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Testing the fed and the Graham & Dodd models: asymmetric vs. symmetric adjustment

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We examine the empirical validity of the Fed model and the Graham & Dodd model for five countries and over a time period spanning three decades by applying the Enders and Granger (1998) and Enders and Siklos (2001) threshold unit-root and cointegration tests. Our results support the hypothesis that the adjustment back to equilibrium is asymmetric.

I. Introduction

The 'Fed model' postulates that the aggregate equity earning yield (E/P) should equal the 10-year government bond yield (Y) in the long-run. This model has been first mentioned for the US in a July 1997 Federal Reserve Monetary Policy Report to Congress by Alan Greenspan and is now used by many strategists on US and nonUS stock markets.[1] A less restrictive model, suggested by Benjamin Graham and David Dodd (1934, 1951, 1962), presumes a linear relationship between the earning yield and the bond yield, which implies that stock prices tend to move to restore deviations from this equilibrium. Lander *et al*. (1997) find some support for this model in the US. They derive 1-month-ahead forecasts of S&P 500 returns and implement a market timing trading rule that outperforms a buy-and-hold strategy. Despite its popularity among practitioners, this kind of models suffers from a 'nominal illusion' by comparing a real quantity, E/P, to a nominal one, Y (see, e.g. Campbell and Vuolteenaho, 2004).

The preliminary graphical analysis suggests that the Fed model has been quite successful as a description of long-run equity valuation ratios rise and fall during the last three decades (at least for France, UK, US, see Figs 1–5) but movements in stock and bond prices are highly persistent.

The aim of this article is to examine the empirical validity of the Fed model and the Graham & Dodd model for five countries over a time period spanning three decades by applying the Enders and Granger (EG: 1998) and Enders and Siklos (ES: 2001) threshold unit-root and cointegration tests.

The article is organized as follows. Section II describes the asymmetric stationary/cointegration test procedure. Data description and symmetric/asymmetric cointegration test results are provided in Section III. Section IV concludes.

II. Cointegration and Asymmetric Adjustment

EG (1998) and ES (2001) extend the Dickey and Fuller (1981) and Engle and Granger (1987) framework to test for nonlinear stationarity and nonlinear cointegration. The residuals, $\hat{\mu}_t$, of the presumed cointegrating

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[1] See, e.g. 'Valuation Check', *Trilogy Advisors*, by Bill Sterling (June 2005). <www.trilogyadvisors.com>

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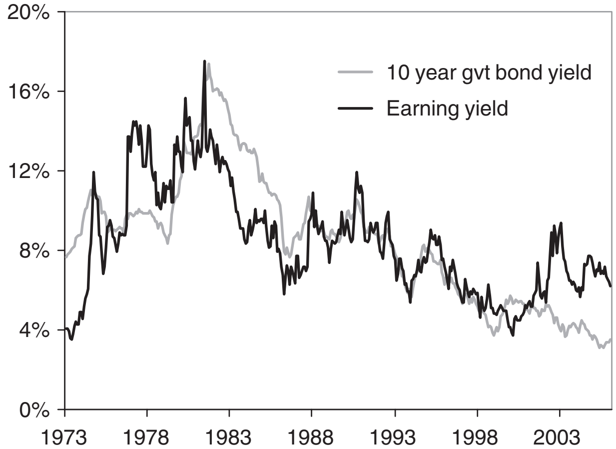

Fig. 1. France

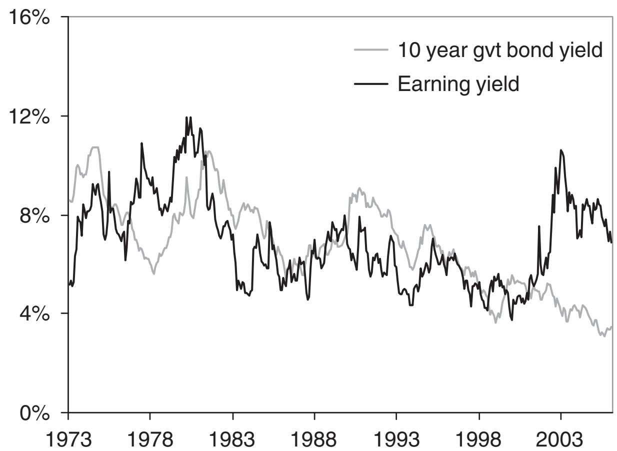

Fig. 2. Germany

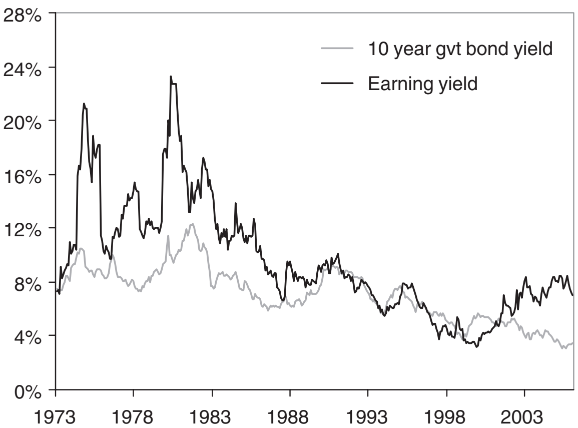

Fig. 3. Netherlands

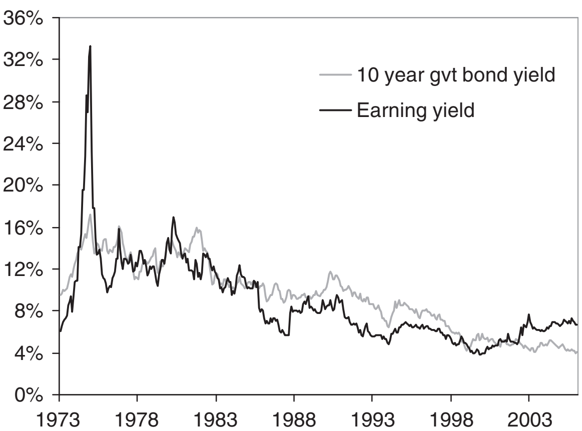

Fig. 4. UK

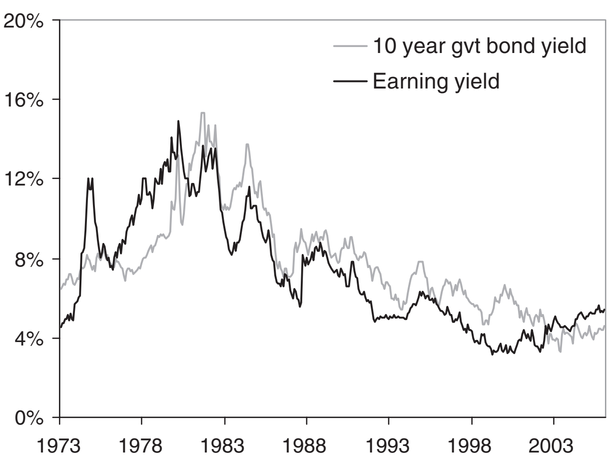

Fig. 5. US

relationship are used in:

$$\Delta\hat{\mu}_t = I_t\rho_1\hat{\mu}_{t-1} + (1 - I_t)\rho_2\hat{\mu}_{t-1} + \sum_{i=1}^{p} \gamma_i\,\Delta\hat{\mu}_{t-i} + \varepsilon_t \qquad (1)$$

where $I_t = [T_t, M_t]$, such that:

$$T_t = \begin{cases} 1, & \text{if } \hat{\mu}_{t-1} \geq \tau \\ 0, & \text{if } \hat{\mu}_{t-1} < \tau \end{cases} \qquad (2A)$$

$$M_t = \begin{cases} 1, & \text{if } \Delta\hat{\mu}_{t-1} \geq \tau \\ 0, & \text{if } \Delta\hat{\mu}_{t-1} < \tau \end{cases} \qquad (2B)$$

where τ denotes the value of the threshold. Equations 1 and 2A represent a Threshold Autoregressive Model (TAR) model, in which the indicator variable I_t depends on the previous period's level of $\hat{\mu}_{t-1}$. The adjustment is modelled by $\rho_1\hat{\mu}_{t-1}$ if $\hat{\mu}_{t-1}$ is above the threshold, and by $\rho_2\hat{\mu}_{t-1}$ if $\hat{\mu}_{t-1}$ is below the threshold.

Equations 1 and 2B represent a Momentum Threshold Autoregressive Model (MTAR) model, in which the indicator variable I_t depends on the previous period's change in $\hat{\mu}_{t-1}$. The adjustment is modelled by $\rho_1\hat{\mu}_{t-1}$ if $\Delta\hat{\mu}_{t-1}$ is above the threshold, and by $\rho_2\hat{\mu}_{t-1}$ if $\Delta\hat{\mu}_{t-1}$ is below the threshold.

The TAR model interprets departures from the equilibrium as creating forces to restore the long-run

Table 1. The Fed model: symmetric vs. asymmetric adjustment, 1973M1–2006M2

	ADF t-test	$\hat{\tau}$	ρ_1	ρ_2	Φ	$\rho_1 = \rho_2$	AIC
	Engle–Granger	TAR					
France	−2.83	0.161	−0.02 (−1.15)	−0.06 (−2.92)	4.90**	1.82	376
Germany	−2.14	−0.268	−0.01 (−0.47)	−0.08 (−3.69)	6.91**	8.90**	333
Netherlands	−2.55	0.348	0.06 (−2.85)	−0.02 (−1.04)	4.58*	2.43	387
UK	−2.94	−0.231	0.03 (−1.66)	−0.07 (−2.42)	4.27*	1.67	215
US	−2.83	−0.206	0.02 (−1.40)	−0.07 (−2.78)	4.82**	2.04	205
		MTAR					
France		−0.001	−0.07 (−3.46)	−0.01 (−0.89)	6.10**	4.17*	374
Germany		0.006	−0.06 (−3.49)	0.00 (−0.14)	6.10**	7.31**	335
Netherlands		0.029	0.01 (0.37)	−0.06 (−3.43)	5.95**	5.13*	385
UK		−0.017	0.06 (−3.29)	−0.00 (0.03)	5.40**	3.90*	212
US		−0.034	0.03 (−1.57)	−0.08 (−2.80)	5.09**	2.58**	205

Notes: ADF t-test indicates t-statistics of the augmented Dickey–Fuller test. TAR is defined by Equations 1 and 2A, MTAR is defined by Equations 1 with 2B. $\hat{\tau}$ denotes the (consistently) estimated threshold (Chan, 1993); ρ_1 and ρ_2, the estimated parameters of the (M)TAR models with t-statistics in parentheses. Φ and $\rho_1 = \rho_2$ denote the F-statistics for the null hypothesis of no cointegration and symmetry, respectively. The lag lengths are selected using the general to specific procedure (Hall, 1994). * and ** denote significance at 5% and 1% level (MacKinnon, 1991; EG, 1998; ES, 2001).

relationship if the size of the disequilibrium is larger than some threshold. The MTAR model can capture an accumulation of changes in the disequilibrium relationship below and above the threshold followed by a sharp movement back to the equilibrium position.

The no cointegration hypothesis (H_0: $\rho_1 = \rho_2 = 0$) is tested using specifically derived critical values provided by EG (1998) in an univariate context and ES (2001) in a multivariate context. The statistic testing this null hypothesis is noted. If the null hypothesis of no cointegration is rejected, the null hypothesis of symmetric adjustment (H_0: $\rho_1 = \rho_2$) can be tested using a standard F-test. To estimate consistently the threshold parameter, τ, Chan's (1993) method is used.[2]

III. Data and Empirical Evidence

Our data set consists of equity earning yield (Total Market Indexes) from Datastream for France, Germany, Netherlands, UK and US. The long-term bond yield we use is the 10-year government bond yield from IMF International Financial Statistics. The sample period ranges from January 1973 to February 2006 (monthly data).

In contrast to the Humphrey–Hawkins Greenspan report and Lander *et al.* (1997), we use current earnings because expected earnings (such as provided by the I/B/E/S database) are available from 1978 for the US but from 1987 for most European countries.

The logarithmic Fed model and Graham & Dodd model are defined respectively by:

$$\ln\left(\frac{E_t/P_t}{Y_t}\right) = \alpha_0 + \mu_t \tag{3}$$

and

$$\ln\left(\frac{E_t}{P_t}\right) = \alpha_0 + \alpha_1 \ln(Y_t) + \mu_t \tag{4}$$

Cointegration tests using both the Engle–Granger and the TAR and MTAR approaches are shown in Tables 1 and 2.[3] For each country, the estimated value of τ, ρ, ϕ and the associated AIC statistic are reported. The null hypothesis of no unit-root and no cointegration cannot be rejected at conventional

[2] The estimated residuals from the estimated cointegration relationship are sorted in ascending order. The largest and smallest 15% of these values are discarded and each of the remaining 70% of estimated residuals are considered as possible thresholds. For each of these possible thresholds, we estimates by ordinary least square an equation in the form of (3.4) and (3.5). The estimated threshold yielding the lowest residual sum of squares is deemed the appropriate estimate of the threshold. The lag-length p in Equation 1 is determined via Hall's (1994) general-to-specific approach starting with a maximum lag-length of $p = 8$.

[3] Preliminary test, results indicate that both E/P and Y are $I(1)$.

Table 2. Cointegration tests between the earning yield and the bond yield (The Graham & Dodd model): symmetric vs. asymmetric adjustment, 1973M1–2006M2

	ADF t-test	$\hat{\tau}$	ρ_1	ρ_2	Φ	$\rho_1 = \rho_2$	AIC
	Engle–Granger	TAR					
Canada	−3.46*	−0.174	0.02 (−1.36)	−0.04 (−2.08)	3.07	0.53	272
Germany	−3.12	0.215	−0.04 (−2.15)	−0.08 (−2.45)	5.67	2.23	277
Netherlands	−2.89	0.327	0.07 (−2.87)	−0.03 (−1.44)	5.11	1.82	391
UK	−3.43*	0.192	0.04 (−1.74)	−0.07 (−2.97)	5.85	0.83	185
US	−2.85	−0.015	0.01 (−0.95)	−0.07 (−3.22)	5.61	3.77	176
		MTAR					
France		0.022	−0.12 (−4.25)	−0.04 (−1.86)	10.71**	5.52*	315
Germany		0.002	−0.10 (−4.40)	−0.00 (−0.19)	9.70**	10.11**	269
Netherlands		0.030	0.00 (0.86)	−0.06 (−3.59)	6.45*	4.45*	388
UK		−0.020	0.08 (−4.22)	0.01 (0.62)	8.93**	6.85**	179
US		−0.049	0.01 (−0.91)	−0.14 (−4.56)	10.78**	13.92**	166

Notes: ADF t-test indicates t-statistics of the augmented Dickey–Fuller test. TAR is defined by Equations 1 and 2A, MTAR is defined by Equations 1 with 2B. $\hat{\tau}$ denotes the (consistently) estimated threshold (Chan, 1993); ρ_1 and ρ_2, the estimated parameters of the (M)TAR models with t-statistics in parentheses. Φ and $\rho_1 = \rho_2$ denote the F-statistics for the null hypothesis of no cointegration and symmetry, respectively. The lag lengths are selected using the general to specific procedure (Hall, 1994). * and ** denote significance at 5% and 1% level (MacKinnon, 1991; EG, 1998; ES, 2001).

significance levels with the Engle–Granger symmetric test. The MTAR model is the only one to reject the hypothesis of no cointegration and to reject symmetry in the error corrections at conventional significance levels except Germany with the Fed model. For this country, we reject the null that $\rho_1 = \rho_2$ with both TAR and MTAR models at the 1% level. As there is no presumption as to whether to use TAR or MTAR adjustment, ES (2001) recommend selecting the adjustment mechanism by a model selection criterion such as the AIC. This information criterion indicates the TAR model for Germany.

IV. Conclusions

This article has considered the relationship between the earning yield and the 10-year government bond yield for five countries over a time period spanning three decades. We applied the EG (1998) and ES (2001) threshold unit-root and cointegration tests and find that the adjustment back to equilibrium is asymmetric. These suggest that an extension of our work would be to investigate whether a nonlinear model can improve forecasts of stock returns based one the Fed model and Graham & Dodd model.

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