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FINANCIAL ECONOMICS | LETTER

Macroeconomic variables and long-term stock market performance. A panel ARDL cointegration approach for G7 countries

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Abstract: Based on the present value model for stock prices, we utilise a pooled mean group estimator for panel ARDL cointegration to estimate the long-run relationship between G7 stock prices and macroeconomic variables over the last 40 years. We find a positive long-run relation between stock prices, industrial production and consumer prices as well as a negative relationship with real 10-year interest rates.

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Keywords: cointegration; stock market; macroeconomy

Jel classification: G12; G7; C32; E44

1. Introduction

An important strand of empirical finance examines the long-run determinants of stock prices. According to the present value model, stock prices should depend upon factors that affect cash flow and risk. Thus, an examination of which macroeconomic variables proxy for these effects is important for both investors, in building portfolios, and academics, in modelling market behaviour. Recent work includes that of Bahmani-Oskooee and Saha (2018), who examine the relation between stock prices and exchange rates. Likewise, Cheah et al. (2017) consider exchange rates, while Tursoy (2019) considers the long-run relation between stock prices and interest rates.

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PUBLIC INTEREST STATEMENT

This article examines the long-run relationship between macroeconomic variables and the G7 stock markets. Theoretical models like the dividend discount model might link stock prices to macroeconomic variables like GDP, inflation, interest rates or money supply. We therefore estimate the long- and short-run relationship between stock prices and these variables. The results show that higher output and lower interest rates leads to higher stock prices in both the short- and long-run. In contrast, higher consumer prices lead to higher long-run but lower short-run stock prices. This change in the nature of the relation between stock and consumer prices is the key finding here. Higher inflation leads to an immediate fall in stock prices as it is likely to signal higher interest rates and greater macroeconomic risk. However, over the long-run stock prices rise with consumer prices, providing an inflation hedge.

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Furthermore, Alqaralleh (2020) study the relationship between inflation and stock returns whereas Humpe and McMillan (2016) analyse the equity-bond correlation. This paper seeks to consider whether key macroeconomic variables exhibit a long-run cointegrating relation with stock prices using a panel ARDL approach for the key G7 markets.

The present value model for stock price determination can be described by:

$$P_t = E_t \sum_{i=0}^{+\infty} \delta^{i+1} D_{(t+i)} \quad \text{with } \delta^{i+1} = \frac{1}{(1+r)^{i+1}} \quad (1)$$

where P_t is the stock price at the beginning of period t, D_t the dividend during period t, E_t the expectations conditioned on information at time t and r the discount rate. This model is used to derive an expected long-term linear relation between stock prices and dividends, which, in an aggregated stock market framework, has been successfully tested via cointegration by Campbell and Shiller (1988). As noted above, this model also serves to link macroeconomic factors to stock prices. Macroeconomic variables that influence future expected dividends or the discount rate should influence stock prices. Following this line of research, we test for a long-term relation between macroeconomic factors and G7 stock market indices.

In determining the macroeconomic variables, we are led by both theory and the empirical literature. Measures of economic output will influence corporate profits and dividends, thus, following Chen et al. (1986), we include industrial production. Interest rates directly impact the discount rate in the present value model, so we include long-term interest rates. The impact of inflation on stock prices is less clear. Fama and Schwert (1977) and Fama (1981) posit a negative effect as higher inflation leads to lower future output. A negative relation can also arise through the money illusion effect where investors discount with nominal as opposed to real rates (see, e.g., Campbell & Vuolteenaho, 2004). In contrast, Bodie (1976) argues for a positive effect on nominal returns (and no effect on real returns) through a Fisher effect.[1] An interesting historical perspective is provided by Antonakakis et al. (2017), who show the change nature of the stock price-inflation relation.

The literature on the long-run relation between macroeconomic variables and the stock market is primarily based on individual country analysis and the results of the size and sign of the above macroeconomic variables on stock prices is mixed and even contradictory (Humpe & MacMillan, 2009). We contribute to the literature by using a panel data approach and thus adding a cross-section dimension to the previous time series approach. This will increase efficiency in estimation as the panel approach enhanced the available degrees of freedom leading to more accurate estimation. As some macroeconomic variables, such as real interest rates, may be stationary in levels, and in contrast to earlier studies, we apply a pooled mean group panel ARDL approach that allows for a mixed order of integration in the variables within the cointegration relation. The results here should be of interest to academic and investors alike who are interested in understanding the determinants of stock price movements.

2. Data and empirical method

To examine the long-run relation between macroeconomic variables and the stock market, we specify the following model:

$$sp_{it} = \alpha_0 + \alpha_1 ip_{it} + \alpha_2 cpi_{it} + \alpha_3 10y_{it} + \varepsilon_{it} \quad (2)$$

where sp_{it} is the logarithm of real stock prices in period t for country i. The term ip_{it} is the logarithm of real industrial production, cpi_{it} the logarithm of the consumer price index, $10y_{it}$ the real interest rates and ε_{it} the random error term. Stock price and CPI data is obtained from the OECD with industrial production and 10-year bond yields from the IMF. All variables are collected monthly and the sample period is from December 1977 to August 2018.

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To model the long-term relation between the stock and macroeconomic variables we use the pooled mean group (PMG) estimator of Pesaran et al. (1999) for ARDL models with individual effects. The choice of a pooled regression is to enhance the number of observations (degrees of freedom), which are limited in macroeconomic studies due to the lower frequency of observations. This improves the accuracy of estimation. The ARDL approach is used due to its flexibility in controlling for variables with different degrees of integration. In particular consumer prices are sometimes found to be stationary in levels or stationarity in first differences (see inter alia Alqaralleh, 2020). Thus, Equation (2) is described as ARDL(p, q, …., q) model:

$$sp_{it} = \sum_{j=1}^{p} \lambda_{ij} sp_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij} x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{3}$$

where x_{it} is a (4 × 1) vector of our explanatory variables and μ_i are fixed effects (Baek, 2016). From Equation (3) the error-correction model becomes:

$$\Delta sp_{it} = \varphi_i \left(sp_{i,t-1} - \alpha_{0i} - \alpha'_i x_{it} \right) + \sum_{j=1}^{p-1} \lambda^*_{ij} \Delta sp_{i,t-j} + \sum_{j=0}^{q-1} \delta^*_{ij} \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{4}$$

where $\varphi_i = -(1 - \sum_{j=1}^{p} \lambda_{ij}), \alpha_i = -(\sum_{j=0}^{q} \delta_{ij}/\varphi_i), \lambda^*_{ij} = - \sum_{m=j+1}^{p} \lambda_{im}, j = 1, 2, .., p-1,$ and $\delta^*_{ij} = - \sum_{m=j+1}^{p} \delta_{im}$ $j = 1, 2, \ldots, q-1$. This approach allows that the intercepts, short-run coefficients and error variances to differ across the cross sections while determining the long-run parameters and the speed of adjustment to equilibrium. To apply the PMG method, the presence of unit roots in the panel must be verified. According to Kim et al. (2010), the PMG estimation of an ARDL regression provides consistent estimators for I(1) and I(0) variables as long as there exists a unique cointegration vector for the long-run relation among the variables. Hence, the PMG method can be applied if the variables are integrated of order zero or one. If the variables are of mixed order of integration, then the variables are tested for cointegration, for which we apply the Pedroni (1999) cointegration tests.

3. Results

Tables 1 and 2 present the panel unit root tests. Overall, the variables appear to be I(1) with the exception of 10 year yields that might be I(0).[2] The Pedroni (1999) cointegration test results are reported in Table 3. These show that six of the seven tests support a cointegrating relation given that the null hypothesis (of no cointegration) is rejected. As the PMG estimator is only consistent and efficient when the long-run coefficients are equal across countries (long-run homogeneity restriction), the mean group (MG) estimator proposed by Pesaran and Smith (1995) is estimated as an alternative. If the long-run homogeneity hypothesis is valid, the PMG is more efficient, and this can be determined by the Hausman test. The results of the test indicate that the null hypothesis of the long-run homogeneity cannot be rejected, even at the 10% level ($\chi^2(3) = 2.59$, p-value = 0.46). Thus, we argue that the PMG is preferable to the MG estimator.

Table 4 shows the panel PMG ARDL estimates. Here, in the cointegrating equation, all variables are significant with industrial production and CPI having a positive relation with stock prices whereas the coefficient for real interest rates is negative. In terms of the short-run parameters, we see slow equilibrium correction (2% per month), a change in output has a positive effect, while a change in both prices and interest rates have a negative effect.

For academics and investors, these results present several key conclusions. A positive long-run relation with CPI supports the idea that stocks can act as a hedge against inflation, although as we use real stock prices, this suggests that nominal stock prices move by more than consumer prices. In the short-run, inflation leads to a fall in prices as they signal higher interest rates and are likely to be associated with lower future growth. A view supported by the

Table 1. Panel unit root tests (Level)			
Variable	**Individual effects and trends**	**Individual effects**	**None**
ADF—Fisher Chi-square			
Stock prices	17.1658	15.8709	1.20248
Industrial production	14.7213	18.3671	0.69202
CPI	153.115***	150.646***	1.59453
10-year yield	37.4447***	19.4699	26.1829**
PP—Fisher Chi-square			
Stock prices	17.3041	15.5412	1.24119
Industrial production	17.1250	18.9658	0.81280
CPI	233.689***	525.009***	0,00006
10-year yield	42.8973***	24.4898**	28.5585**
Im, Pesaran and Shin W-statistic			
Stock prices	−0.91199	−0.91982	-
Industrial production	0.07157	−0.93332	-
CPI	−10.8784***	−9.32117***	-
10-year yield	−3.35115***	−1.47822*	-

Entries are panel unit root tests of Equation (3), statistical significance is denoted at 10% *, 5% ** and 1% ***.

Table 2. Panel unit root tests (1st difference)			
Variable	**Individual effects and trends**	**Individual effects**	**None**
ADF—Fisher Chi-square			
Stock prices	1242.66***	1068.99***	1102.29***
Industrial production	1103.34***	717.499***	808.368***
CPI	121.128***	25.8585**	41.7637***
10-year yield	1162.89***	1042.34***	1106.58***
PP—Fisher Chi-square			
Stock prices	1271.32***	1084.93***	1122.48***
Industrial production	1510.20***	986.989***	1150.74***
CPI	1265.43***	938.241***	816.607***
10-year yield	1408.72***	1130.96***	1193.22***
Im, Pesaran and Shin W-statistic			
Stock prices	−51.2469***	−48.1497***	-
Industrial production	−66.3004***	−61.6071***	-
CPI	−5.50818***	−2.39869***	-
10-year yield	−50.9507***	−52.4551***	-

Entries are panel unit root tests of Equation (3), statistical significance is denoted at 10% *, 5% ** and 1% ***.

negative relation between stocks and interest rates in both the short- and long-run. The negative relation may also arise from a money illusion effect. Higher economic output leads to higher stock prices as it signals both higher future cash flow and lower risk. Overall, these results support the present value model for stock prices and that key macro-variables can provide predictive power for their subsequent movement.

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Table 3. Pedroni cointegration test

Pedroni cointegration test results

	t-statistic	p-value	weighted t-statistic	p-value
Panel v-Statistic	4.7376	0.0000	5.0371	0.0000
Panel rho-Statistic	−2.2221	0.0131	−2.5816	0.0049
Panel pp-Statistic	−2.0066	0.0224	−2.3097	0.0105
Panel ADF-Statistic	−1.2491	0.1058	−1.7326	0.0416
Group rho-Statistic	−2.8028	0.0025		
Group pp-Statistic	−2.7258	0.0032		
Group ADF Statistic	−2.0426	0.0205		

Table 4. Panel ARDL estimates

G7 panel ARDL cointegration (1977M12–2018M8: Dependent variable: stock prices

Variable	Coefficient	Standard Error	t-Statistic	Probability
	Long Run Equation			
Industrial production	0.9159	0.2886	3.1738	0.0015
CPI	0.3089	0.1678	1.8411	0.0657
Real 10-year yield	−0.0460	0.0126	−3.6587	0.0003
Error-Correction (−1)	−0.0240	0.0051	−4.7105	0.0000
D(stock price(−1))	0.2549	0.0282	9.0423	0.0000
D(stock price(−2))	−0.0483	0.0153	−3.1673	0.0016
D(stock price(−3))	0.0686	0.0216	3.1714	0.0015
D(stock price(−4))	0.0171	0.0150	1.1410	0.2539
D(stock price(−5))	0.0759	0.0122	6.2338	0.0000
D(stock price(−6))	−0.0746	0.0160	−4.6710	00000
D(industrial prod.)	0.1584	0.0503	3.1500	0.0016
D(CPI)	−1.3040	0.2869	−4.5449	0.0000
D(real 10-year yield)	−0.0137	0.0041	−3.3532	0.0008
C	−0.0071	0.0047	−1.5029	0.1330

Selected Model: ARDL(7,1,1,1), AIC model selection with 12 lags.

4. Summary and conclusions

Using a pooled mean group estimator for panel ARDL cointegration we establish the nature of the relations between G7 stock prices and macroeconomic variables over the last 40 years. The results show that higher output and lower interest rates leads to higher stock prices in both the short- and long-run. In contrast, higher consumer prices lead to higher long-run but lower short-run stock prices. This change in the nature of the relation between stock and consumer prices is the key finding here. Higher inflation leads to an immediate fall in stock prices as it is likely to signal higher interest rates and greater macroeconomic risk. However, over the long-run stock prices rise with consumer prices, providing an inflation hedge. As we examine real stock prices, the positive long-run relation indicates that real stock prices rise by more than inflation and suggests a role for money illusion within stock price movements.

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Notes

1. We also consider the view that money supply might influence future inflation uncertainty and the discount rate (Rogalski & Vinso, 1977) but find it to be statistically insignificant.
2. Plots of the CPI series show non-stationary, upward trending, behaviour and are clearly I(1).

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