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Article

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FINANCIAL ECONOMICS | RESEARCH ARTICLE

Inflation and infrastructure sector returns in emerging markets—panel ARDL approach

Rabson Magweva^{1*} and Mabutho Sibanda¹

Abstract: This study evaluated the relationship between inflation and infrastructure sector stock returns in emerging markets in the long and short run. It employed a panel autoregressive distributed lag (PARDL) model applying the mean group (MG), pooled mean group (PMG) and dynamic fixed effects (DFE) estimators after preliminary cross-sectional dependence and stationarity tests. The results from the three estimators were insignificant in both the short and long run, illustrating the inability of infrastructure sector returns in emerging markets to hedge inflation. Similar results were obtained when the inflation-hedging capacity of real estate and general listed equity was assessed. This suggests the existence of significant beta risk in emerging stock markets. The results imply that investors interested in hedging inflation in emerging markets should go beyond individual asset classes and embrace the portfolio optimization concept to reduce inflation risk. Given the heterogenic nature of the infrastructure sector, a deeper analysis that focuses on infrastructure sector sub-categories might be fruitful as the pricing power is heterogeneous across these sub-sectors.

Subjects: Econometrics; Finance; Investment & Securities; Pensions

Keywords: inflation; infrastructure; pooled mean group; beta risk; portfolio optimization
JEL classification: E31 H54 C33 G11 O50

1. Introduction

Amidst other economic threats, risk-averse investors aim to protect their investments and wealth from the corrosive effects of inflation. High levels of inflation render pensioners, savers and lenders worse off, thereby reducing the standard of living, and increasing uncertainty and anxiety among

ABOUT THE AUTHOR

Rabson Magweva is a PhD Finance student at the University of KwaZulu-Natal, South Africa. As such this research paper fits well into his academic career path. He has published articles, in among others, the *Journal of Financial and Economic Sciences*, *Journal of Central Banking Theory and Practice* and the *Journal of Contemporary Management*.

Mabutho Sibanda is a Professor in Finance and Dean of the School of Economics, Accounting and Finance at the University of KwaZulu-Natal. He has published many articles in many renowned journals. This paper is one among many under his name as an academician in finance.

PUBLIC INTEREST STATEMENT

The study examined the extent to which infrastructure investments in emerging nations can be used to hedge inflation relative to other comparable assets. We used a Panel Autoregressive Distributed Lag model (PARDL) approach to capture the short- and long-run capacity of these assets and investments to act as a hedge against inflation risk. The results were not significant in both the short and long run, illustrating the inability of infrastructure sector returns in emerging markets to hedge inflation. Similar results were obtained when the inflation-hedging capacity of real estate and general listed equity in emerging markets was assessed.

citizens (Akturk, 2014). Inflation indicates the stability and soundness of the economy at large (Asayesh & Gharavi, 2015). High levels of inflation introduce uncertainty and make planning difficult, thereby promoting short-termism among firms, households, investors and savers. Furthermore, high inflation rates tend to increase the unemployment rate, trade deficits and depreciation of the local currency and reduce aggregate demand (Mugambi & Okech, 2016).

Since the wild inflation swings of the 1970s (when most stock markets recorded significant negative returns), academic debate on different asset classes' ability to hedge inflation has persisted. This indicates the academic, social and financial importance of this issue. The ability of different assets to hedge inflation tends to differ across nations, sectors and time horizons. It is determined by firms' (owners of assets) ability to raise prices in tandem with inflation (Asayesh & Gharavi, 2015). Price adjustments (input and output prices) by firms tend to be uneven. Thus, earning power tends to be skewed towards those that benefit from low input costs while receiving or demanding higher prices for their goods or outputs.

The theoretical literature on the hedging ability of asset classes is based on the Fama-Schwert model of 1977 and Fama's proxy hypothesis model of 1981, both derived from Fisher's (1930) proposition. While these theories are based on equities' ability to hedge inflation, they have been applied to other assets like real estate, commodities and metals. The Fama-Schwert model assumes a positive significant relationship between equity returns and inflation, implying that equities do hedge inflation. The proxy hypothesis posits the existence of a negative relationship between equity and inflation, indicating stocks/equities' inability to hedge inflation risk. Both theories have been supported by empirical studies in developed and developing economies, painting a challenging scenario for investors that seek to preserve their wealth in the face of inflation.

Given widespread awareness of the devastating effects of inflation at national and individual level, investors seek investments and assets which provide returns in tandem with and above the inflation rate. An inflation hedge is an asset or investment whose returns move in step with inflation either in the short or long run (significant positive correlation). The infrastructure sector has the potential to serve as a sound inflation hedge as it can deliver steady, low-volatile and predictable inflation-linked cash-inflows due to its monopolistic and oligopolistic character (Brenchley, 2019). This sector provides essential, difficult-to-substitute goods and services with inelastic demand whose prices are linked to inflation by concessions and agreements. As a result, it has some leeway to manipulate prices in an attempt to earn returns in line with and above inflation.

In contrast, the short-term relationship between inflation and infrastructure sector equity returns is determined not only by the sector's ability to respond to higher input prices with increased output prices, but also by investors' reaction to higher inflation shocks. It has been noted that the infrastructure sector's price to earnings ratio tends to fall in response to increasing inflation. Although the sector can respond by increasing prices, this might be insufficient in light of the rate at which the market discounts future expected cash-inflows from the sector, thereby bringing its ability to hedge inflation into question. Although the economic, social and political significance of the infrastructure sector is evident, there is a paucity of research on this sector in developing and even in advanced economies (let alone in emerging markets). As noted previously, the available literature supports the Fama-Schwert model (the infrastructure sector is a good inflation hedge) and the Fama model (it is a poor inflation hedge).

This study sought to fill this gap in the literature by assessing the inflation-hedging ability of listed infrastructure equities in emerging nations (where the infrastructure market is still developing) in the short and long run. For comparison purposes, it also examined the inflation-hedging ability of real estate and general listed equity in emerging markets applying robust econometric methods. Emerging markets are exposed to radical swings in the inflation rate, posing a risk to investors' wealth and savings (Nassar & Bhatti, 2018). The lack of inflation-linked financial assets further exposes investors to inflation risk. It is thus important to evaluate the inflation-hedging ability of different sectors in emerging markets. The study's findings will be useful for investors and

economic participants at large in their quest to identify inflation-hedging assets. Policymakers in emerging markets can also derive some insights to design inflation-linked concessions and agreements. The study also provides a platform for further research on the infrastructure sector in emerging markets, including more detailed examination, assessment and evaluation.

This paper is structured as follows. The following section briefly reviews related theoretical and empirical literature, while Section 3 presents the tests and empirical model used to examine the inflation-hedging ability of the infrastructure and related sectors in emerging markets. The fourth section details the findings and briefly discusses the results. Section 5 presents conclusions and recommendations focusing on the investment implications of our results.

2. Literature review

Stock returns' ability to hedge inflation is hinged on the ability of the firm or sector in question to increase its prices in tandem with inflation (Asayesh & Gharavi, 2015). Investor sentiments and expectations matter when it comes to the valuation of shares and corresponding returns. The "inflation illusion" bias which affects investors leads to lower stock returns during inflationary periods (Briere & Signori, 2011). This is based on the fact that investors tend to overvalue the impact of inflation on current stock and firm value and undervalue the firm's ability to increase its nominal earnings value in line with inflation. Therefore, instead of the effects canceling one another out, stock prices tend to drop as investors sell their holdings due to bearish sentiment in an inflationary environment. In a nutshell, the relationship between nominal stock returns and inflation tends to be negative (Adusei, 2014).

The effect of inflation on stock returns is two-fold. Firstly, nominal cash inflows or earnings increase as firms adjust their prices in line with inflation trends. Secondly, uncertainty regarding future earnings increases, putting upward pressure on the discount rate or premiums required by providers of capital, and reducing the stock and firm value. Depending on the net effect of inflation on future earnings and discount rate, stock value/returns might increase or decrease as inflation soars.

The theoretical literature on inflation hedging is premised on the Fama-Schwert (1977) model, which is expected to hold in the long run. Derived from the generalized Fisher hypothesis of 1930, this model assumes a significant positive relationship between asset return (in nominal terms) and inflation rate, implying that asset returns hedge inflation and that nominal stock return moves in step with inflation over time. The impact of inflation on nominal cash-inflows is greater than its impact on discount rate and investors' bearish sentiments, thereby increasing the value of the firm and corresponding stock returns.

At the extreme end of the spectrum on stock's ability to hedge inflation is the "proxy hypothesis" proposed by Fama (1981). This posits that an inflationary economic environment is a signal of unstable, depressed economic activity and a bleak future for firms, threatening corporate survival. As such, the relationship between inflation rate and nominal stock returns is expected to be negative (Akturk, 2014). As remarked by Bodie (1976), the negative relationship between inflation and stock returns implies that an investor must short sell stock in order to hedge inflation. This suggests that the net effect of inflation on discount rate is higher than its effect on nominal earnings. In the same vein, a negative relationship between stock returns and inflation implies that "inflation illusion" and irrationality among investors are more pronounced, pointing to the inefficiency of financial markets.

Empirical studies on stock returns and inflation support both the Fama-Schwert model (Emenike & Nwankwegu, 2013; Ibrahim & Agbaje, 2013; Incekara, Demez, & Ustaoglu, 2012) and the proxy hypothesis (Gul & Açikalın, 2008; Lee, 2010; Tripathi & Kumar, 2014). Thus, stocks' ability to hedge inflation tends to differ across stock markets, and according to the period under review and levels of inflation (creeping, walking, galloping, stagflation and hyperinflation).

Turning to the infrastructure sector, in particular, Chhabria, Kohn, Brooks, and Reid (2015) noted that infrastructure firms operate in a market with high barriers to entry. This tends to result in inelastic

demand as the sector mainly provides utilities, thereby reducing commodity price risks and enhancing strong, steady cash flows. The prices of the products and services rendered by such firms tend to be indexed to economic rates such as inflation. Thus, firms have the ability to generate inflation-hedged revenue and earnings. The question is thus whether capital markets are able to transpose the inflation-hedging features of the infrastructure sector into stock prices and stock returns.

It is, however, important to note Blanc-Brude's (2015) observation that the intrinsic features of infrastructure assets are most pronounced in developed markets. This calls for a deeper analysis of emerging markets where the infrastructure market is still rudimentary. On the same note, the infrastructure sector is socially, and politically sensitive, which might call for government intervention during inflationary periods. In other words, the pricing power of an infrastructure firm might be undermined at the time when it is most needed. Even if the sector is able to adjust the prices of final products, the cost of inputs like commodities and capital is likely to rise. In such a scenario, the sector will only be able to hedge inflation if it is able to increase the price of outputs at a faster rate or percentage than the price of inputs.

Given the ongoing debate on the infrastructure sector's ability to hedge inflation, it is important to conduct empirical studies in emerging markets where the infrastructure market is in its infancy, infrastructure needs far outweigh supply, and there is a high inflation risk. Most emerging economies have a narrow range of assets which can be used by domestic investors, amplifying the quest for inflation-hedging assets. The few academic studies on this subject have produced mixed results using basic statistical methods. Wurstbauer and Schafers (2015) concluded that, in the United States (US), direct infrastructure investments have a measure of inflation-hedging capability in the short run but are a sound hedge in the long run. In line with these findings, Colonial First State's (2009) examination of the top five Australian infrastructure funds suggested that infrastructure investment offers inflation protection as the returns were positive and above the inflation rate.

In contrast, Peng and Newell (2007) found a negative (though insignificant) relationship between infrastructure investments (listed and unlisted) and inflation in Australia. This is in agreement with Martin's (2010) findings on listed infrastructure firms in the US and Rodel & Rothballer's (2012) results on listed infrastructure firms in 45 nations. Bitsch, Buchner, and Kaserer (2010), Sawant (2010), and Bird, Liem, and Thorp (2014) produced insignificant results using data from the US and Australia.

3. Data and methodology

This section discusses the econometric steps followed to assess the infrastructure sector's inflation-hedging ability compared to that of general equity and real estate in emerging nations. The study applied panel data as it gives more explanatory power, less collinearity, offers more degrees of freedom, caters for heterogeneity and is more efficient than time series and cross-sectional data (Baltagi, 2008; Hsiao, 2014; Kutu & Ngalawa, 2016).

Monthly data from January 2009 to June 2019 obtained from stock exchanges and central government statistical agencies was used. The data set is unbalanced as some observations were missing for some countries. The study used data from national stock markets in Brazil, China, India and Indonesia. These nations were picked solely considering the availability of specific stock market indices to the general public (especially infrastructure index). These were selected based on their ease of access to the public, researchers and investors. It is easier for investors to access listed liquid stocks during portfolio construction, diversification and portfolio revision than to obtain privately held equity. In a rational world, we expect listed and unlisted stocks to be valued based on the fundamentals, not solely on whether or not the stock is publicly traded. Beta risk (broad market volatility) is expected to be insignificant and frequency of valuation (very high in listed stock) does not affect the business and financial risk of the firms in question, implying the same value for listed and unlisted stocks of similar firms.

The indices used from each nation were selected based on data availability, or the launch date, that is, indices with all data points from 2009 to 2019 were preferred to indices with a short span. The variables are discussed below:

Inflation rate: Monthly consumer price index (CPI) changes per country were used as a proxy for the inflation rate in emerging economies.

Infrastructure sector returns: The following indices on infrastructure were used as a proxy for the infrastructure sector in emerging markets—SSE 180 infrastructure index (China), Nifty infrastructure index (India), FTSE Brazil infrastructure-extended total return (Brazil) and IDX Infrastructure index (Indonesia)

General listed equity returns: The study used the following indices to represent the general or composite listed equity returns in emerging markets—Shanghai Composite index (China), Bovespa index (Brazil), Nifty 500 (India) and FTSE Indonesia index (Indonesia).

Real estate returns—FTSE China A 600 Real estate investment and services (China), S&P BSE realty (India), IDX Property index (Indonesia) and Real estate index (Brazil) were used as a proxy for real estate returns.

Control variables: Gross domestic product (GDP) growth rate and crude oil prices were used as control variables given their importance in determining stock market performance and inflation rate.

In order to apply appropriate unit root and cointegration tests in panel data, there is need to confirm the presence or absence of cross-sectional dependence in the variables (Mallick, Mallesh, & Behara, 2016; Onuoha, Okonkwo, Okoro, & Okere, 2018). To ensure the validity of the results, the following four CSD tests were applied: Breusch–Pagan LM, Pesaran scaled LM, bias-corrected scaled LM and Pesaran CD.

Given the unbalanced nature of our data set and the existence of cross-sectional dependence, most of the second- and first-generation unit root tests were incompatible. Therefore, the study made use of Pesaran's cross-sectional Augmented Dickey–Fuller (PESCADF) and Im-Pesaran-Shin (IPS) tests to ascertain that none of the variables is integrated of order two or higher. Economic variables tend to respond and affect other variables with a lag due to inertia, transmission mechanisms and momentum effect that are most pronounced in capital markets. This calls for dynamic model application in order to determine the relationships among the variables under study. The common estimator used for dynamic panel data is the generalized method of moments (GMM) (Arellano, 1989; Arellano & Bover, 1995). GMM is well suited for panels with many units of interest and a small number of observations per unit. For a larger number of observations and small cross-sections, as in this study, the GMM estimator can produce inconsistent, spurious and incorrect estimates (Nahla, Fidrmuc, & Ghosh, 2013; Pesaran, Shin, & Smith, 2001). Thus, in our heterogeneous panel data setting, we adopted the Panel Autoregressive Distributed Lag (PARDL) following Kutu and Ngalawa (2016) and Fazli and Abbasi (2018).

The PARDL derives most of its merits from the traditional ARDL model. These include the fact that it can simultaneously estimate short- and long-run dynamics, can be used in a case of mixed order of integration (but not on variables integrated of order two or above), and different lags can be used on different variables (Shin, Yu, & Greenwood-Nimmo, 2014). Another key merit of PARDL is its compliance with both small and large sample sizes (Kutu & Ngalawa, 2016; Rafindadi & Yusuf, 2013). The current study made use of three alternative approaches (for comparison purposes), namely, mean group (MG), pooled mean group (PMG) and dynamic fixed effects (DFE) estimators. The three estimators use the maximum likelihood approach and consider the long-run equilibrium and the heterogeneity of the dynamic adjustment process (Onuoha et al., 2018).

The MG approach estimates separate equations for each cross-sectional unit and computes the coefficient means, thereby providing consistent estimates of the average of the coefficients although neglecting the fact that certain coefficients may be homogeneous across the units. The MG estimator is the least restrictive, as it allows for the heterogeneity of both short- and long-run coefficients (Fazli & Abbasi, 2018).

The DFE estimator constrains the long-run coefficients to be the same across the cross-sections. Furthermore, it constrains the short-run coefficients, including the speed of adjustment to be homogeneous. Only the individual intercepts may differ freely (Fuinhas, Marques, & Koengkan, 2017; Nahla et al., 2013).

The PMG estimator constrains the long-run coefficients to be homogeneous (similar to DFE), and like the MG estimator, allows the short-run coefficients, error correction terms, intercepts and the error variances to differ freely across the entire cross-section (Fazli & Abbasi, 2018; Onuoha et al., 2018). PMG and MG provide consistent coefficients despite the possible presence of endogeneity because they include the lags of dependent and independent variables. As is evident from the brief outline, the PMG is more middle-of-the-road approach to heterogeneous panel data estimation.

The general PMG is of the following empirical structure (Lee & Wang, 2015):

$$Y_{it} = \sum_{j=1}^p \lambda_{ij} Y_{i,t-j} + \sum_{j=0}^q \delta'_{ij} X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (1)$$

where Y_{it} is the return for the stock in question (infrastructure, real estate and composite listed stock) for country i , X_{ij} ($k \times 1$) is the vector which captures the actual inflation and control variables as specified above. δ_{ij} are ($k \times 1$) coefficient vectors. Emerging nations are symbolized by $i = 1, 2, \dots, N$, whereas time periods are denoted by $t = 1, 2, \dots, T$. The parameter μ_i is the fixed effects, and ε is the normal error term. The lags included in the model are captured by p and q for dependent and independent variables, respectively (Asghar et al., 2015; Lee & Wang, 2015). The study adopted a re-parameterized Equation (1) structured as follows:

$$\Delta Y_{it} = \left(\varphi_i Y_{i,t-1} + \beta_i X_{it} \right) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta Y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}^* \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (2)$$

where $\Delta Y_{it} = Y_{it} - Y_{i,t-1}$, $\varphi_i = -(1 - \sum_{j=1}^p \lambda_{ij})$, $\beta_i = \sum_{j=0}^q \delta_{ij}$, $\lambda_{ij}^* = -\sum_{m=j+1}^p \lambda_{im}$
 whereas $\delta_{ij}^* = -\sum_{m=j+1}^q \delta_{im}$

4. Findings and results

This section exposes the outcomes from the tests and models applied in this study. Table 1 presents the summary measures of moments for nations used in this study.

In Brazil, the average monthly inflation rate stood at 0.47% below the returns generated by all the assets under considerations. Real estate investors generated high real returns on a monthly basis compared to investors in infrastructure and general listed stocks. The same applies to investors in India, real estate generated the highest positive real returns relative to other assets under consideration. Investors in Indonesia with interests in infrastructure earned returns below the inflation rate on a monthly. Such a negative real rate of returns gives indicative evidence of the incapability of infrastructure sector to hedge inflation. Average monthly returns from all assets were positively skewed save for real estate in India and general stock market returns in China. This might be due to the Chinese stock market crash of 2015 and trade war with the USA.

Table 1. Measures of moments for individual nations

Country	Variable	Mean	Maximum	Minimum	Skewness
Brazil	Infrastructure	0.00476	0.3239	-0.1761	0.743
	Inflation	0.00469	0.0132	-0.0023	0.481
	Composite stock	0.0092	0.1697	-0.1186	0.227
	Real estate	0.0133	0.5395	-0.1413	1.855
China	Infrastructure	0.0049	0.411	-0.238	1.629
	Inflation	0.00199	0.0158	-0.0113	0.371
	Composite stock	0.0063	0.2057	-0.2265	-0.127
	Real estate	0.0051	0.2646	-0.187	0.496
India	Infrastructure	0.00822	0.158	-0.093	0.205
	Inflation	0.00381	0.030	-0.00450	2.072
	Composite stock	0.0134	0.209	-0.114	0.464
	Real estate	0.0146	0.171	-0.163	-0.164
Indonesia	Infrastructure	0.00195	0.212	-0.124	0.552
	Inflation	0.00613	0.458	-0.0165	0.809
	Composite stock	0.013	0.3443	-0.1045	1.613
	Real estate	0.0074	0.793	-0.267	1.917

Authors' compilation.

At the panel data level, the stochastic distribution of the key variables under study is presented in Table 2, indicating the first, second, third and fourth moments of distribution.

On average, the infrastructure sector in emerging markets earned below the inflation rate (0.2% against 0.4%) on a monthly basis. On average, this left investors in infrastructure sector stocks worse off. It could be an indication of the diminished or constrained pricing power of the infrastructure sector in emerging markets. Composite stock returns and real estate earned returns above the average monthly inflation rate during the period under study, which is a favorable scenario as investors were able to protect their wealth from inflation. In a nutshell, the variables under study were positively skewed and exhibited moderate swings during the period.

The bivariate correlation coefficients of the key variables are shown in Table 3:

Inflation is negatively correlated with all the asset classes under study. This supports the proxy hypothesis and inflation illusion in emerging markets. In other words, an increase in inflation is treated as a negative signal as far as economic prospects are concerned and risk-averse investors

Table 2. Stochastic distribution of the variables

	Real estate	Infrastructure	Inflation	Composite stock
Mean	0.013322	0.002402	0.004693	0.009225
Median	0.002300	-0.013900	0.004450	0.006250
Maximum	0.539500	0.323900	0.013200	0.169700
Minimum	-0.141300	-0.176100	-0.002300	-0.118600
Std. Dev.	0.091898	0.101188	0.002979	0.059611
Skewness	1.854655	0.767320	0.480941	0.227244
Kurtosis	10.61479	3.925341	3.488830	2.730134

Authors' compilation.

Table 3. Correlation matrix

	Real estate	Infrastructure	Inflation	Composite stock
Real estate	1.000000			
Infrastructure	0.755833	1.000000		
Inflation	-0.015859	-0.160669	1.000000	
Composite stock	0.779660	0.883822	-0.174369	1.000000

Authors' compilation.

tend to offload their stock portfolios, leading to a fall in stock returns. The infrastructure sector is positively related to real estate and composite stock, which indicates co-movement in the same direction over time. This implies that the shocks which affect stock markets sweep across all sectors in a similar way in emerging markets.

4.1. Cross-sectional dependence (CSD)

To determine whether to apply first or second-generation unit root tests, the study applied cross-sectional dependence tests; the results are shown in Table 4. Four tests were used to ensure validity of the results.

All the statistical values were significant at 1% level of significance, indicating the presence of sectional dependence in the variables under study. This could be due to particular issues pertaining to the BRICS (Brazil, Russia, India, China and South Africa) economic bloc from which three units of study (Brazil, China and India) were drawn. Economic policies, regulatory measures, trading trends and the growth rates of the BRICS nations tend to co-move; hence, the presence of cross-sectional dependence.

Table 4. Cross-sectional dependence test statistics

Variable	Breusch–Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
Infrastructure	276.00	77.9422	77.8978	16.6132
Inflation	756.00	216.5064	216.4904	27.4954
Real estate	487.00	189.209	172.081	18.306
Composite stock	756.00	216.5064	216.4904	27.4954
GDP	756.00	216.5064	216.4904	27.4954
Crude oil	756.00	216.5064	216.4904	27.4954

Extracts from Eviews.

Table 5. Unit root tests results

Variable	PESCADF	IPS	Level of integration
Infrastructure	-3.873	-7.916	Order 1
Inflation	-4.629	-9.7612	Order 1
Real estate	-2.581	-6.052	In levels
Composite stock	-2.893	-18.453	In levels
GDP	-3.942	-7.435	Order 1
Crude oil	-5.924	-12.983	In level

Authors' compilation.

4.2. Unit root tests

Pesaran’s cross-sectional augmented Dickey–Fuller (PESCADF) and Im-Pesaran-Shin (IPS) tests of stationarity were employed to validate the stationarity levels of the variables under study. The results are shown in Table 5.

As can be seen from Table 5, none of the variables is integrated of order greater than 1. This indicates the appropriateness of the PARDL approach. These levels of integration might have been affected by structural breaks such as the European sovereign debt crisis of 2009, Chinese stock market crash of 2015 and arguably the global financial crisis of 2007/8 as some authorities claim that the crises ended in June 2009 in some economies like USA (National Bureau of Economic Research (NBER), 2010).

4.3. Empirical results per asset class return

This section presents the coefficients obtained from the three estimators in assessing the inflation-hedging capacity of infrastructure, real estate and general equity in emerging markets. The parsimonious model specified by the Akaike information criterion was PARDL (1.1) model in all three cases—infrastructure, real estate and general equity.

Individual countries’ short-run coefficients estimated using the PMG estimator are shown in Table 6 (ignoring control variables and constant to conserve space).

From Table 6, it can be noted that a significant long-run relationship was found between the variables for all four nations as evidenced by negative and significant error correction terms. At 10% level of significance (which is very high for inferences in general), the negative relationship between infrastructure sector and inflation is significant for Brazil. All other coefficients are not significant, indicating the inability of different asset classes to hedge inflation in the short run. This is in agreement with the results obtained by Bird et al. (2014); Sawant (2010); and Bitsch et al. (2010) who found insignificant coefficients between inflation and infrastructure in the US and Australia. Given that the generalized Fisher equilibrium hypothesis (where the Fama-Schwert model is derived) is a long-term relationship, the results are not surprising.

4.4. Assessing the infrastructure sector’s inflation-hedging ability

The results derived from the assessment of the infrastructure sector’s ability to hedge inflation using three estimators in emerging markets are presented in Table 7. The short-run coefficients from PMG are excluded as they were shown at individual nation level in Table 6. The model derived from Equation (2) treating infrastructure as the dependent variable is as follows:

$$\Delta \text{Infrastructure}_{it} = (\varphi_1 \text{Infrastructure}_{i,t-1} + \beta'_{1j} \text{inflation}_{it} + \beta'_{2j} \text{GDP}_{it} + \beta'_{3j} \text{crude}_{it}) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta \text{Infrastructure}_{i,t-j} + \sum_{j=0}^{q-1} \delta_{1ij}^* \Delta \text{inflation}_{i,t-j} + \sum_{j=0}^{q-1} \delta_{2ij}^* \Delta \text{GDP}_{i,t-j} + \sum_{j=0}^{q-1} \delta_{3ij}^* \Delta \text{crude}_{i,t-j} + \mu_i + \varepsilon_{it} \quad (3)$$

where in this case, δ_{1ij}^* indicates the extent to which infrastructure hedges inflation in emerging markets in the short run.

Using all three estimators, the relationship between inflation and infrastructure sector returns is not significant in both the short and the long run. This indicates the sector’s inability to hedge inflation in emerging markets in the long run and short run. The findings are in line with estimates obtained using PMG model as specified in Table 5. These results concur with those obtained by Rodel and Rothballer (2012), but are contrary to Colonial First State’s (2009) findings. Crude oil price changes were found to be significant (under DFE only) in determining infrastructure returns in the long run. This is expected given the role played by crude oil in the infrastructure sector in emerging markets in the production and provision of many goods and services. As indicated by the

Table 6. PMG individual nation short-run results

Nation	Asset class		Infrastructure		Real estate		Composite stock	
	Response variable	Coefficient	p-value	coefficient	p-value	coefficient	p-value	
Brazil	ec term	-0.8328	0.00	-0.9236	0.00	-0.94	0.00	
	D(inflation)	-0.1017	0.064	-0.0210	0.463	-0.031	0.112	
China	ec term	-0.939	0.00	-0.917	0.00	-0.886	0.00	
	D(inflation)	-0.0116	0.312	-0.0214	0.084	-0.011	0.231	
India	ec term	-1.0266	0.00	-0.9267	0.00	-0.998	0.00	
	D(inflation)	0.010	0.171	0.01077	0.34	0.0039	0.263	
Indonesia	ec term	-0.923	0.00	-0.864	0.00	-0.93	0.00	
	D(inflation)	0.0082	0.299	-0.0084	0.472	0.0009	0.921	

Extracts from PMG estimation.

Table 7. Infrastructure sector and inflation hedging

	Estimator	MG		DFE		PMG	
		Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Long run	Inflation(-1)	-0.00431	0.387	-0.01098	0.197	-0.00999	0.151
	GDP(-1)	0.0077	0.131	-0.00046	0.933	0.00128	0.825
	Crude oil(-1)	0.18633	0.122	0.1291	0.039	0.0799	0.13
Short run	ec term	-0.947	0.00	-0.941	0.00		
	D(inflation)	-0.01914	0.389	-0.00014	0.983		
	D(GDP)	-0.0033	0.811	0.00772	0.464		
	D(crude oil)	0.0332	0.322	0.02871	0.549		
	Constant	0.00333	0.061	0.0091	0.311		

Extracted from model estimations.

negative and significant error terms from all estimators, long-run relationships exist between infrastructure sector returns and inflation, GDP and crude oil prices in emerging markets.

4.5. Real estate inflation-hedging capacity

The results on real estate's ability to hedge inflation in emerging markets are presented in Table A1. Short-run coefficients from the PMG estimator are excluded from as they are presented in Table 6. Like infrastructure sector returns, real estate returns in emerging markets are poor at hedging inflation in the long and short run, which is in line with Ibrahim & Agbaje's (2013) findings. GDP was found to be positive and significant in determining real estate returns using DFE in the long run, which is acceptable given the non-defensive long-term nature of real estate assets. All other coefficients were not significant except for the error correction terms which exhibit the existence of long run-relationships between real estate returns and GDP, and crude oil prices.

4.6. General listed stock's ability to hedge inflation

Turning to composite stocks' capacity to hedge inflation in emerging markets, the results are shown in Table A2. The insignificant coefficients from the three estimators suggest that listed common stock in emerging markets is not effective in hedging inflation. These findings contradict those of Incekara et al. (2012) and Emenike and Nwankwegu (2013) in the Nigerian market. Only crude oil was positive and significant in the long run using DFE and MG as well as GDP applying DFE. This is expected given the indispensable role of crude oil in emerging nations and the logic that stock markets tend to mirror economic developments.

4.7. Brief discussion of findings

The results from the three estimators (MG, DFE and PMG) indicate the inability of the infrastructure sector, real estate and general equity to hedge against actual inflation in emerging markets in the short and long run. Thus, investing in listed stocks on emerging stock markets cannot provide investors with immunity against inflation.

The lack of inflation-hedging capacity arises due to multiple reasons. It might indicate firms' inability to adjust their prices in line with inflation developments. Consequently, their pricing power might be questionable. This is expected given government intervention in the economic activities of emerging nations. For example, 23.8% of Brazil's CPI basket is composed of prices set by the government. In most cases, the regulated prices are either way above or way below the inflation level. The same can be said of Indonesia where electricity and energy prices are set by the government. Given the bureaucratic nature of emerging nations, price changes by national governments take a long time to take effect (if they do at all) and are almost always below the inflation rate. As a result, stock returns from firms or sectors exposed to government intervention cannot hedge inflation in the short or long run.

Informational inefficiency might also be a reason for stock returns' inability to hedge inflation. The capital markets might be inefficient in incorporating pricing power into stock returns (if firms do indeed have such power). Stock's failure to hedge inflation could also be attributed to the existence of massive debt in the capital structure (which is profound in infrastructure firms). When inflation increases, so does the cost of servicing old and new debt. Thus, even if firms are able to increase prices in line with inflation, the effect of increased debt obligations might offset that of increased earnings on stock value. Furthermore, during inflationary periods, consumption patterns are normally negatively affected as the purchasing power of salaries, savings and wealth, in general, is eroded. Decreased aggregate demand leads to lower sales volume. This implies that even if firms can increase prices in line with inflation, reduced sales volume off-sets this advantage, leading to lower cash-flows to stockholders.

On the same note, the inflation illusion might be significant among financial market participants in emerging markets, with investors discounting the positive impact of inflation on nominal earnings and simultaneously compounding the negative effect of inflation on current values. The

inflation illusion is compounded by the existence of irrational investors and noise traders in the market. Such investors and analysts barely consider fundamentals when valuing and trading stocks, and simply follow the crowd (herd behaviour).

5. Conclusions and recommendations

This study examined the ability of the infrastructure sector, real estate and general listed equity to hedge inflation in emerging markets using monthly data from 2009 to 2019. After noting the existence of cross-sectional dependence (using Breusch–Pagan LM, Pesaran scaled LM, Bias-corrected scaled LM and Pesaran CD), the study used the PECADF and IPS tests to ascertain the variables' level of integration. As all the variables were integrated of less than order two and considering the heterogeneous nature of the data, the study applied a panel ARDL model using MG, DFE and PMG estimators to verify the short-run and long-run inflation-hedging capacity of infrastructure, real estate and composite stocks in emerging markets.

The findings confirm the inability of the infrastructure sector, real estate and composite stocks to hedge inflation in the short and long run. This indicates the existence of significant beta risk in emerging stock markets, implying that when the market is heading north or south, all listed stocks follow suit (no sacred cows). Investors do not gain immunity to inflation by investing in the infrastructure sector in emerging markets. As such, financial market participants should consider commodities, currencies and metals as alternatives in their quest to hedge inflation. It should be emphasized that no asset can hedge inflation under all scenarios. Portfolio revision is key when inflation trends are changing. On the same note, given that the infrastructure sector is still in its infancy in developing nations, investors should keep up to date on regulatory changes which might affect the sector's pricing power. The infrastructure sector is broad and diverse; thus, considering sub-sectors like transport and energy might be profitable for investors in emerging markets.

It is recommended that the regulatory authorities pursue measures which keep inflation under control in order to reduce economic uncertainty and promote stock market development. This would ensure that investors in stock in the infrastructure sector are not exposed to the devastating effects of inflation and thus do not shy away from the sector. Future research could decompose actual inflation into expected and unexpected inflation and assess the infrastructure sector's ability to hedge the same. Research could also be conducted on the inflation-hedging capacity of this sector under different inflation regimes (creeping, galloping and hyperinflation). Given the heterogeneous nature of the infrastructure sector, assessing the inflation-hedging capacity of sub-categories (telecommunication, energy) could also be fruitful.

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Appendices

Table A1. Real estate hedging ability

Estimator	MG		DFE		PMG		
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value	
LR	Inflation(-1)	-0.0116	0.299	-0.0018	0.838	-0.0082	0.432
	GDP (-1)	0.01385	0.129	0.0116	0.049	0.00733	0.199
	Crude oil(-1)	0.0204	0.649	0.0437	0.363	0.0361	0.622
SR	ec term	-0.9354	0.00	-0.924	0.00		
	D(inflation)	-0.0117	0.239	0.00286	0.71		
	D(GDP)	0.0185	0.314	0.0403	0.00		
	D(crude oil)	-0.0335	0.125	-0.019	0.747		
Constant	-0.0051	0.743	-0.0034	0.708			

Authors' compilation.

Table A2. Composite stock hedging capacity

Response variable	MG		DFE		PMG	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Inflation(-1)	-0.0113	0.141	-0.0043	0.497	-0.0038	0.313
GDP (-1)	0.0071	0.139	0.00384	0.252	0.0037	0.081
Crude oil(-1)	0.12	0.007	0.137	0.005	0.1198	0.011
ec term	-0.967	0.00	-0.930	0.00		
D(inflation)	-0.0118	0.233	-0.00005	0.992		
D(GDP)	0.0097	0.243	0.01456	0.005		
D(crude oil)	0.0468	0.189	0.055	0.134		
Constant	0.0022	0.737	0.0056	0.310		

Extracts from model estimation.



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