Implied Dividend Volatility and Expected Growth

By Niels J. Gormsen, Ralph S.J. Koijen, and Ian W.R. Martin*

A large literature is concerned with measuring economic uncertainty and quantifying its impact on real decisions, such as investment, hiring, and R&D, and ultimately economic growth (Bloom, 2009; Jurado et al., 2015). The COVID-19 pandemic underscores the importance of timely measures of uncertainty and expected growth across horizons.

Asset prices, such as dividend futures (van Binsbergen et al., 2013; Gormsen and Koijen, 2020) and index options (Gao and Martin, 2020), provide particularly useful measures as they are forward looking and available at high frequencies. Dividend futures are claims on the dividends of the aggregate stock market in a particular year. As dividend futures are differentiated by maturity, just like nominal and real bonds, we can use these prices to obtain growth expectations by maturity.

We extend this literature by using new data on the prices of options on index-level dividends, from which we can compute *implied dividend volatility*. These implied volatilities differ from the VIX which measures uncertainty about stock prices, not only uncertainty about dividends.

We construct a term structure of implied dividend volatilities that characterizes how uncertainty varies across horizons. We study how this term structure developed over the COVID-19 crisis, documenting a substantial increase in the volatility of near-future dividends that lingers even as the volatility of the overall market portfolio has started to fall.

In addition to introducing this market, we also provide new theoretical results that show how these data can be used to derive lower bounds on expected dividend returns and on expected growth rates, by maturity, by exploiting the insights of Martin (2017). This provides an alternative to methods used in the literature using vector autoregressions or survey expectations, and sharpens alternative bounds in the literature.

I. Pricing and Riskiness of Dividends

The present-value identity implies that the value of the aggregate stock market, S_t, satisfies

$$S_t = \sum_{\tau=1}^{\infty} E_t \left[D_{t+\tau} M_{t:t+\tau} \right], \tag{1}$$

where D_t denotes the aggregate dividend paid at time t, $M_{t:t+\tau} = \prod_{s=1}^{\tau} M_{t+s}$, and M_t denotes the stochastic discount factor. The price of the τ-period dividend claim is $P_t(\tau) = E_t \left[D_{t+\tau} M_{t:t+\tau} \right]$; the return on this claim is $R^{\tau}_{t:t+\tau} = D_{t+\tau}/P_t(\tau)$; and the dividend futures price is $F_t(\tau) = P_t(\tau)/E_t \left[M_{t:t+\tau} \right]$.

A. Data

We use data on dividend futures for the S&P 500 index in the US (SPX) and for the Euro Stoxx 50 index in Europe (SX5E). We source these data from Bloomberg. We also use data from the Center for Research in Security Prices on two ETFs; one ETF tracks long-term Treasuries (with ticker TLT) and the other ETF tracks the investment-grade corporate bond market in the US (with ticker LQD).

We use data on Euro Stoxx 50 dividend options trading on the Eurex Exchange. These are European options on index div-

* Gormsen: University of Chicago, Booth School of Business, 5807 South Woodlawn Avenue, 60637 Chicago, Illinois, USA, niels.gormsen@chicagobooth.edu. Koijen: University of Chicago, Booth School of Business, 5807 South Woodlawn Avenue, 60637 Chicago, Illinois, USA, ralph.koijen@chicagobooth.edu. Martin: London School of Economics, Houghton Street, London WC2A 2AE, United Kingdom, i.w.martin@lse.ac.uk. We thank Stefano Giglio, Lasse Pedersen, and Jessica Wachter for comments and suggestions.

idends. The ten nearest successive annual contracts of the December cycle are available for trading at any point in time. The Eurex Exchange records the daily settlement prices on the options and computes the ATM implied volatilities using a Black (76) model. We source these volatilities from Bloomberg. We note that liquidity in the dividend options market is limited, in particular before the pandemic. We view the current paper mostly as a proof of concept of what can be learned from these markets as they develop.

For dividend options, the maturity coincides with the year in which the dividends are paid. We therefore simultaneously vary the timing of the dividend and the maturity of the option. We use the December 2021, December 2022, and December 2023 contracts in our analysis.[1] For the Euro Stoxx 50, we choose the 12-month and 24-month implied volatilities (VSTOXX) from Bloomberg. We linearly interpolate the series to match the December 2021 maturity. All volatilities are annualized. We sample our data weekly and use data from January 2020 until October 2020.

B. *Empirical results*

We study how prices and implied volatilities of both indexes and dividends changed during the COVID-19 crisis. Figure A.2 in the Online Appendix shows that stock markets in Europe and the US fell by 20-30%, while short-term dividends fell even more for both indexes. During the same period, Treasuries rallied and investment-grade corporate bonds fell by about 10%.

Financial markets recovered since then, with the US stock market and the investment-grade corporate bond market recovering fully and the European stock market recovering about half of its losses. However, short-term dividends have not experienced the same recovery. Prices are still down by almost 20% in the US and more than 30% in Europe, suggesting that the market prices substantial economic losses in the near term.

The left panel of Figure I.B shows the implied dividend volatility of the 2021 option and the implied volatility of the aggregate stock market. In the right panel, we plot the term structure of implied dividend volatilities for the 2020, 2021, and 2022 contracts, alongside the implied volatility of the market, in January, March, and October of 2020.

Implied volatilities before the COVID-19 crisis increase with maturity, and are particularly low for the 2021 contract. The level of volatility is comparable to the historical annual dividend volatility.

During the crisis, the implied dividend volatility increases sharply and, in case of the 2021 contract, rises above the implied volatility of the market. This increase suggests that short-term dividend growth is strongly heteroskedastic. The volatility of the short-term dividends remains high at the end of our sample, with the volatility of the short-term claims approximately at the same level as the market.

As such, the relative increase in volatility during the crisis is stronger for short-term dividends than for the market, and the increase is more persistent. A key takeaway from this section is that investors price the pandemic via lower dividend prices and high uncertainty about short-term cash flows. While the market indexes have largely recovered, the pandemic is reflected in the pricing of near-future cash flows.

Implied dividend volatility represents a new target moment that quantitatively realistic models should confront. In any model in which dividend growth and the SDF are conditionally lognormal, implied dividend volatility satisfies $\sqrt{\operatorname{var}_t^* R_{t:t+\tau}^{\tau}} = R_{t:t+\tau}^{f}\sqrt{e^{\sigma_t^2}-1} \approx \sigma_t$, where σ_t is the (true) volatility of log dividend growth, $\log D_{t+\tau}/D_t$, and var_t^* denotes variance under the risk-neutral measure. Our results show that log dividend growth exhibits substantially more heteroskedasticity than is present in models such as Campbell and Cochrane (1999) or Bansal and Yaron (2004).

[1]While the December 2020 contract is also available, its implied volatility mechanically dwindles during our sample as more dividends are announced.

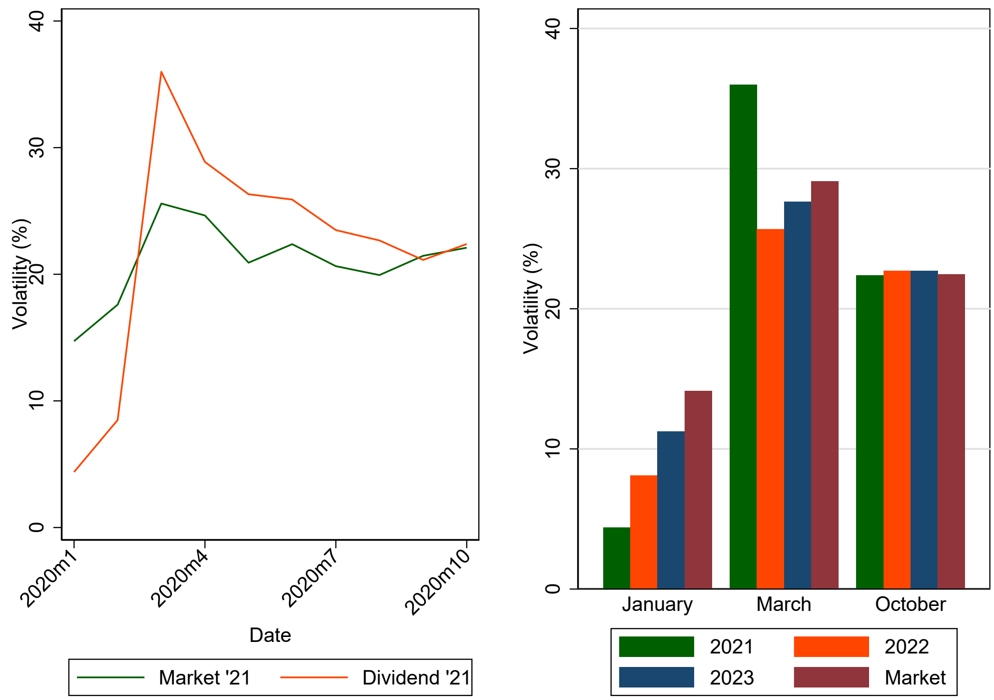

FIGURE 1. VOLATILITY DYNAMICS DURING THE COVID-19 CRISIS. THE YEARS IN THE RIGHT PANEL CORRESPOND TO THE MATURITIES OF THE IMPLIED DIVIDEND VOLATILITIES.

II. Expected Returns and Growth

The price of a dividend claim reflects a combination of the expected return on the claim and the expected dividend. We will derive a lower bound on the expected return, and hence on the expected dividend.

A. *Methodology*

We start from the following identity, which holds for any gross returns $R_{t:t+\tau}$ and $R^{\tau}_{t:t+\tau}$:

$$E_t[R^{\tau}_{t:t+\tau}] - R^f_{t:t+\tau} = \frac{\text{cov}^*_t(R^{\tau}_{t:t+\tau}, R_{t:t+\tau})}{R^f_{t:t+\tau}} - \text{cov}_t(M_{t:t+\tau}R_{t:t+\tau}, R^{\tau}_{t:t+\tau}).$$

We use asterisks to denote risk-neutral moments and write $R^f_{t:t+\tau}$ for the gross risk-free rate between t and $t+\tau$. This relationship, a generalization of the identity in Martin (2017), was derived and applied to currency returns by Kremens and Martin (2019). Here, we will define $R^{\tau}_{t:t+\tau}$ as the spot-return on the τ-period dividend claim, $R^{\tau}_{t:t+\tau} = \frac{D_{t+\tau}}{P_t(\tau)}$.

We will exploit the identity by choosing $R_{t:t+\tau}$ so that the first (risk-neutral) covariance term on the right-hand side can be inferred from observable asset prices, while the sign of the second covariance term can be controlled.

If we set $R_{t:t+\tau} = R^{\tau}_{t:t+\tau}$, for example, then the first term can be inferred from dividend option prices, which pin down the risk-neutral variance of the dividend return. The second term is harder to deal with. In models that imply constant price-dividend ratios, such as Barro (2006), the dividend return $R^{\tau}_{t:t+\tau}$ is proportional to the return on the market itself. Then we will have $\text{cov}_t(M_{t:t+\tau}R_{t:t+\tau}, R^{\tau}_{t:t+\tau}) \leq 0$ whenever the NCC of Martin (2017) holds. But other models generate the opposite sign: in the long-run risk model of Bansal and Yaron (2004), short-term dividends are uncorrelated with the SDF so that the covari-

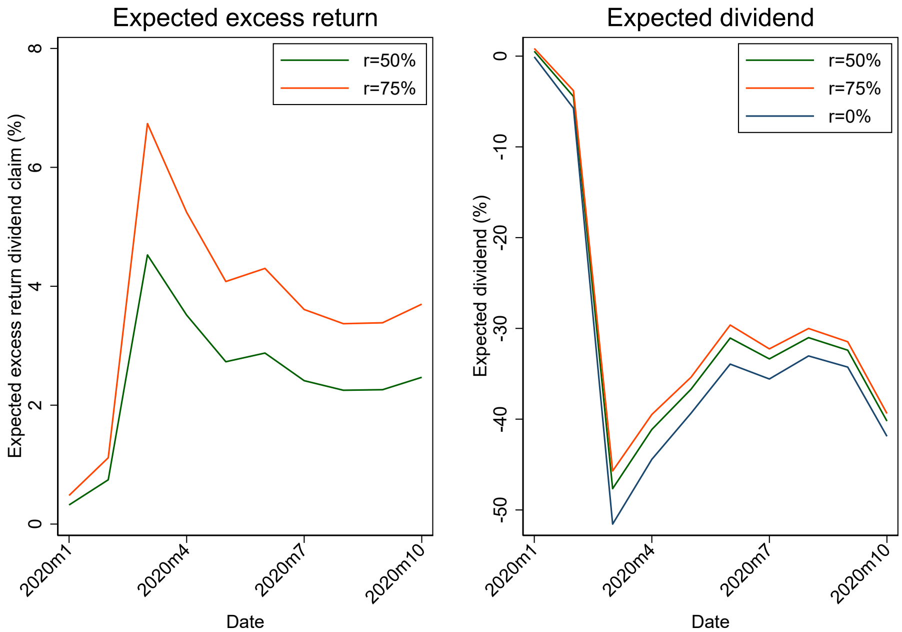

Figure 2. A lower bound on expected excess returns on the short-term dividend claim (left panel) and on the expected dividend in 2021, scaled by the 2019 dividend (right panel). The different lines correspond to conditional correlations between market returns and short-term dividend returns.

ance is positive, while in the Campbell and Cochrane (1999) model, the covariance is negative only in bad states of the world. (See Online Appendix.)

We therefore follow Kremens and Martin (2019) by setting $R_{t:t+\tau} = R^M_{t:t+\tau}$ equal to the return on the aggregate stock market. We also assume that returns, dividends, and the SDF are jointly lognormal.[2] This implies that

$$E_t[R^\tau_{t:t+\tau}] - R^f_{t:t+\tau} = \frac{\rho_t \sigma^*_t(R^\tau_{t:t+\tau})\sigma^*_t(R^M_{t:t+\tau})}{R^f_{t:t+\tau}} - \text{cov}_t(M_{t:t+\tau}R^M_{t:t+\tau}, R^\tau_{t:t+\tau}),$$

where σ^*_t denotes risk-neutral volatility and $\rho_t = \text{corr}_t(R^\tau_{t:t+\tau}, R^M_{t:t+\tau})$. Under our lognormality assumption, true and risk-neutral correlation are equal to one another, as we show in the Online Appendix.

The second covariance term is non-positive under assumptions very similar to those of Martin (2017). As a simple benchmark, if one adopts the perspective of an investor with log utility who chooses to invest fully in the market, then $M_{t:t+\tau} = 1/R^M_{t:t+\tau}$ and the covariance term is zero. More generally, suppose that $M_{t:t+\tau}$ is of the form $\beta u'(W_{t+\tau})/u'(W_t)$ where wealth is invested in the market,[3] $W_{t+\tau} = W_t R^M_{t:t+\tau}$, and risk aversion $-Wu''(W)/u'(W)$—which need not be constant—is at least one at all levels of wealth. Then we have $\text{cov}_t(M_{t:t+\tau}R^M_{t:t+\tau}, R^\tau_{t:t+\tau}) \leq 0$ if the dividend and market returns are non-negatively

[2] We require this assumption as derivatives whose prices would directly reveal the risk-neutral covariance between the market return and dividend growth are not widely traded. By contrast, Kremens and Martin (2019) were able to exploit the fact that index quanto contracts, which reveal the corresponding risk-neutral covariance between the market return and currency appreciation, *are* traded. Although the assumption of lognormality is likely violated, as discussed by Martin (2017), our hope is that this violation has limited impact on our results. We leave it for future research to derive bounds under more general distributional assumptions.

[3] This assumption is stronger than we need. In the appendix, we generalize further to show conditions under which the covariance is negative in the presence of state variables, non-market wealth, and non-lognormal random variables.

correlated. From now on, we will assume that this condition holds.

We then have a lower bound on expected dividends:

$$E_t[D_{t+\tau}] \geq P_t(\tau)\left(\frac{\rho_t \sigma_t^*(R_{t+\tau}^\tau)\sigma_t^*(R_{t+\tau}^M)}{R_t^f} + R_t^f\right).$$

B. Empirical Results

We approximate $R_t^f \simeq 1$ during our sample. As estimating a correlation model is beyond the scope of this paper, we will present results for two values of ρ_t that we consider plausible during times of stress, $\rho_t = 50\%$ or 75%.

We plot the lower bound for expected excess returns in annualized terms in the left panel of Figure I.B. The expected excess return peaks at 4.5% if $\rho_t = 50\%$ and at 6.7% if $\rho_t = 75\%$, indicating substantial expected excess returns on dividend claims.[4]

In the right panel of Figure I.B, we use these estimates to compute a lower bound on the expected dividend in December 2021. To simplify the interpretation, we scale this expectation by the December 2019 dividend. This bound sharpens the lower bound in Gormsen and Koijen (2020), which corresponds to $\rho_t = 0$.

We draw two conclusions. First, most of the variation in dividend futures is due to growth expectations. This underscores the usefulness of dividend futures for forecasting economic growth. Second, while the market recovered in the second part of 2020, near-term growth expectations improved only slightly and indeed deteriorated towards the year's end. Coupled with the high level of implied dividend volatilities, the short-term economic outlook is uncertain and not expected to recover in the near term in Europe.

REFERENCES

Ravi Bansal and Amir Yaron. Risks for the long run: A potential resolution of asset pricing puzzles. *Journal of Finance*, 59 (4):1481–1509, 2004.

Robert J Barro. Rare disasters and asset markets in the twentieth century. *The Quarterly Journal of Economics*, 121(3): 823–866, 2006.

Nicholas Bloom. The impact of uncertainty shocks. *Econometrica*, 77(3):623–685, 2009.

John Y. Campbell and John H. Cochrane. By force of habit: A consumption-based explanation of aggregate stock market behavior. *Journal of Political Economy*, 107(2):205–251, 1999.

Can Gao and Ian Martin. Volatility, Valuation Ratios, and Bubbles: An Empirical Measure of Market Sentiment. *working paper*, 2020.

Niels Joachim Gormsen. Time variation of the equity term structure. *Journal of Finance, forthcoming*, 2020.

Niels Joachim Gormsen and Ralph S J Koijen. Coronavirus: Impact on Stock Prices and Growth Expectations. *The Review of Asset Pricing Studies*, 10(4):574–597, 2020.

Kyle Jurado, Sydney C. Ludvigson, and Serena Ng. Measuring uncertainty. *American Economic Review*, 105(3): 1177–1216, March 2015.

Lukas Kremens and Ian Martin. The Quanto Theory of Exchange Rates. *American Economic Review*, 109(3):810–843, 2019.

Ian Martin. What is the Expected Return on the Market? *The Quarterly Journal of Economics*, 132(1):367–433, 2017.

Jules H. van Binsbergen, Wouter Hueskes, Ralph S.J. Koijen, and Evert B. Vrugt. Equity yields. *Journal of Financial Economics*, 110(3):503 – 519, 2013.

[4]As the volatilities of all dividend claims and the market move significantly during the crisis, so do the lower bounds on the expected excess returns. We refer to Gormsen (2020) for estimates of variation in expected excess returns across maturities.