FINANCIAL ECONOMICS | LETTER

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

Andreas Humpe\(^1\)* and David G. McMillan\(^2\)

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.

Subjects: Macroeconomics; Econometrics; Investment & Securities

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.

ABOUT THE AUTHORS
Andreas Humpe is a Professor in Mathematics and Finance at the University of Applied Sciences Munich, Germany. He has a doctorate from the University of St Andrews and a MSc from the University of Aberdeen.

David G. McMillan is Professor in Finance at the University of Stirling. Prior to joining the University of Stirling, he held positions in the University of Aberdeen, Durham and St Andrews. Dr McMillan specialities are finance and econometrics, on which he has written at least 70 papers.

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.

© 2020 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.
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:

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

(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.³ 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:

\[ sp_{it} = \alpha_0 + \alpha_1 \hat{ip}_{it} + \alpha_2 cpi_{it} + \alpha_3 10y_{it} + \epsilon_{it} \]  

(2)

where \( sp_{it} \) is the logarithm of real stock prices in period \( t \) for country \( i \). The term \( \hat{ip}_{it} \) is the logarithm of real industrial production, \( cpi_{it} \) the logarithm of the consumer price index, \( 10y_{it} \) the real interest rates and \( \epsilon_{it} \) 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.
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:

\[ sp_t = \sum_{j=1}^{p} \lambda_j sp_{t-j} + \sum_{j=0}^{q} \delta_j x_{t-j} + \mu_t + \epsilon_t \]  

(3)

where \( x_t \) is a \((4 \times 1)\) vector of our explanatory variables and \( \mu \) are fixed effects (Baek, 2016). From Equation (3) the error-correction model becomes:

\[ \Delta sp_t = \phi_1 (sp_{t-1} - \alpha_0 - \alpha' t_k) + \sum_{j=1}^{p-1} \lambda_j \Delta sp_{t-j} + \sum_{j=0}^{q-1} \delta_j \Delta x_{t-j} + \mu_t + \epsilon_t \]  

(4)

where \( \phi_1 = -(1 - \sum_{j=1}^{p} \lambda_j), \alpha_t = -(\sum_{j=0}^{q} \delta_j/\phi_1), \lambda_j = -\sum_{m=j+1}^{p} \lambda_m, j = 1, 2, ..., p - 1 \), and \( \delta_j = -\sum_{m=j+1}^{p} \delta_m \).

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). 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 (\( \chi^2(3) = 2.59, p\text{-value} = 0.46 \)). 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
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.

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% ***.
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 |
|-------------------------------|-------------|----------------|-------------|-------------|
| 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     | 0.0000      |
| D(industrial prod.)           | 0.1584      | 0.0503         | 3.1500      | 0.0016      |
| D(CPI)                        | −3.3532     | 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.

Acknowledgements
This work was financially supported through the Open Access Publication fund of the Munich University of Applied Sciences (MUAS) [RR / 7120 / 54740 / 4187].

Funding
This work was supported by the Open Access Publication fund of the Munich University of Applied Sciences (MUAS) [RR / 7120 / 54740 / 4187].
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)).

References
Alqaralleh, H. (2020). Stock return-inflation nexus; revisited evidence based on nonlinear ARDL. Journal of Applied Economics, 23(1), 66–74. https://doi.org/10.1080/15403262.2019.1706828
Antonakakis, N., Gupta, R., & Tiwari, A. (2017). Has the correlation of inflation and stock prices changed in the United States over the last two centuries? Research in International Business and Finance, 42, 1–8. https://doi.org/10.1016/j.ribaf.2017.04.005
Boek, J. (2016). A new look at the FDI-income-energy-environment nexus: Dynamic panel data analysis of ASEAN. Energy Policy, 91, 22–27. https://doi.org/10.1016/j.enpol.2015.12.045
Bohmani-Oskooee, M., & Saha, S. (2018). On the relation between exchange rates and stock prices: A non-linear ARDL approach and asymmetry analysis. Journal of Economics and Finance, 42(1), 112–137. https://doi.org/10.1080/122197-017-9388-8
Bodie, Z. (1976). Common stocks as a hedge against inflation. The Journal of Finance, 31(2), 459–470. https://doi.org/10.1111/j.1540-6261.1976.tb01899.x
Campbell, J. Y., & Shiller, R. J. (1988). Stock prices, earnings, and expected dividends. The Journal of Finance, 43(3), 661–676. https://doi.org/10.1111/j.1540-6261.1988.tb04598.x
Campbell, J. Y., & Vuolteenaho, Y. (2004). Inflation illusion and stock prices. American Economic Review Papers and Proceedings, 94(2), 19–23. https://doi.org/10.1257/0002828041301533
Cheah, S.-P., Yiew, T.-H., & Ng, C.-F. (2017). A nonlinear ARDL analysis on the relation between stock price and exchange rate in Malaysia. Economics Bulletin, 37, 336–346. http://www.accessecon.com/Pubs/EB/2017/volume37/EB-17-V37-11-P30.pdf
Chen, N. F., Roll, R., & Rossi, S. A. (1986). Economic forces and the stock market. Journal of Business, 59(3), 383–403. https://doi.org/10.1086/296344
Fama, E. F. (1981). Stock returns, real activity, inflation and money. American Economic Review, 71(1), 545–565. DOI: 10.2307/1806180
Fama, E. F., & Schwert, G. W. (1977). Asset returns and inflation. Journal of Financial Economics, 5(2), 115–146. https://doi.org/10.1016/0304-405X(77)90014-9
Humpe, A., & MacMillan, P. (2009). Can macroeconomic variables explain long-term stock market movements? A comparison of the US and Japan. Applied Financial Economics, 19(2), 111–119. https://doi.org/10.1080/09603100701748956
Humpe, A., & McMillan, D. G. (2016). Equity-bond returns correlation and the bond yield: Evidence of switching behaviour from G7 markets. Credit and Capital Markets, 49(3), 415–444. https://doi.org/10.3790/ccm.49.3.415
Kim, D. H., Lin, S. C., & Suen, Y. B. (2010). Dynamic effects of trade openness on financial development. Economic Modelling, 27(1), 254–261. https://doi.org/10.1016/j.econmod.2009.09.005
Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. Oxford Bulletin of Economics and Statistics, 61(s1), 653–678. https://doi.org/10.1111/1468-0084.61.s1.14
Pesaran, M. H., Shin, Y., & Smith, R. P. (1999). Pooled mean group estimation of dynamic heterogeneous panels. Journal of the American Statistical Association, 94(446), 621–634. https://doi.org/10.1080/01621459.1999.10471156
Pesaran, M. H., & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. Journal of Econometrics, 68(1), 79–113. https://doi.org/10.1016/0304-4076(94)01644-F
Rogalski, J. R., & Vinso, J. D. (1977). Stock returns, money supply and the direction of causality. The Journal of Finance, 32(4), 1017–1030. https://doi.org/10.1111/j.1540-6261.1977.tb03306.x
Tursoy, T. (2019). The interaction between stock prices and interest rates in Turkey: Empirical evidence from ARDL bounds test cointegration. Financial Innovation, 5(1), 7. https://doi.org/10.1186/s40854-019-0124-6
