Dividends and earnings in the S&P 500 from 1871 to 2016

By Lucky Dube*

This paper investigates the relationship between dividends and earnings in the S&P 500 in the 1871 to 2016 period. Data on dividends and earnings for the entire period are drawn from the US stock market dataset on Robert J. Shiller's website. The results find that dividends are significantly associated with dividends in the previous year, and earnings in the current and previous years. The results also find that the ratio of dividends to income is not constant in the long run.

I. Data

The data used in this analysis are nominal dividends per year and nominal earnings per year of the S&P 500 from 1871 to 2016. The data are subset of US stock market data published on Robert J. Shiller's website.

A plot of nominal dividends and nominal earnings show the value of these variables has grown exponentially over the 1871 to 2016 period. Shocks in dividends and earnings from 1871 to 1950 are difficult to identify in this plot (Fig 1a). The logarithm (log) of nominal dividends and nominal earnings have been generated and plotted for comparison. Shocks in the variables across the entire period can be identified in the plot.

The pay-out ratio for every year – the proportion of earnings paid out as dividends – has been generated. The plot of the pay-out ratio (Fig 2a) shows that there are instances where the ratio is greater than one, where the amount paid out in dividends exceeds earnings in that year. Looking at the plot of log dividends and log earnings this has happened in years with large transitory shocks in income where dividends have not adjusted in the same year. The pay-out ratios in this period are positively skewed as shown by the histogram in Fig 2b. The pay-out ratios have a mean of 0.63, a skewness of 2.3 and kurtosis of 8.43. The highest and lowest pay-out ratios are in 2008 and 2010 at 1.91 and 0.29 respectively. The high kurtosis shows that there is a high probability of values of the pay-out ratio in the tails of the distribution. The highest 5% of pay-out ratios are between 1 and 1.91, the lowest 5% fall between 0.29 and 0.35.

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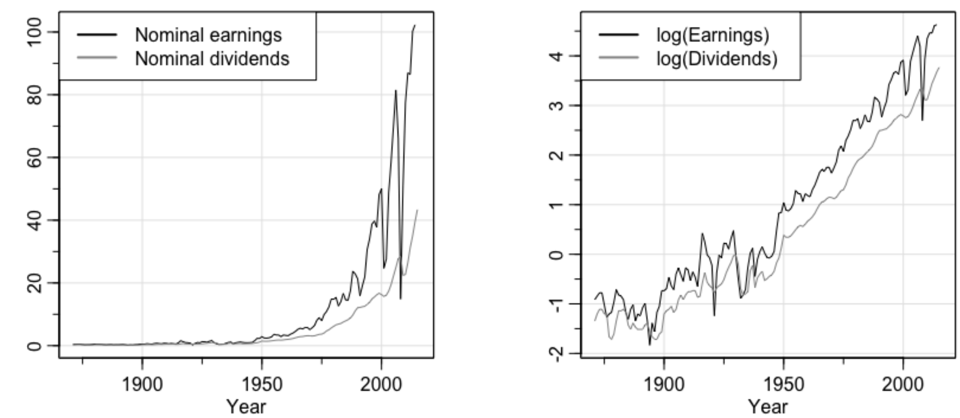
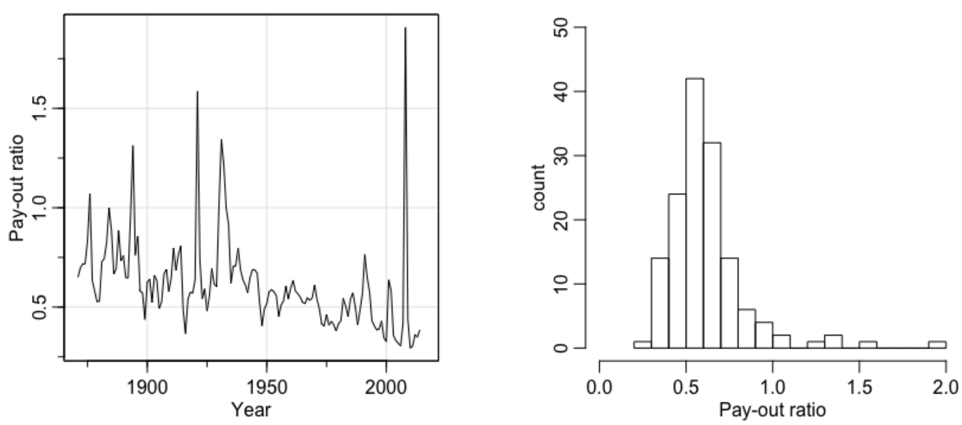


(a) Nominal dividends and nominal earnings

(b) log(dividends) and log (earnings)

Figure 1. : Plots of sample variables



(a) Pay-out ratio by time

(b) Histogram of pay-out ratio

Figure 2. : Pay-out ratio plots

Table 1—: Pay-out ratio descriptive statistics

Mean	0.62
Std.Dev	0.23
Min	0.29
Q1	0.49
Median	0.58
Q3	0.69
Max	1.91
IQR	0.20
CV	0.37
Skewness	2.30
Kurtosis	8.43
N	144

II. Analysis

Analysis was carried out using R in combination with the RStudio interface.

The following model – of the log of dividends as a linear function of the log of earnings (this will be referred to as the static model throughout the analysis) – has been estimated:

$$d_t = a_0 + b_0 e_t + u_t \tag{1}$$

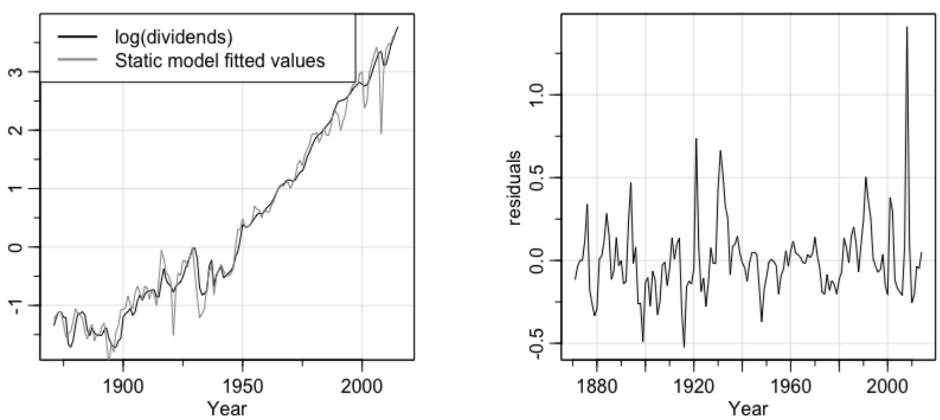
Table 2—: OLS Regression output for model (1)

	Estimate	Std.error	t value	p value
a_0	-0.4288	0.02159	-19.87	$<2\times10^{-16}$
b_0	0.8756	0.01085	80.70	$<2\times10^{-16}$
	N =	144		
	R^2 =	0.9787		
	Adjusted R^2 =	0.9785		
	SER =	0.2315		
	$F(b_0 = 0)$ =	6513	p value	$<2\times10^{-16}$

Table 3—: Regression diagnostics for model (1)

Durbin-Watson	DW =	1.1483	p value	8.43^{-8}

There is a statistically significant association between the log dividends and the log of earnings over the 1871 to 2016 period. A plot of log dividends and the fitted values of the static model (Fig 3a) shows that the model over predicts local maxima and in under predicts local minima. The over and under predictions are particularly marked in periods of high volatility in log dividends. The residual plot (Fig 3b) shows that there are periods where the residuals have a discernible pattern. A Durbin-Watson test carried out on the model provides evidence of first order serial correlation (Table 3).



(a) log(dividends) and model (1) fitted values

(b) Model (1) residuals

Figure 3. : Static model plots

The following autoregressive distributive lag model - ARDL(1,1) - was specified:

$$d_t = \alpha_0 + \alpha_1 d_t - 1 + \beta_0 e_t + \beta_1 e_t - 1 + \gamma t + \epsilon_t \tag{2}$$

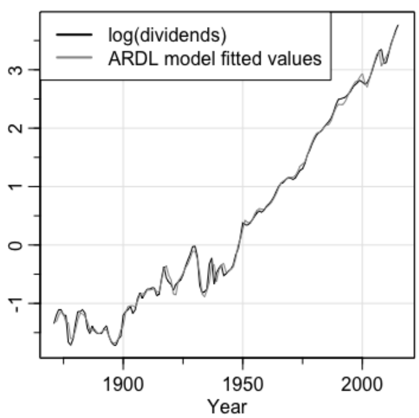
Table 4—: OLS Regression output for model (2)

	Estimate	Std.error	t value	p value
α_0	-2.04	1.242	-1.642	0.1027
α_1	0.6306	0.03494	18.049	$<2\times10^{-16}$
β_0	0.1950	0.02599	7.502	6.98×10^{-12}
β_1	0.1197	0.03289	3.642	0.000382
γt	0.0009867	0.000643	1.535	0.1271
	N =	144		
	R^2 =	0.9971		
	Adjusted R^2 =	0.9971		
	SER =	0.08551		
	$F(\alpha_0 = \alpha_1 = \beta_0 = \beta_1 = \gamma = 0) =$	6513	p value	$<2\times10^{-16}$

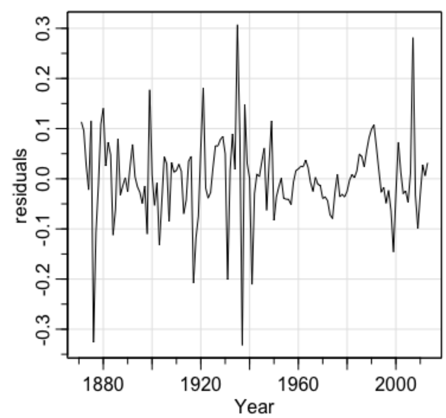
Table 5—: Regression diagnostics for model (2)

F test	$F(\beta_1 = \gamma = 0) =$	7.3808	p value =	0.0009
Durbin-Watson	DW =	1.7955	p value =	0.07485
Wald test	$W(\gamma = 0, \alpha_1 + \beta_0 + \beta_1 = 1) =$	29.648	p value =	3.649×10^{-7}

Coefficients for log earnings, lagged log dividends and lagged log earnings are significant at the 5% and 1% level. Coefficients for the intercept and time trend are not significant at the 5% level. The coefficients for lagged log earnings and the time trend are jointly significant. A plot of log dividends and the fitted values for the ARDL model (Fig 4a) show that this model does not over and under predict local maxima and minima to the extent that the static model does. A plot of the residuals (Fig 4b) shows less of a discernible pattern compared to the static model. Diagnostic tests provide evidence of no first order serial correlation (Table 5).



(a) log(dividends) and model (2) fitted values



(b) Model (2) residuals

Figure 4. : ARDL(1,1) model plots

Earlier it was noted that there has been instances where the more than 100% of earnings have been paid out as dividends in a given year. Dividends in the current period are associated with their value in the previous period. Dividends are weakly responsive to changes in earnings in the same period such that a 10% drop in earnings is associated with a 2% decrease in dividends. This indicates that firms in the 1871 to 2016 period prefer to delay adjustment to dividends after shocks in income. Where a shock in earnings has resulted in more than 100% of earnings being paid in dividends, the data shows that the pay-out ratio decreases to below one in the next year. The only exception to this is the years 1930 to 1933, where dividends took 4 years to adjust to a pay-out ratio below one after a shock in earnings at the beginning of the Great Depression.

In the long run, the elasticity of dividends to earnings is 0.85 (App 1). To find the standard error of the long run coefficient of earnings, the ARDL(1,1) model was been reparametised such that:

$$\Delta d_t = \alpha_0 + (\alpha_1 + \beta_0 + \beta_1)d_{t-1} + \beta_0(e_t - d_{t-1}) + \beta_1(e_{t-1} - d_{t-1}) + \epsilon_t \tag{3}$$

The following model was specified:

$$\Delta d_t = a_0 + a_1 d_{t-1} + b_0(e_t - d_{t-1}) + b_1(e_{t-1} - d_{t-1}) + e_t \tag{4}$$

Table 6—: OLS Regression output for model (4)

	Estimate	Std.error	t value	p value
a_0	-0.1339	0.01628	-8.232	1.20×10^{-13}
a_1	-0.3483	0.03232	-10.779	$<2\times10^{-16}$
b_0	0.2031	0.02558	7.942	6.05×10^{-13}
b_1	0.1154	0.03293	3.505	0.000614
	N =	143		
	R^2 =	0.5264		
	Adjusted R^2 =	0.5162		
	SER =	0.08593		
	$F(a_1 = b_0 = b_1 = 0)$ =	51.5	p value	$<2\times10^{-16}$

Table 7—: Regression diagnostics for model (4)

LR test		
Model (5)	Log Likelihood =	106.64
Model (1)	Log Likelihood =	151.29
Chisq =	89.298	
p value =	$<2.2\times10^{-16}$	

$$\Delta d_t = a_0 + b_0(e_t - d_{t-1}) + b_1(e_{t-1} - d_{t-1}) + e_t \tag{5}$$

The coefficient for lagged dividends is significantly different from 0, indicating that the sum of slope coefficients in the in the ARDL(1,1) model is significantly different from 1. A restricted model (5), where the coefficient of lagged log dividends in model (4) has been set to 0, has been specified and tested against the ARDL model. The results of the test (Table 7) provide evidence that the restriction is not supported by the observed data. As such, the long run elasticity of dividends with respect to earnings is not 1. This indicates that the long run ratio of dividends to earnings is not constant (App 2).

III. Conclusion

Dividends in the in S&P 500 in the 1871 to 2016 period are significantly associated with dividends in the previous year, and earnings in the current and previous year. There is evidence for a preference of firms to adjust dividends to shocks in earnings in the next year. As such, in years where there has been a large negative shock in earnings, firms have paid out over 100% of earnings in dividends that year and have paid less than 100% of earnings in dividends in subsequent years. The only case where this is not true is the beginning of the Great Depression where more than 100% of earnings were paid out as dividends for 4 years after an initial shock in earnings between 1929 and 1930. In the long run, the elasticity of dividends to earnings is 0.85. As such there is evidence that the ratio of dividends to earnings is not constant over the 1871 to 2016 period.

Mathematical Appendix

1. The long run relationship of dividends to earnings is given by:

$$d = \frac{\alpha_0}{1-\alpha_1} + \frac{\beta_0+\beta_1}{1-\alpha_1} e \Longrightarrow d = \Theta_0 + \Theta_1 e$$

$$\text{where } \Theta_0 = \tfrac{\alpha_0}{1-\alpha_1}; \Theta_1 = \tfrac{\beta_0+\beta_1}{1-\alpha_1} \tag{A1}$$

2. The derivation of the long run ratio of dividends to income is given by:

$$d = log(D); e = log(E)$$

$$\Longrightarrow log(D) = \Theta_0 + \Theta_1 log(E) \Longleftrightarrow D = \exp(\Theta_0) E^{\Theta_1}$$

$$\text{let K} = \exp(\Theta_0) \Longrightarrow \tfrac{D}{E^{\Theta_1}} = K \tag{A2}$$

N.B. Lower case letter denote logarithms of nominal variables. Upper case letters denote nominal variables.