposition 1: Denote D_i as the optimal R&D investment (or debt issue size) with only active investors. The first-order condition (FOC) of (8) gives

$$0 = \gamma z \xi_i D_i^{\gamma-1} k_i - e^{2\alpha D_i} \left[(1 + 2\alpha D_i) + 2\lambda\phi D(1 + \alpha D) \right]. \tag{10}$$

When passive investors are present, denote $\hat{D}_i$ as the optimal R&D investment. The FOC of (9) gives

$$\begin{aligned} 0 = \gamma z \xi_i \hat{D}_i^{\gamma-1} k_i - (1-p) e^{2\alpha \hat{D}_i} \left[(1 + 2\alpha \hat{D}_i) + 2\lambda\phi \hat{D}_i (1 + \alpha \hat{D}_i) \right] \\ - p e^{2\alpha(\hat{D}_i - P)} \left[\left((1 + 2\alpha \hat{D}_i) + 2\lambda\phi \hat{D}_i (1 + \alpha \hat{D}_i) \right) + 2\lambda\phi P \underbrace{(\alpha P - 2\alpha \hat{D}_i - 1)}_{<0} \right]. \end{aligned} \tag{11}$$

If we set $\hat{D}_i = D_i$, then it is easy to see that the RHS of (11) is positive. Hence, $\hat{D}_i$ must be larger than D_i as the objective function is concave. □

Proof of Lemma 1: For a fixed debt issuance size, having passive investors can lower the yield and refinancing cost. As long as the probability p is positive, the equity value is higher in an economy with ETF. □

Proof of Lemma 2: The result follows from the fact that the RHS of (11) is increasing in the probability p. □

Proof of Proposition 2: Let us consider the case when only active investors are present. Rearranging (10) gives

$$\gamma z \xi_i D_i^{\gamma-1} k_i = e^{2\alpha D_i} \left[(1 + 2\alpha D_i) + 2\lambda\phi D(1 + \alpha D)\right].$$

Suppose we increase ξ_i. If D_i is unchanged, then the RHS is unchanged, but the LHS has increased. If D_i decreases, then the RHS decreases as well. However, since $\gamma < 1$, a decrease in D_i implies an increase in $D_i^{\gamma-1}$, which increase the LHS. Hence, we must have an increase in D_i. Next, consider when the passive investors are present. Rearranging (11) gives

$$\gamma z \xi_i \hat{D}_i^{\gamma-1} k_i = (1-p) e^{2\alpha \hat{D}_i} \left[(1 + 2\alpha \hat{D}_i) + 2\lambda\phi \hat{D}_i(1 + \alpha \hat{D}_i)\right] \\ + p e^{2\alpha(\hat{D}_i - P)} \left[\left((1 + 2\alpha \hat{D}_i) + 2\lambda\phi \hat{D}_i(1 + \alpha \hat{D}_i)\right) + 2\lambda\phi P(\alpha P - 2\alpha \hat{D}_i - 1)\right].$$

It is easy to show that the RHS is increasing in D_i since $D_i > P$. Therefore, the same logic applies. This completes the proof. □

Proof of Corollary 2: According to Proposition 2, with a sufficiently high ξ_i, firm i's issuance will be larger than $\underline{D}$. The second part of the corollary is a direct application of Proposition 2. □

Proof of Proposition 3: Since the firm's optimal interior issuance $\hat{D}_i$ is less than $\underline{D}$ when passive investors are present, any issuance larger than $\hat{D}_i$ will lower the equity value. Thus, the firm will issue exactly $\underline{D}$ if it is optimal to be considered for an ETF. □

Proof of Proposition 4: Let $\overline{E}_i(\xi_i)$ be the equity value when firm i issues exactly $\underline{D}$ units of debt and passive investors are present, i.e., plugging in $\underline{D}$ into (9). Let $E_i^A(\xi_i)$ be the equity value when firm i optimally chooses its debt with only active investors.

It is clear that $\lim_{\xi_i \to 0} \overline{E}_i(\xi_i) < 0 = \lim_{\xi_i \to 0} E_i^A(\xi_i)$ because the firm has zero output yet it still has to service its debt. According to Proposition 2, there exists an innovation efficiency $\widehat{\xi}$ such that the optimal debt issuance at $\widehat{\xi}$ coincides with $\underline{D}$ when passive investors are present. By Lemma 1, we know that $\overline{E}_i(\widehat{\xi}) > E_i^A(\widehat{\xi})$. Since equity values are continuous and monotone in ξ_i, there exists a unique $\underline{\xi}$ such that $\overline{E}_i(\underline{\xi}) > E_i^A(\underline{\xi})$ according to the intermediate value theorem. This completes the proof. □