Corporate Asset Pricing

Andreas Brøgger

May 4, 2021

For latest version click *here*

Abstract

I show the new fact that Idiosyncratic volatility significantly predicts the convenience yield. This fact poses a puzzle with current safe asset theories. I develop a new theory that reconciles this puzzle - a theory I label Corporate Asset Pricing (CAP). CAP explains 29% of future convenience yield variation and is verified in the cross-section of firm treasury holdings. I show theoretically that when managers are exposed to moral hazard, corporate demand will be determined by their idiosyncratic risk. I isolate my demand-based effect from confounders by using exogenous cross-sectional variation from corporate size and industry exposures. The results provide support for the importance of corporates as an investor class.

Keywords: Safe asset demand, Convenience yield, Idiosyncratic volatility, Investment.

JEL Classification: G11, G12, G31, G32.

I thank Jules van Binsbergen, Jens Dick-Nielsen, Itay Goldstein, Stefan Hirth (Discussant), Juan Felipe Imbett, David Lando, Alejandro Lopez-Lira, Thomas Kjær Poulsen, Roberto Steri, and participants at the Princeton initiative on Macro, Money and Finance, Copenhagen Business School PhD Seminar, and Nordic Finance Network PhD Symposium, for helpful comments and suggestions. Part of this research was conducted while visiting the Wharton School at the University of Pennsylvania. All remaining errors are mine. I am grateful to FRIC for financial support, grant no. DNRF102.

*Copenhagen Business School, Department of Finance, Center for Financial Frictions (FRIC), Solbjerg Plads 3, 2000 Frederiksberg, Denmark; Email: anbr.fi@cbs.dk; Website: andreasbrogger.com.

1 Introduction

Convenience yields are hard to reconcile with standard asset pricing models. The CAPM would say that a risk free asset should give you the risk free rate. Not more, not less. This has lead papers such as Sidrauski (1967), Krishnamurthy and Vissing-Jorgensen (2012), and Nagel (2016) to include money in the utility function to explain why some risk free assets give a return below the risk free rate. The insufficiencies of current models are further demonstrated by Koijen and Yogo (2019, 2020), who show that the majority of asset price variation is left unexplained. I, on the other hand, show that convenience yields can be explained without departing from our standard risk-based frameworks.

If we are to make progress as a field, we need frameworks that work out of sample, meaning across a wide range of asset-classes, markets and settings. If we for each anomaly add a new factor, motivated from a different model we end up with a factor zoo and no fundamental knowledge. Instead, this paper centers around the fundamental principle of finance that the marginal utility of the marginal investor should price assets. Hence, figuring out who the marginal agents are, and understanding how they make financial choices, are critical for understanding asset prices. Recent work by Koijen and Yogo (2019, 2020) show that unexplained latent demand is responsible for 81% of the cross-sectional variance in stock-returns and 43% in bond yields. This paper helps explain where this latent demand arises from. Although often overlooked, I find that corporations are a key investor class in many assets. As an illustration, I show that corporate demand has created a convenience yield on treasuries of on average 31 bp, which amounts to 83% of the average convenience yield.

The growing influence of corporations is evidenced by their assets increasing from 31% of GDP in 1950 to a massive 183% by the end of 2019. At the same time the fraction of their assets held in financial assets increased from 7% in 2000 to 12% by 2019, peaking at 17% in 2017. Combined, these two facts mean that corporates have been a growing investor class who today manages trillions of dollars of financials securities. In other words their holdings make up a sizeable fraction of several asset markets. At the same time, firms cash holdings have increased from close to 0% in the 60's to 6.3% by the end of 2019 and their investment ratio has been steadily declining since its peak in the 80's of 11.3% to 4.8% by the end of 2019, a puzzle to a large literature.[1] Together, this means that corporates are now an investor class that we cannot continue to ignore.

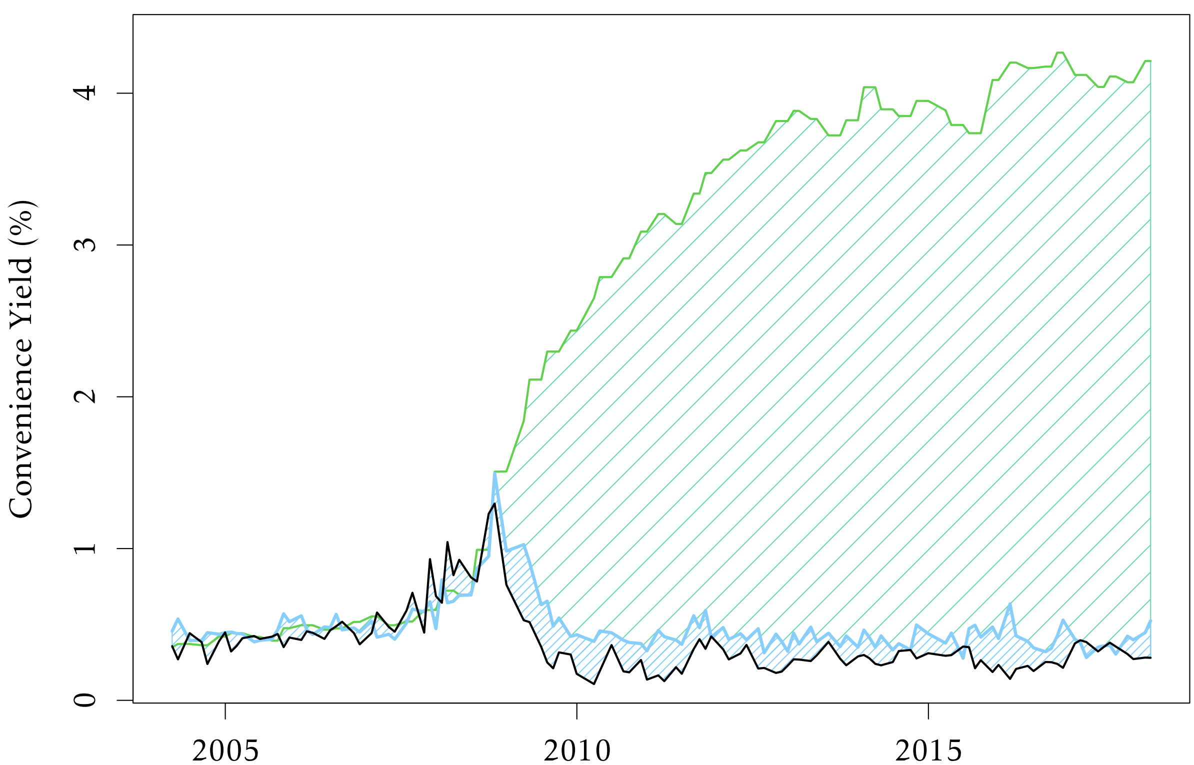

Figure 1: Figure shows the Convenience Yield Puzzle (Green area) and the Corporate Asset Pricing solution (Blue area). [Description on next page]

[1]See Bloom, Bond and van Reenen (2007), Bond and Van Reenen (2007), for an overview of how firms underinvest relative to what would be predicted from the neoclassical q-model. Also related is the idea of underinvestment from the seminal work by Myers (1976) and Stulz (1990), and more recent work by Bloom, Bond and Van Reenen (2007) involving uncertainty and underinvestment. Finally, Asker, Farre-Mensa and Ljungqvist (2015) speaks to public firms underinvesting.

[Figure on previous page] Green line shows the predicted convenience yield as estimated from dates prior to 2009 using Krishnamurthy and Vissing-Jorgensen (2012) and Nagel (2016). The black line shows the actual convenience yield. The shaded green area is hence the prediction error and illustrates the Convenience Yield Puzzle. The blue line shows the predicted convenience yield as estimated from dates prior to 2009 using idiosyncratic volatility of corporates. Shown for a maturity of 18 months and idiosyncratic volatility as estimated in Ang, Hodrick, Xing and Zhang (2006, 2009). Idiosyncratic volatility is annualized.

As mentioned, this paper centres around the fundamental idea of asset pricing: $P = E[m * R]$, where m is the marginal investors marginal utility, and R is the return on the financial asset. This implies that the marginal investor's marginal utility can be used to price assets and as a consequence what factors into their optimality conditions should price assets.

Even though isolating the impact of corporate demand on asset prices is hard, one key insight allows me to identify demand effects. This new insight is that in the presence of moral hazard, corporate demand will be determined by their idiosyncratic risk.[2] Considering how asset prices are influenced by the idiosyncratic risk of corporates also has the benefit that it is uncorrelated with the supply of safe assets. Another benefit of using idiosyncratic volatility over using asset holdings as our measure of demand is that asset holdings are only observable at the quarterly level, and the data quality is poor.[3] On the other hand idiosyncratic volatility is measured from equity prices, which are highly liquid and available at the same frequency as other asset prices (for example daily). Additionally, there is a timing issue, as the demand of a firm may rise today, which due to general equilibrium effects would manifest in prices right away, however one would not observe the change in asset holdings until the next quarter, or the next if they gradually work towards their optimal portfolio. All of these issues are avoided when using idiosyncratic volatility as a proxy for corporate demand.

[2] I will formalise this insight in the conceptual framework section.

[3] Additionally the reporting standards may vary from firm to firm.

I start off by providing the motivating fact that there indeed exists a strong relationship between my measure for corporate demand, idiosyncratic volatility, and the future convenience yield. When plotting the future convenience yield against the past idiosyncratic volatility, a clear linear relationship is visible. Indeed, the correlation is high at 65%.[4] The result is robust as it is not driven by our choice of measure. In other words, the same outcome emerges both for realised and implied idiosyncratic volatility as well as for other measures of safe asset premia, such as the Banks acceptance rate to Treasury Bill spread used by Nagel (2016).

To identify the corporate demand effects, I go on to construct a conceptual framework of corporate asset pricing. My framework leads to corporate demand being determined by their idiosyncratic volatility. In standard asset pricing models such as the Capital Asset Pricing Model (Sharpe, 1964, Lintner, 1965), and Arbitrage Pricing Theory (Ross, 1976), investors idiosyncratic volatility does not affect their decisions, as it can get diversified away. However, I show that the existence of moral hazard in corporate managers behaviour, requires us to do away with this simplified result. Instead, the firm owners optimal contract demands that managers take on uninsured idiosyncratic risk to ensure high (unobservable) effort is exerted. In fact, surprisingly, it turns out that systematic risk alternatively has no effect on this channel.

Moral hazard, compared to a hypothetical situation without its existence, leads to higher savings and less investment, a wedge that is increasing in the idiosyncratic volatility of the firm. I confirm both the saving and investment effects is in the data. Overall, this means that investment has been around 5% lower annually, than it would have been without moral hazard.

Overall, the important testable implications of my theory are that as idiosyncratic volatility increases: (1) Convenience yield increases, (2) Investment decreases, and (3)

[4] The convenience yield is from Van Binsbergen, Diamond and Grotteria (2021).

Savings increase. To test these I create measures of idiosyncratic volatility. I take the volatility of the unexplained variance from a regression of CRSP firm returns on a widely used asset pricing model, such as the Fama-French 3 factor model used in Ang et al. (2006, 2009). As an alternative, I create an option implied idiosyncratic volatility measure using CBOE SP500 options. As asset prices to test, I use the Convenience yield measure by Van Binsbergen, Diamond and Grotteria (2021), other safe asset returns from Nagel (2016), corporate yields from Moodys, and aggregate market returns from French' website. To test idiosyncratic volatilities effects on savings and investment I use Compustat to get firms' savings and investment. This new implied measure provides useful external validation, both for myself and the literature on idiosyncratic volatility at large.

After constructing the data, I first regress the asset price returns on my proxy for corporates' demand (the idiosyncratic volatility measures), and find that corporate demand explains up to 69% of the time series variation and can explain 83% of the average convenience yield. Additionally, understanding corporates helps explain prices in other assets, which they are a large part of the investor base; such as corporate debt, commercial paper, deposits, as well as the expected risk premium.

As idiosyncratic volatility is a valid measure for corporate demand I can get an estimate of corporates' price impact. To do this I instrument corporate treasury holdings on their past idiosyncratic volatility, which is highly significant. Using the instrumented demand in a two-stage least squares regression, I then find the price impact to be around 50 bp, as measured by % price change per % of outstanding assets sold. This is a bit smaller than the macro-estimates found in Gabaix and Koijen (2020) of around 5%, and larger than the micro-estimates found in Koijen and Yogo (2019) of 25 bp, which is sensible as corporate sector level is in between the asset class level and the single seller level.[5]

[5]Koijen and Yogo (2019) measure price impact as % price change from a 10% demand change of an investor. It also makes sense that the price impact on bonds should be smaller than that on stocks on the aggregate level, which they use in those papers.

Also important to keep in mind, is that prior theoretical estimates based purely on rational expectations puts the price impact at around 100 times lower than both mine and Gabaix and Koijen (2020)) estimates, hence I provide supporting evidence that the price impact is higher than previously thought. And hence that understanding investors behaviour is more important than previously thought.

I go on to show that idiosyncratic volatility explains and predicts the risk premia and convenience yield in excess of current asset pricing models including competing theories. My corporate demand proxy has better explanatory power, and especially predictive power, than the intermediary asset pricing proxy of He, Kelly and Manela (2017), also in excess of the dividend-price ratio. The intermediate asset pricing factor also becomes insignificant when including the corporate demand factor in explaining the convenience yield. This speaks to the debate on whether idiosyncratic volatility matters for the equity risk premium. In addition to previous findings, I show that idiosyncratic volatility innovations do matter throughout a long time period for a capitalisation-weighted measure, and while controlling for the dividend-price ratio and the market volatility.[6]

I provide a plethora of robustness tests. I show that my results are robust to controlling for total realised volatility, implied volatility (VIX), different ways of correcting the standard errors, using different maturities, and considering a difference-in-difference specification. I find that my proxy explains the government yield, but not the option implied rate, which makes sense as most managers do not have a mandate to invest in options, but are allowed to have bonds on their balance sheet. This finding confirms the validity of market segmentation ensuring the spread remains. This is because for financial intermediaries, the risk-free return achievable from options completely dominates the one achievable from government debt. However, as corporates cannot access options to the same extend, they are left with other safe assets, such as government debt. Ad-

[6]See Goyal Sandal (2003,JF), Bali et al (2005), Wei Zhang (2005), Garcia et al. (2014, JFQA)

ditionally, it is not possible for the intermediaries to equalise the rates through shorting government bonds, as the markets are not developed nor large enough. Lastly, there is also a fee to shorting, which the spread would not be able to go below. Overall, my results are confirmed by all of these additional tests.

To test empirical predictions (2) and (3) I regress firms investment and savings rate in a panel "within" regression and indeed find evidence in accordance with my empirical predictions. This validates my proxy. On average idiosyncratic volatility has lead to a decrease in the investment rate of 5% over the time period, partially explaining the underinvestment puzzle.

A problem in my identification arises if idiosyncratic volatility is not randomly distributed across firms and time, as then it may be correlated with variables that move prices. For example idiosyncratic volatility may be high in periods of market turbulence, which also leads to higher risk aversion and lower prices. Or, idiosyncratic risk may be high at firms with risk-loving CEO's who take on idiosyncratic risk and hold a large fraction of financial assets on their books. To account for this, I instrument idiosyncratic volatility with exogenous variation purely from factors which are plausibly exogenous: variation in firms size using the Granular Instrumental Variable method of Gabaix and Koijen (2019), and firms exposure to external risk factors from Alfaro, Bloom and Lin (2018). When doing so I confirm and give causal evidence that corporate demand is a determinant of the convenience yield.

Overall, my contribution is to narrow the gap of our understanding of what drives asset prices. I do so by introducing a new corporate demand based asset pricing framework, corporate asset pricing, which helps explain previously unexplained demand movements which are the cause of 81% of the variation in cross-sectional stock-returns. My framework, as an example, provides the first demand based convenience yield explanation. The implication is that to understand asset price movements it is important to figure out who the marginal investor is and what factors affect their financial decisions.

In doing so, my work additionally helps quantify an economic cost of moral hazard, as it has decreased investment and growth in the economy, in addition to inflating prices on government debt and money leading to deflationary effects. It also helps explain the breakdown of the lower interest rates and investment growth relationship as witnessed in the last decades.

A policy implication of my results is that if central banks try and lower rates, they may not be effective if these changes also reduce non-financials idiosyncratic risk. A situation which is not unlikely. Additionally, if lowering interest rates actually leads to reaching for yield and increasing idiosyncratic volatility, it would reduce investment and curb the stimulating effect of the lower rates.

This work has implications for how we view asset pricing. Specifically, knowing who the marginal investor is and what matters to them can help us price assets widely across the economy, such as what the government pays to fund its debt, and firms' cost of capital. This in turn affects investment materialization through their financing cost and ultimately affects how our economy develops.

Contribution to the literature. I provide an explanation of latent demand, which explains a large fraction of price changes (Koijen and Yogo (2019)). Other papers that consider the effects of demand on asset prices include Shleifer (1986), Harris and Gurel (1986). Chang, Hong and Liskovich (2015) study index inclusions, and Ben-David, Li and Song (2020) consider advice driven demand from Morningstar.

What separates my work is that I am the first to provide a demand-based explanation of the convenience yield. The closest paper to mine empirically is Jiang, Krishnamurthy and Lustig (2018), but their empirical analysis instead uses the convenience yield to explain exchange rate phenomena. Additionally, they do not provide an explanation of where the foreign convenience yield arises from, but instead derives from a no-arbitrage relationship given the existence of the foreign convenience yield. Another close paper is Koijen and Yogo (2020) as they also get a measure of foreign demands influence on convenience yield, however their analysis is also not an explanation of where the latent demand arises from, which is what I present. Papers that instead empirically consider safe asset returns from a supply perspective include Krishnamurthy and Vissing-Jorgensen (2012), Sunderam (2015), and Nagel (2016).

A theoretical contribution is to link the moral hazard of corporate managers to the convenience yield earned on safe assets. This new insight allows me to be the first to supply a theory of safe asset demand, and get a convenience yield, *without* money in the utility function such as Gorton and Pennacchi (1990), Dang, Gorton and Holmström (2012), Krishnamurthy and Vissing-Jorgensen (2015), Diamond (2020).

Theoretically, some previous work has considered idiosyncratic volatility and interest rates, and others have considered moral hazard and investment. But not moral hazard on interest rates, and hence giving an explanation as to why the idiosyncratic volatility of corporates should be left uninsured. Previous studies of idiosyncratic volatility and safe assets include Aiyagari (1994), who theoretically shows that uninsured idiosyncratic risk leads to a risk-free rate below the time preference rate and an increase in aggregate savings, and Angeletos (2007) who illustrate that uninsured idiosyncratic risk, from incomplete markets, leads to lower investment, worsened by a higher exogenous risk. Boileau and Moyen (2010) document that cash to assets have roughly doubled between 1971 and 2006. They mention that prior research attributes this increase to a rise in firms' cash flow volatility, and divide this between a precautionary savings motive and liquidity need. They conclude that liquidity is the main driver. Sánchez, Yurdagul et al. (2013) are a bit more careful in their conclusion, they mention that increases in aggregate risk together with idiosyncratic risk may have lead to the increase in cash holdings of firms.

My work provides a single simple model which unifies these theoretical and empirical findings and extends the results to the convenience yield and risky assets.

Studies considering idiosyncratic volatility in combination with moral hazard include Ramakrishnan and Thakor (1984), who show that idiosyncratic risk will generally be important in investment decisions, but they do not endogenise the investment decision.[7] Ou-Yang (2005) constructs an equilibrium asset pricing model with idiosyncratic risk and moral hazard, and show it affects the expected return through systematic risk. The closest paper to ours is written by Panousi and Papanikolaou (2012), who show that executive incentives induce effort, but expose them to idiosyncratic risk, and if they are risk-averse they may under invest when idiosyncratic volatility increases. Authors additionally empirically document this decrease, and that it is larger when managers own a larger fraction of the firm. This effect can be lowered by using options rather than stock compensation, or if institutional investors form a large part of the shareholder base. I extend this analysis by letting the optimal contract be an endogenous outcome, and considering the effects on the equilibrium risk-free rate and convenience yields.

My explanation exploits identification from corporate driven finance. Baker (2009) provide a summary of capital market-driven corporate finance, and Ma (2019) shows the importance of nonfinancial firms in asset markets as arbitrageurs of their own securities. Recently Mota (2020) show that non-financials strategically issue debt. Whereas these papers focus on the supply side of corporates, my paper on the other hand shows that the demand side is important.

As I consider corporates demand effects, a relevant paper is Duchin et al. (2017), which shows that non-financial firms investment into non-cash risky financial assets. The paper finds that risky assets make up 40% of the financial assets and 6% of total

[7] Moral Hazard started by canonical paper by Holmstrom (1979), extends work by Mirrlees (1976), Harris and Raviv (1979).

book assets, and confirms the growing importance of corporates as an investor class.

To proxy for corporate demand I use realised and implied idiosyncratic volatility. Other papers that consider the realised idiosyncratic volatility effects on asset prices include Ang et al. (2006, 2009), Chen and Petkova (2012), Herskovic et al. (2016), and Chen et al. (2020). Other papers that consider option implied volatility effects include An et al. (2014), who look at stocks, and Cao et al. (2019) who look at bonds, but they do not distinguish between idiosyncratic and systematic implied volatility.

For identification I partially rely on segmented markets. Another paper that considers the implications of separated markets include Vandeweyer (2019).

Recently, an active literature on uncertainty and low investment has started lead by Bloom (2007). Gilchrist, Sim and Zakrajšek (2014) looks at idiosyncratic risk lowering investment versus financial frictions empirically and in a macroeconomic model. Other papers include Bloom, Bond and van Reenen (2007), Gilchrist, Sim and Zakrajšek (2014), and Tella (2020). DeMarzo et al. (2012) consider q-theory and incentive contracting (hence on investment), but do not consider the demand for safe assets and the effect on the convenience yield.

As mentioned, the closest paper to mine is Panousi and Papanikolaou (2012), who also consider the implications of moral hazard on investment. However they do not solve for endogenous contracts and neither do they investigate the effects of increased idiosyncratic risk on the convenience yield.

2 The Convenience Yield Puzzle

Until 2009 the Treasury Bond supply and the interest rate has been good explanators for the convenience yield, as shown in Figure 1. The figure additionally shows that this is not the case after 2009 as the predicted convenience yield is much higher than the actual convenience yield. This is illustrated in the figure as the shaded green area.[8] These findings of the convenience yield puzzle are further shown in Table 1. Robustness are shown in Table 2. Here Column 1 shows that the Krishnamurthy and Vissing-Jorgensen (2012) model works well prior to 2009. Column 2 shows this is also the case for the Nagel (2016) model. The figure shows in blue that the puzzle is resolved when instead using the idiosyncratic volatility to explain the convenience yield. The shaded blue area is much smaller than the green. This result is also visible in Column 3 of Table 1.

3 The Corporate Balance Sheet Expansion

The growing influence of corporations is evidenced by their assets increasing from 31% of GDP in 1950 to a massive 183% by the end of 2019. At the same time the fraction of their assets held in financial assets increased from 7% in 2000 to 12% by 2019, peaking at 17% in 2017 (Figure 3). Combined these two facts mean that corporates have been a growing investor class and today manage trillions of dollars of financials securities. Their holdings make up a sizeable fraction of several asset markets, as depicted in Figure 4.[9] At the same time, firms cash holdings have increased from close to 0% in the 60's to 6.3% by the end of 2019. Their investment ratio has been steadily declining since its peak in

[8]Figure 9 shows that the difference is unlikely to be driven by bond purchases as they make out a reasonably small portion of the total bond supply.

[9]Their ownership can also be volatile as seen from the drop in financial ownership from 17% to 13% in just one year in 2018. Equivalent to USD 292 billion.

the 80's of 11.3% to 4.8% by the end of 2019, a puzzle to a large literature.[10] Together, this means that corporates are now an investor class that we cannot continue to ignore.

4 A Theory of Corporate Safe Asset Demand

4.1 A Simple Conceptual Framework

Here I illustrate why performance based pay of CEOs leads to a convenience yield. To be able to do so, we make some functional assumptions. First, let the manager's utility be characterised as:

$$U(w,a) = \mathrm{E}[1 - e^{-Aw+a^2}], \tag{1}$$

where A describes the agents degree of risk aversion, and a his effort level. Secondly, let the investment technology available be equal to $\sqrt{k}$.

Assumption (Performance based pay). CEO's performance based pay make up such as large fraction of their income that they cannot feasible hedge it all. Additionally, they may not be allowed by the board to short the company. Later it will be shown that this assumption in fact is a natural consequence from agency frictions as well as being empirically apt.

Proposition (Idiosyncratic risk and the convenience yield). In equilibrium the convenience yield will be given by

[10]See Bloom, Bond and van Reenen (2007), Bond and Van Reenen (2007), for an overview of how firms underinvest relative to what would be predicted from the neoclassical q-model. Also related is the idea of underinvestment from the seminal work by Myers (1976) and Stulz (1990), and more recent work by Bloom, Bond and Van Reenen (2007) involving uncertainty and underinvestment. Finally, Asker, Farre-Mensa and Ljungqvist (2015) speaks to public firms underinvesting.

$$\boxed{R^c = \frac{1}{2}A\sigma_i^2 - k^{-1/2}.} \tag{2}$$

Proof. The first order condition requires the marginal utility of investment to equal the marginal utility of saving in safe assets.

$$\begin{aligned} U_k' &= U_b' && (3) \\ U_k' &= (k^{-\frac{1}{2}}A\mu + \frac{1}{2}A^2\sigma^2)e^{-A\mu\sqrt{k}+1/2A^2k\sigma^2-a^2} && (4) \\ U_b' &= (R^c + R^f)Ae^{-A\mu\sqrt{k}+1/2A^2k\sigma^2-a^2}. && (5) \end{aligned}$$

Which gives that

$$R^c = \frac{1}{2}A\sigma^2 - k^{-1/2} - R^f.$$

And as the risk free rate is

$$R^f = \frac{1}{2}A\sigma_m^2. \tag{6}$$

Can write in general as

$$\begin{aligned} R^c &= \frac{1}{2}A\sigma_{i+m}^2 - k^{-1/2} - \frac{1}{2}A\sigma_m^2 \\ &= \frac{1}{2}A(\sigma_{i+m}^2 - \sigma_m^2) - k^{-1/2} \\ R^c &= \frac{1}{2}A\sigma_i^2 - k^{-1/2}. \end{aligned}$$

The convenience yield is hence increasing in the idiosyncratic volatility and amount invested. The reason why there can be a difference to the risk free rate is because of moral hazard leading the principal to requiring manager to be exposed to the additional idiosyncratic risk. A risk that is increasing in k.

4.2 Empirical Specification

Testing. We can test by $R^c \sim \beta\sigma^2 + \gamma k^{-1/2}$ or more simply by $R^c \sim \alpha + \beta\sigma + \gamma k$. This means that we just have measurement error left at the end, like so: $R^c = \alpha + \beta\sigma + \gamma k + \epsilon$, where ϵ is measurement errors and time varying factors that affect the convenience yield who are outside the model.

A few remarks are in order. First, I note that measurement error in σ_i and k will bias downward my effect, and hence what I present is a lower bound of the actual effect. Second, note that if there are more investors σ_i and k will be the asset-weighted idiosyncratic risk and investment respectively. Third, the reason why the risk free rate is not pushed down is because the agents exposed to the additional idiosyncratic risk are excluded from investing in this asset. ie the options where you can set it up to get a risk-free return as a combination of put, call and futures.

5 Creating an Idiosyncratic Volatility Measure

Data. To test this I create measures of idiosyncratic volatility. I create both realised and implied idiosyncratic volatility measuries. Aditionally for the realised I create both a daily and monthly version. My preferred measure is the implied one. Here I create an option implied idiosyncratic volatility measure using CBOE SP500 options. It is the product of the square-root of implied correlation subtracted by 1 multiplied by the implied volatility (VIX), both from CBOE. This idiosyncratic volatility measure is inspired by Kelly, Lustig and Van Nieuwerburgh (2016), and is a simple consequence of the facts that $TVAR = SVAR + IVAR$, $SVAR = \rho TVAR$, and $VAR = VOL^2$, which substituting for $SVAR$ and $IVAR$, and solving for $IVOL$, gives that $IVOL = \sqrt{1-\rho}\sqrt{TVAR}$.

For the realised measure I take the volatility of the unexplained variance from a regression of CRSP firm returns on my preferred asset pricing model, such as the Fama-French 3 factor model used in Ang et al. (2006, 2009). For the monthly I average within the month. For daily I run rolling regressions covering the last year.

As asset prices to test I use the Convenience yield measure by Van Binsbergen, Diamond and Grotteria (2021), other safe asset returns from Nagel (2016), corporate yields from Moodys, and aggregate market returns from French' website. To test idiosyncratic volatilities effects on savings and investment I use Compustat to get firms' savings and investment.

6 Measuring the Impact of Corporate Demand

6.1 Motivational result

Corporate idiosyncratic volatility. Figure 5 provides motivational evidence that my proxy for corporate demand, idiosyncratic volatility is important for the future convenience yield, as a clear linear relationship can be seen between lagged idiosyncratic risk and the next period convenience yield. The correlation between these two variables is high at 65%. Figures 6 shows the similarity in the evolution of the convenience yield and the idiosyncratic volatility in the time series.

The convenience yield is from van Binsbergen et al. (2019), and is the difference in the government yield and an risk free rate available from trading calls, puts and forwards. The idiosyncratic volatility here seen is a measure that I compute and is the product of the square-root of implied correlation subtracted by 1 multiplied by the implied volatility (VIX), both from CBOE. This idiosyncratic volatility measure is inspired by Kelly, Lustig and Van Nieuwerburgh (2016), and is a simple consequence of the facts that $TVAR =$

$SVAR + IVAR$, $SVAR = \rho TVAR$, and $VAR = VOL^2$, which substituting for $SVAR$ and $IVAR$, and solving for $IVOL$, gives that $IVOL = \sqrt{1-\rho}\sqrt{TVAR}$.

6.2 Main result

This section exhibits why corporates are important for asset prices.

Corporate demand and asset prices (time series result). Motivated by theory I will start off the result section by using idiosyncratic volatility as a proxy for corporate demand. In this spirit, Table 3 shows how increased corporate demand increases the prices of safe assets such as the convenience yield; the banks acceptable rate to t-bill spread, and the commercial deposit T-bill spread. Also safe assets such as debt on AAA-rated firms are affected, and even less safe debt as as BBB-rated debt.

We further see that corporate demand has a higher explanatory power in markets where corporates are a bigger player, which seems sensible, and further validates the findings.

We also see that the option implied measure seems to do better, which I suspect is because it is a forward looking measure, rather than a backwards looking measure such as the standard IVol measure. And that is faster to update as it is computed daily and not as an average over a month. Both of these factors are important as we look at the explanatory power of a lagged variable on future asset prices.

By far the largest explanatory power is for the convenience yield, perhaps because it is so precisely measured. Because of this, and because there is still little known about what determines the convenience yield, the rest of this section will mainly focus around the convenience yield results.

The timeline of the different regressions differs to a great extend. Our main specification with the convenience yield starts in 2007 and ends in 2018, and is limited by the availability of the Convenience yield measure. On the other hand the banks acceptance rate regression data starts in 1926 and goes until 2011, and the others are in between. This suggests that my results are not driven by a specific time period, but is instead applicable to all.

As both idiosyncratic risk and the prices are autocorrelated, a worry is that the error term also will be. Hence I correct this by using Newey and West (1994) errors with automatic lag length choice.

In terms of price impact it tends to follow where corporates are a bigger player, as we see the corporate demand proxy having its largest coefficient in corporate bond markets and less so in government bonds and the bank rates.

The effect is economically meaningful as a 1 standard deviation increase in the daily idiosyncratic volatility moves the convenience yield 9 bp. And equivalently 12 bp when measured from implied idiosyncratic volatility changes. This means that 3 days of 1 standard deviation moves, or a single 3 standard deviation event, would would move the convenience yield 36 bp, which is equivalent to it's long term average. This is visible in figure 7, which plots the model implied convenience yield next to the realised convenience yield.

Importantly, this effect comes purely from corporates, and only from their idiosyncratic risk exposure. And the reason they do not move the option implied risk free rate is because they are largely excluded from this market due to institutional differences, costs of having an option desk, and owners management provisions. This effect has swung the convenience yield 88 bp from peak to through, with an average effect over the sample of 31 bp or 84% of the average size of the convenience yield.

[Table 3 and Figure 7 about here]

Price impact. Table 4 gives us an estimate for the price impact of corporate demand. We see that the convenience yield increases 171 to 105 bp per USD trillion treasuries bought by the corporates for the ordinary least squares estimate, depending on duration. However the instrumental variable estimate is an increase of 523 to 467 bp per USD trillion treasuries bought. This difference suggests that confounding factors are biasing our estimate downwards. For example that corporates may tend to purchase more treasuries when they know the price impact is low. On the other hand our instrumental variable result is more reliable as the treasury purchases are instrumented from the exogenous change in the corporates idiosyncratic volatility.

To get an idea of the economic meaning of the price impacts consider the case where treasuries outstanding had been constant during the period at USD 10 trillion, which is close to the average value. Then we get that if corporates were to buy 1% of the treasuries it would increase the convenience yield by 50 bp, suggesting a price impact of $\frac{1}{2}$ in terms of yields.

This equates to approximately the same for prices as the duration is around 1 year (6 months to 18 months). In general the price impact in terms of returns are declining in maturity, helping to equalise the price impact in terms of unit prices. This is a bit smaller but in line with the findings by Gabaix and Koijen (2020) of around 5%, and is within the two-sigma confidence interval. Additionally, theirs is an estimate for equities, and it makes sense that the price impact on bonds to be lower than for equities. Also important to keep in mind that prior theoretical estimates based purely on rational expectations puts the price impact at around 100 times lower than both mine and Gabaix and Koijen (2020) estimates, hence I provide supporting evidence that the price impact is higher than previously thought. And hence that understanding investors behaviour is more important than previously thought. Additionally, my estimate is higher than the price impact found in Koijen and Yogo (2019), which is for an individual investor, and as Gabaix and Koijen (2020) is at the completely aggregate level, it makes sense that my result will be somewhere in between.

[Table 4 and 5 about here]

Prices when including investment (full model specification). My theory suggests that the model specification should be equal to

$$R^c = \frac{1}{2}A\sigma_i^2 - k^{-1/2}.$$

And hence the convenience yield should in equilibrium be affected by the level of investment. I run regressions including the investment level of corporates in table 6. The results show that the coefficient of investments indeed is negative. This means that an increase in investment *increases* the convenience yield, as investment k is raised to a negative power, which combined by the negative coefficient gives a positive relationship. The observation that the coefficient is not one, is explained by the simple assumption o the investment function, in a more complicated model this coefficient would be pinned down by the returns to investing ie how efficiently investment converts capital today to capital tomorrow. The main point now is that it has the correct directional relationship, as this is a robust feature of both type of models. It also holds for all maturities of the convenience yield. The standard errors are corrected using generalised least squares. The coefficient on idiosyncratic volatility corresponds to a risk aversion of around 13, which fits within an order of magnitude of external estimates of the risk aversion coefficient.

[Table 6 about here]

Risk premium explanation and prediction. Table 7 shows that implied idiosyncratic risk innovations predict future returns on the market portfolio. It hence works as a risk-factor, the beta of which is approximately 10% and highly significant. Column (2) includes the fama-french three factors, as controls as they are known to explain equity returns, and does not alter the predictability of the idiosyncratic volatility. The same goes for Column (3) which includes the momentum factor. Column (4) and (5) adds the Intermediary Asset Pricing factor and Intermediary Asset Pricing Leverage ratio from Kelly He Manela (2017). The factor is around as significant as the idiosyncratic volatility factor, but the leverage ratio itself is not. The idiosyncratic volatility innovations remain around 10% and highly significant for all specifications, and illustrates the relevance of corporates in explaining the expected equity premium in the time series.

[Table 7 about here]

Table 8 shows that the variance of the idiosyncratic volatility factor, or more precicely the square of the idiosyncratic volatility innovations explain the risk premium, as they predict the return of the market portfolio. They do this in excess of the dividend-price ratio (Column 2) and the variance of the market portfolio (Column 3).

[Table 8 about here]

Table 9 repeats Table 7's specification for explanation instead of prediction where the idiosyncratic volatility factor remains highly significant. Important to notice here that current realisations command a negative return, which together with the observation from the previous table that they predict higher returns going forward, are exactly what we would expect from a risk factor which commands a positive risk premium. This again yields support to the validity of this framework derived from our model.

[Table 9 about here]

Impulse response functions of convenience yield on idiosyncratic volatility shocks. Figure 8 shows that idiosyncratic volatility shocks take about a month to get into the government bond prices. And that they have a permanent effect. The results are shown for convenience yield maturities of 6, 12, and 18 months, and are similar across. The specification of the VAR also includes changes in the total volatility and the autocorrelation of the convenience yield. The daily change of the convenience yield associated with a 1 standard deviation shock to the idiosyncratic volatility is about 20 bp in the first day to 15 after a month, after which there are no more significant daily changes. This accumulated to a change in the convenience yield after two weeks, assuming no other shocks, of about 2%.

[Figure 8 about here]

6.3 Robustness

Table 13 shows that the main results are robust to different error specifications.

Table 14 shows that the main results are robust to considering different maturities.

Table 15 shows that the main results are robust to using a differences-on-differences specification. This specification gets rid of worries that both convenience yield and idiosyncratic volatility is driven by the same stochastic trend.

Note that the results are robust to both using the realised idiosyncratic volatility and the option implied idiosyncratic volatility. Additional results of the option implied measure are shown in Table 16. The results are also robust to estimating the idiosyncratic volatility using other risk models such as the CAPM. The results are also robust to measuring idiosyncratic volatility at the daily level using a rolling regression with a window of 1 year, instead of averaging the daily rates to a monthly value, which is the method of Ang et al. (2006, 2009).

Table 17 shows that the main results are robust to controlling for total volatility, however due to correlation between the two variables multicollinearity can cause the standard errors to occasionally blow up.

Table 18 shows that corporate demand proxied by idiosyncratic volatility affects government bond yields, but does not affect the option implied box yield. This is consistent with the idea of market segmentation, where corporates do not have access to trading the option implied safe asset, but can purchase government bonds.

[Table 13, 14, 15, 16, 17, and 18 about here]

Also note that table 1 shows that the results are robust to considering other convenience yield measures. Table 1 also shows that the results are robust to considering different time periods.

Important to note that the results are robust to excluding financial firms in the calculation of the idiosyncratic volatility, which is done for idiosyncratic volatility measures.

6.4 Panel including cross-sectional results

Table 19 shows if firms experience higher idiosyncratic risk then they increase their savings and reduce investment. Columns (1) - (4) report the investment results.

Column (1) shows that the investment rate decreases by 1.7 percentage points (pp) if the idiosyncratic risk is doubled. This estimate decreases to 0.7 pp in Column (2), where I control for the systemic risk. However note that idiosyncratic risk and systemic risk is correlated and is thus prone to multi-colinearity which may bias the coefficients and inflate the standard errors. Columns (3) and (4) show that a doubling in the idiosyncratic volatility is associated with a decrease in the amount spent on property, plant, and equipment by 5.2 pp. Dropping to 4.5 pp when controlling for systemic risk.

Columns (5) and (6) show that a doubling of the idiosyncratic risk leads to an increased cash holding rate of 4.2 pp (2.5 pp when controlling for systemic risk). Columns (7) and (8) show this to almost double to 7.6 (4.9) pp when including cash equivalents to in the savings measure. On the other hand Column (9) shows that this effect is partly offset by a decrease in short term investments, as a savings measure which include cash, cash equivalents and short term assets decreases to 1.2 (1.3) pp.

These panel findings provide cross-sectional validity for my theory. Overall, the average level of idiosyncratic risk has decreased corporate investment by around 5% annually over the sample.

[Table 19 about here]

7 Instrumental Variables Results

This section shows that the main result is robust to instrumenting idiosyncratic volatility with several sources of exogenous variation. The reason to consider this is that one may be concerned about confounding factors that may affect the convenience yield and be correlated with the aggregate level of idiosyncratic volatility.

Such as systemic volatility, which due to multicolinearity issues may be hard to control for in a normal regression. Another example is that Nagel (2016) shows that the interest level to be a determining factor of the convenience yield, and this may be correlated with the aggregate idiosyncratic risk. Maybe from a reach for yield channel. Again, this may be hard to control for in a normal regression, maybe due to non-linearities near the zero lower bound. A last example is that the supply of government debt may be a confounding factor. An increase in the supply of government debt may decrease the convenience yield, and be correlated with aggregate idiosyncratic volatility, for example around large crises which demand fiscal intervention. Of course, this effect goes in the opposite direction, and would imply that my estimate for the convenience yield effect is a lower bound.

Nevertheless, exploiting these sources of exogenous variation, is a way to control for these confounding factors, and certify the external validity of my results.

Table 20 shows that the main result is robust to using exogenous variation in firm sizes. Exploiting the Granular Instrumental Variables of Gabaix and Koijen (2019). The idea of this method is that since idiosyncratic is determined at the firm level, one can control for the factors affecting idiosyncratic risk by subtracting an equally weighted idiosyncratic risk measure from the original value-weighted idiosyncratic risk measure, leaving just the effect from the fact that larger firms happen to have an increase in their idiosyncratic risk relative to the average change. Hence, it is a way to exploit differences in firm size, which is plausibly exogenous to the confounding factors we are worried about, to construct a measure that is independent of factors affecting idiosyncratic risk, but still is correlated to the aggregate idiosyncratic risk level. I then use this measure to instrument for the aggregate level of idiosyncratic risk and run a two-stage least-squares estimation and compare it to the ordinary least squares estimates. This is done for all three maturities: 6, 12, and 18 months. Column (1) and (2) shows the results for the 6 month maturity, where Column (1) is the OLS estimate from Section 6.2. Column (2) on the other hand shows the new granular instrumental variable result. Here we see that effect is still significant, although highly attenuated. Columns (3-6) show the results for the other maturities. I note that the instrument is not weak as the first stage F test statistic is very high at 9634. It makes sense that the GIV estimates to be weaker, as they indicate that if a firm has increased idiosyncratic risk independently of the rest, their price impact also tend to be smaller, as there are less firms competing for the safe assets. Overall, the results help establish a causal relationship from the idiosyncratic volatility to the convenience yield.

[Table 20 about here]

Another way to see this is shown in table 21. This table shows that the main result is robust to using the exogenous variation in industry external exposures from Alfaro, Bloom and Lin (2018). I use the exposure to the implied variance of the external factors, while controlling for the exposure to the implied change in the factors. The variation in these exposures are used to instrument for each firms idiosyncratic volatility, after which I value-weigh the instrumented idiosyncratic volatility as previously. I can then regress the convenience yield on this instrumented idiosyncratic volatility measure, without worrying about endogeneity concerns. This is done for all three maturities: 18, 12, and 6 months. Column (1) shows the result for the 18 month maturity. Here we see that the effect is still significant, and very close to the OLS estimate from Table 20. Columns (1) and (2) show the results for the other maturities, where the effect is decreased a little compared to the OLS estimates and the errors also increase. It makes sense that the errors increase as we are losing variation. The instrument is not weak as the first stage F test statistic is 18.3. The results suggest that our main estimates are not greatly biased and help establish a causal relationship from the idiosyncratic volatility to the convenience yield.

[Table 21 about here]

Table 22 shows that the main result of idiosyncratic volatility leading to higher savings and less investment is robust to instrumenting idiosyncratic volatility with the same measure from Alfaro, Bloom and Lin (2018) as used in Table 21. Columns (1)-(3) report savings results and Columns (4)-(6) report investment results. First the OLS result is repeated and then the IV result is shown but without and with controlling for the first order moments of the instruments. We see from the IV estimates of Columns (2), (3), (5), and (6) that controlling for the 1st moment does not change the results much. We also see that the IV and OLS results have the same sign, but that they are much greater, suggesting our original results to have been biased downwards.

[Table 22 about here]

8 Discussion and Concluding Remarks

Overall, my paper shows the importance of corporates as an investor class. And that their previously unexplained demand can partially be explained by an optimal exposure to the firms idiosyncratic risk. A great example is for the convenience yield, where corporate demand can explain 84% of the convenience yield over the time period. Hence, my paper gives hope to understanding outstanding asset pricing and macroeconomics puzzles, as it shows that the largely unexplored avenue of taking corporates moral hazard issue seriously and incorporate their idiosyncratic risk as a factor is promising

One implication of my finding is if you could measure CEO effort better then one could reduce the externality on investment. Additionally, constructing better payoffs using options is also a way to reduce the externality. Indeed, this is a move we see more and more in the industry.

Understanding who the marginal investor is and their asset demand is a promising avenue to pursue. Whilst my work has focused on corporate firms, important work still exists in understanding other large investors such as pension funds, hedge funds, banks, and other institutional investors, and how they interplay.

Additionally on a more macroeconomic level, my work helps quantify an economic cost of moral hazard, as it has decreased investment and growth in the economy, in addition to inflating prices on government debt and money leading to deflationary effects. It also helps explain the break down of lower interest rates and investment growth as witnessed in the last decades. And in terms of future work my paper opens up for the interesting research question of whether the increase in (knowledge-based) intangible assets, which are prone to creative destruction, has lead to an increase in idiosyncratic risk, which could help explain the higher degrees of savings and drop in investment that we have observed over the last decades.

I provide a highly tractable framework that can easily be extended to help explain current macro-finance questions, such as the idea of an interest rate trap or reversal-rate.[11]

[11] Reversal-rate is the idea that there is an interest rate level that if you lower it below this it would lead to less growth, rather than higher growth. To see this in my framework one simply needs to implement the idea that investors have an absolute return requirement. The channel would be that as the interest rate is lowered there will be an increasing incentive for the investor/owner to incentivise the manager to take on more risk, but this would require a higher managerial compensation due taking on more investments with moral hazard. There would then be a level where the lower investment due to moral hazard outweighs the investors preference for higher returns. In such a situation the right policy would not be monetary, but to reduce idiosyncratic volatility for example through fiscal spending.

References

Aiyagari, S Rao, "Uninsured idiosyncratic risk and aggregate saving", *The Quarterly Journal of Economics*, 1994, *109*(3), 659–684. 9

Alfaro, Ivan, **Nicholas Bloom** and **Xiaoji Lin**, "The finance uncertainty multiplier", Technical report, National Bureau of Economic Research, 2018. 7, 26, 27

An, Byeong-Je, **Andrew Ang**, **Turan G Bali** and **Nusret Cakici**, "The joint cross section of stocks and options", *The Journal of Finance*, 2014, *69*(5), 2279–2337. 11

Ang, Andrew, **Robert J Hodrick**, **Yuhang Xing** and **Xiaoyan Zhang**, "The Cross-section of Volatility and Expected Returns", *The Journal of Finance*, 2006, *61*(1), 259–299. 5, 11, 16, 23

Ang, Andrew, **Robert J. Hodrick**, **Yuhang Xing** and **Xiaoyan Zhang**, "High idiosyncratic volatility and low returns: International and further U.S. evidence", *Journal of Financial Economics*, 2009, *91*(1), 1–23. 5, 11, 16, 23

Angeletos, George-Marios, "Uninsured Idiosyncratic Investment Risk and Aggregate Saving", *Review of Economic Dynamics*, 2007, *10*(1), 1–30. 9

Asker, John, **Joan Farre-Mensa** and **Alexander Ljungqvist**, "Corporate investment and stock market listing: A puzzle?", *The Review of Financial Studies*, 2015, *28*(2), 342–390. 2, 13

Baker, Malcolm, "Capital market-driven corporate finance", *Annu Rev Financ Econ*, 2009, *1*(1), 181–205. 10

Ben-David, Itzhak, **Jiacui Li** and **Yang Song**, "Advice-Driven Demand and Systematic Price Fluctuations", Working paper, University of Arizona, 2020. 8

Bloom, Nicholas, **Stephen Bond** and **John van Reenen**, "Uncertainty and Investment Dynamics", *Review of Economic Studies*, 2007, *74*(2), 391–415. 2, 11, 13

Bloom, Nick, "Uncertainty and the Dynamics of R&D", *American Economic Review*, 2007, *97*(2), 250–255. 11

Bloom, Nick, **Stephen Bond** and **John Van Reenen**, "Uncertainty and investment dynamics", *The Review of Economic Studies*, 2007, *74*(2), 391–415. 2, 13

Boileau, Martin and **Nathalie Moyen**, "Corporate cash savings: Precaution versus liquidity", Working paper, CIRPEE, 2010. 9

Bond, Stephen and **John Van Reenen**, "Chapter 65 Microeconometric Models of Investment and Employment", in James J. Heckman and Edward E. Leamer, editors, "Handbook of Econometrics", volume 6 of *Handbook of Econometrics*, pages 4417 – 4498, Elsevier 2007. 2, 13

Cao, Jie, **Amit Goyal**, **Xiao Xiao** and **Xintong Zhan**, "Implied volatility changes and corporate bond returns", Working Paper 19-75, Swiss Finance Institute, 2019. 11

Chang, Yen-Cheng, **Harrison Hong** and **Inessa Liskovich**, "Regression discontinuity and the price effects of stock market indexing", *The Review of Financial Studies*, 2015, *28*(1), 212–246. 8

Chen, Linda H., **George J. Jiang**, **Danielle D. Xu** and **Tong Yao**, "Dissecting the idiosyncratic volatility anomaly", *Journal of Empirical Finance*, 2020, *59*(October 2019), 193–209. 11

Chen, Zhanhui and **Ralitsa Petkova**, "Does Idiosyncratic Volatility Proxy for Risk Exposure?", *Review of Financial Studies*, 2012, *25*(9), 2745–2787. 11

Dang, Tri Vi, **Gary Gorton** and **Bengt Holmström**, "Ignorance, debt and financial crises", Working paper, Yale University and Massachusetts Institute of technology, 2012. 9

DeMarzo, Peter M, **Michael J Fishman**, **Zhiguo He** and **Neng Wang**, "Dynamic agency and the q theory of investment", *The Journal of Finance*, 2012, *67*(6), 2295–2340. 11

Diamond, William, "Safety transformation and the structure of the financial system", *The Journal of Finance*, 2020, *75*(6), 2973–3012. 9

Duchin, Ran, **Thomas Gilbert**, **Jarrad Harford** and **Christopher Hrdlicka**, "Precautionary Savings with Risky Assets: When Cash Is Not Cash", *Journal of Finance*, 2017, *72*(2), 793–852. 10

Gabaix, Xavier and **Ralph S. J. Koijen**, "Granular Instrumental Variables", *SSRN Electronic Journal*, 2019, pages 1–82. 7, 25

Gabaix, Xavier and **Ralph S. J. Koijen**, "In Search of the Origins of Financial Fluctuations: The Inelastic Markets Hypothesis", *SSRN Electronic Journal*, 2020. 5, 6, 19, 20

Gilchrist, Simon, **Jae W Sim** and **Egon Zakrajšek**, "Uncertainty, financial frictions, and investment dynamics", Technical report, National Bureau of Economic Research, 2014. 11

Gorton, Gary and **George Pennacchi**, "Financial intermediaries and liquidity creation", *The Journal of Finance*, 1990, *45*(1), 49–71. 9

Harris, Lawrence and **Eitan Gurel**, "Price and volume effects associated with changes in the S&P 500 list: New evidence for the existence of price pressures", *the Journal of Finance*, 1986, *41*(4), 815–829. 8

Harris, Milton and **Artur Raviv**, "Optimal incentive contracts with imperfect information", *Journal of Economic Theory*, 1979, *20*(2), 231–259. 10

He, Zhiguo, **Bryan Kelly** and **Asaf Manela**, "Intermediary asset pricing: New evidence from many asset classes", *Journal of Financial Economics*, 2017, *126*(1). 6

He, Zhiguo and **Arvind Krishnamurthy**, "Intermediary Asset Pricing and the Financial Crisis", *Annual Review of Financial Economics*, 2017, pages 1–37. 49, 50, 51

Herskovic, Bernard, **Bryan Kelly**, **Hanno Lustig** and **Stijn Van Nieuwerburgh**, "The common factor in idiosyncratic volatility: Quantitative asset pricing implications", *Journal of Financial Economics*, 2016, *119*(2), 249–283. 11

Holmstrom, Bengt, "Moral Hazard and Observability", *The Bell Journal of Economics*, 1979, *10*(1), 74. 10

Holmstrom, Bengt and **Paul Milgrom**, “Multitask principal-agent analyses: Incentive contracts, asset ownership, and job design”, *JL Econ & Org*, 1991, *7*, 24.

Jiang, Zhengyang, **Arvind Krishnamurthy** and **Hanno N. Lustig**, “Foreign Safe Asset Demand and the Dollar Exchange Rate”, *SSRN Electronic Journal*, 2018, pages 1–93. 8

Kelly, Bryan, **Hanno Lustig** and **Stijn Van Nieuwerburgh**, “Too-systemic-to-fail: What option markets imply about sector-wide government guarantees”, *American Economic Review*, 2016, *106*(6), 1278–1319. 15, 16, 38, 47, 49, 50, 51

Koijen, Ralph S. J. and **Motohiro Yogo**, “Exchange Rates and Asset Prices in a Global Demand System”, *SSRN Electronic Journal*, 2020, pages 1–53. 1, 9

Koijen, Ralph S.J. and **Motohiro Yogo**, “A demand system approach to asset pricing”, *Journal of Political Economy*, 2019, *127*(4), 1475–1515. 1, 5, 8, 20

Krishnamurthy, Arvind and **Annette Vissing-Jorgensen**, “The aggregate demand for treasury debt”, *Journal of Political Economy*, 2012, *120*(2), 233–267. 9, 12

Krishnamurthy, Arvind and **Annette Vissing-Jorgensen**, “The impact of Treasury supply on financial sector lending and stability”, *Journal of Financial Economics*, 2015, *118*(3), 571–600. 9

Lintner, John, “SECURITY PRICES, RISK, AND MAXIMAL GAINS FROM DIVERSIFICATION*”, *The Journal of Finance*, 1965, *20*(4), 587–615. 4

Ma, Yueran, “Nonfinancial Firms as Cross-Market Arbitrageurs”, *Journal of Finance*, 2019, *74*(6), 3041–3087. 10

Mirrlees, James, “The Optimal Structure of Incentives and Authority Within an Organization”, *Bell Journal of Economics*, 1976, *7*(1), 105–131. 10

Mota, Lira, “The Corporate Supply of (Quasi) Safe Assets”, *Available at SSRN*, 2020. 10

Myers, Stewart C., “Determinants of corporate borrowing”, Working papers 875-76., Massachusetts Institute of Technology (MIT), Sloan School of Management, 1976. 2, 13

Nagel, Stefan, "The liquidity premium of near-money assets", *Quarterly Journal of Economics*, 2016, *131*(4), 1927–1971. 4, 5, 9, 12, 25

Newey, Whitney K and **Kenneth D West**, "Automatic lag selection in covariance matrix estimation", *The Review of Economic Studies*, 1994, *61*(4), 631–653. 18

Ou-Yang, Hui, "An equilibrium model of asset pricing and moral hazard", *The Review of Financial Studies*, 2005, *18*(4), 1253–1303. 10

Panousi, Vasia and **Dimitris Papanikolaou**, "Investment, idiosyncratic risk, and ownership", *The Journal of finance*, 2012, *67*(3), 1113–1148. 10, 11

Ramakrishnan, Ram T S and **Anjan Thakor**, "The Valuation of Assets under Moral Hazard", *Journal of Finance*, 1984, *39*(1), 229–38. 10

Ross, Stephen, "The arbitrage theory of capital asset pricing", *Journal of Economic Theory*, 1976, *13*(3), 341–360. 4

Sánchez, Juan M, **Emircan Yurdagul et al.**, "Why are corporations holding so much cash?", *The Regional Economist*, 2013, *21*(1), 4–8. 9

Sharpe, William, "Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk", *The Journal of Finance*, 1964, *19*(3), 425–442. 4

Shleifer, Andrei, "Do demand curves for stocks slope down?", *The Journal of Finance*, 1986, *41*(3), 579–590. 8

Stulz, ReneM, "Managerial discretion and optimal financing policies", *Journal of financial Economics*, 1990, *26*(1), 3–27. 2, 13

Sunderam, Adi, "Money creation and the shadow banking system", *The Review of Financial Studies*, 2015, *28*(4), 939–977. 9

Tella, Sebastian Di, "Risk Premia and the Real Effects of Money", *American Economic*

Review, 2020, *110* (7), 1995–2040. 11

Van Binsbergen, Jules H, **William F Diamond** and **Marco Grotteria**, "Risk-free interest rates", *Journal of Financial Economics*, 2021, page Accepted. 4, 5, 16, 38

Vandeweyer, Quentin, "Treasury debt and the pricing of short-term assets", Working paper, Chicago Booth, 2019. 11

Figures and Tables

Figures

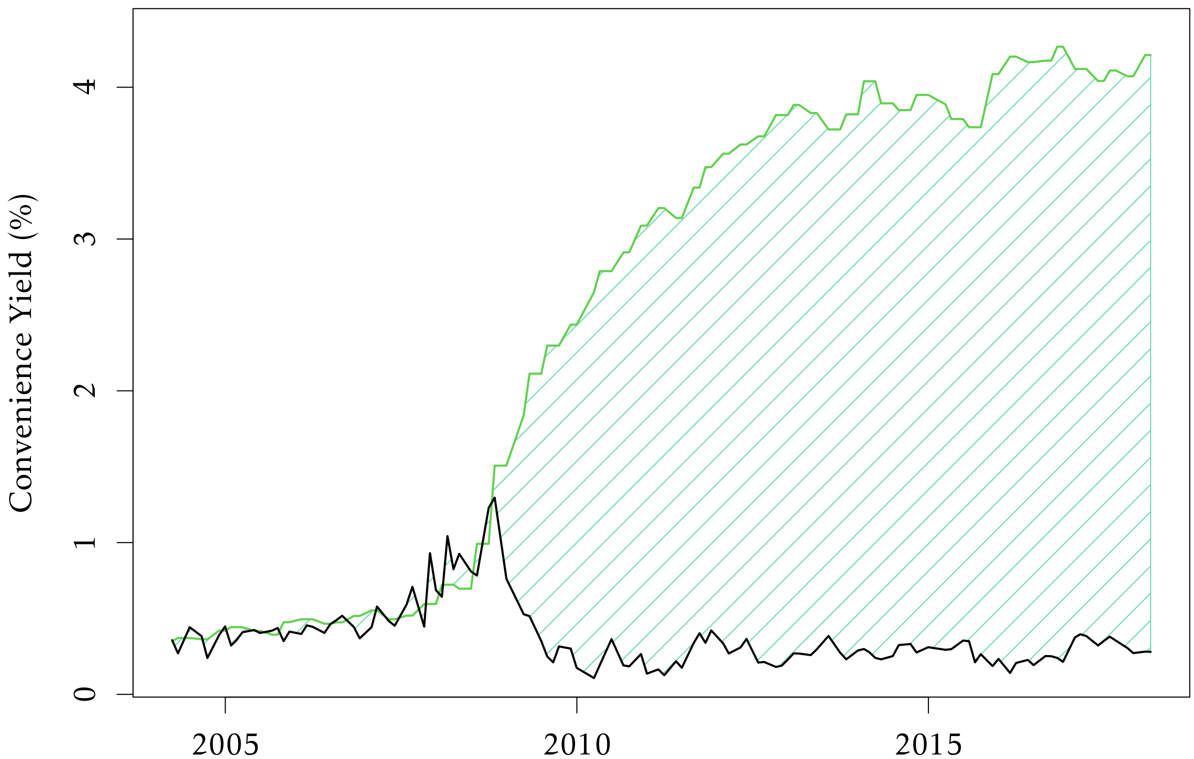

Figure 2: Figure shows the Convenience Yield Puzzle. Green line shows the predicted convenience yield as estimated from dates prior to 2009 using Krishnamurthy and Vissing-Jorgensen (2012) and Nagel (2016). The black line shows the actual convenience yield. The shaded green area is hence the prediction error and illustrates the Convenience Yield Puzzle. Shown for a maturity of 18 months and idiosyncratic volatility as estimated in Ang, Hodrick, Xing and Zhang (2006, 2009). Idiosyncratic volatility is annualized.

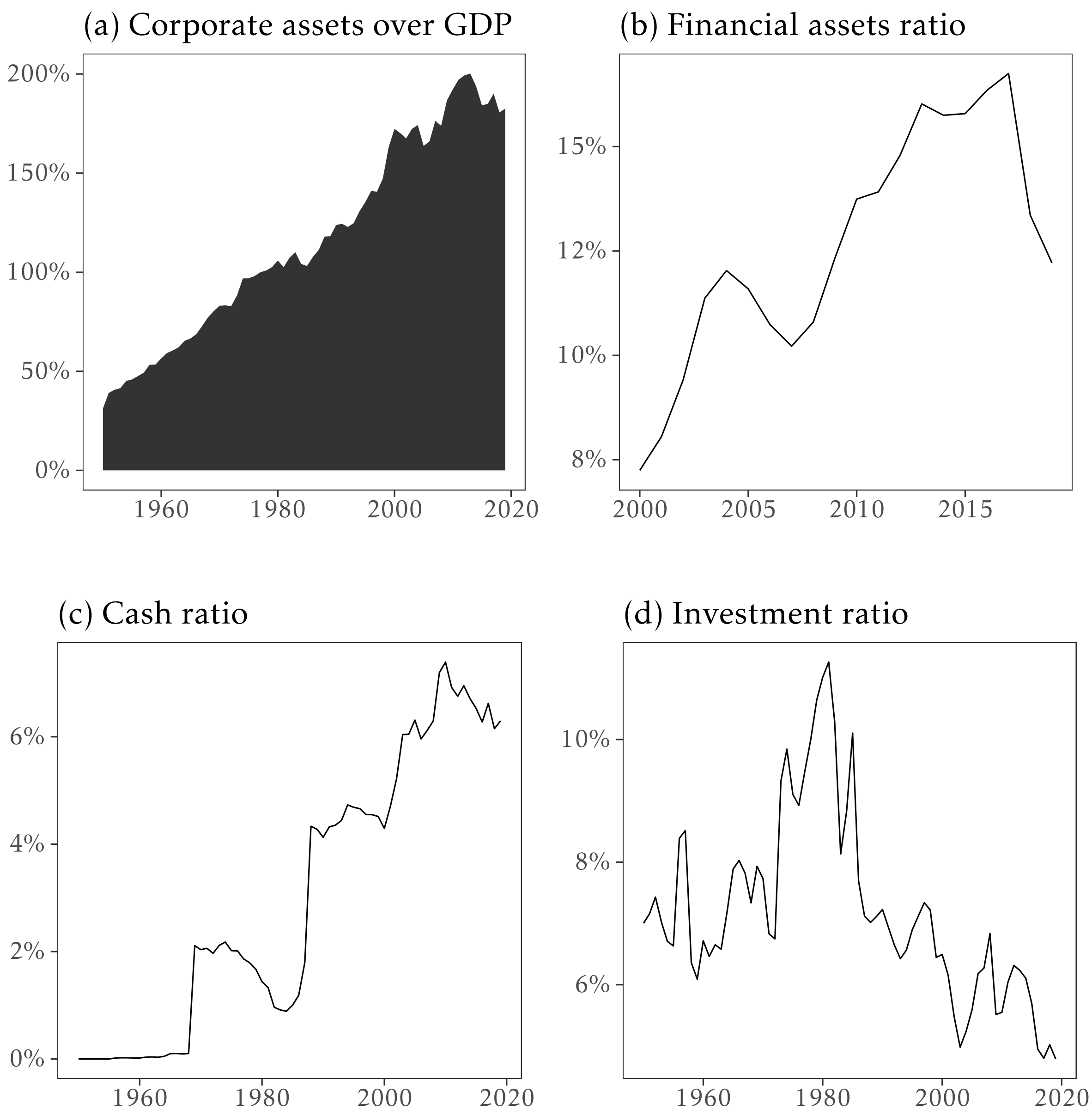

Figure 3: **The rise of the corporate investor class.** Panel (a) shows firms total assets as a fraction of GDP. Panel (b) shows total financial assets held by firms as a fraction of their assets. Panel (c) shows firms savings as amount of their assets placed in cash or cash-equivalents. Panel (d) shows corporates investment ratio.

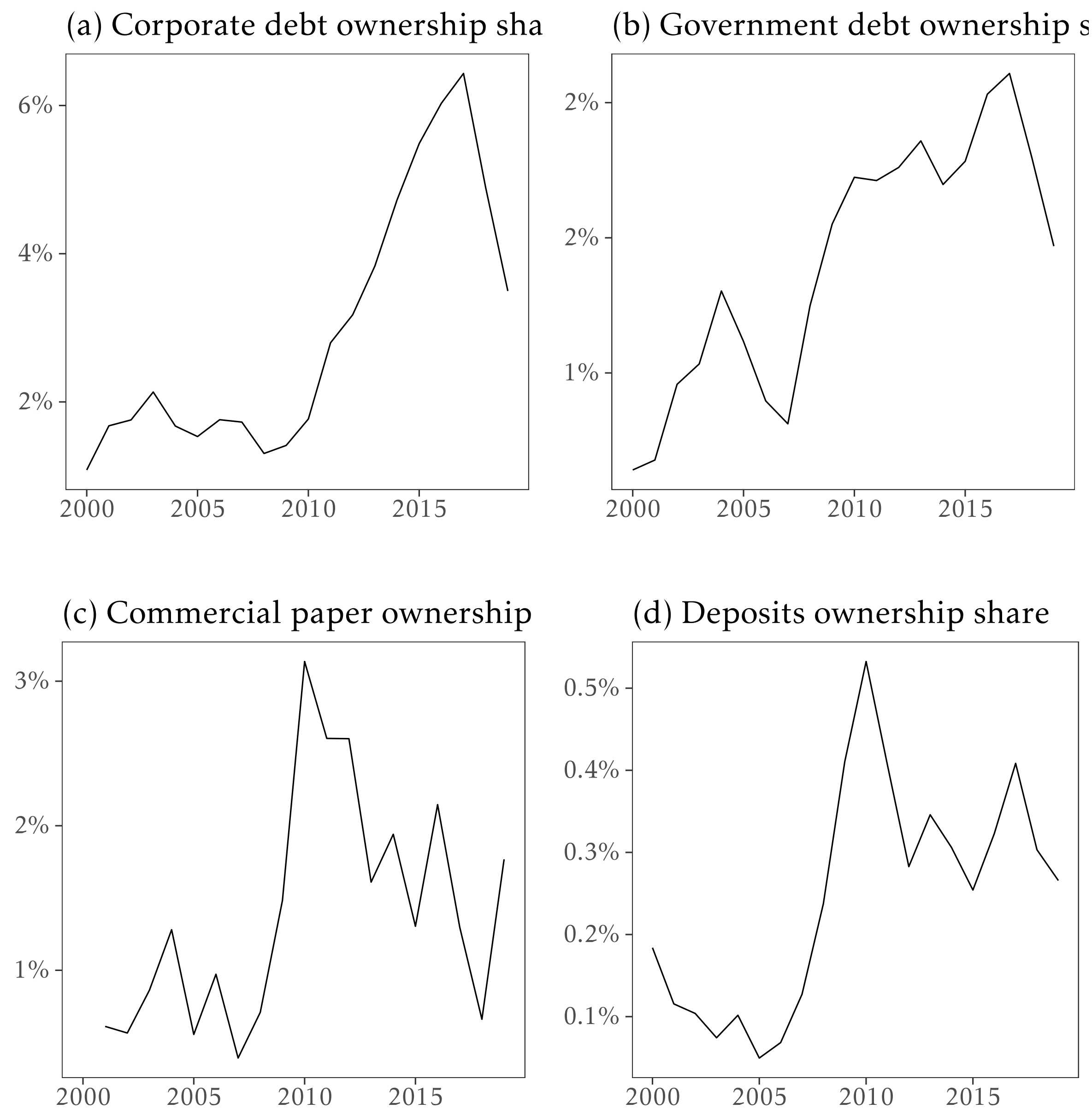

Figure 4: **Corporates security ownership shares**. Panel (a) shows firms total ownership of corporate debt as a fraction of corporate debt outstanding in the US. Panel (b) shows firms total ownership of government debt as a fraction of government debt outstanding in the US. Panel (c) shows firms total commercial paper ownership ratio. Panel (d) shows firms total deposit ownership ratio.

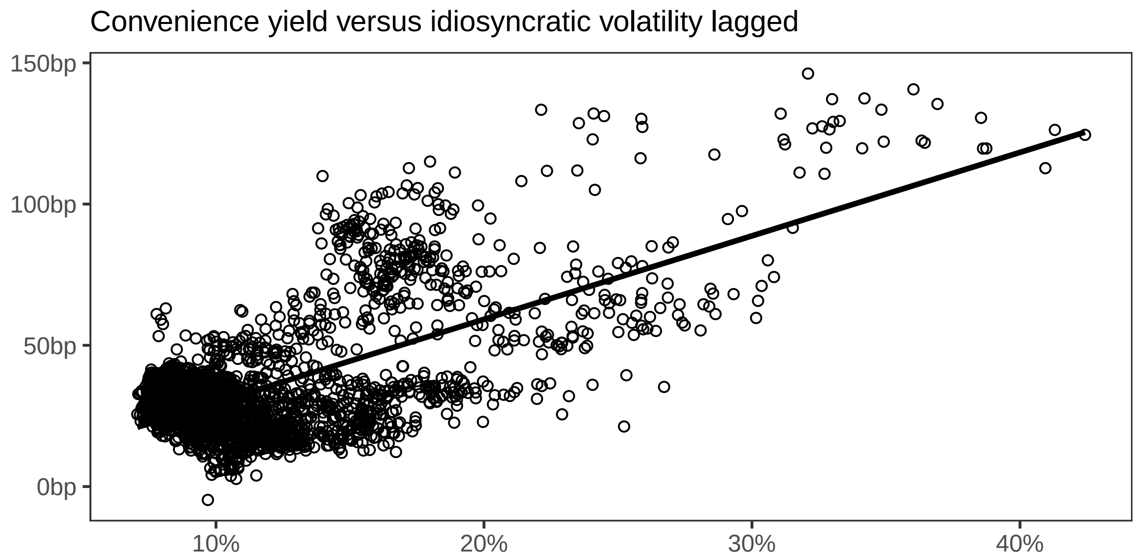

Figure 5: Figure shows how the idiosyncratic volatility predicts idiosyncratic volatility. Black line shows the OLS regression line $R_t^c \sim \sigma_{t-1}^i + \alpha$. Pearsons correlation coefficient (r) is 65%. Shown for a maturity of 18 months and option implied monthly idiosyncratic volatility. Idiosyncratic volatility is annualized.

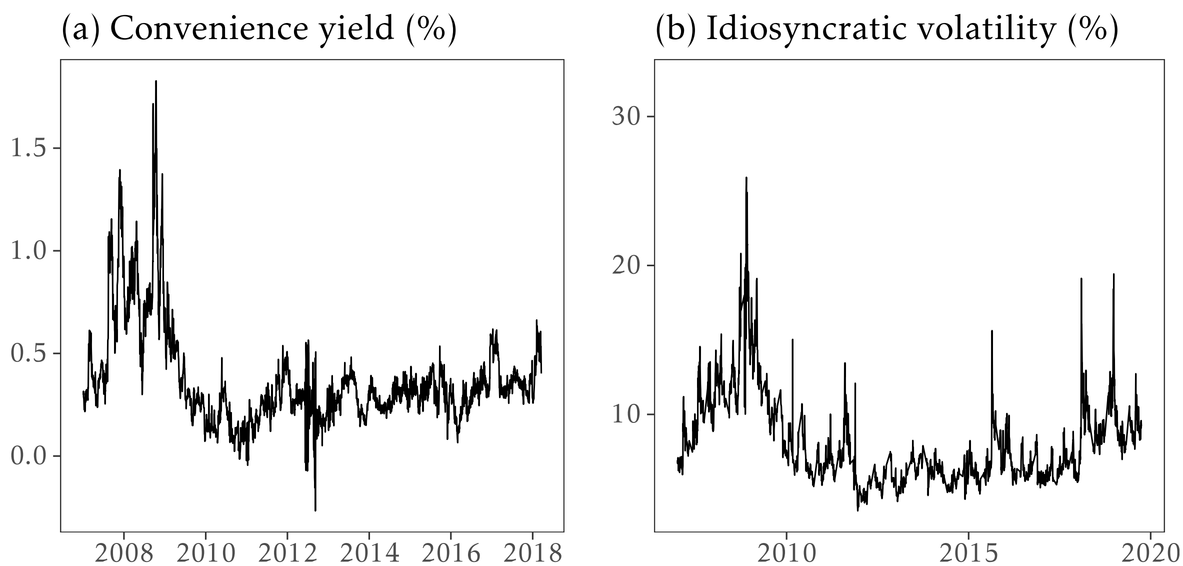

Figure 6: **Convenience yield and idiosyncratic volatility over time**. The correlation of the two graphs is 61% ± 2%. Convenience yield is for 6 months and is from Van Binsbergen, Diamond and Grotteria (2021). Idiosyncratic volatility is the product of the square-root of implied correlation subtracted by 1 multiplied by the implied volatility (VIX), both from CBOE. This idiosyncratic volatility measure is inspired by Kelly, Lustig and Van Nieuwerburgh (2016).

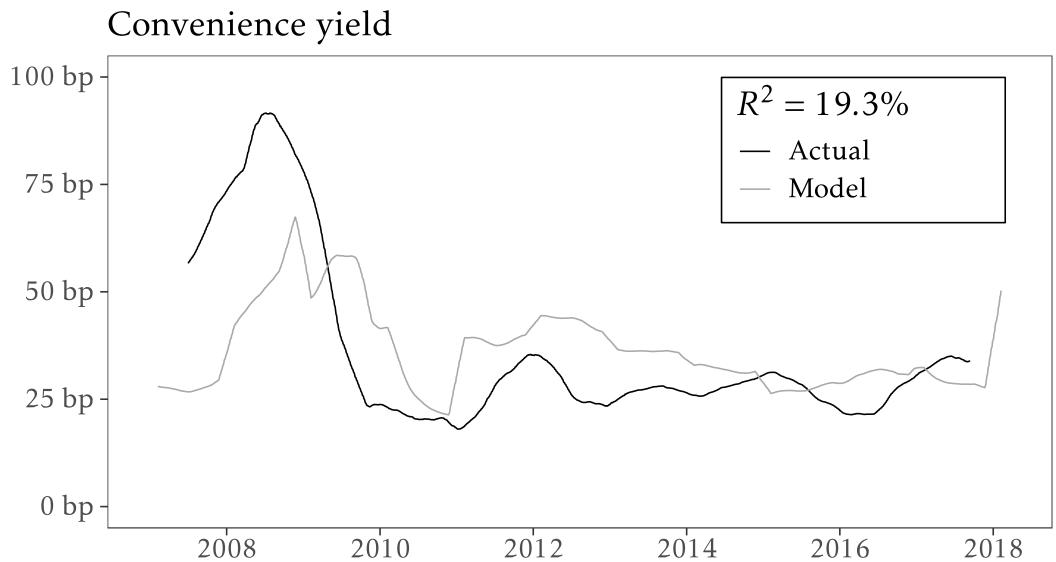

Figure 7: **Realised versus model implied convenience yield**. Figure shows the convenience yields. Black line shows the yearly smoothed actual yield. Grey line shows the smoothed predicted value from the OLS regression $R^c \sim \sigma^i + k^{-1/2} + \alpha$. The explained variance is 19.3%. Shown for a maturity of 18 months and daily realised idiosyncratic volatility.

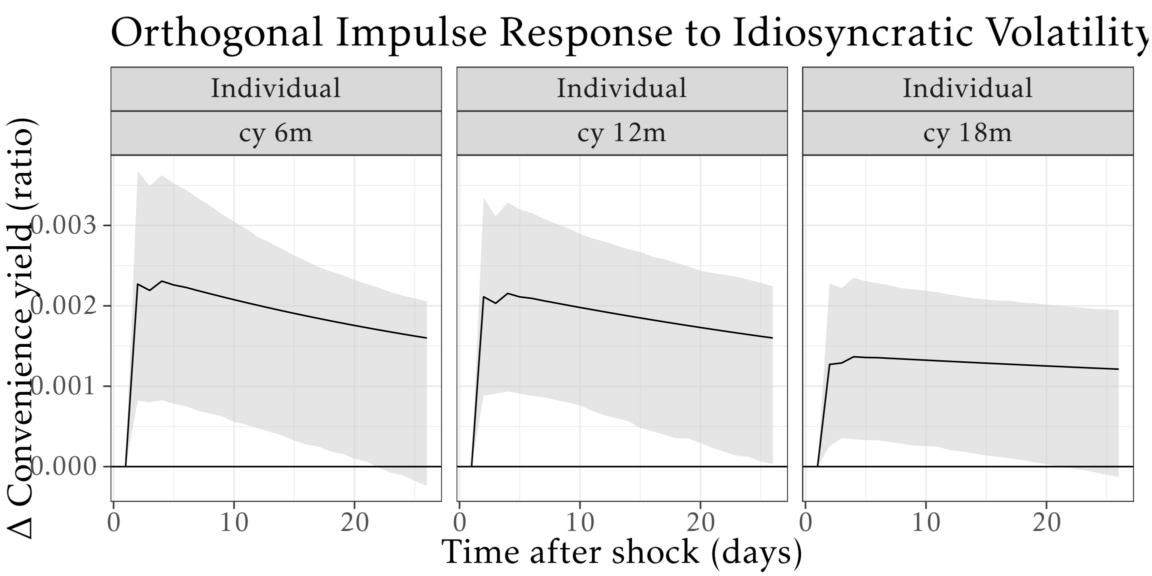

Figure 8: Figure shows the daily cumulative response of the convenience yield to a shock to idiosyncratic volatility. Measured as the orthogonal impulse response to a one standard deviation shock. Confidence bounds in grey. Lower bound is the 10th decile and upper 90th of a 1000 bootstraps. Resulting from a vector autoregression with two lags on convenience yield, idiosyncratic volatility and total volatility. [Formula]

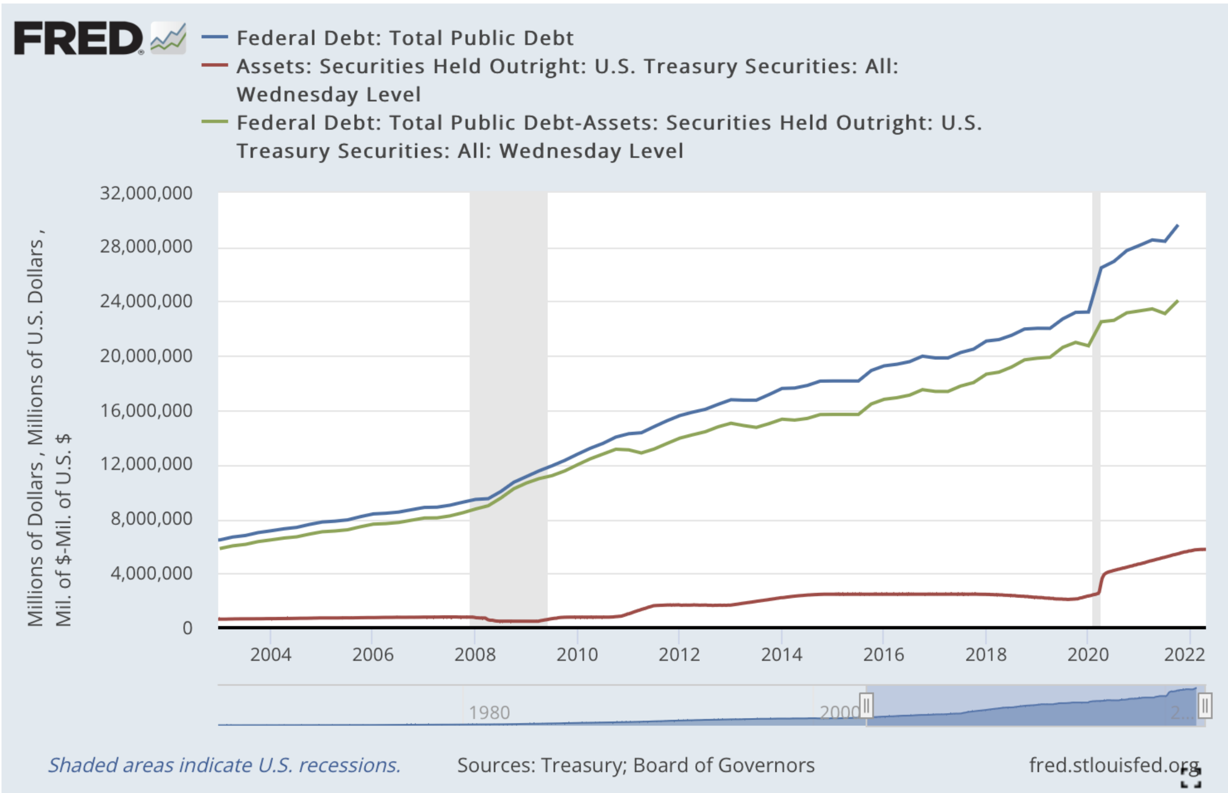

Figure 9: Figure shows the Net Bond Supply.

Tables

Table 1: **The Convenience Yield Puzzle**

Table shows how well previous theories explain the convenience yield. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. Results are shown for 18 month maturity, but are the same for the other maturities I have data on (6 and 12 months). The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Fundfunds is the Fed funds rate as used in Nagel (2016) and is from FRED. The debt to GDP ratio as used in Krishamurthy and Vissing-Jorgensen (2012) and is from FRED. IVol is the idiosyncratic volatility as estimated in Ang, Hodrick, Xing and Zhang (2006, 2009). Standard errors are Newey-White (1994) with automatic lag length choice. T-statistics are shown in square brackets.

	Convenience Yield (%)		
	Before 2009	After 2009	
	Model 1	Model 2	Model 3
(Intercept)	−4.795***	0.723***	0.057
	[−17.449]	[3.572]	[0.185]
debt_to_gdp_fred	8.605***	−0.475*	−0.026
	[19.013]	[−2.368]	[−0.106]
fedfunds	−0.165	7.280	5.642
	[−0.172]	[1.056]	[0.453]
ivol_mvmean			21.283**
			[3.358]
Num.Obs.	42	77	77
R2	0.737	0.128	0.307
R2 Adj.	0.723	0.104	0.278
AIC	−47.7	−141.6	−157.3
BIC	−40.8	−132.3	−145.6
Log.Lik.	27.865	74.823	83.667

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 2: **Robustness of the Convenience Yield Puzzle**

Table shows how well previous theories explain the convenience yield. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. Results are shown for 18 month maturity, but are the same for the other maturities I have data on (6 and 12 months). The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Fundfunds is the Fed funds rate as used in Nagel (2016) and is from FRED. The debt to GDP ratio as used in Krishamurthy and Vissing-Jorgensen (2012) and is from FRED. IVol is the idiosyncratic volatility as estimated in Ang, Hodrick, Xing and Zhang (2006, 2009). Standard errors are Newey-White (1994) with automatic lag length choice. T-statistics are shown in square brackets.

	Convenience Yield							
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
(Intercept)	−4.812***	0.628**	0.639	0.273***	−4.795***	0.723***	−5.294**	0.057
	[−16.974]	[3.171]	[0.524]	[13.835]	[−17.449]	[3.572]	[−3.262]	[0.185]
debt_to_gdp_fred	8.623***	−0.355+			8.605***	−0.475*	9.562**	−0.026
	[18.436]	[−1.794]			[19.013]	[−2.368]	[3.093]	[−0.106]
fedfunds			−2.675	3.322	−0.165	7.280	−0.376	5.642
			[−0.099]	[0.628]	[−0.172]	[1.056]	[−0.298]	[0.453]
ivol_mvmean							−6.799	21.283**
							[−0.330]	[3.358]
Num.Obs.	42	77	42	77	42	77	42	77
R2	0.737	0.075	0.026	0.013	0.737	0.128	0.738	0.307
R2 Adj.	0.730	0.062	0.002	0.000	0.723	0.104	0.717	0.278
AIC	−49.7	−139.1	5.2	−134.1	−47.7	−141.6	−45.9	−157.3
BIC	−44.5	−132.0	10.4	−127.1	−40.8	−132.3	−37.2	−145.6
Log.Lik.	27.858	72.538	0.408	70.052	27.865	74.823	27.939	83.667

+ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: **Corporate Safe Asset Demand**

Table shows asset prices as affected by corporate demand proximated by idiosyncratic volatility. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. Results are shown for 18 month maturity, but are the same for the other maturities I have data on (6 and 12 months). The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). BAcc/T-Bill is the spread of the Bank Acceptance Rate and Treasury Bill Rate from Nagel (2016). Also from this paper is the Commercial Deposit Rate minus Treasury Bill Spread (CD/T-Bill). The AAA and BBB Yield are the yields on corporate debt with the corresponding rating. Data is provided by Moody's. IVol is the idiosyncratic volatility is estimated as in Ang, Hodrick, Xing and Zhang (2006, 2009). IIVol is the option implied idiosyncratic volatility. Results are the same for other models, such as the CAPM-model. Standard errors are Newey-White (1994) with automatic lag length choice. T-statistics are shown in square brackets.

	Convenience Yield		BAcc/T-Bill		CD/T-Bill		AAA Yield		BBB Yield	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IVol(t-1)	0.2945***		0.2310***		0.2655		2.1824***		2.9517***	
	[5.7570]		[2.6273]		[1.4897]		[2.8458]		[3.9062]	
IIVol(t-1)		0.1137***		0.0803*		0.6115***		0.5975***		1.0403***
		[16.2499]		[1.7579]		[4.2508]		[5.5895]		[9.3752]
Intercept	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Start Date	2007-01-03	2007-01-03	1926-07-31	2007-01-31	1976-01-31	2007-01-31	1926-07-31	2007-01-31	1926-07-31	2007-01-31
End Date	2018-03-19	2018-03-19	2011-12-31	2011-11-30	2011-12-31	2011-11-30	2019-12-31	2018-11-30	2019-12-31	2018-11-30
Observations	2797	2307	1026	36	432	36	1122	85	1122	85
R^2	**0.19**	**0.29**	**0.04**	**0.10**	**0.02**	**0.38**	**0.10**	**0.43**	**0.17**	**0.69**
Stand. errors	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)	NW (auto)

* p < 0.1, ** p < 0.05, *** p < 0.01

Table 4: **Corporate Demand and Convenience Yield: Price Impacts of Asset Purchases**
Table shows the convenience yield as affected by non-financials treasury holdings instrumented by idiosyncratic volatility. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Implied IVol is the option implied idiosyncratic volatility. IVol is the idiosyncratic volatility is estimated as in Ang, Hodrick, Xing and Zhang (2006, 2009). Holdings are in USD trillions. IVol is in percent daily. The second stage results are limited back in time due to the availability of the convenience yield measure. T-statistics are shown in square brackets.

	Dependent variable:						
	Holdings(t-1)	$\Delta_{2,-1}$ Convenience Yield (bp). Maturity:					
		18m		12m		6m	
	1 Stage	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Holdings(tri), t -1		171**	523*	149**	467*	105*	391
		[3]	[2]	[2]	[2]	[2]	[2]
Implied IVol, t -2	20540***						
	[4]						
Constant	20408***	-15852**	-48867*	-13792**	-43661*	-9486*	-36249
	[3]	[-3]	[-2]	[-2]	[-2]	[-2]	[-2]
Obs (Quarters)	279	28	28	28	28	28	28
F-stat, p	0.00005						
Weak Instruments, p			0.07		0.07		0.07
Wu Hausman, p			0.05		0.09		0.06
Wald test p-value	0.00	0.02	0.07	0.04	0.10	0.07	0.10

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: **Corporate Demand and Convenience Yield: Price Impacts of Asset Purchases. Earlier purchasing period**

Table shows the convenience yield as affected by non-financials treasury holdings instrumented by idiosyncratic volatility. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Implied IVol is the option implied idiosyncratic volatility. IVol is the idiosyncratic volatility is estimated as in Ang, Hodrick, Xing and Zhang (2006, 2009). Holdings are in USD trillions. IVol is in percent daily. The second stage results are limited back in time due to the availability of the convenience yield measure. T-statistics are shown in square brackets.

	Dependent variable:						
	Holdings(t-1)	$\Delta_{1,-2}$ Convenience Yield (bp). Maturity:					
		18m		12m		6m	
	1 Stage	OLS	IV	OLS	IV	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Holdings(tri), t -1		116*	478**	96	451**	85	322**
		[2]	[2]	[1]	[2]	[2]	[2]
Implied IVol, t -2	20540***						
	[4]						
Constant	20408***	-10727	-44817**	-8872	-42261**	-7645	-29879*
	[3]	[-2]	[-2]	[-1]	[-2]	[-1]	[-2]
Obs (Quarters)	279	28	28	28	28	28	28
F-stat, p	0.00005						
Weak Instruments, p			0.07		0.07		0.07
Wu Hausman, p			0.05		0.09		0.06
Wald test p-value	0.00	0.10	0.03	0.18	0.05	0.13	0.05

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: **The convenience yield curve with idiosyncratic volatility and investment**
Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. The Convenience Yield is shown for three different maturities: 6, 12, and 18 months. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility is estimated at the daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). Regression method is Generalised Least Squares. T-statistics are shown in square brackets.

	Dependent variable:			
	Convenience Yield			
Maturity:	6 months		12 months	18 months
	(1)	(2)	(3)	(4)
Idiosyncratic Volatility	27.930***	30.946***	25.967***	27.244***
	t = 14.970	t = 16.199	t = 14.602	t = 15.514
Investment	0.0001***			
	t = 8.349			
-Investment$^{-1/2}$		58.617***	55.980***	40.253***
		t = 10.460	t = 11.558	t = 8.680
Constant	✓	✓	✓	✓
Regression method	GLS	GLS	GLS	GLS
Observations	2,798	2,798	2,798	2,798
R^2	0.074	0.086	0.076	0.079

Note: *p<0.1; **p<0.05; ***p<0.01

Table 7: **Idiosyncratic volatility and equity premium prediction**
Table shows the Equity premium as affected by corporate demand proximated by idiosyncratic volatility. The equity premium is from Ken French' website. The implied ivol factor f^{IIVOL} is the AR(1) innovations in the option implied idiosyncratic volatility measure inspired by Kelly, Lustig and Van Nieuwerburgh (2016). Results are the same for other models, such as the CAPM-model. T-statistics are shown in square brackets.

	Dependent variable:				
	Equity premium$_t$				
	(1)	(2)	(3)	(4)	(5)
f_{t-1}^{IIVOL}	0.121***	0.116***	0.117***	0.093***	0.101***
	t = 3.801	t = 3.602	t = 3.638	t = 2.742	t = 2.952
f_{t-1}^{smb}		0.033	0.037	0.040	0.039
		t = 0.754	t = 0.840	t = 0.911	t = 0.880
f_{t-1}^{hml}		−0.057	−0.011	0.035	0.019
		t = −1.599	t = −0.241	t = 0.709	t = 0.377
f_{t-1}^{mom}			0.050*	0.029	0.037
			t = 1.682	t = 0.942	t = 1.168
f_{t-1}^{iapf}				−3.971**	
				t = −2.376	
f_{t-1}^{iapr}					−2.529
					t = −1.343
Alpha	0.037	0.036	0.036	0.036	0.037
	t = 1.523	t = 1.506	t = 1.507	t = 1.498	t = 1.540
Observations	2,460	2,460	2,460	2,460	2,460
Adjusted R^2	0.005	0.006	0.007	0.009	0.007
Note:			*p<0.1; **p<0.05; ***p<0.01		

Table 8: **Monthly idiosyncratic volatility and equity premium prediction**
Table shows the Equity premium as affected by corporate demand proximated by idiosyncratic volatility. The equity premium is from Ken French' website. The ivol factor f^{IVOL} is the square of the AR(1) innovations in the idiosyncratic volatility estimated at daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). Results are the same for other models, such as the CAPM-model.

	Dependent variable:		
	Equity Premium$_t$		
	(1)	(2)	(3)
f_{t-1}^{IVOL}	-140.499^{***}	-137.016^{***}	-119.155^{**}
	t = −3.840	t = −3.744	t = −2.427
Dividend-Price ratio$_{t-1}$		0.036^{*}	0.046^{*}
		t = 1.755	t = 1.782
(Equity Premium^2)$_{t-1}$			−1.314
			t = −1.020
Constant	0.001^{***}	0.003^{***}	0.003^{***}
	t = 3.836	t = 3.234	t = 2.891
Observations	815	815	539
Adjusted R^2	0.017	0.019	0.017
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 9: **Idiosyncratic volatility and equity premium explanation**
Table shows the Equity premium as affected by corporate demand proximated by idiosyncratic volatility. The equity premium is from Ken French' website. The implied ivol factor f^{IIVOL} is the AR(1) innovations in the option implied idiosyncratic volatility measure inspired by Kelly, Lustig and Van Nieuwerburgh (2016). f^{iapf} and f^{iapr} is the intermediary asset pricing factor and intermediary leverage ratio of He and Krishnamurthy (2017) respectively. Results are the same for other models, such as the CAPM-model. T-statistics are shown in square brackets.

	Dependent variable:				
	Equity Premium				
	(1)	(2)	(3)	(4)	(5)
f^{IIVOL}	−0.636***	−0.541***	−0.547***	−0.276***	−0.200***
	t = −21.821	t = −20.340	t = −21.002	t = −13.354	t = −10.591
f^{smb}		0.361***	0.342***	0.308***	0.303***
		t = 9.885	t = 9.552	t = 11.332	t = 12.397
f^{hml}		0.672***	0.437***	−0.067**	−0.215***
		t = 22.701	t = 11.961	t = −2.228	t = −7.725
f^{mom}			−0.254***	−0.023	0.039**
			t = −10.523	t = −1.231	t = 2.249
f^{iapf}				43.829***	3.648*
				t = 42.746	t = 1.907
f^{iapr}					51.617***
					t = 23.978
Alpha	0.037*	0.036*	0.036*	0.039***	0.020
	t = 1.669	t = 1.820	t = 1.857	t = 2.650	t = 1.519
Observations	2,461	2,461	2,461	2,461	2,461
Adjusted R^2	0.162	0.319	0.348	0.626	0.697
Note:					*p<0.1; **p<0.05; ***p<0.01

Table 10: **Corporate vs intermediary based asset pricing: Convenience yield explanation**

Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. Shown for a convenience yield of 18 months maturity. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Implied IVol is the option implied idiosyncratic volatility. The implied ivol factor f^{IIVOL} is the AR(1) innovations in the option implied idiosyncratic volatility measure inspired by Kelly, Lustig and Van Nieuwerburgh (2016). f^{iapf} and f^{iapr} is the intermediary asset pricing factor and intermediary leverage ratio of He and Krishnamurthy (2017) respectively.

	Dependent variable:			
	Convenience Yield			
	(1)	(2)	(3)	(4)
IIVol	0.054***	0.054***		
	t = 50.516	t = 50.593		
f^{IIVOL}			0.031***	0.032***
			t = 4.841	t = 5.086
f^{iapf}	0.022		−0.218	
	t = 0.137		t = −0.900	
f^{iapr}		0.076		0.005
		t = 0.453		t = 0.018
Constant	−0.062***	−0.062***	0.365***	0.365***
	t = −6.816	t = −6.839	t = 78.425	t = 78.402
Observations	2,334	2,334	2,310	2,310
Adjusted R^2	0.524	0.524	0.012	0.012
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 11: **Corporate vs intermediary based asset pricing: Convenience yield prediction** Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. Shown for a convenience yield of 18 months maturity. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Implied IVol is the option implied idiosyncratic volatility. The implied ivol factor f^{IIVOL} is the AR(1) innovations in the option implied idiosyncratic volatility measure inspired by Kelly, Lustig and Van Nieuwerburgh (2016). f^{iapf} and f^{iapr} is the intermediary asset pricing factor and intermediary leverage ratio of He and Krishnamurthy (2017) respectively.

	Dependent variable:			
	Convenience Yield$_t$			
	(1)	(2)	(3)	(4)
IIVol$_{t-1}$	0.047***	0.047***		
	t = 37.629	t = 37.668		
f_{t-1}^{IIVOL}			0.031***	0.033***
			t = 4.783	t = 5.001
f_{t-1}^{iapf}	0.261		0.007	
	t = 1.421		t = 0.029	
f_{t-1}^{iapr}		0.299		0.207
		t = 1.543		t = 0.796
Constant	−0.004	−0.004	0.365***	0.365***
	t = −0.387	t = −0.383	t = 77.121	t = 77.114
Observations	2,307	2,307	2,283	2,283
Adjusted R^2	0.381	0.381	0.010	0.010
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 12: **Predictive convenience yield curve regressions: VAR specification**
Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. The Convenience Yield is shown for three different maturities: 6, 12, and 18 months. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility is estimated at the daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). Regression method is Generalised Least Squares. T-statistics are shown in square brackets.

	Dependent variable:		
	cy_6_m$_t$	cy_12_m$_t$	cy_18_m$_t$
	(1)	(2)	(3)
IVol_{t-1}	6.319***	4.686***	3.315***
	[3.758]	[3.360]	[2.953]
TVol_{t-1}	−3.645***	−2.752***	−1.919***
	[−3.631]	[−3.300]	[−2.878]
cy_6m$_{t-1}$	0.953***		
	[166.481]		
cy_12m$_{t-1}$		0.963***	
		[190.627]	
cy_18m$_{t-1}$			0.976***
			[238.126]
Constant	−0.004	−0.002	−0.003
	[−0.743]	[−0.312]	[−0.676]
Observations	2,797	2,797	2,797
R^2	0.925	0.940	0.962
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 13: **Idiosyncratic volatility and the convenience yield: Different regression methods**.
Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. The columns vary how the main regression specification is computed. The Convenience Yield is shown for a maturities of 18 months. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility is estimated at the daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). Regression method is Generalised Least Squares. T-statistics are shown in square brackets.

	Dependent variable:		
	Convenience Yield		
	OLS	White	GLS
	(1)	(2)	(3)
Idiosyncratic Volatility	16.551***	16.551***	25.457***
	[17.796]	[12.536]	[19.125]
Constant	0.129***	0.129***	0.007
	[9.255]	[7.760]	[0.384]
Observations	2,798	2,798	2,798
R^2	0.102	0.102	0.116
Note:	*p<0.1; **p<0.05; ***p<0.01		
	T-stat in square brackets		

Table 14: **The convenience yield curve**.
Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. The Convenience Yield is shown for three different maturities: 6, 12, and 18 months. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility is estimated at the daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). Regression method is Generalised Least Squares. T-statistics are shown in square brackets.

	Dependent variable:		
	cy_6m	cy_12m	cy_18m
	(1)	(2)	(3)
IVol	18.655***	18.131***	25.457***
	[13.380]	[13.502]	[19.125]
Constant	0.105***	0.117***	0.007
	[5.679]	[6.708]	[0.384]
Standard errors	GLS	GLS	GLS
Observations	2,798	2,798	2,798
R^2	0.060	0.061	0.116
Note:			*p<0.1; **p<0.05; ***p<0.01
			T-stat in square brackets

Table 15: **Idiosyncratic volatility and the convenience yield: difference-on-difference specification**.
The convenience yield curve. Table shows the Convenience Yield as affected by corporate demand proximated by idiosyncratic volatility. The Convenience Yield is shown for the maturity of 18 months. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility is estimated at the daily frequency using a 1 year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). For the monthly frequency a rolling version is not necessary and not used. Regression method is Generalised Least Squares. T-statistics are shown in square brackets.

	Dependent variable:	
	ΔConvenience Yield$_t$	
	(1)	(2)
Δ Idiosyncratic Volatility$_{t-1}$	0.012***	0.014**
	[5.912]	[2.296]
Constant	0.000	0.000
	[-0.333]	[-0.460]
Frequency	Daily	Monthly
Observations	2740	72
R^2 Adjusted	0.049	0.157

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 16: **Option implied idiosyncratic volatility**
Table shows the convenience yield as affected by non-financials treasury holdings instrumented by idiosyncratic volatility. The results control for the market return and volatility, both realised and implied. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). Implied IVol is the option implied idiosyncratic volatility. T-statistics are shown below.

	Dependent variable:				
		cy_6m		cy_12m	cy_18m
	(1)	(2)	(3)	(4)	(5)
IIVol	0.050^{***}		0.070^{***}	0.060^{***}	0.060^{***}
	t = 40.077		t = 34.895	t = 31.936	t = 33.458
IIVol^2		0.002^{***}			
		t = 38.873			
Equity Premium			0.0003	−0.0004	−0.001
			t = 0.083	t = −0.135	t = −0.205
Equity Premium^2			0.001	0.003^{***}	0.002^{***}
			t = 1.396	t = 3.477	t = 2.626
VIX			-0.009^{***}	-0.005^{***}	-0.003^{***}
			t = −12.417	t = −7.486	t = −4.478
Constant	✓	✓	✓	✓	✓
Observations	2,334	2,334	2,334	2,334	2,334
R^2	0.408	0.393	0.447	0.468	0.528
Note:				*p<0.1; **p<0.05; ***p<0.01	

Table 17: **Idiosyncratic volatility and the convenience yield: Controlling for total volatility**
Table shows the convenience yield as affected by non-financials treasury holdings instrumented by idiosyncratic volatility. The results control for total volatility. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility and is estimated at the daily frequency using a 1-year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). T-statistics are shown below.

	Dependent variable:		
	cy_6m	cy_12m	cy_18m
	(1)	(2)	(3)
Idiosyncratic Volatility	123.311***	117.929***	120.868***
	[24.526]	[26.023]	[27.568]
Total Volatility	−64.491***	−60.638***	−57.634***
	[−21.557]	[−22.673]	[−22.378]
Constant	−0.181***	−0.172***	−0.276***
	[−8.430]	[−8.500]	[−13.835]
Standard errors	GLS	GLS	GLS
Observations	2,798	2,798	2,798
R^2	0.197	0.215	0.262
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 18: **Idiosyncratic volatility and the convenience yield: Different rates**
Table shows different rates as affected by non-financials treasury holdings instrumented by idiosyncratic volatility. The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility and is estimated at the daily frequency using a 1-year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). T-statistics are shown below.

	Dependent variable:			
	box_6m	gov_6m	box_12m	gov_12m
	(1)	(2)	(3)	(4)
IVol	−6.704	-19.683^{***}	1.370	-10.159^{*}
	t = −1.093	t = −3.515	t = 0.232	t = −1.883
Constant	1.365^{***}	1.181^{***}	1.294^{***}	1.086^{***}
	t = 14.886	t = 14.099	t = 14.682	t = 13.453
Observations	2,798	2,798	2,798	2,798
R^2	0.0004	0.004	0.00002	0.001
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 19: **Idiosyncratic volatility leads to less investment and higher savings**

Table shows investment and savings as affected by by corporates idiosyncratic volatility. A is total assets. CAPX is capital expenditure. PPEGT is property plant and equipment. CH is cash. CHE is cash and cash equivalents. CHECH is CHE plus short term assets. IVol is the idiosyncratic volatility is estimated as in Ang, Hodrick, Xing and Zhang (2006, 2009). SVol is systemic volatility. T-statistics are shown in square brackets.

	Dependent variable:									
	Investment				Savings					
	$\frac{\text{capx}}{\text{A}}$		$\frac{\Delta_{0,-12}\text{ppegt}}{\text{A}_{t-12}}$		$\frac{\text{ch}_t}{\text{A}_t}$		$\frac{\text{che}_t}{\text{A}_t}$		$\frac{\text{chech}_t}{\text{A}_t}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IVol_{t-12}	-0.017^{***}	-0.007^{***}	-0.052^{***}	-0.045^{***}	0.042^{***}	0.025^{***}	0.076^{***}	0.049^{***}	0.012^{***}	0.013^{***}
	t = −44.507	t = −16.475	t = −15.954	t = −12.725	t = 47.411	t = 26.348	t = 76.865	t = 45.500	t = 10.619	t = 10.955
SVol_{t-12}		-0.032^{***}		-0.023^{***}		0.052^{***}		0.085^{***}		-0.005^{***}
		t = −60.783		t = −5.211		t = 43.153		t = 63.163		t = −3.056
Firm FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	1,965,336	1,965,336	1,784,510	1,784,510	1,977,215	1,977,215	2,012,746	2,012,746	1,976,925	1,976,925
Adjusted R^2	−0.016	−0.015	−0.017	−0.017	−0.016	−0.015	−0.014	−0.012	−0.017	−0.017

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table 20: **Instrumented Idiosyncratic Volatility's and the Convenience Yield**
Table shows the convenience yield as affected by corporates idiosyncratic volatility. Results are also shown for idiosyncratic volatility instrumented using exogenous variation in firms size as in Gabaix Koijen (2019). The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility and is estimated at the daily frequency using a 1-year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). T-statistics are shown below.

	Dependent variable: Convenience Yield					
	6m		12m		18m	
	OLS	GIV	OLS	GIV	OLS	GIV
	(1)	(2)	(3)	(4)	(5)	(6)
IVol	18.97***	3.06**	16.79***	-0.60	22.63***	4.09***
	[14.83]	[2.08]	[13.93]	[-0.43]	[19.04]	[2.94]
Constant	0.09***	0.32***	0.12***	0.38***	0.03*	0.30***
	[4.55]	[14.53]	[6.78]	[18.00]	[1.65]	[14.48]
N (years)	2798	2798	2798	2798	2798	2798
R^2	0.07	0.02	0.06	0.00	0.11	0.04
F 1st stage		9634		9634		9634

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 21: **Instrumented Idiosyncratic Volatility's and the Convenience Yield**
Table shows the convenience yield as affected by corporates idiosyncratic volatility. Here idiosyncratic volatility is instrumented using exogenous variation in firms foreign risk exposures as in Alfaro et al. (2018). The Convenience Yield is how much lower the Government debt rate is compared to a risk-free rate achievable from a option-strategy. The Convenience Yield data is from Binsbergen Diamond and Grotteria (2020). IVol is the idiosyncratic volatility and is estimated at the daily frequency using a 1-year regression of the Fama-French 3 factor specification used by Ang, Hodrick, Xing and Zhang (2006, 2009). T-statistics are shown below.

	Convenience Yield		
	18m	12m	6m
	(1)	(2)	(3)
IVol	20.47**	14.21*	13.24
	[2.44]	[1.83]	[1.64]
Constant	-0.82	-0.47	-0.44
	[-1.67]	[-1.02]	[-0.91]
N (years)	10	12	12
R^2	0.43	0.25	0.21
F 1st stage	18.3	18.3	18.3

* p < 0.1, ** p < 0.05, *** p < 0.01

Table 22: **Instrumented Idiosyncratic Volatility's effect on Savings and Investment**
Table shows savings and investments as affected by by corporates idiosyncratic volatility. Here the idiosyncratic volatility is instrumented using exogenous variation in firms foreign risk exposure from Alfaro et al. (2018). A is total assets. Savings S is cash. Investment K is capital expenditure. IVol is the idiosyncratic volatility is estimated as in Ang, Hodrick, Xing and Zhang (2006, 2009). T-statistics are shown in square brackets.

	Saving, S(t)/A(t-1)			Investment, K(t)/A(t-1)		
	OLS	IV		OLS	IV	
	(1)	(2)	(3)	(4)	(5)	(6)
IVol(t-1)	0.09***	1.25**	1.18**	-0.01*	-1.33***	-1.21***
	[4.08]	[2.56]	[1.97]	[-1.76]	[-5.65]	[-3.93]
N	19448	19448	19448	19552	19552	19550
1st Moment 10IV(t-1)			✓			✓
Firm FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
F 1st stage	18.3	18.3	18.3	18.3	18.3	18.3

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$