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ARTICLE

Stock return-inflation nexus; revisited evidence based on nonlinear ARDL

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ABSTRACT

Understanding the Stock Return-Inflation Nexus is a continuing concern among scholars. The main goal of the current study was to critically examine the view that the relation between stock return and inflation is potentially asymmetric. To capture the possibility of dynamic nonlinearity and, in turn, asymmetry, the nonlinear Autoregressive Distributed lag model (NARDL) was deployed. This study has identified that the responses of stock return are generally asymmetric. In other words, the results suggest that contractionary time appears to reduce the stock returns more than expansionary time does.

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Stock return; Inflationary regimes; Economic cycle phase; Nonlinear ARDL; G7 countries

1. Introduction

Awareness of the relationship between inflation and stock return is not recent, having perhaps been described first in the work of Fisher (1930). His seminal hypothesis was that inflation and the nominal assets return change one-for-one, whereas the real stock return is taken to be constant. Thus, inflation is recognized as independently driven through real stock returns.

Much of the available evidence in this regard supports this hypothesis. In his interesting analysis of the relationship between stock returns and inflation in a sample of highly inflation-prone countries, Choudhry (2001) identifies a positive relationship in the short-term asset returns between inflation and current stock market returns. Likewise, some authors have mainly reported that common stocks provide a hedge against inflation over a long run horizon (see, inter alia, Alagidede, 2009; Alagidede & Panagiotidis, 2010; Boudoukh & Richardson, 1993; Kaul, 1987). Other researchers shed light on the cross-sectional dependence issue using nonlinear models and assert that the Fisher hypothesis finds support in their panel data set see, among others, Li, Balcilar, Gupta, and Chang (2016); Omay, Yuksel, and Yuksel (2015); Gregoriou and Kontonikas (2010).

Empirical evidence from several studies, however, has indicated a serious challenge to the Fisher hypothesis and has come to conflicting conclusions (see Ang, Brière, & Signori, 2012; Worthington & Pahlavani, 2007; Gallagher & Taylor, 2002; among others). Early examples of studies into the fact that equity returns are not hedges against inflation is the work of Fama (1981). The results open new ground for studying more essential

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relationships between real activity and stock returns. Another study in this area is the work of Gultekin and Gultekin (1983), which consistently highlights the view that common stocks are a poor hedge against inflation.

The rather contradictory results in the above studies may be due to the fact that the linear models are not adequate in the presence of nonlinearity. Indeed, many macroeconomic and financial data such as the interest rates, stock returns and inflation incorporate nonlinear properties (Boswijk, Hommes, & Manzan, 2007; Brock & Hommes, 1998). Moreover, several explanations for such potential asymmetry in the relations between stock price and inflation have been proposed. The most likely cause of this nonlinearity is asymmetric hedging. That is to say, stock return is expected to be different for periods of inflation, as opposed to periods of deflation (see, among others, Bahloul, Mroua, & Naifar, 2017). In effect, adopting linear models may not be an appropriate way to explore the relation between stock returns and inflation and may provide misleading evidence. This suggests that, when nonlinearities are present, the response of the stock return's shocks may be asymmetric. However, only a handful studies have been found in the literature to give prominence to this asymmetrical relationship between inflation and stock returns (e.g. Ajaz, Nain, Kamaiah, & Sharma, 2017; Chuliá, Martens, & van Dijk, 2010; Zare & Azali, 2015). for an excellent review on such studies see Madadpour and Asgari (2019)

The present study, therefore, seeks to plug the gaps in the inflation–stock returns nexus by investigating this possible asymmetric relationship. The contribution of doing so is twofold. First, given the lack of consensus on such a nexus, new insights may be derived from adopting an asymmetric model such as the nonlinear Autoregressive Distributed Lag (ARDL) cointegration technique, which permits to incorporate the possibility of asymmetric effects of positive and negative changes in explanatory variables on the dependent variable. Second, this study for the first time uses an updated dataset for the G7, unlike the previous literature.

From the economic standpoint, the paper studied the G7 countries because these countries present the greatest economic instability in the world (see, Antonakakis and Badinger, 2016; Byrne & Davis, 2005). According to Dash, Maitra, Debata, and Mahakud (2019) such instability has have contributed significantly to variation in stock market returns and inflation changes at business cycle horizons in these countries. Hence it contributes to the risk for investors in the stock market. Thus, investors who take a position in any of the G7's stock exchange markets can reduce their risk by changing the holding period of a stock in different inflationary time and business cycle horizons (e.g. Diaz, Molero, & de Gracia, 2016; Fratzscher, 2008; among others). Moreover, these effects can become worldwide as G7 stock markets have been the trading platform for international market capitalization in last decades.

The findings of this research provide evidence of the asymmetric impact of inflation on stock returns. In specific, the impact of positive inflation is found to support Fisher's hypothesis that inflation moves one-to-one with stock returns. Nevertheless, the effect of negative inflation shock is found to be mixed. Further, considering IPI as a proxy for measuring the economic cycle, stock prices are more sensitive to the external shocks in economic activity. The insights gained from this study may help to understand the inconsistencies in the previous literature on this topic. That is to say, the conclusion that either Fisher's theory (Fisher, 1930) or Fama's hypothesis (Fama, 1981) is to be favored should not be separated from the inflationary regimes or the position of the economic cycle.

2. Asymmetric feedback and nonlinear ARDL

Asymmetries in financial series (such as stock return prices) are apparent as a puzzling phenomenon, due to the excessive fluctuation when financial markets finance systems. Further, the particular asymmetry in stock return prices may stem from the nonlinearity of such market fundamentals as the economic cycle and inflation (e.g., McMillan, 2003).

From the standpoint of modelling, asymmetric behavior occurs when the response to shocks in one phase of the financial cycle is different from the response in another. Consequently, models relying on linear assumptions may be incapable of generating asymmetric fluctuations (Canepa, Chini, & Alqaralleh, 2019; Sichel, 1993). For this reason, the use of a nonlinear approach in modeling such asymmetry will yield more reliable results.

This indicates the need to grasp more fully these asymmetries in the stock price adjustment process by using a particularly popular approach – to model the regimes as unobserved, but following a Markov process. A model such as the Nonlinear Autoregressive Distributed Lagged model (henceforward, NARDL), developed by Shin, Yu, and Greenwood-Nimmo (2014), has the ability to capture the potential asymmetry that lies in the relationship between inflation, economic growth and the movements of stock returns.

Following the work of Bahmani-Oskooee and Saha (2015), suppose the symmetric long run relation between stock return index(SR_t), inflation shock (inf_t), and the economic cycle (IPI_t) can be defined as

$$SR_t = \beta_0 + \beta_1 inf_t + \beta_2 IPI_t + \varepsilon_t \tag{1}$$

Where β_i are the long-run parameters to be estimated and ε_t is the white-noise error term.

The Model in Eq. (1) can be modified to address the asymmetric effect such that the vector of the variables (inf_t) and (IPI_t) is decomposed into its positive and negative sum. This decomposition of the vector can be written as

$$inf_t = inf_0 + \sum_i^t \max(\Delta inf_i, 0) + \sum_i^t \min(\Delta inf_i, 0) \tag{2}$$

$$IPI_t = IPI_0 + \sum_i^t \max(\Delta IPI_i, 0) + \sum_i^t \min(\Delta IPI_t, 0) \tag{3}$$

where **max**$(\cdot)$ stand for the positive change, while **min**$(\cdot)$ in the considered variables.

The nonlinear long-run error correction can, then, be formulated in the NARDL form, in which, both the long-run equilibrium relationship and the dynamic adjustment process are allowed to vary between the regimes defined by the partial sums in Eq (2) and Eq. (3) as follows:

$$\begin{aligned}\Delta SR_t = \delta_0 + \rho SR_{t-1} + \vartheta_1 inf_t^+ + \vartheta_2 inf_t^- + \vartheta_3 IPI_t^+ + \vartheta_4 IPI_t^- + \sum_{i=1}^{P-1} \Delta SR_{t-i} + \\ \sum_{i=1}^{q-1} (\beta_i \Delta inf_{t-i}^- + \gamma_i \Delta inf_{t-i}^+ + \theta_i \Delta IPI_{t-i}^- + \varphi_i \Delta IPI_{t-i}^+) + \varepsilon_t\end{aligned} \tag{4}$$

The set of partial sum coefficients ($\beta_i, \gamma_i, \theta_i, and\ \varphi_i$) in Equation (4) will be assessed to judge whether the variation of inflation and economic status has an asymmetric impact on the stock return. A reasonable approach to tackle this issue is to test the null hypotheses for each variable of the form

$$H_0;\ \beta_i = \gamma_i \tag{5}$$

$$H_0;\ \theta_i = \varphi_i \tag{6}$$

Equation (5) tests the asymmetric effect of the inflation, whereas Equation (6) tests the hypothesis of the economic status. Based on the Wald test, if both partial sums have the same signs and their sizes are not statistically different from one another, it may be concluded that the considered variables have asymmetric effects.

3. Data

Following the influential works in this field (see, e.g. Fama, 1981; Gallegati, 2008), we make use of a monthly stock prices index and the Consumer Price Index (CPI). Further, we use the Industrial Production Index as a proxy for economic activity to signify the importance of the economic cycle. The data were collected monthly over the period January 2000 to January 2019 for the G7 countries. As highlighted in the introduction, the G7 countries merit special attention because they provide extreme examples of financial instability and unsustainable asymmetric cycles (see, inter alia, Alqaralleh, 2019). To calculate the inflation and stock returns, the log differences of real stock prices and CPI were computed.

Table 1 presents the summary statistics for the variables that were considered. Almost all of these variables exhibit positive skewness (with some exceptions) as well as high values of kurtosis, implying that the asymmetric model is appropriate. Further statistical tests revealed that the series is cointegrated of order one at most, since we do not reject the null hypothesis of the KPSS tests. It is worthy to mention that we established that none of the variables is integrated of order 2.

Table 1. Descriptive statistics and unit root test.

		Std. Dev.	Skewness	Kurtosis	Jarque-Bera	KPSS	Integration order
US	**IPI**	0.023	−0.271	2.105	[0.006]	[0.116]	*I*(1)
	INF	0.003	−1.318	12.603	[0.000]	[0.259]	*I*(1)
	SR	0.018	−0.770	4.570	[0.000]	[0.273]	*I*(0)
UK	**IPI**	0.023	−0.020	1.467	[0.000]	[0.133]	*I*(1)
	INF	0.075	−11.214	138.822	[0.000]	[0.346]	*I*(0)
	SR	0.017	−0.654	3.823	[0.000]	[0.104]	*I*(0)
Canada	**IPI**	0.024	−0.354	4.037	[0.001]	[0.161]	*I*(1)
	INF	0.004	1.746	13.665	[0.000]	[0.313]	*I*(0)
	SR	0.018	−1.024	5.938	[0.000]	[0.129	*I*(0)
Germany	**IPI**	0.044	−0.219	1.558	[0.000]	[0.390]	*I*(1)
	INF	0.004	0.409	4.849	[0.000]	[0.281]	*I*(0)
	SR	0.026	−0.917	6.139	[0.000]	[0.165]	*I*(0)
France	**IPI**	0.022	−0.062	1.728	[0.000]	[0.218]	*I*(1)
	INF	0.003	−0.287	3.608	[0.036]	[0.365	*I*(0)
	SR	0.022	−0.612	3.887	[0.000]	[0.159]	*I*(0)
Italy	**IPI**	0.044	0.016	1.348	[0.000]	[0.128]	*I*(1)
	INF	0.008	−0.269	4.672	[0.000]	[0.201]	*I*(1)
	SR	0.026	−0.379	3.655	[0.009]	[0.327]	*I*(0)
Japan	**IPI**	0.029	−0.357	4.749	[0.000]	[0.149]	*I*(1)
	INF	0.003	1.182	10.706	[0.000]	[0.351]	*I*(0)
	SR	0.025	−0.768	4.519	[0.000]	[0.292]	*I*(0)

P-value presented between square brackets.

4. Empirical results

The first set of analyses sought evidence that stock returns and inflation, as well as economic growth, have long-run cointegration. Its worthy noting that detecting asymmetry in the considered series is important since traditional Gaussian models are incapable of generating asymmetric fluctuations. Evidence of this asymmetry may guide empirical investigators toward a particular class of nonlinear specifications able to model asymmetric response. Therefore, prior to attempting any model estimation, one should show the presence of nonlinearity in the series. Following the extensive literature for test of nonlinearity (e.g. Canepa et al., 2019; Hasanov & Omay, 2008; Omay, 2011), this can be done by using LM-test following the work of Luukkonen et al. (1988). The authors highlight that the linearity can be tested using the Lagrange Multiplier (LM), which is asymptotically χ^2-distributed, under the null hypothesis (e.g. Omay & Hasanov, 2010). Since the nonlinearity tests are sensitive to autocorrelation, we first choose the optimal lag order p of the linear model and tests this order against any misspecification.[1] It is worthy noting that the maximal lag order of the AR(p) model has been tested against presence of ARCH effects since this effect in the residual has far-reaching consequences on the autoregressive estimated AR models. Once we define the optimal linear$AR(P)$, the Lagrange Multiplier (LM) is used to verify the presence of Linearity. As shown in Panel A of Table 2, the presence of ARCH effects is rejected in all cases. Moreover, the linearity is rejected in all cases since the $P-$ value is less than 5% and, hence, we accept the nonlinearity.

Having confirmed our conjecture that a nonlinear specification needs to be used to model the series at hand, the next test in this study sought to find evidence of nonlinearity in the long-run between the variables. Based on the bound test, as shown in panel B of Table 2, evidence of cointegration among the variables could be found, since the F statistics were found to be less than the lower bound critical and, thus, the null hypothesis of no cointegration is rejected (as suggested by the p-values). After testing for the presence of cointegration, the Wald tests for symmetry was applied to rule out the possibility that this relation is asymmetric. According to Panel C of Table 2, the Wald test for symmetry shows that in all cases the NARDL with asymmetry

Table 2. Cointegration and long run asymmetry tests.

	US	UK	Canada	Germany	France	Italy	Japan
Panel A; Linearity tests							
F-statistic	[0.002]	[0.017]	[0.001]	[0.028]	[0.004]	[0.007]	[0.018]
Remaining ARCH	1.294	1.104	1.924	1.451	1.632	1.164	0.983
	[0.264]	[0.356]	[0.106]	[0.226]	[0.207]	[0.354]	[0.423]
Panel B; Bound Test							
F-statistic	2.492	3.131	2.523	3.827	2.816	2.996	2.310
	[0.044]	[0.016]	[0.031]	[0.002]	[0.036]	[0.012]	[0.045]
Panel C; Wald Long Run Asymmetry test							
t-statistic	2.676	4.534	4.318	2.847	2.321	2.947	3.508
	[0.020]	[0.000]	[0.000]	[0.005]	[0.021]	[0.004]	[0.001]
F-statistic	7.810	20.555	18.643	8.105	5.385	8.685	12.306
	[0.029]	[0.000]	[0.000]	[0.005]	[0.021]	[0.004]	[0.001]

The critical values have been obtained from Pesaran et al. (2001) for the lower and upper bound as, respectively, I (0) = 4.01 and I (1) = 5.07. P-value presented between square brackets.

[1]The lag structure of the model is selected by applying Schwarz Information Criterion (SIC).

outperformed the symmetric ARDL. It is therefore likely that ignoring such nonlinearity in modeling the relationship will result in spurious conclusions.

On completion of the cointegration and asymmetric tests, the process of parameter estimation was carried out. The main findings from this analysis are summarized in Table 3. The results show that the statistically significant estimated results further support the asymmetrical effect of the changes in the positive (negative) inflation and economic status proxied by the change in the industrial production index. In other words, the relationship between stock returns and inflation varies in different economic status.

As can be seen from Table 3, first, the short-run effect indicates an asymmetric effect, since the coefficient associated with $(DINF_P)$ and $(DINF_N)$and their lagged variables was in most cases found significant. Such asymmetry in the short run is evident because the

Table 3. NARDL estimated results.

	US	UK	Canada	Germany	France	Italy	Japan
SR (−1)	−0.961*	−0.892*	−0.735*	−0.957*	−0.942*	−0.982*	−0.934*
	(0.070)	(0.066)	(0.102)	(0.066)	(0.069)	(0.067)	(0.115)
INF_N (−1)	−0.657**	−0.517**	−0.432**	0.483**	−0.597**	−0.607**	−0.667**
	(0.280)	(0.202)	(0.204)	(0.217)	(0.203)	(0.315)	(0.317)
INF_P (−1)	−0.578**	−0.779**	−0.396**	−0.284**	−0.612**	−0.621**	−0.705*
	(0.283)	(0.315)	(0.159)	(0.126)	(0.295)	(0.255)	(0.289)
IPI_N (−1)	−0.126**	−0.267**	−0.020**	−0.251**	−0.197**	−0.159**	−0.129**
	(0.061)	(0.086)	(0.009)	(0.084)	(0.086)	(0.071)	(0.071)
IPI_P (−1)	0.253**	0.155	0.048	0.261**	0.218**	0.247**	0.182**
	(0.117)	(0.153)	(0.030)	(0.142)	(0.104)	(0.086)	(0.091)
DINF_P	1.806*	1.141*	0.487**	1.007**	−0.551	−1.177**	0.564
	(0.839)	(0.500)	(0.210)	(0.553)	(0.724)	(0.566)	(0.725)
DINF_P (−1)	1.750**	_	0.681	_	_	−0.512	_
	(0.770)	_	(0.596)	_	_	(0.328)	_
DINF_P (−2)	_	2.059*	−0.351**	−1.013**	1.288	_	1.440*
	_	(0.477)	(0.160)	(0.564)	(0.819)	_	(0.578)
DINF_N	−1.542**	_	0.572	1.007**	0.782	1.197**	−0.464**
	(0.726)	_	(0.455)	(0.553)	(1.027)	(0.548)	(0.267)
DINF_N (−1)	0.628	1.290*	1.226**	−0.055*	1.399**	−0.422	−0.082
	(0.850)	(0.511)	(0.539)	(0.021)	(0.704)	(0.498)	(0.071)
DINF_N (−2)	_	0.530**	1.175**	−0.352	_	1.750**	−0.982**
	_	(0.204)	(0.491)	(0.202)	_	(0.770)	(0.409)
DIPI_P	−1.612**	0.698	−0.557**	−1.232*	1.329	_	−0.518
	(0.874)	(0.463)	(0.271)	(0.416)	(0.492)	_	(0.469)
DIPI_P (−1)	1.007	_	−0.630	_	_	0.661	_
	(0.742)	_	(0.425)	_	_	(0.516)	_
DIPI_N	4.259*	−0.090**	1.658	−1.219*	0.421**	0.900**	0.256*
	(0.777)	(0.045)	(0.477)	(0.469)	(0.148)	(0.419)	(0.049)
DIPI_N (−2)	−0.982	0.828**	−0.518**	−0.592**	−0.555	0.470*	−0.421**
	(0.709)	(0.380)	(0.230)	(0.284)	(0.445)	(0.150)	(0.272)
DSR (−1)	−0.068	0.363**	−0.094	−0.077**	−0.137**	−0.130**	−0.105**
	(0.051)	(0.143)	(0.090)	(0.048)	(0.055)	(0.053)	(0.096)
Panel B; Diagnostics Tests							
Adj- R^2	0.544	0.552	0.461	0.508	0.476	0.526	0.455
$\chi^2 - H$	[0.013]	[0.025]	[0.007]	[0.002]	[0.037]	[0.031]	[0.046]
ARCH test	[0.120]	[0.192]	[0. 312]	[0.097]	[0.132]	[0.207]	[0.219]
$\chi^2 - LM$	[0.143]	[0.687]	[0.169]	[0.492]	[0.680]	[0.805]	[0.727]

1. Sig. Codes: *: 1%, **:5%.
2. Standard error between parentheses.
3. $\chi^2 - H$, ARCH test and $\chi^2 - LM$explain the p-value of the heteroscedasticity, ARCH- effects and Breusch-Pagan-Godfrey tests for Serial Correlation, respectively.
4. Some lagged variables are automatically removed in order to select the appropriate model specific with appropriate lags.

Table 4. Long-run asymmetric effects.

	US	UK	Canada	Germany	France	Italy	Japan
INF_N (−1)	−0.684	−0.580	−0.588	0.505	−0.633	0.618	0.714
INF_P (−1)	−0.601	−0.873	−0.539	−0.297	−0.650	−0.632	−0.755
IPI_N (−1)	−0.131	−0.300	−0.027	−0.262	−0.209	−0.162	−0.138
IPI_P (−1)	0.263	0.062	0.066	0.273	0.231	0.251	0.195

coefficient of the negative inflation is different from that of the positive one. Second, the Long-Run Asymmetric effects (shown in Table 4) indicated that a positive change in inflation negatively affects the stock returns. In specific, in all the countries considered, a 1% increase in negative inflation causes a decrease of around 0.30% – 0.87% in stock returns. However, the impact of negative inflation was found to be mixed: Italy, Japan, and Germany were positively affected, whereas, the rest of the sample was found to move one-to-one with inflation.

These long-run coefficients provide further support for previous conclusions and suggest that cointegration between inflation and the return index is asymmetric. The coefficients related to downward changes in the CPI are higher than those associated with upward changes.

Third, with regard to the position of the economic cycle, the results show that the return during the contraction period (identified by a negative industrial index) was negatively estimated to have the lowest impact in Canada (around 0.03%) and the highest impact in the UK (around 0.3%). During periods of expansion, a 1% increase in economic growth (indicated by a positive industrial index) causes around a 0.06% increase in the UK stock return and a return of around 0.27% in Germany, the highest impact recorded. These results endorse the studies that found a positive relationship between stock returns and real economic activity (see, for example, Chen, Roll, & Ross, 1986; Humpe & Macmillan, 2009; Ratanapakorn & Sharma, 2007; Tiryaki, Ceylan, & Erdoğan, 2019).

Finally, further statistical tests were applied to check how well the asymmetry was modelled in the NARDL model and, thus, to verify whether the estimated parameters were reliable. As shown in panel B of Table 3, we concluded that the NARDL model adopted in the study is well specified, since it lets us accept the null hypothesis that there is no ARCH effect, no serial correlation, and the model is homoscedastic. This is what is suggested by the ARCH effect test, Breusch–Godfrey serial correlation and heteroscedasticity test.

5. Conclusion

The relationship between stock returns and inflation could be negative, positive, or statistically insignificant. This study set out to evaluate this relationship by considering the possibility of an asymmetrical response among the variables. To this end, the analysis was based on a nonlinear Autoregressive Distributed lag model (NARDL) which was able to capture the dynamic asymmetry in the conditional mean of e series.

This study has found that the effects of the changes in the industrial production index (as a proxy for the economic cycle) and in inflation on stock returns are generally asymmetric, and the effects and asymmetry of the independent variables on stock returns are greater in the downward phase than in the upward phase of the economic cycle. These

findings are in line with the work of Bahmani-Oskooee and Saha (2015) and (Ajaz et al. (2017). The findings reported here shed new light on the importance of different inflationary and economic regimes for investment decisions. In other words, the inflation risk and also the contraction time can be dealt with by changing the holding period of a stock.

Disclosure statement

No potential conflict of interest was reported by the author.

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