Four centuries of return predictability

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Abstract

We analyze four centuries of stock prices and dividends in the Dutch, English, and U.S. market. With the exception of the post-1945 period, the dividend-to-price ratio is stationary and predicts returns throughout all four centuries. "Excess volatility" is thus a pervasive feature of financial markets. The dividend-to-price ratio also predicts dividend growth rates in all but the most recent period. Cash-flows were therefore much more important for price movements before 1945, and the dominance of discount rate news is a relatively recent phenomenon. This is consistent with the increased duration of the stock market in the recent period.

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1. Introduction

One of the most important questions in asset pricing is whether prices (or rather the dividend-to-price ratio) can predict returns. If so, asset prices would be "excessively volatile"; that is they move more than is warranted by fundamentals, such as dividends (Shiller 1981; LeRoy and Porter 1981). The empirical evidence suggests that returns are indeed partially predictable (Campbell and Shiller 1988; Fama and French 1988; Cochrane, 2008; Binsbergen and Koijen 2010). This has motivated an important theoretical literature that incorporates time-varying returns in equilibrium models (Campbell and Cochrane 1999; Bansal and Yaron 2004; Albuquerque, Eichenbaum, and Rebelo 2014).

Two issues remain. First, in the recent period the dividend-to-price ratio is highly persistent, virtually indistinguishable from a unit root. Combined with the relatively short sample this biases estimates in favor of finding return predictability (Stambaugh 1999). Second, the existing evidence does not only suggest that returns are predictable, it also indicates that dividend growth rate predictability is limited (Campbell and Shiller 1988; Campbell 1991; Cochrane 1992; 2008; 2011). This suggests that "excess volatility" is extreme: prices seem to only move in response to changing expected returns and not to news about future dividends. The jury is still out on what can explain this feature of the data.

In this paper we extend the time series of asset prices and dividends to cover the whole history of modern financial markets starting in 17th century Amsterdam. In particular, we focus on the dominant stock markets of the time: the Dutch stock market in the 17th and 18th century, the U.K. stock market in the 18th and 19th century, and the U.S. stock market from the end of the 19th century onwards. This way, we cover a large fraction of global market capitalization. The included companies are very similar to those of today, with limited liability for shareholders, separation of ownership and control, and an active secondary market for shares. By extending the time series we add independent variation to the data. This is more difficult to achieve in the cross-section, where markets often move together, especially in the recent period.

The paper has three key findings. First, over the long run the dividend-to-price ratio is stationary, fluctuating around a long-run average of five percent (minus three in logs, see Figure 1 for details). It is only after around 1945 that the dividend-to-price ratio starts to persistently decrease. This is interesting in its own right, but also means that, for the period as a whole, predictability results are not biased. Second, we find robust evidence for return predictability. In the full period covering all four centuries, the predictive coefficient on the dividend-to-price ratio is positive and highly significant. In subperiods, the predictive coefficient is remarkably stable (although not always statistically significant). Thus, excess volatility appears to be a pervasive characteristic of financial markets. Third, there are important differences between periods in terms of dividend growth predictability. While the dividend-to-price ratio strongly predicts dividend growth rates in the earlier periods, such predictability completely disappears around 1945. In line with this observation our analysis implies that, before 1945, changes in cash-flows were more important for price movements than changes in discount rates. The dominance of discount rate news is therefore a relatively recent phenomenon.

We hypothesize that the growing importance of time-varying expected returns is related to the increased duration of the market as a whole. Following the bond pricing literature, we view stock duration in terms of the timing of dividends. As dividend payments are shifted into the future and duration increases, prices become more sensitive to discount rate shocks. This hypothesis is supported by several empirical observations. First, the dividend-to-price ratio of the market has fallen considerably in the recent period. At the same time, expected returns have not decreased and investors receive most of their returns through capital appreciation. This is consistent with Fama and French's (2002) evidence on the disappearance of dividends and firms reinvesting cash-flows. Second, we document that in the post-1945 period the discounted value of the next ten years of (expected) dividends accounts for a significantly smaller portion of current stock valuations than in earlier periods. Using one minus this discounted value as a proxy for stock duration, we find it to be highly correlated with the importance of discount rate news. Finally, we document that the market betas of long maturity Treasury bonds have increased relative to the betas of short maturity bonds in the recent U.S. period. Thus, the stock market as a whole has become more correlated with longer-duration assets.

Our paper relates to a large literature on the importance of dividend growth and discount rates for stock prices. See Koijen and van Nieuwerburgh (2011) for an overview. Most closely related are Goetzmann, Ibbotson, and Peng (2001), Chen (2009), and Rangvid, Schmeling, and Schrimpf (2014). Using primary sources, Goetzmann et al. estimate an index for the New York stock market between 1815 and 1925. They find little evidence for return predictability, but due to data limitations they must approximate dividends for the period before 1870. Chen examines the differences between the pre- and post-1945 U.S. periods and argues that before 1945 returns were not predictable, assigning almost all variation in the dividend-to-price ratio to expected dividend growth rates. Rangvid et al. show that discount rates are less important in countries with relatively small companies and less dividend smoothing.

Our paper is also related to a growing literature that emphasizes the predictability of dividend growth rates (Menzley, Santos, and Veronesi 2004; Lettau and Ludvigson 2005; Cochrane 2008; Binsbergen and Koijen 2010; Golez 2014). Relative to this literature, we provide a long term perspective on the sources of asset price movements that help us understand why discount rate news dominates in the recent period. Finally, our paper is related to le Bris, Goetzmann, and Pouget (2014), who analyze six hundred years of dividend and price data for the Bazacle Company in France.

2. Data

We extend the time series of stock prices and dividends back in time until 1629 using the most important financial markets of a specific period. In particular, for the period between 1629 and 1811 we focus on the equity market in Amsterdam (that included a number of English securities). For 1825-1870, we look at London. For the period after 1870 we rely on the U.S. market data. In total, we construct an annual time series from 1629 to 2012, with only a small gap for the years between 1811 and 1825.

While the American data have been extensively studied, the Dutch and English data have received limited attention in the literature and merit closer inspection. This paper is the first to look at return and dividend growth rate predictability in these markets.

During the 17th and 18th century, Amsterdam was the financial capital of the world and it was closely integrated with the London market (Neal 1990). Although technologically less advanced, the market functioned much like the one today. Harrison (1998) provides evidence that returns in these markets had similar distributions and time series properties as today. Koudijs (2014) shows that the Amsterdam market responded to the arrival of news in an efficient way and that trading costs were very similar to the recent period. The (negative) autocorrelation of returns on a daily level is comparable to today. We take the perspective of an Amsterdam investor, assuming that he held a value-weighted portfolio of Dutch and English securities. We use exchange rate information to convert returns in Pounds Sterling into Dutch Guilder returns.[1] There is information available for 5 securities: the Dutch East India Company (from 1629 onwards), the Bank of England (1694), the (United) British East India Company (1693), the South Sea Company (1711), and the (Second) Dutch West India Company (1719).

The Dutch East India Company (VOC) was the world's first publicly traded corporation; its shares were freely tradable and shareholders enjoyed limited liability. There was a clear separation between ownership and control. The Company was founded in 1602 and its capital became permanent in 1613 (Gelderblom, Jong, and Jonker 2013). It held the Dutch monopoly on trade with Asia and operated an extensive trade network there. It started to pay annual dividends in 1685, before that it paid dividend every two to three years.[2] The company was nationalized by the government in 1796. One of the contributions of this paper is the collection of a complete VOC price series for the years between 1629 and 1719 from the original sources.

The Dutch West India Company (WIC) was founded in 1675 and was involved in slave trade and the administration of (slave) colonies in Africa and Caribbean. It paid out dividends sporadically and was nationalized in 1791. Price information is only available for 1719 onwards. In that year it only constituted one percent of our index, so the omission of the WIC during 1675-1718 probably has little impact on our estimates.

The Bank of England (BoE) was founded in 1694 to help finance the English government debt. It held an effective monopoly over issuing banknotes and provided short-term credit to merchants and banks. It was also an important lender to the British East India Company (EIC). The EIC was created in 1708 through a merger of the Old and New East India Companies

[1] Since both England and the Dutch Republic were on metallic standards, exchange rate fluctuations were only of minor importance.
[2] It is impossible to calculate annual dividend growth rates and dividend-to-price ratios for the VOC up to 1684. Since it is the only company in our sample for that period, we can only run our annual regressions for the years after 1684.

(between 1693 and 1707 we use the prices of the Old EIC). It held the English monopoly on trade with Asia. The South Sea Company (SSC) started in 1711 after receiving a monopoly on the trade with South America. These activities never materialized and the Company was mainly a vehicle to finance the English government debt. It performed a number of debt-for-equity swaps; the final one resulted in the South Sea Bubble in 1720. In that year the company accounts for 60% of our value-weighted index. After the bubble burst, the company was largely liquidated; in 1732 it only constituted 6% of our index. Remaining shares were mainly backed by government debt. It matters very little for our results whether we keep the company in our index after 1732 or not. The English companies have a complicated history of capital calls, rights issues, and other "capital events". We use the work by Shea (*in preparation*) to adjust stock prices where necessary.

It is important to note that, even though these are only 5 securities, they effectively constitute the universe of traded equities in Amsterdam and London. Only during the bubble year of 1720 did new equities enter the market; most of these new companies were liquidated before the end of the year (Frehen, Goetzmann, and Rouwenhorst 2013). The few surviving companies were relatively small and were not widely traded.

The companies in our index were quite large: the total market capitalization to GDP of securities held by Dutch investors ranged from 15% (during the 1630s and again in the early 1800s) to 64% (during the 1720s).[3] This means that diversification was provided within companies, rather than between them. In comparison, for the U.S., stock market capitalization

[3] To compute these numbers we use the GDP of Holland, the only Dutch region for which reliable figures are available for the 17th and 18th centuries (Van Zanden and Van Leeuwen 2012). Holland was the largest province of the Dutch Republic, comprising the most populous and developed parts of the country, including important cities like Amsterdam and Rotterdam. The historical evidence suggests that most Dutch investors lived in this area. We used information from Bowen (1989) and Wright (1997) to calculate what fraction of English securities were held by Dutch investors.

amounted to 39% of GDP in 1913 and 152% in 1999 (Rajan and Zingales 2003). In addition, there were many investment opportunities available outside the stock market such as shipping, trade and small manufacturing that would have expanded the efficient portfolio frontier.[4]

For the period between 1825 and 1870 we focus on the London market. After the Napoleonic Wars, London became the financial capital of the world and the United Kingdom was the largest economy in the world.[5] Starting in the 1810s many new equities were issued. Initially, these were mainly canals and insurances companies. Later on, banks and railroad companies became the most important issuers of new equity. The period covers the so-called Railroad "Manias" of the 1830s and 1840s. It is important to note that before 1855 the newly issued companies had full shareholder liability. Afterwards, it became possible to issue shares with limited liability, but many banks and insurance companies remained to have full liability.

We use the value-weighted stock market index constructed by Acheson, Hickson, Turner, and Ye (2009) (henceforth, AHTY) that includes all regularly traded domestic equities traded in London starting in 1825. The index covers between 125 (1825) and 250 (1870) different securities. Total market capitalization accounted for between ten and 30 percent of British GDP. During this period, there were many new issues and delistings. AHTY (2009) omit all securities that were traded for less than 12 months (most of these companies failed to raise sufficient capital to start their business) and adjust for survivorship bias. In addition, there were many capital calls, rights issues, and other capital events. AHTY (2009) omit individual security returns for the months that these events took place. See AHTY (2009) and Hickson, Turner, and Ye (2011) for more details.

[4] Though the overall riskiness of a portfolio depends on diversification possibilities, it should not affect return or dividend growth predictability.
[5] During this period the U.S. had a smaller economy than the U.K.

Starting in 1871, we rely on the U.S. stock market. By 1900, U.S. had become the largest economy of the world, with a well-developed capital market in New York. For the period between 1871 and 1925 we rely on information from Cowles (1939) that covers between 50 (1871) and 258 (1925) securities. Following the existing literature, (e.g. Shiller 1981) we switch to the S&P 500 index in 1926, with data provided by CRSP. Before 1957, this was actually the S&P 90. As before, our U.S. return index is value-weighted.

3. Methodology

As it is standard in the asset pricing literature, we take the perspective of an individual investor who is interested in the per share value of a company. An investor receives dividends as the only source of cash-flows. Other types of distributions (e.g. repurchases) are assumed to be reinvested in the company.[6]

3.1 Present value relations

The holding period return per share of equity consists of the dividend yield and any price appreciation:

$$R_t = \frac{P_t + D_t}{P_{t-1}}, \tag{1}$$

where P_t is the per share price at time t and D_t are the per share dividends accumulated from $t-1$ to t. We take logs and define the dividend-to-price ratio as $dp_t = \log(D_t / P_t)$ and the dividend growth rate as $dg_t = \log(D_t / D_{t-1})$. Using a first-order Taylor expansion around the long-run

[6] An alternative approach would be to take a perspective of a representative investor who is interested in the value of the whole company. As shown in Larrain and Yogo (2008), under this alternative one needs to account for repurchases and issuances of both equity and debt. This would be interesting to do in our setting. Unfortunately historical data on debt issuances is very incomplete.

mean of the dividend-to-price ratio $\overline{dp}$, Campbell and Shiller (1988) show that log returns can be expressed as:

$$r_{t+1} \simeq dp_t + dg_{t+1} - \rho dp_{t+1}, \tag{2}$$

where all variables are demeaned and $\rho = \exp(-\overline{dp}) / 1 + \exp(-\overline{dp})$ is the linearization constant. Rewriting Eq. (2) in terms of the dividend-to-price ratio we obtain:

$$dp_t \simeq r_{t+1} - dg_{t+1} + \rho dp_{t+1}. \tag{3}$$

Eq. (3) shows that a high dividend-to-price ratio is either related to (and should therefore predict) high future returns, low future dividend growth rates, and/or a high future dividend-to-price ratio. Because the predictive coefficients are interrelated, return and dividend growth predictability should best be studied jointly (Lettau and Ludvigson 2005; Cochrane 2008; Binsbergen and Koijen 2010; Golez 2014).

Iterating Eq. (3) forward and excluding rational bubbles, the dividend-to-price ratio can also be expressed as an infinite sum of discounted returns and dividend growth rates (since the relationship holds ex-ante and ex-post, an expectations operator can be added to the right-hand sight):

$$dp_t \simeq E_t \sum_{j=0}^{\infty} \rho^j (r_{t+1+j}) - E_t \sum_{j=0}^{\infty} \rho^j (dg_{t+1+j}). \tag{4}$$

Thus, ultimately, any variation in the dividend-to-price ratio must be related to future changes in expected returns and/or expected dividend growth rates.

Finally, the above present value model also allows studying variation in unexpected returns (Campbell 1991). Subtracting the expectations of Eq. (4) at time *t+1* from the expectations at time *t* yields:

$$r_{t+1} - E_t r_{t+1} = -\left(E_{t+1} - E_t\right)\sum_{j=1}^{\infty} \rho^j (r_{t+1+j}) + \left(E_{t+1} - E_t\right)\sum_{j=0}^{\infty} \rho^j (dg_{t+1+j}). \quad (5)$$

Hence, unexpected return can be high either because the expected future dividend growth rate is high or because future expected returns are low.

3.2 Estimation

We estimate the joint dynamics of returns, dividend growth rates, and the dividend-price ratio through a vector autoregression (VAR) model:

$$x_{t+1} = \phi x_t + \varepsilon_{t+1}, \quad (6)$$

where $x_t = [r_t, dg_t, dp_t]^{'}$ is a column vector of three variables. All variables are demeaned. Denote by $\Sigma = E[\varepsilon_t \varepsilon_t^{'}]$ the covariance matrix of residuals, and by $\Gamma = E[x_t x_t^{'}]$ the covariance matrix of the variables.

The model is identified by nine moment conditions:

$$E[(x_{t+1} - \phi x_t) \otimes x_t] = 0 \quad (7)$$

The present value relations in Eq. (3) add further restrictions on the estimated parameters. Let I be a three by three identity matrix, and let e_i denote the *i*th column of the identity matrix. Then the restrictions can be written as:

$$\left(e_1^{'} - e_2^{'} + \rho e_3^{'}\right)\phi = e_3^{'}. \quad (8)$$

In total we have nine moment conditions, nine parameters and three linear restrictions. The VAR model is therefore overidentified. We estimate the model using iterative GMM and we test for overidentifying restrictions using a *J*-test. Heteroscedasticity and autocorrelation consistent statistics are based on Bartlett kernel with optimal bandwidth determined by the Newey-West method. A similar approach is used by Larrain and Yogo (2008), among others.

3.3 Decompositions

Using the VAR model, we infer long-horizon estimates from their short-run analogs. We start by decomposing the variance of the dividend-to-price ratio into the covariances with future returns and dividend growth rates (Cochrane 1992):

$$Var(dp_t) = Cov\left(dp_t, \sum_{j=0}^{\infty} \rho^j (r_{t+1+j}) \right) + Cov\left(dp_t, -\sum_{j=0}^{\infty} \rho^j (dg_{t+1+j}) \right) \tag{9}$$

In terms of the VAR model, the covariance terms can be written as:

$$Var(dp_t) = e_3^{'}\Gamma e_3 = e_1^{'}\phi\left(I-\rho\phi\right)^{-1}\Gamma e_3 - e_2^{'}\phi\left(I-\rho\phi\right)^{-1}\Gamma e_3. \tag{10}$$

The first covariance term can be interpreted as the variation of the dividend-to-price ratio due to discount rates. The second term captures variation due to cash-flows. To determine the relative importance of the two components, we divide the covariance terms by the variance of the dividend-to-price ratio and express them in percentages.

Similarly, we can decompose the variance of unexpected returns from Eq. (5) into a discount rate and a cash flow component.

$$Var\left(r_{t+1}-E_t r_{t+1}\right) = -Cov\left[r_{t+1}-E_t r_{t+1}, \left(E_{t+1}-E_t\right)\sum_{j=1}^{\infty}\rho^j (r_{t+1+j}) \right] + Cov\left[r_{t+1}-E_t r_{t+1}, \left(E_{t+1}-E_t\right)\sum_{j=0}^{\infty}\rho^j (dg_{t+1+j}) \right]. \tag{11}$$

In the context of the VAR model, the covariance terms can be written as:

$$Var(r_{t+1}-E_t r_{t+1}) = -e_1^{'}\rho\phi\left(I-\rho\phi\right)^{-1}\Sigma e_1 + e_2^{'}\left(I-\rho\phi\right)^{-1}\Sigma e_1. \tag{12}$$

(Campbell 1991). Again, to determine the relative importance of each component, we divide the covariance terms by the variance of unexpected returns and express them in percentages.

4. Results

We start by presenting the summary statistics, followed by the VAR estimates, and the decomposition results.

4.1 Summary statistics

Figure 1 plots the main variables of interest: annual returns, dividend growth rates, and the dividend-to-price ratio. Dashed lines separate the different time periods: Netherlands/U.K. (1685-1809), U.K. (1825-1870), and the two U.S. samples. Following Chen (2009), we split the U.S. sample in the early U.S. period (1871-1945) and the recent U.S. period (1945-2012). Table 1 presents the corresponding summary statistics.

What stands out the most is the remarkable stationarity of the dividend-to-price ratio. It always oscillates around the long-run average of approximately 5% (minus 3 in log terms). Only in the recent period (post-1945), the dividend-to-price ratio becomes persistently decreasing. Whereas the persistence of the dividend-to-price ratio in the first three periods is between 0.51 and 0.66, it increases to as much as 0.91 in the post-1945 data. The recent U.S. period is the only period for which we cannot reject a unit root.

Average returns are between 5.10% and 6.94% in the earlier years and increase to 9.96% in the post-1945 period. At the same time, the volatility of returns is somewhat higher in the two U.S. periods. Therefore, we do not observe any clear differences in the Sharpe ratios across the different periods. Persistence of returns is relatively low, with the AR(1) ranging between -0.09 and 0.05.

Capital appreciation is much more important for returns in the recent period. Whereas in the earlier periods around two thirds of returns stem from dividends (and only one third comes from capital appreciation), this is exactly the opposite in the recent U.S. sample.

We also see highly volatile dividend growth rates in the early years of the first period. This is due to the fact that companies did not always pay out dividends each and every year and this is reflected by the increased volatility of aggregate dividend growth. Volatility is substantially lower after 1720, which can be interpreted as a first indication of dividend smoothing. The volatility of dividend growth rates increased again in London in the 19th century and in the early U.S. period. It flattened out once again in the recent years, probably due to increased dividend smoothing. Accordingly, dividend growth rates become increasingly persistent over time. While the AR(1) for dividend growth is -0.22 in the Dutch/English period, it increases to 0.39 in the recent U.S. period. To reduce the effect of both lumpy dividends in the initial years and overly smooth dividends in the recent period, we also report results based on triennial data (in addition to annual data). By using triennial data we also are able to extend the time period backwards by 56 years to 1629.[7]

4.2 VAR estimates and decomposition results

Table 2 presents the VAR estimates and decomposition results based on annual data. We estimate a VAR for each period as well as for the full sample (by appending periods). The same results based on the triennial data are reported in Table 3. When using triennial data, we estimate our model on three different non-overlapping samples and then report the mean of the estimated parameters across those samples. We always report the full parameter matrix associated with the

[7] See footnote 2 for details.

VAR system, but focus our attention on the parameters associated with the lagged dividend-to-price ratio.

We start by analyzing the results reported in Table 2 that are based on annual data. We first note that, in the full period, the dividend-to-price ratio predicts both returns and dividend growth rates. The estimated parameters on the dividend-to-price ratio are of the expected sign; positive at 0.08 in the return regression, and negative at -0.12 in the dividend growth regression. Both parameters are also highly significant. This stands in sharp contrast to the recent evidence that the dividend-to-price ratio only predicts returns.

Note once more that the dividend-to-price ratio in the full sample is stationary and our sample spans 310 annual observations. Thus, our inference does not suffer from the general problems associated with predictability regressions that use highly persistent predictors in small samples (Stambaugh 1999).[8]

We observe substantial variation between periods. Whereas the estimated parameter in the return regression is fairly stable, the estimated parameters in the dividend growth and the dividend-to-price regressions change importantly in the recent period. Effectively, the predictability of the dividend growth rate disappears in the recent period and is substituted with increased persistence of the dividend-to-price ratio.[9]

In particular, in the return regression, the estimated parameter on the dividend-to-price ratio is always positive and relatively stable, between 0.08 and 0.12. It is significant in the Dutch/English period and in the recent U.S. sample. Even in the 19th c. U.K. period and the early U.S. period, where the estimated parameters are statistically insignificant, Wald tests suggest that

[8] We also note that the correlation between residuals in the return regression and innovations in the dividend-to-price ratio is less negative in the full sample at -0.69 as compared to the recent period -0.93.

[9] Estimated parameters on the dividend-to-price ratio need to satisfy the linear restriction $\phi_{\mathrm{r,dp}} - \phi_{\mathrm{dg,dp}} + \varphi\phi_{\mathrm{dp,dp}} = 1$. This means that a change in one of the parameters needs to be accompanied with a change in at least one other parameter.

these two coefficients are **not** statistically significantly different from the rest of the period. This implies that returns have always been predictable by the dividend-to-price ratio. In comparison, the estimated parameter in the dividend growth regression is much less stable. It is negative, between -0.19 and -0.23, and significant in the first three periods, but turns out to be (exactly) zero in the recent U.S. period. According to a Wald test, this difference is highly statistically significant. The disappearance of dividend growth predictability is associated with an increased persistence of the dividend-to-price ratio. Whereas the dividend-to-price ratio predicts itself with the estimated parameter between 0.61 and 0.73 in the first three periods, this coefficient increases to 0.90 in the recent U.S. sample.

Thus, the recent U.S. period appears very different. Return predictability is somewhat higher but what stands out is the complete lack of dividend growth predictability, and a highly persistent dividend-to-price ratio. This also reflects itself in the decomposition results reported in Panel B of Table 2. While in the first three samples cash-flows are much more important, in recent years all the variation in the dividend-to-price ratio appears to be driven by discount rates. We obtain qualitatively similar results if we focus on the decomposition of unexpected returns. In both cases, cash-flows account for approximately two thirds of the variation in the first three samples and do not matter at all in the recent period. In comparison, discount rates account for only one third of variation in the early periods and completely dominate in the most recent period.

Given the stark differences between results in different periods, we also conduct a Wald test on the full period imposing a break in 1945. The Wald test confirms the presence of a structural break with a p-value of 0.003. When we endogenously search for one break, we arrive at 1961 (using a Sup statistic). Finally, we conduct Monte Carlo simulations. We use the distribution of parameters and errors estimated using the data up to 1945 to simulate 10,000 datasets that match the length of the post-1945 period. We then perform the same decompositions as in the main analysis. We confirm that the results in the post-1945 period are statistically different with a p-value of 0.002 when the decomposition is based on the dividend-to-price ratio and a p-value of 0.000 when the decomposition is based on unexpected returns.[10]

All the results are qualitatively similar when we use triennial (rather than annual) data, as reported in Table 3. The dividend-to-price ratio predicts both returns and dividend growth rates in the full period. The observation that price movements are mostly driven by cash-flow news in the early years and dominated by the discount rate news in the recent period remains robust and strong. Both a Wald test and simulation results confirm that the importance of discount rate news is significantly higher in the recent period. Thus, the documented pattern appears to be a deep characteristic of the market that seems to go beyond dividend lumpiness or smoothing.

5. Reconciling the evidence

The recent U.S. period is substantially different from the earlier years. The dividend-to-price ratio has decreased considerably. At the same time, returns have not decreased and investors are now receiving most of their returns through capital appreciation. Furthermore, whereas cash-flows seem to be more important for price movements in the earlier years, discount rates appear to be the sole determinant of price movements in the recent years.

We hypothesize that these empirical observations are driven by the increased duration of the stock market in the recent years.

[10] To speed up simulations, we use one step GMM estimation and set the Newey-West bandwidth to 3.

5.1 Increased duration of the stock market

Borrowing the intuition from bond pricing, we think of stock duration in terms of the timing of dividend payments as those represent the actual stream of cash-flows to investors. When companies postpone dividend payments, duration increases. This decreases current dividends, but leaves prices unaffected (assuming perfect markets). As a result, the dividend-to-price ratio decreases, capital appreciation becomes a much more important part of total returns, and prices come to be more sensitive to changes in discount rates.

Our hypothesis is supported by the empirical evidence. For example, Fama and French (2002) report that the propensity to pay dividends among existing and new companies decreased in recent years. This is consistent with firms reinvesting cash-flows and pushing dividend payments into the future.

Postponing dividends should also increase stock duration and, following the intuition from bond pricing, raise the importance of discount rates. There is, however, an important difference between fixed income and the stock market. In the case of bonds, coupons are fixed, and bond duration therefore maps directly into interest rate sensitivity. In the stock market, however, dividends might change over time. This means that increased duration could increase the importance of both discount and dividend growth rates.

To verify that the increased importance of discount rates in the recent period is indeed related to stock duration, we first calculate a simple proxy for duration and check its correlation with the discount rate news component. In particular, for each year, we calculate the fraction of the price that is accounted for by the present value of the next ten years of expected dividends. Our proxy for duration is then one minus this fraction. For simplicity, we assume that growth rates follow a random walk with drift μ. We thus model the next ten years of expected dividends as $\sum_{n=1}^{10} D_t(1+\mu)^n$. We calculate our duration measure for the four periods within our sample. For each period, we estimate the drift μ by regressing dividend growth rates on a constant. As a proxy for the discount rate, we take the average within period market return.

The average values for our measure of stock duration in the four periods are 0.63 for Netherlands/U.K., 0.62 for U.K., 0.58 for the early U.S. period, and 0.71 for the recent U.S. period. Thus, as expected, stock duration increased considerably in the recent years. The difference is statistically significant with a *t*-statistic of 6.72.

As conjectured, we also find that duration is highly correlated with the discount rate components for each period reported in Table 2. Depending on whether we look at the decomposition of the dividend-to-price ratio or unexpected returns we find a correlation of 0.87 or 0.93 (p-values of 0.13 and 0.08).

To better account for time-variation and analyze the within-period relationship between duration and discount rates, we use a rolling windows approach. We set the length of the window to 68 years to match the post-1945 period. In each window, we estimate the importance of discount rates and our measure for duration. Because the U.K. period is too short, we only rely on the Dutch/English period (1685-1809) and the combined U.S. periods (1871-2012). Figure 3 plots the time series of duration along with either the discount rate component of the dividend-to-price ratio (Panel A) or the discount rate component of unexpected returns (Panel B). In both periods, we see clearly that duration and the discount rate component are increasing and are positively correlated. In a pooled regression of discount rate news on a constant and duration, we get R-squares of 28% (based on Panel A) or 59% (based on Panel B). The relationship is preserved in both subsamples. The respective R-squares are 52% and 49% in the

Netherlands/U.K. period and 74% and 81% in the U.S. period. Thus, duration and discount rate news are strongly correlated across periods as well as within periods.

Finally, if duration of the U.S. stock market has increased over time, we would expect that the stock market's comovement with (other) long duration assets has increased. Following Cornell (1999) we verify this by calculating market betas for medium and long term Treasuries. We use data from Ibbotson & Associates (2013) for the period between 1926 and 2012. Estimates are reported in Table 4. As expected, we find that betas increased over time, especially for long term treasuries. While betas for medium and long term bonds are 0.01 and 0.02 in the 1926-1945 period, they are 0.03 and 0.07 after 1945 (adding up the level and interaction coefficients). For long term bonds, the post-1945 beta is marginally significant with a p-value of 0.06, but the relative increase in betas is not significant. Consistent with our duration hypothesis, the increase in beta is larger for long- than for medium- term bonds (4.1 vs 2.6 times), but the difference is not statistically significant.

If we exclude the years after 2007, which are heavily influenced by the impact of QE on long term bond yields, the increase in betas is more pronounced. In this case, betas increase to 0.04 and 0.11, and are statistically significant with p-values of 0.05 and 0.01. Also, the increase in beta is significant for long-term bonds. Again, the increase in beta is larger for long- than for medium- term bonds (6.2 vs 3.8 times). For the sample up to 2007, this difference is highly statistically significant.

5.2 Alternative explanations and related research

Many studies have attempted to explain the puzzling observation that all variation in the dividend-to-price ratio in the recent period is driven by discount rates. The main explanation pursued in the literature is a changing dividend policy and the departure of dividends from other measures of cash-flows. In particular, companies have become increasingly reluctant to change dividend payments. This results in very smooth dividends and a weak link between dividends and the true cash-flow potential of the companies (Chen, Da, and Priestly 2012). However, even with smoothing, dividends have to adjust at some point. As long as these moments of adjustment (such as the recent financial crisis) are in the sample, we would expect that the dividend-to-price ratio remains a strong predictor of the dividend growth rate.

Many companies also increased stock repurchasing activity while simultaneously decreasing dividends. In our empirical analysis, we follow the standard approach of Campbell and Shiller (1988) and rely on the view of an individual investor, who is interested in the per share value of the company. Because repurchases affect the total value of the company, but not the per share value of the company, they have no direct impact on our analysis.[11] Note also that stock repurchases are often done for reasons other than distribution of cash. For example, companies may engage in repurchases to support the depressed price of the stock (Hong, Wang, and Yu 2008). Importantly, even if we add stock repurchases to dividends, we still observe a downward trend in the dividend-price ratio in the recent period.[12] Thus, stock repurchases alone do not seem to be able to account for both empirical observations in the post war period.

Koijen and van Binsbergen (2010) show that aggregate dividends are predictable by the whole history of returns and dividend ratios. The dominance of discount rate news, however, still prevails. The existing literature has also analyzed other statistical properties of the dividend-to-price ratio. For example, Lettau and Van Nieuwerburgh (2008) suggest adjusting the dividend-

[11] In our analysis repurchases only have an indirect effect through the weighting scheme in our indices.

[12] Data provided by Boudoukh et al. (2007) indicates that the aggregate log dividend yield decreased from -3.18 in 1945 to -4.02 in 2003. In comparison, the yield corrected for repurchases decreased to -3.49 or -3.73, depending on how we measure repurchases.

to-price ratio in the post-war period for one (or two) structural breaks. Again, the dominance of discount rates remains.

6. Conclusions

We analyze return predictability and excess volatility in the most important financial markets of the last four centuries. In particular, we analyze the Dutch and English stock markets in the 17th and 18th century, the U.K. stock market in the 18th and 19th century, and the U.S. stock market from the end of the 19th century onwards.

We find that the dividend-to-price ratio is stationary across all periods and predicts both returns and dividend growth rates. There are, however, important differences between the different periods. Whereas returns appear to be always predictable, dividend growth predictability disappeared after 1945. This suggests that cash-flow news used to be much more important for price movements, and the dominance of the discount rate news is a rather recent phenomenon. We argue that this is consistent with increased duration of the stock market in recent years.

Our findings have important implications for the theoretical asset pricing literature. They imply that the role of fundamentals can be masked by the increased duration of the stock market. Hence, "excess volatility" is best being studied in a framework that explicitly takes the timing of dividends into account. Increased duration may also have contributed to the high levels of stock market volatility in the recent period.

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Table 1: Summary statistics

This table reports summary statistics for the main variables, starting with the 1685-1809 period based on the Netherlands and the U.K. data in column (1) (because dividends were not paid out every year before 1685, column (1a) reports separately the main return statistics for 1629-1809); column (2) reports the same statistics for the U.K. period 1825-1879; column (3) and (4) collect the statistics for the U.S. data before and after 1945; column (5) reports the statistics based on the full sample. Capital appreciation is denoted by *ca*. Sharpe ratio is calculated assuming zero variation in the risk-free rate. The Augmented Dickely Fuller (ADF) tests for the presence of a unit root. Statistical significance of the ADF at the one, five, and ten percent is denoted by three, two, and one asterisks.

	(1)	(1a)	(2)	(3)	(4)	(5)
	Neth./U.K. 1685-1809	Neth./U.K. 1629-1809	U.K. 1825-1870	U.S. 1871-1945	U.S. 1945-2012	Full period
r	0.051	0.056	0.069	0.069	0.100	0.069
$Cap.\ app.\ (ca)$	0.008	0.011	0.026	0.018	0.066	0.026
ca / r	0.164	0.194	0.373	0.253	0.661	0.372
$AR1(r)$	-0.076	-0.090	0.043	0.053	-0.031	0.015
rf	0.032	-	0.033	0.026	0.042	0.033
$Risk\ premium$	0.019	-	0.036	0.043	0.058	0.036
$Std.(r)$	0.089	-	0.069	0.190	0.162	0.135
$Sharpe\ ratio$	0.213	-	0.529	0.228	0.356	0.263
dg	0.001	-	0.034	0.013	0.058	0.021
$Std.(dg)$	0.201	-	0.100	0.157	0.066	0.157
$AR1(dg)$	-0.223		0.182	0.204	0.389	-0.056
dp	-3.163	-	-3.126	-2.964	-3.458	-3.174
$Std.(dp)$	0.242	-	0.167	0.253	0.440	0.335
$AR1(dp)$	0.654	-	0.659	0.512	0.910	0.816
$ADF(dp)$	-4.096***	-	-4.638***	-4.765***	-2.098	-4.709***

Table 2: Vector autoregression (VAR) estimates: Annual data

Panel A reports VAR estimates of returns, dividend growth rates, and the dividend-to-price ratio. The data is annual. The model is estimated by iterative generalized method of moments subject to the present value model constraints. Heteroskedasticity and autocorrelation corrected standard errors based on Bartlett kernel are reported in parentheses below the estimated parameters. The Newey and West method is used for the selection of the optimal bandwidth. In brackets we report a Chi-square statistic on the difference of a coefficient between a specific sub-period and the rest of the sample. Statistical significance at the one, five, and ten percent is denoted by three, two, and one asterisks. Panel B reports decomposition results based on the VAR estimates from Panel A.

		(1)	(2)	(3)	(4)	(5)
		Neth./U.K. 1685-1809	U.K. 1825-1870	U.S. 1871-1945	U.S. 1945-2012	Full period
Panel A: VAR estimates						
Dep. variable: r_{t+1}						
	dp_t	0.112***	0.075	0.117	0.123***	0.081***
		(0.038)	(0.046)	(0.104)	(0.036)	(0.029)
		[3.311*]	[0.512]	[1.433]	[0.677]	
	r_t	-0.055	0.071	0.144	-0.038	0.051
		(0.078)	(0.128)	(0.208)	(0.102)	(0.079)
	dg_t	0.030	-0.099	-0.270**	-0.095	-0.044
		(0.077)	(0.069)	(0.117)	(0.221)	(0.056)
Dep. variable: dg_{t+1}						
	dp_t	-0.187**	-0.342***	-0.225***	0.000	-0.123***
		(0.086)	(0.094)	(0.059)	(0.018)	(0.030)
		[5.374**]	[2.126]	[0.213]	[13.653***]	
	r_t	0.019	-0.122	0.420***	0.119	0.279***
		(0.108)	(0.261)	(0.075)	(0.081)	(0.056)
	dg_t	-0.035	0.255***	0.135*	0.415***	0.088
		(0.113)	(0.091)	(0.075)	(0.084)	(0.099)
Dep. variable: dp_{t+1}						
	dp_t	0.730***	0.609***	0.692***	0.904***	0.830***
		(0.098)	(0.128)	(0.102)	(0.051)	(0.043)
		[10.79***]	[2.229]	[2.089]	[9.564***]	
	r_t	0.077	-0.202	0.290	0.161	0.238**
		(0.152)	(0.358)	(0.227)	(0.158)	(0.096)
	dg_t	-0.067	0.370***	0.425***	0.526**	0.137
		(0.123)	(0.116)	(0.150)	(0.248)	(0.120)
J-test		2.674	0.399	1.806	1.391	8.702**
Panel B: Decomposition results						
Dividend-to-price						
	DR	0.364	0.204	0.395	1.272	0.438
	CF	0.636	0.796	0.605	-0.272	0.562
Unexpected returns						
	DR	0.288	0.210	0.243	1.002	0.266
	CF	0.713	0.791	0.762	-0.003	0.735

Table 3: Vector autoregression (VAR) estimates: Triennial data

Panel A reports VAR estimates of returns, dividend growth rates, and the dividend-to-price ratio. The data is triennial. Reported are the means of the estimated parameters and statistics estimated on three consecutive non-overlapping samples. The VAR model is estimated by iterative generalized method of moments subject to the present value model constraints. Heteroskedasticity and autocorrelation corrected standard errors based on Bartlett kernel are reported in parentheses below the estimated parameters. Bandwidth is set to three. In brackets we report a Chi-square statistic on the difference of a coefficient between a specific sub-period and the rest of the sample. Statistical significance at the one, five, and ten percent is denoted by three, two, and one asterisks. Panel B reports decomposition results based on the VAR estimates from Panel A.

	(1)	(2)	(3)	(4)	(5)
	Neth./U.K. 1629-1809	U.K. 1825-1870	U.S. 1871-1945	U.S. 1945-2012	Full period
Panel A: VAR estimates					
Dep. variable: r_{t+1}					
dp_t	0.204**	0.125	0.405	0.343***	0.162***
	(0.081)	(0.176)	(0.250)	(0.088)	(0.057)
	[1.890]	[0.532]	[1.075]	[0.521]	
r_t	0.012	-0.215	0.006	0.074	0.034
	(0.118)	(0.229)	(0.208)	(0.134)	(0.123)
dg_t	-0.066	-0.030	-0.408**	-0.361	-0.034
	(0.055)	(0.106)	(0.192)	(0.532)	(0.056)
Dep. variable: dg_{t+1}					
dp_t	-0.592**	-0.774***	-0.338**	0.050	-0.374**
	(0.294)	(0.213)	(0.152)	(0.039)	(0.147)
	[1.084]	[0.308]	[1.281]	[12.862***]	
r_t	0.157	-0.100	0.372**	-0.026	0.347***
	(0.411)	(0.209)	(0.152)	(0.082)	(0.115)
dg_t	-0.045	0.054	-0.226**	-0.202	-0.164
	(0.166)	(0.097)	(0.095)	(0.202)	(0.111)
Dep. variable: dp_{t+1}					
dp_t	0.231	0.113	0.298	0.768***	0.521***
	(0.267)	(0.376)	(0.245)	(0.093)	(0.171)
	[4.721]	[0.919]	[0.275]	[9.384*]	
r_t	0.163	0.129	0.423**	-0.109	0.352**
	(0.400)	(0.427)	(0.208)	(0.180)	(0.167)
dg_t	0.024	0.094	0.210	0.172	-0.146
	(0.156)	(0.181)	(0.181)	(0.469)	(0.117)
J-test	2.520	0.351	0.703	0.574	2.529
Panel B: Decomposition results					
Dividend-to-price					
DR	0.278	0.216	0.579	1.090	0.351
CF	0.722	0.784	0.421	-0.090	0.649
Unexpected returns					
DR	-0.064	0.283	0.438	1.073	0.120
CF	1.046	0.725	0.571	-0.082	0.880

Table 4: Treasury betas

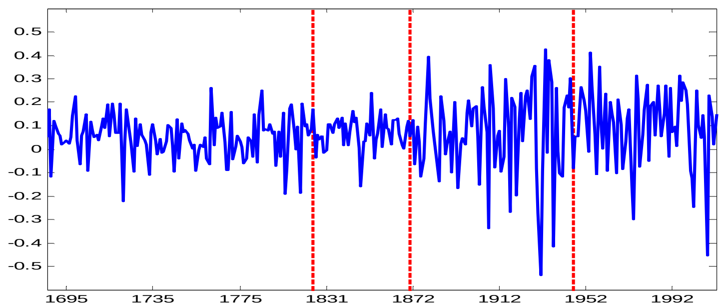
This table reports GMM estimates of the market betas of medium- and long-term Treasury bonds, where we take the S&P 500 as the market and T-bills as the risk-free rate. Monthly data is from Ibbotson and Associates (2013). Heteroskedasticity and autocorrelation corrected standard errors based on Bartlett kernel are reported in parentheses below the estimated parameters. Bandwidth is set to 10. Statistical significance at the one, five, and ten percent is denoted by three, two, and one asterisks. We report a Chi-square test on the difference in interaction terms between medium and long term bonds.

	1926-2012		1926-2007	
	Medium-term	Long-term	Medium-term	Long-term
$R_M - r_f$	0.010	0.017	0.010	0.017
	(0.007)	(0.012)	(0.007)	(0.012)
$(R_M - r_f) \times Post-1945$	0.016	0.052	0.028	0.089**
	(0.019)	(0.039)	(0.021)	(0.040)
$Post-1945$	-0.000	-0.000	-0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
N	1044	1044	984	984
$\Delta\beta^{medium} = \Delta\beta^{long}$	2.120		7.920***	
(p-value)	(0.145)		(0.005)	

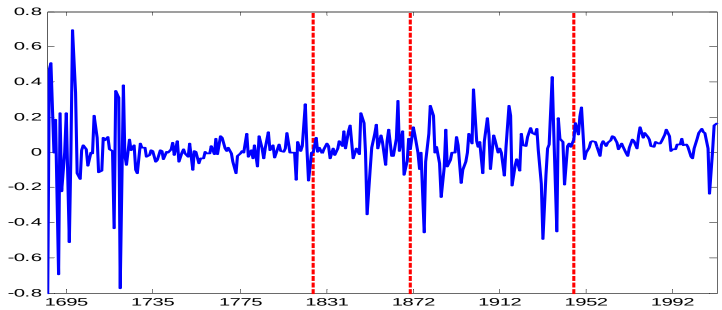
Figure 1: Returns, dividend growth rates, and the dividend-to-price ratio

This figure plots returns, dividend growth rates, and the dividend-to-price ratio. The data is annual. Vertical dashed lines denote the time periods: Netherlands and U.K. (1685-1809), U.K. (1825-1879), U.S. pre-war (1871-1945), and U.S. post-war (1945-2012).

Panel A: Annual returns



Panel B: Annual dividend growth rates



Panel C: Dividend-to-price ratio

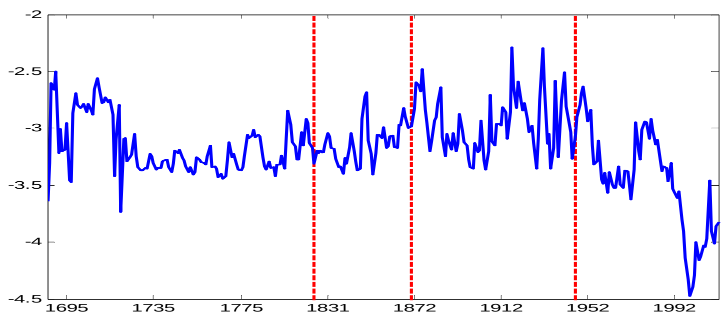
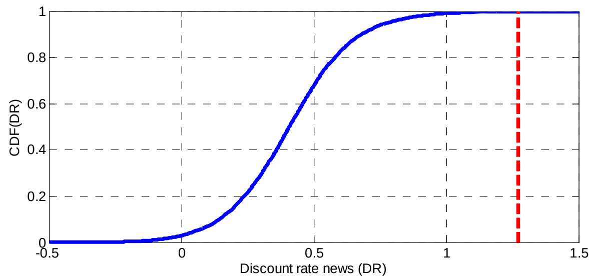


Figure 2: Monte Carlo simulations: Cumulative distribution functions (CDF)

This figure plots simulated cumulative distribution functions for the discount rate news component in the dividend-to-price ratio (Panel A) and in the unexpected returns (Panel B). We simulate 10,000 data paths based on the distribution of parameters and errors estimated on the pre-1945 data. The simulated data match the length of the post-1945 period. Vertical dashed lines denote the post-1945 point estimates.

Panel A: CDF: Discount rate component of the dividend-to-price ratio



Panel B: CDF: Discount rate component of unexpected returns

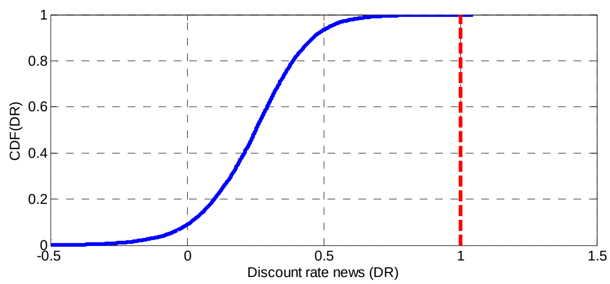
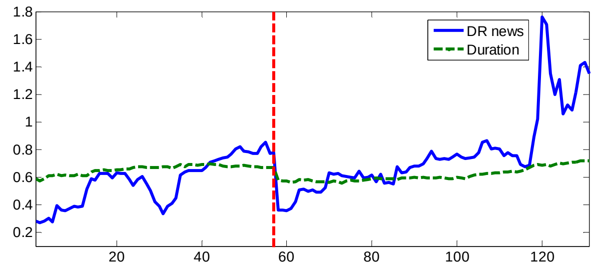


Figure 3: Duration and discount rates: Rolling windows

This figure plots our measure of duration along with either the discount rate component of the dividend-to-price ratio (Panel A) or the discount rate component of unexpected returns (Panel B). All measures are estimated on rolling windows of 68 years (to match the length of the post-1945 period). Estimations are done separately for the Netherlands/U.K. (1685-1809) period and both U.S. periods (1871-2012), and are separated by the vertical dashed line.

Panel A: Duration and discount rate component of the dividend-to-price ratio



Panel B: Duration and discount rate component of unexpected returns