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ASYMMETRY IN THE STOCK PRICE RESPONSE TO MACROECONOMIC SHOCKS: EVIDENCE FROM THE KOREAN MARKET

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Abstract. This study investigates stock price movements in response to macroeconomic shocks, allowing for asymmetry in this relationship. Given Ferson's (1989) finding that large and small stocks can exhibit different risk behaviors, we examine the behaviors of the KOSPI and KOSDAQ stock markets in response to changes in the price level, real interest rate, and real USD/KRW exchange rate using simple and nonlinear autoregressive-distributed lag (ARDL) models. We find that the long-run effects of macroeconomic shocks are relatively insignificant under the simple ARDL model, whereas a significant and negative long-run effect is found for almost every explanatory variable–market pair under the nonlinear model. In addition, we find that the long-run effects of stock price shocks on macroeconomic variables are more significant under the nonlinear model. Overall, the results imply that it is difficult to identify the relationship between macroeconomic variables and stock price dynamics without considering asymmetry.

Keywords: asymmetric relationship, autoregressive-distributed lag, emerging market, macroeconomic shocks, KOSDAQ, KOSPI.

JEL Classification: C22, E44, G12.

Introduction

Academic research has been investigating the dynamic relationship between stock prices and macroeconomic variables for decades. As Flannery and Protopapadakis (2002) point out, macroeconomic variables can be regarded as priced risk factors because they affect the cash flows and discount rates of numerous firms simultaneously, making it difficult to diversify away from the associated stock price changes. This notion is implied by, for instance, informed trading before macroeconomic policy announcements, as shown in the recent studies

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of Bernile, Hu and Tang (2016) and Lee, Ryu and Kutan (2016). Thus, following the pioneering works of, for example, Chan, Chen and Hsieh (1985) and Chen, Roll and Ross (1986), numerous studies have investigated the relationship between stock price changes and macroeconomic shocks. However, as Bianchi, Guidolin and Ravazzolo (2017) mention, a large group of studies, including those of Chan, Karceski and Lakonishok (1998), Schwert (1981), and Shanken and Weinstein (2006), find that macroeconomic variables have a limited effect on stock returns. Thus, the mechanism through which macroeconomic variables explain stock prices remains an open question.

An alleged obstacle that prevents researchers from identifying the specific relationship between macroeconomic shocks and stock returns is the nonlinearity of the relationship. A number of previous studies, including Guidolin, Hyde, McMillan and Ono (2014), Maasoumi and Racine (2002), and Qi (1999) argue that nonlinear models should be used to predict stock returns based on economic variables. One possible rationale for this argument is Timmermann's (2008) statement that linear models do not reflect investors' learning processes or structural changes in the underlying data-generating process. Furthermore, as shown in Ryu, Kim and Yang (2017) and Yang and Zhou (2016), who reveal that investor sentiment affects asset returns, the behavioral characteristics of investors can complicate the relationship between macroeconomic shocks and stock returns. Thus, problems may arise if nonlinearity is not considered when modeling this relationship.

This study investigates the effect of incorporating the nonlinearity (or, more specifically, asymmetry) in the relationship between the aggregate stock price level and the macroeconomic variables in an empirical analysis that uses linear models to identify the relationship. Specifically, we investigate the relationship between stock market dynamics and macroeconomic variables in the Korean market, which is a leading and influential emerging market. We construct simple and nonlinear autoregressive-distributed lag (ARDL) models to determine the effects of including the asymmetry in this relationship in the estimation model. We are motivated by the studies on emerging markets by Han, Guo, Ryu and Webb (2012), Lee and Ryu (2013), and Ryu and Shim (2017), which show that stock returns have asymmetric relationships with related variables, such as volatility. Using the ARDL framework, we can obtain consistent estimates of long-run coefficients, regardless of the existence of unit roots, as shown in Pesaran and Shin (1999).

We choose inflation, the real interest rate, and the real exchange rate as the independent variables. A large strand of the literature analyzes and tries to explain the negative relationship between stock returns and inflation (Lee, 2010). Therefore, inflation should be included as an independent variable.[1] In addition, including exchange and interest rates is appropriate, given that several studies report a significant relationship between stock prices and these two variables.[2] Most previous studies find a negative relationship between the interest rate and stock prices. Kim (2003) argues that this result can be attributed to reduced capital

[1] See, for instance, Fama (1981), Geske and Roll (1983), and Stulz (1986) for analyses of the negative relationship between stock prices and inflation.

[2] Studies such as Harasty and Roulet (2000), Jensen, Johnson and Bauman (1997), and Lee (1997) examine the relationship between stock prices and interest rates. The effects of exchange rates on stock prices have been investigated by, for instance, Bartov and Bodnar (1994), Griffin and Stulz (2001), and Ma and Kao (1990).

expenditures and to portfolio rebalancing through bond buying. Because this negative relationship is amplified by large exogenous shocks when the Bank of Korea, much like the U.S. Federal Reserve, makes a target rate adjustment, the interest rate must be considered as an independent macroeconomic factor that affects stock prices. Furthermore, examining the effects of exchange rates on stock prices is meaningful, given the two competing schools of thought (i.e., stock-oriented and flow-oriented models) that try to explain the relationship between the two, but from opposite directions. Given the finding of Moore and Wang (2014) that flow-oriented models are more applicable in emerging countries and stock-oriented models are more applicable in developed countries, we can determine how developed the Korean market is by investigating which model better explains the market.

The Korea Composite Stock Price Index (KOSPI) and the Korea Securities Dealers Automated Quotation (KOSDAQ) markets are the primary and secondary stock markets in Korea, respectively. As such, we use monthly price data from the two markets for the period from July 1996 to December 2016 as a proxy for aggregate stock prices after a price level adjustment. In addition, the GDP deflator, price-level-adjusted 91-day certificate of deposit interest rate, and price-level-adjusted USD/KRW exchange rate are used as proxies for the price level, real interest rate, and real exchange rate, respectively.

Our empirical results show that most macroeconomic variables reveal more significant long-run effects on the stock price level when a nonlinear ARDL model is used. Furthermore, the relationship between the KOSPI market and the real exchange rate is found to be bidirectional, whereas the relationship between the KOSDAQ market and the real exchange rate is unidirectional. Overall, these results suggest that the asymmetry in the relationship between stock prices and macroeconomic variables can make it difficult to identify these relationships using a linear model. Therefore, incorporating asymmetry is necessary to investigate the effects of macroeconomic variables on stock price levels. In addition, the results imply that the impact of macroeconomic policy on the stock market should be measured while considering the nonlinearity in relationship. Indeed, Agnello, Castro and Sousa (2012) reveal that the U.S. fiscal policy exhibits a nonlinear relationship with aggregate wealth and asset prices.

The remainder of this paper is organized as follows. Section 1 reviews the relevant literature. Section 2 summarizes the simple and nonlinear ARDL models. Section 3 describes the Korean market and the dataset used in this study, and Section 4 reports the results of the empirical analysis.

1. Literature review

The relationship between stock prices and macroeconomic shocks has been studied in the field of economics and finance. Chan, Chen and Hsieh (1985) examine the firm-size effect using a multifactor pricing model, finding that risk measures of the changing risk premium and the changing state of the economy can explain most of the size effect. Chen, Roll and Ross (1986) investigate whether fluctuations in macroeconomic variables are priced risk factors in the stock market and show that macroeconomic risk is a significant factor. However, a different strand of literature reports a non-significant relationship between macroeconomic variables and stock returns. Schwert (1981) tests S&P500 spot returns and finds only a weak and slow response of daily stock prices to news on inflation. Cutler, Poterba and Summers (1989) employ the VAR model to identify and estimate the relation between macroeconomic news and monthly stock return variance. They reveal that macroeconomic shocks and news can explain no more than one-third of the return variance. These inconsistent findings imply that it is not an easy task to identify the relationship between macroeconomic variables and stock prices.

A major factor that hinders the identification of the relationship is its complicated and nonlinear nature. The nonlinearity can stem from a number of issues. Timmermann (2008) points out that data-generating processes for stock price dynamics change over time, and that individual models can only reveal evidence of local predictability. Yang and Zhou (2016) argue that investor sentiments and individual investor trading generate anomalies in stock price dynamics. Yang, Ryu and Ryu (2017) reveal that stock prices are linked to behavioral factors, such as investor sentiment, especially in the case of small-cap, low-priced, and highly volatile stocks with a high book-to-market ratio and excess returns. This complexity induces a need to consider numerous factors or, at least, nonlinearity in the relationship when modelling the relationship between macroeconomic factors and stock returns.

Because it is impractical to include all relevant factors in a model, several studies have suggested using nonlinear models to forecast stock returns using economic variables. Qi (1999) specifies the relationship between excess returns and major economic variables recursively using a neural network model. This model produces a smaller estimation error and a higher correlation with returns than those of a linear regression model. Maasoumi and Racine (2002) employ a metric entropy measure of dependence to characterize the nonlinearity in the dependence structure of stock return series and reveal a nonlinear unconditional serial dependence within the return series. Guidolin, Hyde, McMillan and Ono (2014) examine the forecasting ability of linear and non-linear models in the spot and bond markets of the United Kingdom. They conclude that the asset returns require that non-linear dynamics be modeled. Given this evidence, it seems necessary to consider nonlinearity when modeling the relationship between macroeconomic variables and stock prices.

The classic ARDL framework can be developed further to reflect nonlinearity, while maintaining consistency in long-run coefficient estimations. Although the ARDL model has been employed in economic studies for decades, appearing in early studies such as Bewley (1979), its current popularity as a tool in cointegration analyses stems from recent works. Pesaran and Shin (1999) show that the long-run coefficient estimates of ARDL model are asymptotically normal and consistent, regardless of whether the variables follow an $I(0)$ or an $I(1)$ process. Pesaran, Shin and Smith (2001) demonstrate that an error-correction approach based on the ARDL model can be applied to small samples and derive the critical values for an F-bounds test of long-run coefficient estimates. More recently, Shin, Yu and Greenwood-Nimmo (2013) extend the simple ARDL model by separating variables into positive and negative partial sums to construct a nonlinear ARDL model, thereby further specifying the asymmetric and nonlinear relationship. This approach enables using a relatively simple nonlinear model within the linear regression framework.

2. Methods of study

An ARDL model is a linear time series model that includes lag terms of both the dependent and the independent variables. If y_t is the dependent variable and $x_{1,t},\cdots,x_{n,t}$ are n independent variables, then a simple ARDL$\left(p,q_1,\cdots,q_n\right)$ model can be specified as follows:

$$y_t = a_0 + a_1 t + \sum_{i=1}^{p} \psi_i y_{t-i} + \sum_{j=1}^{n} \sum_{l_j=0}^{q_j} \beta_{j,l_j} x_{j,t-l_j} + \varepsilon_t . \tag{1}$$

Pesaran, Shin and Smith (2001) show that Equation (1) can be reduced to obtain a conditional error-correction form of the VAR(p) model. Once the lag lengths $p,q_1,\cdots,q_n$ are determined, the cointegration relationship can be estimated using the ordinary least squares method. In this study, lag lengths are chosen based on the work of Akaike (1981), allowing for a maximum lag length of two.

The nonlinear version of ARDL, proposed by Shin, Yu and Greenwood-Nimmo (2014), is an extension of the simple ARDL model that separates variables into a set of partial sums. For a time-series variable x_t, this separation is performed as follows:

$$x_t = x_0 + x_t^+ + x_t^- , \tag{2}$$

where $x_t^+ = \sum_{i=1}^{t} \max\left(\Delta x_i, 0\right)$ and $x_t^- = \sum_{j=1}^{t} \min\left(\Delta x_j, 0\right)$ are the partial sum processes of the positive and negative first differences in x_t, respectively. Using the separation approach in Equation (2), the asymmetric effects of the independent variables $x_{1,t},\cdots,x_{n,t}$ can be measured using the following asymetric error-correction model in the ARDL$\left(p,q_1,\cdots,q_n\right)$ framework:

$$\Delta y_t = \rho \xi_{t-1} + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} + \sum_{k=1}^{n} \sum_{l_k=0}^{q_k-1} \left(\pi_{k,l_k}^+ \Delta x_{k,t-l_k}^+ + \pi_{k,l_k}^- \Delta x_{k,t-l_k}^- \right) + \varepsilon_t ,$$

where $$\xi_t = y_t - \sum_{i=1}^{n} \left(\beta_i^+ x_{i,t}^+ + \beta_i^- x_{i,t}^- \right). \tag{3}$$

In Equation (3), ξ_t is the nonlinear error correction term. β_i^+ and β_i^- are the associated asymmetric long-run parameters. The asymmetric effects of independent variable shocks can be estimated using Equation (3). The effects of positive and negative shocks to a single variable are captured by two different terms. Therefore, the model enables us to test, for instance, whether the direction and the magnitude of the response to a shock differ for positive and negative shocks.

In this study, the real aggregate stock price is used as the dependent variable, and the price level, real interest rate, and real exchange rate are used as independent variables. The KOSPI200 and KOSDAQ indices, which reflect the primary and secondary stock markets in Korea, respectively, are used as proxies for the aggregate stock price.[3] For each index, both simple and nonlinear ARDL models are employed to investigate how the empirical results of a cointegration analysis change after incorporating asymmetry.

[3] The KOSPI200 index, a value-weighted index of the 200 largest stocks on the KOSPI market, is used in this study instead of the KOSPI index to emphasize the larger capitalization of the KOSPI market relative to that of the KOSDAQ market.

3. Korean market and sample data

3.1. Korean stock market

The South Korean economy has been growing at a fast, steady pace, positioning its financial market as one of the leaders among emerging economies (Kim, Cho, & Ryu, *forthcoming*; Shim, Kim, Kim, & Ryu, 2016). Despite experiencing the aftershocks of the 1997 Asian financial crisis and the 2008 global financial crisis, the Korean economy has experienced sustained and steady growth, and become the world's 11th largest one in 2016, with a nominal GDP of USD 1.404 billion. The Korean financial market is one of the leading and representative markets in the Asia-Pacific region. On the Korea Exchange (KRX), each individual stock is listed on either the KOSPI, KOSDAQ, or Korea New Exchange (KONEX) market. The stocks of start-up, venture, and/or young companies are traded on the KOSDAQ or KONEX market, whereas those of established and large companies are traded on the KOSPI market.[4] Thus, whereas the KOSPI market can be regarded as the primary market, covering most major Korean firms, the KOSDAQ market is a secondary, alternative equity-offering market that includes small- and medium-sized firms. The KOSPI200 index, one of the KRX benchmark indices, is a representative, value-weighted average spot price index consisting of the stock prices of the 200 largest KOSPI-listed companies.

The Korean financial market has two unique characteristics that make analyses of this market meaningful and informative for our research questions. First, the Korean market has been successfully attracting global and local investors, resulting in high liquidity (Chung, Park, & Ryu, 2016; Ryu, 2011, 2013, 2016). Second, the market exhibits unique investor participation rates. Specifically, there is relatively high participation by individual investors, who are easily affected by market sentiment, and foreign institutional investors, who are sensitive to macroeconomic and market-wide shocks (Ahn, Kang, & Ryu, 2008; Ryu, 2015; Sim, Ryu, & Yang, 2016; Yang, Choi, & Ryu, 2017; Yang, Lee, & Ryu, 2018). The ample liquidity, unique investor composition, and the academic evidence that macroeconomic variables affect the stock market make the Korean market an ideal setting in which to examine the issues raised in this study.

3.2. Sample data

The monthly historical data of stock indices and macroeconomic variables used in this study span the period from 1997 to 2016. The 20-year sample period covers two major financial crisis periods, namely, the Asian financial crisis and the U.S. subprime mortgage crisis (i.e., the global financial crisis). Given the adequately long and comprehensive sample period, our empirical tests derive generally applicable implications. All data are obtained from the Economic Statistics System, which is a database maintained by the Bank of Korea. The real levels of the KOSPI200 and KOSDAQ indices, which are calculated as the nominal indices divided by the GDP deflator, are used as proxies for the aggregate stock price. The GDP deflator

[4] More details about the Korean equity markets can be found in the recent studies of Chung, Kang and Ryu (2018) and Ryu, Ryu and Hwang (2017). We exclude the stocks listed on the KONEX market because the market is very new, with firms on the market often being delisted.

is also used as a proxy for the price level. Because the GDP deflator is reported quarterly, we use the method of Chow and Lin (1971) to approximate the monthly level. The 91-day certificate of deposit interest rate divided by the GDP deflator is used as a proxy for the real interest rate. Finally, the USD/KRW exchange rate multiplied by the GDP deflator is chosen as a proxy for the real exchange rate. Given this definition, an increase in the exchange rate denotes a depreciation of the domestic currency (i.e., KRW). All variables, except the real interest rate, are measured as log levels.

Table 1 reports the summary statistics of the levels of, and the differences in the dependent and independent variables used in our empirical analysis. The KOSPI200 and KOSDAQ indices and the proxies for the price level, real interest rate, and real exchange rate are denoted as *K*, *Q*, *P*, *I*, and *E*, respectively. The summary statistics reveal some notable features of our data. First, the real level of the KOSPI200 index has increased over time, whereas that of the real KOSDAQ index has decreased during the sample period. Second, the stock indices are found to be much more volatile than are the price level and the real exchange rate. Finally, the distribution of the real interest rate has fat tails, possibly due to discrete interest rate policy changes.

Table 1. Summary statistics

Panel A. Levels					
	Dependent variables		Independent variables		
	lnK	*lnQ*	*lnP*	*I*	*lnE*
Mean	0.463	1.967	4.504	6.223	6.917
Median	0.630	1.824	4.496	4.744	6.939
Maximum	1.059	3.541	4.699	29.031	7.295
Minimum	−0.809	1.175	4.268	1.239	6.372
Std. Dev.	0.453	0.483	0.124	5.430	0.178
Skewness	−0.663	1.229	−0.164	2.141	−0.972
Kurtosis	2.445	3.848	1.763	7.511	4.067
# of obs.	246	246	246	246	246
Panel B. Differences					
	Dependent variables		Independent variables		
	ΔlnK	*ΔlnQ*	*ΔlnP*	*ΔI*	*ΔlnE*
Mean	0.003	−0.004	0.002	−0.067	0.003
Median	0.002	0.000	0.002	−0.016	−0.001
Maximum	0.421	0.462	0.016	5.333	0.341
Minimum	−0.323	−0.357	−0.015	−3.914	−0.181
Std. Dev.	0.083	0.101	0.006	0.743	0.044
Skewness	0.377	0.286	−0.016	1.369	1.904
Kurtosis	6.735	6.923	2.621	27.828	19.385
# of obs.	245	245	245	245	245

4. Empirical results

4.1. Preliminary analysis

In this section, we first report the results of some preliminary analyses. Table 2 reports the results of the augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit root tests.[5] The optimal lag is chosen based on the work of Akaike (1981), and the *p*-values are calculated based on the work of MacKinnon (1996). The table shows that it is difficult to conclude whether the variables follow an *I*(0) or *I*(1) process, because the results are inconsistent across test methods and specifications. The ARDL model can be an appropriate choice in this case because, as shown in Pesaran and Shin (1999), the model produces asymptotically normal and consistent estimates, regardless of whether the variables follow an *I*(0) or an *I*(1) process. Although the ARDL model can be unstable when *I*(2) variables are included, Table 2 suggests that none of the variables follow an *I*(2) process.

Table 2. Unit root tests

	ADF test					PP test			
	Intercept only		Intercept & Trend			Intercept only		Intercept & Trend	
	t-stat.	*p*-value	*t*-stat.	*p*-value		*t*-stat.	*p*-value	*t*-stat.	*p*-value
Panel A. Levels									
lnK	−1.361	0.601	−3.355	0.060		−1.487	0.539	−3.147	0.098
lnQ	−2.021	0.278	−2.175	0.501		−2.263	0.185	−2.647	0.260
lnP	−0.894	0.789	−3.480	0.044		−1.280	0.639	−2.749	0.218
I	−2.268	0.183	−2.107	0.539		−2.218	0.201	−2.709	0.234
lnE	−2.884	0.049	−3.620	0.030		−2.943	0.042	−3.393	0.055
Panel B. First differences									
ΔlnK	−13.502	0.000	−13.474	0.000		−13.420	0.000	−13.391	0.000
ΔlnQ	−14.573	0.000	−14.568	0.000		−14.739	0.000	−14.725	0.000
ΔlnP	−5.186	0.000	−8.374	0.000		−8.466	0.000	−8.427	0.000
ΔI	−5.905	0.000	−6.041	0.000		−9.087	0.000	−9.053	0.000
ΔlnE	−13.789	0.000	−13.783	0.000		−13.774	0.000	−13.764	0.000

Table 3 summarizes the results of the cointegration bound tests for the simple ARDL approach of Pesaran, Shin and Smith (2001) and the nonlinear ARDL model of Shin, Yu and Greenwood-Nimmo (2013). The optimal lag is chosen based on the work of Akaike (1981), allowing for a maximum lag of two. Each model includes a linear trend term. The results in Table 3 more clearly indicate a long-run cointegrating relationship for the KOSPI200 and KOSDAQ indices when the nonlinear ARDL model is employed. The *F*-statistic does not

[5] We also conduct a Zivot and Andrews (1992) unit root test. The results are consistent with the other unit root tests. We do not include the results because our main results are not affected by whether the variables are I(0) or I(1), given the characteristics of ARDL.

significantly exceed the lower bound for the KOSDAQ index when the simple ARDL model is employed. However, the statistic surpasses the lower bound at the 10% significance level when the nonlinear ARDL model is used. Overall, the results in Table 3 imply that a nonlinear ARDL approach is more appropriate for identifying the relationship between the South Korean stock indices and macroeconomic variables.

Table 3. Cointegration bound test

Dependent Variable	Model	*F*-stat.	Lower bound		Upper bound	
			10%	5%	10%	5%
lnK	Simple ARDL	6.76	2.97	3.38	3.74	4.23
	Nonlinear ARDL	9.14	2.33	2.63	3.25	3.62
lnQ	Simple ARDL	1.36	2.97	3.38	3.74	4.23
	Nonlinear ARDL	2.33	2.33	2.63	3.25	3.62

4.2. Response of stock prices to macroeconomic variables

In this subsection, we estimate the response of stock prices to macroeconomic variables using the simple and nonlinear ARDL models. Table 4 summarizes the long-run coefficient estimation results for the two models. Panel A shows that when the simple ARDL model is used, the KOSPI market responds significantly to shocks to the real interest rate and the real exchange rate, whereas the KOSDAQ market does not respond significantly to any of the macroeconomic variables. In contrast, Panel B reveals that when the nonlinear ARDL model is used, shocks to all three macroeconomic variables significantly impact at least one of the two stock markets. Specifically, the estimation results for both indices suggest that stock prices respond negatively to shocks to all three macroeconomic variables.

Table 4. Long-run coefficient estimates: Impact of macroeconomic shocks on stock prices

	KOSPI	KOSDAQ
Panel A. Linear ARDL		
lnP	0.645	–12.461
	(2.964)	(10.868)
I	–0.042***	0.006
	(0.015)	(0.043)
lnE	–0.809*	–0.219
	(0.451)	(1.019)
Panel B. Nonlinear ARDL		
lnP^{+}	–14.166*	–11.611
	(6.853)	(11.177)
lnP^{-}	–0.836	–9.940*
	(4.246)	(5.958)

End of Table 4

	KOSPI	KOSDAQ
I^{+}	−0.192*	−0.167*
	(0.094)	(0.089)
I^{-}	−0.206**	−0.068
	(0.086)	(0.059)
lnE^{+}	−1.320*	−0.341
	(0.777)	(1.003)
lnE^{-}	−1.329	−2.410
	(1.376)	(2.322)

Note: The superscripts + and − denote positive and negative partial sums, respectively. Each model includes a linear trend term. Newey and West (1987) standard errors (in parentheses) are used to control for heteroskedasticity. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

The negative relationship between stock prices and the general price level is consistent with the findings of previous studies that demonstrate and explain this negative relationship using various methods. Because stocks can serve as a hedge for inflation via the Fisher effect and, therefore, are expected to be unaffected by the price level, numerous studies have tried to interpret this counterintuitive negative relationship. Modigliani and Cohn (1979) suggest that investors tend to undervalue stocks when inflation occurs, and Ritter and Warr (2002) show evidence that the undervaluation of levered firms during inflationary periods results in the deflation of stock prices. Fama (1981) argues that this negative relationship is caused by the negative relationship between inflation and real activity. This argument is supported by the empirical findings of Rapach (2001). Geske and Roll (1983) suggest that this negative relationship may be caused by a combination of reversed adaptive inflation expectations and a reversed money growth/stock returns model. Yang, Kim, Kim and Ryu (2018) empirically show a negative relationship between the KOSPI index and the price level.

Another strand of literature reports and interprets the negative relationship between stock prices and the real interest rate. Christie (1982) suggests that this negative relationship is due to the impact of the interest rate on stock price volatility. Flannery and James (1984) argue that the interest rate affects stock prices because of the maturity mismatch between bank assets and liabilities. Bernanke and Kuttner (2005) show that a cut in the target federal funds rate is associated with an increase in broad stock indices, and this increase can be attributed to the effect of unanticipated monetary policy on expected returns. Similarly, by employing a structural vector autoregression, Crowder (2006) shows that equity returns negatively respond to the federal fund changes. Finally, the negative relationship between stock prices and the real exchange rate can be explained by stock-oriented exchange rate models. Flow-oriented models suggest that an appreciation in the domestic currency exacerbates the competitiveness of exporters and negatively affects real income and output. In contrast, stock-oriented models regard each currency as a conduit toward a single market, so that exchange rates reflect how investors rebalance their market portfolios. In this approach, an exchange rate is determined by the supply and demand for the corresponding currency and, therefore, an appreciation in the domestic currency may lead to an increase in the stock price level. Using an error correction model, Ajayi and Mougoué (1996) show that a currency depreciation incurs a long-run effect on the spot price decrease. Given the finding of Moore and Wang (2014) that flow-oriented models better explain emerging countries and that stock-oriented models are more suitable for developed countries, our empirical results imply that the Korean market is well developed.[6]

To further investigate the effect of reflecting nonlinearity in the ARDL model, we estimate ARDL models in which partial sums are employed for part of the independent variables only. Specifically, we convert either *I* or *E* into positive and negative partial sums, while including the other as is, without considering asymmetry. Table 5 reports the estimation results. Compared with the results shown in Table 4, the significance of the relationship between stock price levels and the macroeconomic variables weakens or even vanishes, especially for the KOSDAQ. This result implies that although the difference between the coefficients of the positive and negative partial sums seems minor for some macroeconomic variables (such as *I* and *E*), including nonlinearity causes a significant change in the estimation results for the variables.

Table 5. Long-run coefficient: mixed ARDL model specification

	Panel A. Linear *I*, nonlinear *E*		Panel B. Nonlinear *I*, linear *E*	
	KOSPI	KOSDAQ	KOSPI	KOSDAQ
lnP+	−1.178	−20.272	−14.035*	−0.602
	(3.130)	(16.689)	(7.554)	(4.646)
lnP−	2.767	−2.873	−0.732	−0.616
	(2.236)	(9.240)	(4.134)	(9.032)
I	−0.058***	−0.086		
	(0.016)	(0.120)		
I+			−0.187*	−0.240
			(0.102)	(0.224)
I−			−0.201**	−0.106
			(0.082)	(0.133)
lnE			−1.130*	0.346
			(0.675)	(1.340)
lnE+	−1.433***	0.003		
	(0.464)	(1.561)		
lnE−	−2.271***	−0.019		
	(0.815)	(3.648)		

Note: The superscripts $^{+}$ and $^{-}$ denote positive and negative partial sums, respectively. Each model includes a linear trend term. Newey and West (1987) standard errors (in parentheses) are used to control for heteroskedasticity. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

[6] Although Korea is classified as an emerging country in Moore and Wang (2014), their sample period of 1980–2006 is significantly older than that used in this study (1996–2016).

Table 6. Long-run coefficient: impact of stock price shocks on macroeconomic variables

	Dependent variable					
	lnP		*I*		*lnE*	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Linear ARDL						
KOSPI	0.011		4.817		−0.545***	
	(0.020)		(4.067)		(0.114)	
KOSDAQ		−0.031***		8.860***		−0.166
		(0.004)		(2.440)		(0.225)
lnP			84.633	181.804***	2.823***	0.297
			(72.354)	(62.219)	(1.106)	(4.538)
I	−0.000	0.001			−0.001	0.039
	(0.001)	(0.001)			(0.008)	(0.033)
lnE	0.041	0.021	−9.695	−9.932***		
	(0.033)	(0.015)	(9.199)	(3.284)		
Panel B. Nonlinear ARDL						
$KOSPI^+$	0.032***		0.895		−0.377***	
	(0.011)		(1.658)		(0.049)	
$KOSPI^-$	−0.028**		5.995***		−0.208***	
	(0.013)		(1.749)		(0.073)	
$KOSDAQ^+$		−0.010		4.655***		−0.191
		(0.009)		(1.451)		(0.126)
$KOSDAQ^-$		−0.026***		5.304***		−0.091
		(0.006)		(1.106)		(0.092)
lnP^+			91.478*	75.544*	1.682	4.546*
			(49.510)	(45.938)	(1.237)	(2.455)
lnP^-			78.076***	107.09***	3.193***	2.796
			(27.655)	(28.529)	(0.825)	(1.974)
I^+	−0.002	−0.000			−0.010	−0.029
	(0.002)	(0.002)			(0.012)	(0.020)
I^-	0.004***	0.001			−0.031***	−0.013
	(0.001)	(0.001)			(0.009)	(0.010)
lnE^+	0.071***	0.023	−9.948	−9.738**		
	(0.026)	(0.019)	(7.179)	(4.632)		
lnE^-	0.046	−0.023	−14.224	−7.348		
	(0.045)	(0.040)	(13.019)	(8.769)		

Note: The superscripts $^+$ and $^-$ denote positive and negative partial sums, respectively. Each model includes a linear trend term. Newey and West (1987) standard errors (in parentheses) are used to control for heteroskedasticity. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

4.3. Response of macroeconomic variables to stock prices

To complete our identification of the dynamic relationship between stock prices and macroeconomic variables, and to investigate the effect of this asymmetric relationship from the opposing side, we conduct another set of regressions. We use one of the three macroeconomic variables as the dependent variable and include the stock index and the other macroeconomic variables as the independent variables. Table 6 reports the results. Consistent with the results shown in Table 4, the response of the macroeconomic variables to a stock price shock is clearer when a nonlinear ARDL model is used. Specifically, although we find no significant response for KOSPI market shocks when the price level or real interest rate is used as the dependent variable in the simple ARDL model, when the nonlinear ARDL model is used, we find that a negative shock to the KOSPI market has a long-run effect on both variables.

An interesting finding is that only the KOSPI market significantly affects the USD/KRW exchange rate, and that an increase in the real stock price tends to be followed by an appreciation of the Korean won. This result supports the argument in the previous section that the negative relationship between stock prices and the real exchange rate can be explained by a stock-oriented exchange rate model. Richards (2005) shows that a considerable portion of KOSPI market trading volume comes from foreign investors, whereas the KOSDAQ market is dominated by domestic investors. This phenomenon, combined with stock-oriented exchange rate models, can explain why the exchange rate responds only to shocks to the KOSPI market, and not to shocks to the KOSDAQ market. In addition, it is also notable that stock price shocks and macroeconomic shocks tend to amplify each other in the case of the price level and the exchange rate, whereas stock price shocks and interest rate shocks tend to dampen each other. These relationships imply that the interest rate is the main instrument used by the government for economic intervention.

Overall, the empirical results suggest that the relationship between stock prices and macroeconomic variables is largely consistent in Korea, even across the primary and secondary markets. Furthermore, this consistency can be explained in greater detail when nonlinearity is incorporated in a model of this relationship. This result supports those of studies such as Guidolin, Hyde, McMillan and Ono (2014), Han, Kutan and Ryu (2015), Maasoumi and Racine (2002), Qi (1999), and Song, Ryu and Webb (2016), which show that that nonlinear models should be used to explain the relationship between stock returns and economic variables.

Conclusions

This study examines whether the asymmetric relationship between stock prices and macroeconomic variables affects related empirical analyses and, if so, how this effect occurs. We analyze indices of the KOSPI and KOSDAQ stock markets, along with macroeconomic data (the price level, real interest rate, and real exchange rate), using simple and nonlinear ARDL models to investigate whether including asymmetry influences identifying the relationship. Our empirical results reveal that shocks to almost all the macroeconomic variables we consider have a significant long-term effect on stock prices when the nonlinear ARDL model is used, but that some of these effects cannot be identified when using a simple ARDL model. Furthermore, the KOSPI market and the real exchange rate mutually affect each other, whereas the real exchange rate has a one-sided effect on the KOSDAQ market. Overall, the results suggest that an empirical analysis of the relationship between stock prices and macroeconomic variables can be misdirected if the nonlinearity in the relationship is not considered. Thus, nonlinear models, such as ARDL, must be employed to address this issue.

Future studies might investigate whether there are other consequences of the nonlinear relationship between stock prices and macroeconomic variables that affect empirical analyses. In addition, they might examine the relationship between derivative prices and macroeconomic variables, while considering nonlinearity. As shown in recent studies, asset prices and volatilities are affected by macroeconomic variables in a nonlinear fashion, even across countries. Hence, it is worth investigating whether this nonlinearity at least partially originates from the nonlinear relationship between stock prices and macroeconomic variables.

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