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The Inflation Hedging Effectiveness of Residential Property- Evidence from Three Emerging Asian Markets

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Using a non-causality approach based on the conventional approach of Fama and Schwert (1977), cointegration method in Johansen (1988), and autoregressive distributed lag (ARDL) cointegration technique in Pesaran et al. (2001) and Granger et al. (2000), this study examines the inflation hedging effectiveness of residential property in three of the largest emerging market (EM) economies: China, India and Russia. While the results of the Fama and Schwert (1977) regression indicate that residential properties in China and Russia provide a short-term hedge against expected inflation, this is not the case for those in India against both expected and unexpected inflation. Consistent with the results of the developed economies, the Johansen and ARDL cointegration results provide strong evidence to support the hypothesis that inflation and the residential properties in the three largest EM economies are cointegrated. This implies that the residential properties in these three countries provide a long-term hedge for inflation. In addition, the causality results show evidence that inflation has a lead effect on residential property prices in India over the long run. The empirical results of the cointegration tests confirm that residential properties could be considered as a reliable hedge against inflation for EMs in the long run and suggest that investors should overweigh their investment in residential property assets during periods of persistent inflation in EMs.

Keywords

ARDL Cointegration, Residential Property, Emerging Housing Market, Inflation Hedging, Fisher Hypothesis.

1. Introduction

The impact of inflation on property returns has long been a financial concern of investors since the emergence of global inflation in the 1970s. As homeowner equity represents the largest share of the investment portfolio of most households in many developed economies, such as the United States (US), United Kingdom (UK), Japan and Hong Kong, any changes in the real value of homeowner equity have important implications for personal wealth as well as the national economy. In this regard, the ability of property assets to hedge against inflation compared to other forms of individual wealth, notably stocks and bonds, has been the subject of ongoing interest in the finance and real estate economics literature. In particular, housing markets in emerging economies, such as Russia, China and India, have been the object of investor interest. However, the ability of property assets to hedge against inflation remains uncertain in emerging market (EM) countries, particularly India and Russia. For the citizens of EMs, residential property assets are the most favored type of investment. The percentage of housing ownerships increased from 55% to 89.68% between the 1990s and 2011, versus the 66.1% in the US in 2011 (Wu and Tidwell, 2015). Investors in EMs who are interested in safeguarding the real value of money and their purchasing power during periods of high and persistent inflation therefore should be accurately informed of the inflation-hedging effectiveness of property assets to hedge their investment risk.

First coined by van Agtmael (2007) in the 1980s, the term EM is defined as a fast-growing economy along with rapid industrialization. Cavusgil et al. (2013) further explain and show that EMs are countries that have gone through rapid growth and industrialization but trapped between the developing to developed markets. Moreover, Morgan Stanley Capital International (2016) describes Russia, India and China as the major global EMs. These three countries have transitioned from developing countries to EMs. Each of them as an individual market and their combined effect as a whole have impacts in the changing global economics and politics. Data provided by the International Monetary Fund in 2020 (estimated) indicate that these three EM economies have a combined nominal GDP of US$19.3 trillion, about 23% of the gross world product and 92% of the nominal GDP of the US; a combined gross domestic product purchasing power parity (GDP (PPP)) of around US$41.3 trillion (31.8% of the global GDP (PPP)) and 200% of the GDP (PPP) of the US.

The inflation hedging ability of the residential properties in the three largest EM economies is examined for the following reasons. First, even though numerous related studies of various assets have appeared in the finance and investment literature after the seminal work of Fama and Schwert (1977), little is known about the empirical relevance of the EM economies, regardless of their increasing economic significance. Despite the large amount of attention that the impact of inflation on asset returns has received in the real estate economics literature, there have been only a few studies on the inflation-hedging ability of property assets in EMs until recently. Many such studies largely focus on the US, Europe and the newly industrialized nations in Asia, such as Hong Kong, Singapore, South Korea and Taiwan, which may not fully explain the EM case. To the best of my knowledge, this research could be considered as the first study to examine the inflation hedging effectiveness of residential properties in Russia and India based on the generalized Fisher hypothesis (GFH).

Second, EM economies that have historically experienced a higher rate of inflation and higher average expected returns of property assets over the decades in comparison to the developed economies have attracted research interest in investigating how the GFH (Fisher, 1930) performs for the property markets in EM countries. In particular, the extent that EM property assets are able to protect their investors against a high inflation environment. Third, EMs are typically characterized by less informed and less rational investors than the developed markets (Spyrou 2004). This characteristic renders a direct comparison of the inflation-hedging effectiveness of residential property much more worthwhile in EMs.

Finally, the risk of rising inflation is even more apparent in EMs. For instance, the annual inflation rate in 2020 in India (3.9%), Russia (3.2%) and China (3.8%) was higher than that of the more developed economies of the Four Asian Tigers: Taiwan (-0.1%), South Korea (0.5%), Hong Kong (-0.2%) and Singapore (-0.41%) (Statista and Hong Kong Monthly Digest of Statistics). Compared with the relatively lower inflation rate of the Four Asian Tigers, the higher inflation risks in the three countries of concern also indicate that inflation hedging is a more critical component for investors in those markets. Thus, this study will extend previous studies on inflation hedging effectiveness with residential properties in China and provide a more comprehensive understanding based on two other larger EMs in Asia: India and Russia. A noteworthy point is that Russia has territory in both Europe and Asia and therefore a transcontinental country. In fact, two-thirds of Russia is in Asia so Russia can be considered as part of Asia. This study is an important one for investors and policy-makers to further understand the similarities and dissimilarities among the largest EMs in Asia.

The aim of this research work is to examine the inflation-hedging ability of residential properties in the three largest EMs in Asia. The proposition embedded in what is termed the GFH (Fisher, 1930) will be examined in that property price should move positively in a one-to-one relation with the prices of goods and, hence, expected nominal returns on property will be equal to inflation rates. Aside from using the approach in Fama and Schwert (1977), the bounds testing cointegration in Johansen (1988) or Pesaran et al. (2001) is used to examine the causality between inflation and residential properties in these three EMs. In order to investigate the extent to which similar or dissimilar patterns are found across the three EMs, this study uses a country to country cointegration model rather than a panel cointegration model. The objective of this study is to explore the short-run and long-run inflation-hedging properties in the three EMs. The major research questions are: Do the largest EM residential properties in Asia hedge against inflation in the short run? Against inflation in the long run? Do residential properties in China behave differently than those in India and Russia in terms of their inflation-hedging properties? The empirical results of this study are essential for investors and policy-makers to further recognize the similarities and dissimilarities among the largest EMs in Asia and provide worthwhile information to investors who are seeking the best investment opportunities in EMs and government bodies who are assessing a variety of public policy options.

2. Literature Review

Over the last four decades, a large body of theoretical and empirical works have been published in the literature that examine the validity of the inflation hedging capability of various types of properties in the context of the GFH. One can group the studies in the literature into the three following determinant categories: 1. Earlier empirical works: primarily motivated by the surge of inflation in the 1970s in developed economies, the relations between property and inflation in the highly developed markets of major industrialized countries are examined and whether property and common stocks in those markets have the ability to hedge against inflation based on Fama and Schwert (1977) is determined; 2) studies that extend the empirical testing of the GFH in Fama and Schwert (1977) to newly developed economies, such as Hong Kong and Singapore and South Korea; and 3) research work that uses an alternative cointegration framework, such as the cointegration approach in Engle and Granger (1987), Johansen (1988), and Pesaran et al. (2001) and other panel cointegration approaches that empirically test the GFH in the long run.

The effectiveness of property assets as an inflation hedge has been researched since the late 1970s. However, earlier studies on the inflation-hedging ability of private properties have traditionally used data from the US and the UK because quality data are only available for relatively long periods in these two developed economies. In a pioneering study, Fama and Schwert (1977) examine the inflation hedging ability of residential properties, government bonds, common stock and human capital in the US between 1953 and 1971 through classical regression models. They built on the work of Fisher (1930), decomposing inflation into its expected and unexpected component parts. Fama and Schwert (1977) conclude that only residential real estate can completely hedge against expected and unexpected inflation based on the results of the GFH. Also, Treasury bills and labor income have some hedging ability, but common stock does not show any significant hedging effectiveness and is found to be negatively related to expected and unexpected inflation. In another study that uses US data, Rubens et al. (1989) examine the inflation-hedging effectiveness of not only residential real estate but also farmland, business real estate, corporate government bonds and common stock over the period of 1960-1986. Through the use of a classical regression analysis, they find that only residential real estate is a complete hedge against expected and unexpected inflation. Also, Treasury bills have some hedging ability, but common stock does not show any significant hedging effectiveness. The result is consistent with that of Fama and Schwert (1977) and both studies demonstrate that only residential real estate can completely hedge against expected and unexpected inflation in the US.

In another rigorous study, Hoseli et al. (1994) examine the inflation hedging ability of residential properties and common stock in Switzerland between 1943 and 1991 with the use of classical regression models. They also built on Fisher (1930), and decompose inflation into its expected and unexpected component parts. The regression model in Fama and Schwert (1977) shows that only property offers a better hedge against expected and unexpected inflation than common stock. When the inflation rate is decomposed into its expected and unexpected components, all of the coefficients are negative for stocks, whereas some of the coefficients are positive for property. In a later study based on regression and data from Asia, Sing and Low (2000) conclude that property provides a better hedge against inflation than stock and securitized property in the Singapore market based on only classical regression results. Among the various types of property, industrial property is the most effective hedge against both expected and unexpected inflation, whereas retail property only offers a significant hedge against expected inflation.

Earlier studies that examine the inflation-hedging effectiveness of property and stock with a traditional econometric approach, that is, the model in Fama and Schwert (1977), assume that most time series data have stationarity. However, a common technical problem in gauging the relationship between property returns and inflation with the use of time series data in a conventional multivariable regression model is using the non-stationary properties of most macroeconomic time series. These classical models appear to overlook these characteristics and their results and findings are subject to spurious regression bias.

Spurious regression bias means that the parameter estimates produced from the regression models might not be accurate. To address this problem, the approach in Engle and Granger (1987) and the cointegration approach in Johansen (1988) have been used to examine the inflation hedging effectiveness of real estate returns in the long-term with data from since the late 1990s including: Ganesan and Chiang (1998) for Hong Kong, Chu and Sing (2004) for four major cities in China and Li and Ge (2008) for Shanghai, China.

Ganesan and Chiang (1998) find conflicting results from regression and cointegration modeling. Using the co-integration approach in Engle and

Granger (1987), it is found that there is no long-term relationship or equilibrium between inflation and property assets, and property assets have failed to provide a long-term inflation hedge in Hong Kong over the period of 1984-1994. With regard to the short-term regression results, office and industrial properties offer a partial hedge in the short-term against unexpected inflation; and retail and residential properties offer a complete hedge against expected and unexpected inflation based on OLS regression models.

Chu and Sing (2004) examine the short-term inflation hedging characteristics of real estate markets (residential, commercial (retail) and offices) in four major cities in China: Beijing, Chengdu, Shanghai and Shenzhen. The results of the OLS regression modeling show that property assets in these four Chinese cities are poor hedges against both expected and unexpected inflation. This finding contradicts many earlier studies, such as Fama and Schwert (1977) and Ganesan and Chiang (1998), who conclude that residential property assets are a good hedge against expected inflation and unexpected inflation in the short-term. Chu and Sing (2004) also examine the long-term inflation hedging characteristics of Chinese properties by using cointegration models. The cointegration tests, which use country-level data, show insignificant long-term relationships between property return and inflation in the Chinese market. Countering the traditional belief that property is a good hedge against inflation in the long-run, the findings from both city-level and country-level property market data in China reject the inflation-hedging proposition for Chinese properties. Furthermore, the Granger causality results indicate that Granger causality runs one-way, from inflation to property and not the other way around. The results indicate that the variations for inflation are ahead of property returns.

Li and Ge (2008) conduct a similar study and investigate the inflation-hedging ability of housing properties in Shanghai for both the short-term and long-term. They find that these residential properties do not provide adequate hedge against inflation in the short-run based on regression results for 1997 to 2005. However, the augmented Dickey and Fuller (ADF) statistics of the residual tests based on Engle and Granger (1987) show that in the long run, Chinese properties provide an effective hedge against inflation. In contrast to Chu and Sing (2004), the Granger causality test results confirm a one-way causality from property returns to inflation. This indicates that variations in property returns might be ahead of the inflation rate. Both the cointegration and causality results contradict the findings of Chu and Sing (2004).

As for cointegration and error correction studies that focus on the markets of the developed economies of the US, Ireland, Amsterdam and the UK, Stevenson (2000) examines the long-term relationship between inflation and the housing market in the UK, and the cointegration results provide strong evidence that housing and inflation share a common long-term trend. However, where the inflation hedging ability of the Irish property markets is examined, Stevenson and Murray (1999) find that Irish real estate does not provide a good hedge against inflation in both the ordinary least square (OLS) and cointegration tests. In a later study based on the error correction approach, Hoseli et al. (2008) explore the relationship between commercial property returns and economic, fiscal and monetary factors and inflation for the US and UK markets. The results indicate that property returns are positively linked to anticipated inflation but not inflation shocks when real and monetary variables are included. In a more recent study, Brounen et al. (2014) examine the inflation hedging capacity of private homes by using long-term data for inflation, house price dynamics and rents in Amsterdam that date back to 1814. The data which span almost a century allow Brounen et al. (2014) to study total housing returns in different inflation regimes and for different investment horizons. The empirical results show that protection of homeownership against actual and expected inflation increases with the investment horizon. Inflation protection from housing is stronger when inflation is persistent, and the hedging capacity of housing against unexpected inflation is low. In addition, Wurstbauer and Schafers (2015) investigate the short- and long-term inflation-hedging characteristics and the inflation protection associated with infrastructure and real estate assets in the US from 1991 to 2013. They use the framework in Fama and Schwert (1977) and cointegration tests in Engle and Granger (1987). Granger causality tests were conducted to gain insight into the short- run dynamics. Their results show that direct infrastructure is the only partial hedge in the short run with the use of the framework in Fama and Schwert (1977) On the other hand, the cointegration tests indicate hedging in the long term as all series co-move with inflation in the long run. Wurstbauer and Schafers (2015) report reverse unidirectional causality from their causality tests. That is, inflation Granger causes real estate asset returns, but is caused by infrastructure asset returns.

Instead of using a traditional cointegration approach, Anari and Kolari (2002), Zhou and Clements (2010) and Lee (2013) structure an alternative ARDL approach to investigate long term relationships between inflation and residential property. Anari and Kolari (2002) investigate the relationships between inflation and residential properties in the US by using ARDL bounds testing and recursive regression. The cointegration results show strong evidence to support the cointegration of inflation and housing price and the recursive regression indicates a linear relationship between housing price and inflation. The ARDL cointegration results indicate that US property assets are an effective long-term hedge against inflation. In another study that adopts ARDL cointegration (bounds testing), Zhou and Clements (2010) investigate the inflation hedging ability of real estate in China. Their results do not support the cointegration of housing price and inflation and conclude that Chinese real estate is not an effective hedge against inflation over the long run. Likewise, Lee (2013) investigates the causal relationship between inflation and property return and the inflation hedging effectiveness of real estate assets in Hong Kong in both the short- and long-term. The regression results show that Hong Kong residential property is the only type of property that effectively hedges against actual, expected and unexpected inflation during the sample period. The ARDL bounds testing results strongly support the cointegration of inflation and residential property and thus property in Hong Kong is a good long-term hedge against inflation. Using panel vector autoregressive models, Wu and Tidwell (2015) evaluate different inflation hedging properties in eastern, middle and western real estate markets. Their empirical results suggest that only the middle real estate market provide the best hedging opportunities for anticipated inflation. In a recent study, Upadhyay (2019) examines how inflation, capital market development and the real estate sector in India are related by using monthly time series for January 2007 to January 2017. The consumer price index (CPI) is taken as a measure of inflation and real estate returns represent the real estate sector. Upadhyay (2019) finds that there are several factors which may impact the price movement in the real estate sector, but inflation is considered to be an important factor that affects the price movement of residential property. Real estate is one of the few assets that reacts proportionately to inflation. However, only Granger causality testing is conducted and the results indicate that inflation does not cause real estate returns in the short run and suggest that further investigation of the long run relationship between inflation and real estate should be done with a cointegration approach. In summary, the results in previous studies are conflicting, thus reflecting the different time period of the studies, price measure, type of property data, stage of economic development and economic cycle used. The empirical literature indicates that while property is likely to be a hedge against inflation, definitive details concerning whether property is an inflation hedge remain ambiguous.

3. Data and Methodology

This research work uses time-series quarterly data to investigate the inflation hedging effectiveness of residential properties in three of the largest EM countries. While the data series on inflation rate are extracted from the IMF financial statistics, those of residential real estate returns are collected from the Global Property Guide, IMF Global Housing Watch, and the Bank of International Settlement (BIS) property price statistics. Due to the limited availability of residential property prices, the estimation will cover different periods across the three EMs and defined as follows: 1) Russia: from 2003Q1 to 2019Q2, 2) China: from 2003Q1 to 2019Q2, and 3) India: from 2010Q1 to 2019Q2. While the inflation rate is represented by the CPI for Russia, India and China, the house prices in three EMs are defined as follows: 1) house prices in China are based on the second-hand house price index of Shanghai, 2) house prices in India are based on the house price index of the Reserve Bank of India. The National Housing Bank (NHB) publishes a quarterly house price index for India called Residex. It is based on actual transaction prices, and covers house prices in many different regions of India, and 3) house prices in Russia are based on the average per square meter price of residential property (published by the Federal State Statistics Service).

3.1 Measures of Various Asset Returns and Inflation Rate

The total return on residential property cannot be accurately measured, andit is also difficult to find representative data that reflect the various property leasing markets in EMs. As such, following Fama and Schwert (1977), capital gain returns are used for residential property with the residential property price index as an adequate proxy for the variation of the total return. The use of various property prices as a measure of total property return prevents the problems of estimating imputed rental income and returns to various residential properties in Russia, India and China. With regard to the inflation rate as a measure, Fama and Schwert (1977) conclude that the CPI is an acceptable proxy for the price levels that investors face. Similar to Fama and Schwert (1977) and Wurtzebach et al. (1991), this study also uses CPI as a proxy to represent the price level.

3.2 Actual Inflation Model

Equation 1 shows that the first model is designed to test whether the various residential properties effectively hedge actual inflation. This is the same as assuming that the expected inflation can be predicted by using the naive model such as in Gultekin (1983), and provides perfect forecasts of inflation:

$$\Delta REit = a_0 + b_i \Delta INFit + eit \quad (1)$$

where $\Delta REit$ denotes returns from residential property, $\Delta INFit$ denotes the actual rate of inflation, i is the EM country, t is the time period, and eit is an error term of i at time t.

While the intercept a_0 can be interpreted as representative of the real rate of return, the beta coefficient on $bi\Delta INFit$ shows the impact of the property returns on changes in actual changes in inflation. All of the underlying variables are in the logarithm form.

3.3 Fama and Schwert Model

The second regression model is based on Fama and Schwert (1977) who built on Fisher (1930). Fisher (1930) asserts that the nominal rate of return can be expressed as the product of the expected real return and the expected rate of inflation. They proposed a regression model (Equation 2) to examine the ability of property to act as a hedge against both expected and unexpected inflation.

$$\Delta REit = a_0 + b_i E(\Delta INFit/\sigma_{t-1}) \\ +c_i\{\Delta INFit - E(\Delta INFit/\sigma_{t-1})\} + eit \tag{2}$$

where $\Delta REit$ represents the return on residential property, $\triangle INFit$ is the actual rate of inflation, $E(\Delta INFit/\sigma_{t-1})$ denotes the expected rate of inflation, given available information at time t-1, and $\{\Delta INFit - E(\Delta INFt/\sigma_{t-1})\}$ is the unexpected rate of inflation. All of the underlying variables are in the logarithm form. Fama and Schwert (1977) indicate that if an asset hedges against expected inflation, b will be statistically indistinguishable from one. On the other hand, if an asset hedges against unexpected inflation, *c* will be statistically indistinguishable from one. When both coefficients, b and c, are equal to one and statistically significant, an asset completely hedges against inflation. In other words, an asset is defined to be a complete hedge against inflation, if and only if the nominal rate of return moves one-to-one with both the expected and unexpected inflation rates. As with the previous model, the intercept can also be representative of the real rate of return. In addition, an asset partially hedges against inflation if the significant coefficients are less than 1, but larger than zero. If an asset offers significant coefficients that are statistically higher than 1, then the asset offers additional hedge against the exposure of the other assets to inflation.

3.4 Forecasting Expected Inflation Rate

3.4.1 Time Series Method (ARIMA Forecasting)

The robustness of the regression results with the use of Equation 2 is not only affected by the measure used for price but also the forecasting model that is used to generate inflationary expectations. The empirical literature indicates that the three most popular proxies for expected inflation are: past inflation series (time series method), Treasury bill yields (economic variable method), and average of inflation forecasts (survey based method). Empirical studies, such as Hartzell et al. (1987), Onder (2000) and Lee (2013) utilize time series methods and derive by using either a univariate (AR1 and MA1) or multivariate (autoregressive integrated moving average (ARIMA)) method for a one-step forecasting of price changes. In this study, the ARIMA model will be constructed to the set of information available at the time at which the forecast is made and it is an ex-ante forecast. The order of the ARIMA (*p*, *d*, and *q*) models are determined based on an Akaike information criterion (AIC). A detailed explanation of the ARIMA procedures is provided in Box and Jenkins (1976) and the actual order for ARIMA (*p*, *d*, and *q*) for each ARIMA forecast is not reported here but available upon request.

3.5 Estimation Procedures – Johansen Cointegration Approach

This study will use the Johansen cointegration approach in which the integration order of all of the underlying variables is integrated in the order of one. Therefore, the first step in the Johansen cointegration approach is pre-modelling the unit root tests. The Phillips and Perron (PP) and the ADF tests are used investigate whether the time-series data are stationary over time. The equivalent to testing whether a particular economic time series (X_t) is stationary is by testing for the significance of β_2, i.e. $H_0 = \beta_2 = 0$ in the ADF regression in Equation 3. If the null hypothesis (H_0) is rejected, then the time series (X_t) is said to be stationary.

$$\Delta X_t = \beta_0 + \beta_{1_{time}} + \beta_2 X_{t-1} + \sum_{i=1}^{k} \lambda_i \Delta X_{t-i} + e_t \tag{3}$$

If the results of the unit root tests suggest that the underlying variables are integrated in the same order, normally an $I(1)$ variable, this implies that they are able to form a cointegrating vector.

After establishing the number of unit roots, the lag lengths of the underlying variables in the vector autoregression (VAR) model must be determined by using either the AIC or Schwarz information criterion (SIC) to test for the existence of cointegration. In addition, it is important to determine whether the VAR model has included only the intercepts, only the trends or both of them. In the third step, the maximum eigenvalue and trace statistics are used to determine the number of statistically significant cointegrating vectors that are found among the underlying variables in the estimated equation. If one or more cointegrating vectors exist, the long-run parameter estimates are subsequently derived from the cointegrating vector. In the second stage, we incorporate the lagged value of the error correction term (ECT), which is derived from the statistically significant cointegrating vectors, with other underlying variables in the differenced form to estimate the inflation and residential property relations in the vector error correction model (VECM). Following Tarbert (1996), Stevenson (2000) and Lee (2013), only actual inflation is examined in the cointegration analysis since the purpose of a cointegration analysis is to test for evidence of a long-run relationship, and therefore it is safe to assume that the actual and expected rates of inflation are equal.

3.6 Estimation Procedures of ARDL Models

To investigate whether the underlying time series variables for residential property and inflation rate are stationary, this study uses the ADF and PP unit root tests as the pre-modelling tests to examine the stationarity conditions of the time-series data in relation to the level form and first differences. If the underlying variables are not integrated with the same order but the orders zero and one, the Pesaran bounds testing cointegration technique will be used for further analysis.

The bounds testing procedures in Pesaran et al. (2001) involve two stages. An unrestricted error correction model (UECM) in Equation 4 is constructed to test for the existence of a long-run relationship, where *Y* is the dependent variable, *X* is the independent variable, *K* is the number of lags, and *D* represents the differences. The maximum lag order (*K*) is set to 6 for the quarterly data, thus ensuring that there is no evidence of serial correlation, as emphasized in Pesaran et al. (2001).

In the first stage, we use *F*-statistics to determine the significance of the lagged levels of the included variables in the underlying ARDL model, as shown in Equation 5. The values of the *F* statistics can show the existence of a long-run relationship between the underlying variables in the residential property price and inflation models.

$$DY_t = a_0 + \sum_{i=1}^{K} b_i DY_{t-i} + \sum_{i=0}^{K} d_i DX_{1t-i} + g_1 Y_{t-1} + g_2 X_{1t-1} + \mu_t \tag{4}$$

The null hypothesis of the non-existence of long-run relationships is tested by using the following equation:

$$\begin{aligned} H_0 &: g_1 = g_2 = 0 \\ H_1 &: g_1 \neq 0, g_2 \neq 0 \end{aligned} \tag{5}$$

The relevant test statistic for the existence of cointegration is the value of the *F*-statistic for the joint significance of g_1, and g_2 in Equation 5. The appropriate critical values tabulated in Pesaran et al. (2001) depend on the number of explanatory variables, and whether the ARDL model contains an intercept and/ or time trend. A time trend may be added to the UECM in Equation 4.

The null hypothesis of the non-existence of a long-run relationship is investigated by testing Equation 5 without lagged level variables. Next, a variable addition test with both differenced and level variables is performed to test the joint significance of the lagged level variables by using the Wald test in Equation 4.

In the second stage of the ARDL estimation process, a two-step method is further used to estimate the relationship between asset return and inflation. In the first step, the orders of the lags for all level variables in the ARDL model are selected either by using SIC or AIC while ensuring that there is no serial correlation problem. The maximum lag order set for selection is 6 for the quarterly data, thus ensuring more lagged differenced variables can be included in the error correction model (ECM). In the second step, the short run estimates from the associated ECMs are derived from the selected ARDL model. The selected Pesaran ECM will be applied to conduct causality tests as noted in Granger et al. (2000).

3.7 Estimation Procedures of Causality Models

After testing for the existence of cointegrating relationships, the ECM in Pesaran et al. (2001) is then estimated to perform Granger non-causality tests as in Granger et al. (2000). If a cointegration relationship is established with Equation 4, the bivariate VAR model might be adopted to test for Granger causality by including an ECT in Equations (6) and (7), where $y1t$ and y2t denote the asset returns and inflation. In doing so, the causality model is specified in Equations 6 and 7. The potential short-term causality and long-term equilibrium relations are examined with Equations 6 and 7.

If cointegration exists between Y_{1t} and Y_{2t}, an ECT is required in testing for Granger causality as shown in Equations 6 and 7. According to Engle and Granger (1987), the existence of cointegration implies a long-term causality among a set of variables as shown by [A1] + [A2] = 0 in which A1 and A2 denote the speed of adjustment in Equations 6 and 7, respectively.

Failing to reject $H0$: $b21= b22=\ldots b2$k = 0 and A1= 0 implies that inflation does not Granger cause asset prices while failing to reject $H0$: $d11= d12=\ldots\ldots d1$k = 0 and A2 = 0 indicates that asset prices do not Granger cause inflation. A Wald test is used to test for the joint significance of the lagged difference of the independent variables in Equations 6 and 7.

$$DY_{1t} = b_0 + \mathrm{A1}ECT + \sum_{i=1}^{K} b_{1i}DY_{1t-i} + \sum_{i=0}^{K} b_{2i}DY_{2t-i} + \mu_{1t} \tag{6}$$

$$DY_{2t} = d_0 + \mathrm{A2}\ ECT + \sum_{i=1}^{K} d_{1i}DY_{1t-i} + \sum_{i=1}^{K} d_{2i}DY_{2t-i} + \mu_{2t} \tag{7}$$

4. Fama and Schwert, Cointegration and Causality Results

4.1 Results of Actual Inflation Tests

Although the OLS regression models cannot capture the co-integration relationships that may exist between inflation and residential property returns in the long-term, OLS modeling is a good start for an empirical analysis as this gives initial insights when testing the relationship between actual inflation and residential property returns.

The results of the actual inflation model with the use of quarterly data estimated from Equation 1 in Table 1 indicate that the residential property reports of China are significant (at an error rate of 10%) and a positive beta coefficient of 3.4046 whereas those of India and Russia show a non-significant negative sign. Therefore, the results of the actual inflation model indicate that there is only evidence to accept the actual inflation-hedging effectiveness of residential property assets in the Chinese market. The results are consistent with those of Tarbert (1986), Stevenson (2000) and Lee (2013). As noted by Tarbert (1986), the property market cannot react quickly to inflation shocks. Moreover, it is important to note that China, India and Russia report significantly positive intercepts at the 95% significance level, thus indicating a significantly positive real return of residential property investment.

Table 1 Results of Actual Inflation Model

Variables/ Country (Quarterly data)	***a* (Q)**	***t*-statistic**	***b* (Q)**	***t*-statistic**	**R^2(Q)**	**LM (*p*-value)**
China	0.015	3.304***	3.405	1.866*	0.052	0.000
India	0.026	4.523***	-0.109	-0.410	0.005	0.000
Russia	0.024	3.451***	-0.003	-0.164	0.000	0.007

***Notes*:** 1) *, ** and ***: Significant at the 10%, 5%, and 1% levels. 2) After correcting for serial correlation, the Durbin Watson statistics suggest that the residuals are not serially correlated.

4.2 Results of Fama and Schwert Approach

The results of the Fama and Schwert (1977) model estimated by using Equation 2 shown in Table 2 indicate that residential properties in China and Russia are an effective hedge against expected inflation. Although the beta coefficient on the unexpected inflation of residential properties in China is significant at the 10% level, that on unexpected inflation has the wrong sign and is negatively related to unexpected inflation. This implies that residential properties in China and Russia are a short term hedge against expected inflation but fail to provide any hedge against unexpected inflation at the 5% level.

Regarding the results of India, the quarterly beta coefficients of the expected and unexpected inflation are negative and insignificant. This implies that residential properties in India act in the opposite manner when hedging expected and unexpected inflation. In addition, it is important to note that all of the selected EM countries report positive intercepts but only China reports a significant intercept at the 5% level. The significantly positive intercept of China indicates a significantly positive real rate of return of residential property in China in the short run.

Table 2 Results of Fama and Schwert Model

Variables/ Country (Quarterly data)	***a*(Q)**	***t*-statistic**	***b*(Q)**	***t*-statistic**	***C* (Q)**	***t*-statistic**	**LM**
China	0.010	2.180**	5.800	2.310**	-3.580	-1.900*	0.000
India	0.010	0.004	-0.340	0.940	-0.130	1.480	0.000
Russia	0.004	0.520	4.160	3.970***	0.004	0.310	0.070

***Notes*:** 1) *, **, and ***: Significant at the 10%, 5% and 1% levels. 2) After correcting for serial correlation, the Durbin Watson statistics suggest that the residuals are not serially correlated.

4.3 Cointegration Results and Interpretation – Johansen Cointegration Approach (China)

4.3.1 Unit Root Test Results (China)

The first step of the cointegration analysis is to investigate the time-series properties of the underlying variables by using unit root tests. The results of the ADF and PP unit root tests (with constant and time trend) in Table 3 indicate that the p- value of the ADF and PP statistics are below an error rate of 5% for all of the underlying variables in the first differenced form. Moreover, the p-value of the ADF and PP statistics is higher that the critical value at an error rate of 5% for all of the underlying variables in the level form. Thus, it can be concluded that all of the underlying variables in the China model are classified as $I(1)$ variables and can form a cointegrating vector. This suggests that the Johansen cointegration model is a feasible method for China.

Table 3 Results of ADF/ PP Unit Root Tests (China)

Variable	**Level with Time Trend**	**First Difference with Time Trend**
LNHOME (ADF)	-1.794 [0.380]	-4.398 [0.001]
LNINF (ADF)	-1.200 [0.669]	-5.149 [.000]
LNHOME (PP)	-2.148 [0.227]	-3.669 [0.007]
LNINF (PP)	-0.921 [0.776]	-7.700 [0.000]

***Notes*:** 1) Ln = series in logarithm form, HOME = Residential property returns in China, INF = Inflation variable of China. 2) All of the above series have been estimated by using models with intercepts and a linear time trend, as shown in Equation 4. 3) Figures in brackets [ ] are the *p* value. 4) The results of the ADF unit root test indicate that all of the series in Table 3 have no mixed results between the models with constant and linear trends and with constant and no linear trend. 5) In line with the study reporting guidelines, all of the results of the unit root test statistics are shown based on the general regression model with constant and time trends.

4.3.2 Johansen Cointegration Results (China)

The Johansen's maximum likelihood (ML) approach is used to test for cointegration in China. The VAR(*k*) model is estimated with unrestricted intercepts and without deterministic trends. The test statistics of the selection criteria for choosing the order of the VAR model are presented in Table 4. The results of the selection criteria indicate that the AIC selects the VAR(6) model and the SIC selects the VAR(2) model. Therefore, the results of the final prediction error (FPE) and likelihood ratio (LR) with the Hannan-Quinn criterion (HQ) are checked and all of the criteria indicate an order of six. The test results of the FPE, LR and HQ are not reported here but available upon request. Ultimately, the VAR(6) model is selected for the cointegration estimation process.

Table 5 shows the results of the maximum eigenvalue and trace statistics of the Johansen ML approach for the VAR (6) models with unrestricted intercepts and without trends. As shown in Table 5, the statistics for the trace tests reject the null hypothesis of no cointegrating vectors, which suggests that one cointegrating vector exists. In addition, the null hypothesis of at most one cointegrating vector ($r \leq 1$) among all of the variables is rejected. The analysis produces a trace statistic of 6.3367, which is higher than an error rate of 5% of 3.841. Two cointegrating vectors are therefore recommended. Likewise, the maximum eigenvalue test also indicates that there are two cointegrating vector at an error rate of 5% as the maximum eigenvalue statistic of 6.336 is higher than the critical error rate of 5% of 3.841. Therefore, the Johansen results show that the inflation rate and residential property prices in China are cointegrated.

In addition, the long-run parameter estimates of residential property price and inflation rate in the cointegration model for China in Table 6 indicates that the Fisher coefficient is 2.8242 and greater than unity. This suggests that residential property provides superior long-term hedging against inflation in China.

Table 4 Results of Selection Criteria for Selecting Order of VAR Model (China)

Order	AIC	SIC
6	-11.532*	-10.624
5	-11.396	-10.628
4	-10.966	-10.338
3	-11.049	-10.858
2	-11.111	-10.974*
1	-10.591	-10.509

Notes: AIC = Akaike Information Criterion, SIC = Schwarz Information Criterion

Table 5 Results of Johansen Cointegration Test Based on λ_{max} and λ_{trace} (China)

Maximum Eigenvalue Test					Trace Test				
Null	Alt	Stat	95% CV	*P* value	Null	Alt	Stat	95% CV	Prob
r=0	r=1	13.106	14.265	0.0756	r=0	r≥1	19.44	15.49	0.012
r≤1	r=2	6.336	3.841	0.0118	r≤1	r≥2	6.3367	3.841	0.0118

Notes: 1) Trace and maximum eigenvalue statistics for testing the null of no cointegration against the alternative cointegrating relations among the variables in the long-run model (China). 2) 95% of critical values in this table are obtained from Pesaran and Pesaran (1997). 3) Period of estimation is from 2003Q1 to 2019Q2. 4) Johansen co-integration tests are estimated based on the VAR (6) models.

Table 6 Results of Cointegration Regression (China)

Series	Coefficient
LNHOCHI	1.0000
LNINFCHI	-2.8242

Note: Coefficient is derived from the normalized co-integrating vector value.

4.3.3 Causality Test Results (China)

It is well understood in time series econometrics that the existence of a cointegration relationship between inflation and residential property does not prove that there is any causality. Causality tests are recommended by using VECMs derived from the cointegrating vector, where causality runs from inflation to residential property returns. Hence, we have constructed a VECM derived from a selected cointegrating vector, to test the significance of the coefficient of the lagged ECT and joint significance of the lagged differences of the explanatory variables by using a Wald test. For the error correction equation shown in Table 7, the coefficient of the lagged ECTs (ECT1) for the China model is -0.0556 and insignificant at the 5% level, thus indicating that the adjustment of property to inflation is very low. As Granger et al. (2000) suggest, an insignificant ECT is indicative of insignificant long-run causality. It was concluded that inflation will not lead residential property prices in China over the long run. Furthermore, the F and chi square statistics results of the Wald test indicate that the joint significance of the lagged differences of the inflation rate variables are insignificant, thus indicating no evidence of short-run causality. This is consistent with Tarbert (1986) in that the property market cannot react quickly to inflation shocks. Finally, the statistics value of 1.9803 (Durbin Watson (DW) test for serial correlation) in Table 7 (Note 1) and the graph of a cumulative sum control chart (CUSUM) test of the model stability suggest that the ECMs are well specified and stable. The CUSUM tests (in graphical form) are not reported here but available upon request.

Table 7 Results of ECM – (China)
Coefficient and *t*-Statistics

Variable	Coefficient Estimate	*t*-statistic
ECT1	-0.057	-1.177
DLNHOCHI1	0.900	6.296
DLNHOCHI2	-0.278	-1.485
DLNHOCHI3	0.063	0.337
DLNHOCHI4	-0.239	0.337
DLNHOCHI5	-0.280	1.423
DLNHOCHI6	-0.169	-1.030
DLNINFCHI1	-0.305	-0.601
DLNINFCHI2	0.165	0.351
DLNINFCHI3	-0.088	-0.246
DLNINFCHI4	-0.088	-0.246
DLNINFCHI5	0.406	0.575
DLNINFCHI5	0.198	0.216
CST	-0.044	-1.778

Notes: 1) R^2= 0.374, $\overline{R}^2$ = 0.327, DW=1.980. 2) Wald tests = *F* statistics (DLNINFCHI, DLNINFCHI2, DLN3, DLNINFCH4, DLNINFCH5, DLNINFCH6) 0.599 (0.730) chi square 3.5937 (0.732). 3) Long run cointegration regression = LNHOCHI = 8.504-2.824LNINFCHI. 4) ECT1 = Error correction term (one lag), derived from cointegration regression.

4.4 Cointegration Results and Interpretation – Johansen Cointegration Approach (India)

4.4.1 Unit Root Test Results (India)

The results of the ADF and PP unit root test in Table 8 indicate that the p-value of the ADF and PP statistics are below an error level of 5% for all of the underlying variables in the first differenced form. Moreover, the p-value of the ADF and PP statistics are above the critical value at the 5% level for all of the underlying variables in level form. Therefore, it is concluded that all the underlying variables in the model are classified as an *I*(1) variable and the Johansen cointegration approach is a plausible method to use for India.

4.4.2 Johansen Cointegration Results (India)

The tests statistics of the selection criteria for choosing the order of the VAR model for the cointegration analysis are presented in Table 9. The results of the selection criteria indicate that the AIC selects the VAR(5) model and the SIC selects the VAR(1) model.

Table 8 Results of ADF/ PP Unit Root Tests (India)

Variable	Level with Constant and Time Trend	First Difference with Constant and Time Trend
LNHOME (ADF)	-2.543 [0.103]	-5.152 [0.000] **
LNINF (ADF)	-1.286 [0.875]	-5.232 [0.000] **
LNHOME (PP)	-2.635 [0.095]	-5.232 [0.000] **
LNINF (PP)	-2.530 [0.313]	-7.490 [0.000] **

Notes: 1) Ln = series in logarithm form, HOME = Residential property return in India, INF = Inflation variable for India. 2) All of the above series have been estimated by using models with intercepts and a linear time trend, as shown in Equation 4. 3) Figures in brackets [ ] are the *p* value. 4) The results of the ADF unit root test indicate that all of the series in Table 8 have no mixed results between the models with constant and linear trends and with constant and no linear trend. 5) In line with the study reporting guidelines, all of the results of the unit root test statistics are shown based on the general regression model with constant and time trends.

Therefore, the results of the FPE and LR criterion are checked, and the FPE indicates the VAR(5) model and LR indicates the VAR(3) model. Since both AIC and FPE select the VAR(5) model, the VAR(5) model is used in the stage of the cointegration estimation process.

Starting with the null hypothesis of no cointegrating vector ($r=0$) among the variables in Table 10, the trace test statistic of 25.153 exceeds the 95% level of significance of 15.490. This implies that the null hypothesis of no cointegrating relation should be rejected. However, for the null hypothesis of the one cointegrating relation ($r \leq 1$) between the variables, the trace statistic of 3.630 is lower than the 95% level of significance of 3.841 respectively. This implies that the null hypothesis of $r \leq 1$ cannot be rejected. Therefore, the cointegration test, based on the trace of the stochastic matrix, indicates that one cointegrating relation exists at an error level of 5%. Likewise, the null hypothesis of no cointegration ($r=0$) is rejected at an error level of 5% and in favor of $r=1$ based on the results of the maximum eigenvalue statistics of 21.523. However, the null hypothesis of the one cointegrating relation ($r \leq 1$) between the underlying variables is rejected as the maximum eigenvalue statistic of 3.630 is lower than an error level of 5% of 3.841. The results of the trace and maximum eigenvalue statistics indicate that there is one cointegrating vector in the model for India.

The Fisher coefficient for the case of India shown in Table 11 is 1.327, which is higher than one. This indicates that residential property provides additional long-term hedging against inflation in India.

Table 9 Results of Selection Criteria for Selecting Order of VAR Model (India)

Order	AIC	SIC
5	-12.852*	-11.854
4	-12.740	-11.924
3	-12.646	-12.011
2	-12.482	-12.029
1	-12.695	-12.422*

Note: AIC = Akaike Information Criterion, SIC = Schwarz Information Criterion

Table 10 Results of Johansen Cointegration Test Based on λ_{max} and λ_{trace} (India)

Maximum Eigenvalue Test					Trace Test				
Null	Alt	Stat	95% CV	*P* value	Null	Alt	Stat	95% CV	Prob
r=0	r=1	21.523	14.265	0.019	r=0	r≥1	25.153	15.490	0.001
r≤1	r=2	3.630	3.841	0.055	r≤1	r≥2	3.630	3.841	0.057

Notes: 1) Trace and maximum eigenvalue statistics for testing the null of no cointegration against the alternative cointegrating relations among the variables in the long-run model (China). 2) 95% of critical values in this table are obtained from Pesaran and Pesaran (1997). 3) Period of estimation is from 2010Q1 to 2019Q2. 4) Johansen co-integration tests are estimated based on the VAR(5) models.

Table 11 Results of Cointegration Regression (India)

Series	Coefficient
LNHOIND	1.000
LNINFIND	-1.327

Note: Coefficient is derived from the normalized co-integrating vector value.

4.4.3 Causality Test Results (India)

As one cointegrating vector is found in the model for India, a VECM derived from the selected cointegrating vector is constructed to test for the significance of the coefficient of the lagged ECT and joint significance of the lagged differences of the explanatory variables by using a Wald test. As shown in Table 12, the coefficient on the lagged ECTs (ECT1) is -0.428 and significant at an error level of 5% in India. This indicates that inflation leads residential property returns in India over the long run and the adjustment of property to inflation is moderate to high. Although the F and chi square statistics of the Wald test indicate the joint significance of the lagged differences of the inflation rate variables, they are negatively related to residential property in the short run and counter the expected sign based on the FGH. The negative results are consistent with the findings in the regression model of Fama and Schwert (1977) for India as shown in Table 2. Finally, the statistics value of the DW test of serial correlation in Table 12 (Note 1) of 1.804 and the results of the CUSUM test of the model stability indicate that the ECMs are well specified and stable.

Table 12 Results of ECM – (India)
Coefficient and *t*-Statistics

Variable	Coefficient Estimate	*t*-ratio
ECT1	-0.428	-4.577
DLNHOIND1	0.072	0.483
DLNHOIND2	-0.168	1.209
DLNHOIND3	0.175	1.329
DLNHOIND4	-0.079	-0.565
DLNINFIND1	-1.031	-3.527
DLNININD2	-0.676	-2.026
DLNINFIND3	-0.501	-1.802
DLNINFIND4	-0.694	-2.306
CST	-0.063	4.180

Notes: 1) R^2=0.63032 $\overline{R^2}$ = 0.486, and DW=1.804. 2) Wald tests = *F* statistics (DLNINFIND1, DLNINFIND2, DLNINFIND3, DLNINFIND4, and DLNINFIND5) F =3.939 (0.014), Chi square = 15.754 (0.003). 3) Long run cointegration regression = LNHOIND = 1.382-1.327LNINFIND. 4) ECT1 = Error correction term (one lag), derived from cointegration regression.

4.5 Cointegration Results and Interpretation – ARDL Approach (Russia)

4.5.1 Unit Root Test Results (Russia)

The ADF and PP tests (with constant and time trends) for the inflation and residential property price variables are implemented to determine the order of integration of the variables. While the inflation variable is *I*(1) based on the results of the ADF and PP tests in Table 13, the residential property variables under investigation are *I*(0) variables at an error level of 5%. In order to ensure the robustness of the unit root test results, it is a good idea to search for the breakpoint for residential property prices. The specified breakpoint represents a one off event of the 24% drop in residential property price in Russia over the period of 2010Q4-2011Q1. Both the p-value of the breakpoint test with a constant only and a constant and trend for property price variables in the differenced form, are lower than the 5% level. In addition, the p-value of the breakpoint test for property price in the level form variables is higher than the 5% level. This therefore suggests that the residential property variables under investigation should be *I*(1) variables at an error level of 5%. Due to the uncertainty of finding the same order of integration for the underlying variables, it is recommended that the ARDL approach is used for cointegration and a causality analysis. The ARDL approach allows for both *I*(0) and *I*(1) variables in the estimating equation.

Table 13 Results of ADF/ PP Unit Root Tests/ Break Point Test (Russia)

Variable	**Level with Constant and Time Trends**	**First Difference with Constant and Time Trends**
LNINFRUS (ADF)	-0.869 [0.953]	-6.013 [0.000] **
LNINFRUS (PP)	-0.633 [0.974]	-5.995 [0.000]
LNHOMERUS (ADF)	-5.051 [0.028]**	-8.825 [0.000] **
LNHOMERUS (PP)	-5.051 [0.028]**	-8.825 [0.000] **
Variables and Break point test	**Level with Constant and Time Trend**	**First Difference with Constant and Time Trends**
LNHOMERUS (Breakpoint test with constant only)	-3.01 [> 0.1]	-14.604[0.000] **
LNHOMERUS (Breakpoint test with constant and time trends)	-2.376 [> 0.5]	-14.577[0.000] **

Notes: 1) Ln = series in logarithm form, HOME = Residential property return in China , INF = Inflation variable of China. 2) All of the above series have been estimated by using models with intercepts and a linear time trend, shown in Equation 4. 3) Figures in brackets [ ] are the *p* value. 4) The results of the ADF unit root test indicate that all of the series in Table 3 have no mixed results between the models with constant and linear trends and with constant and no linear trend. 5) In line with the study reporting guidelines, all of the results of the unit root test statistics are shown based on the general regression model with constant and time trends.

4.5.2 ARDL Cointegration Results (Russia)

Based on the assumption that serial uncorrelated errors are important for the validity of the bounds test, it is prudent to select 6 lags for the quarterly data in Table 14 to ensure less likelihood of a serial correlation problem and sufficient lagged explanatory variables are found in the ECM. When the model is running from inflation to residential property returns, the results in Table 14 indicate that the *F*- and chi square statistics of all of the different lags (4, 5 and 6 lags) are higher than their respective critical values at an error level of 5%. The result of lag 4 with the smallest p-value strongly suggests a stable long-run relationship that runs from inflation to residential property returns at the 5% level and causality tests will be conducted to examine the long-run and short run causalities between inflation and residential property returns. As shown in the notes for Table 15 (No. 2), the long run cointegrating regression indicates that the Fisher coefficient of Russia is 0.960, a bit smaller than unity. This indicates that residential properties only offer a partial long- term hedge against the inflation rate in Russia.

Table 14 Results of *F*-Statistics – Testing for Existence of Long-Run Relationships (Russia)

Lagged structure	*F*-Statistics: Based on regressions with intercept	Chi Square Statistics based on Wald test on level variables: Based on regressions with intercept
P, *q*1,	$F\ (Y_1, X_1)$	
6,6	3.682 (0.033)	-7.364 (0.025)
5,5	3.670**(0.033)	-7.341 (0.026)
4,4	4.253(0.020)	8.506 (0.014)

Note: *P* value in brackets [ ].

4.5.3 Causality Test Results (Russia)

Causality tests are then carried out with the ECM which is derived from the selected ARDL model based on the AIC. The ECM is used to test the significance of the coefficient of the lagged ECT and the joint significance of the lagged differences of the explanatory variables by using a Wald test. As shown in Table 15, the coefficient on the ECTs is -0.038 and insignificant at the 5% level. A very small ECT value indicates that the adjustment of property to inflation is very weak or slow. As Granger et al. (2000) suggest that a non-significant ECT is indicative of the absence of long-run causality, this suggests that inflation does not lead residential property price in Russia over the long run. Moreover, the lagged differences of the inflation variables are negative and insignificant, thus showing no evidence of short run causality from the direction of inflation to residential property returns. Finally, the value of the DW test for the serial correlation in Table 15 (Note 1) of 2.088 and the results of the CUSUM test of the model stability indicate that the ECMs are well specified and stable.

Table 15 Results of ECM – ARDL(2,0) (Russia)
Coefficient and *t*-Statistics

Variable	Coefficient Estimate	*t*-ratio
CST	0.004	0.363
DLNHORUS1	0.303	2.438
DLNHORUS2	0.266	2.149
DLNINFRUS	-0.003	-0.754
ECT1	-0.038	-1.519

Notes: 1) R^2= 0.25768, $\overline{R^2}$= 0.206, DW=2.088. 2) Long run cointegration regression = LNHORUS = -0.167+**0.960**LNINFRUS. 3) ECT1 = Error correction term (one lag), derived from cointegration regression.

4.6 Results Comparisons and Discussion of Inflation Hedging Effectiveness

4.6.1 Short Term Hedge

This study provides a number of important insights. A summary of the inflation-hedging characteristics of residential property is presented in Tables 16 and 17. Overall, there are three major findings. First, it is very difficult to hedge unexpected inflation risk. The empirical findings here confirm that it is very difficult for residential property to hedge unexpected inflation the short-run in the three largest Ems in Asia. A summary of the empirical findings in Table 16 shows limited ability of residential property to hedge unexpected inflation over the short run. However, short term anticipated inflation-hedging results of residential property are found at the 5% level in China and at the 1% level in Russia, thus suggesting that residential properties in these two developed markets are a good hedge against expected inflation. It is important to note that only China reports significant positive intercepts at the 5% level in the Fama and Schwert model, which shows a significantly positive real return of residential property investment in China. In sum, residential properties in China are the best short-term hedge against inflation as opposed to India and Russia.

Table 16 Short-run Inflation-Hedging Ability (Based on Fama and Schwert Results)

Country	Actual Inflation	Expected Inflation	Unexpected Inflation
China	YES (superior hedging at 10% level)	YES (superior hedging at 5% level)	NO (hedging at 10% level but with negative sign)
India	NO	NO	NO
Russia	NO	YES (superior hedging at 1% level)	NO

4.6.2 Long Term Hedge

Residential property in EMs can provide a positive hedge against inflation over the long run. The exceptional results of the ability of residential properties to hedge inflation in the long run were evident for China, India and Russia, thus suggesting that residential properties in these markets serve as a good long term hedge. The empirical ARDL and Johansen cointegration results in Tables 5, 10 and 14 and the summary of the findings from the cointegration tests in Table 17 suggest the good ability of residential properties to hedge against inflation in the long run, and it can be concluded that residential properties in China, India and Russia are an effective type of investment for long term inflation hedging. Moreover, the results imply that residential properties in the three markets are probably a better hedge against longer-term inflation risks as opposed to shorter-term inflation risks.

Table 17 Long-run Inflation-Hedging Ability (Based on Johansen and ARDL Cointegration Results)

Country	Inflation hedging ability	Degree of hedging ability	Confidence level
China	YES	Superior	5% rate of error
India	YES	Additional	5% rate of error
Russia	YES	Partial	5% rate of error

4.6.3 Generalized Fisher Hypothesis

Lastly, it is found that the ability of residential property to hedge against inflation over the long run is more robust in China than India and Russia. The long-run cointegration coefficient of residential property with respect to inflation rate for China as shown in Tables 6 and 17 indicates that the long run Fisher coefficient is 2.824 and greater than unity. The Fisher coefficient results of China not only agree with the GFH but also suggest that residential properties in China provide a superior long-term hedge against inflation rate. In comparison with the long run Fisher coefficient for India (1.327) and Russia (0.960), the long-term hedging ability of residential property as an investment in China is at least twofold stronger than that of India and Russia.

In summary, strong short run and long-run inflation-hedging evidence of residential property is only documented in China. Given that residential properties in India and Russia are typically characterized by thin trading, lower liquidity and possibly less informed and less sophisticated investors than China, there might be expected differences in inflation hedging effectiveness in China as opposed to India and Russia. The strong hedging ability of residential properties in China can be attributed to the higher percentage of savings of Chinese citizens, degree of financial development, such as the availability of mortgage credit, and relatively higher involvement of institutional investor in China after China joined the World Trade Organization (WTO) in 2001. The evidence in this study supports the suggestion that the inflation-hedging properties of residential property assets depend on the degree of financial development and investor constituents in a given market.

5. Conclusion and Implications

Residential properties in the EMs of Asia have been receiving increasingly more attention from investors in recent years. Previous studies have examined the inflation-hedging effectiveness of residential properties in China but the results are rather mixed. This study examines the inflation-hedging effectiveness of residential properties not only in China but also two of the largest EMs in Asia: India and Russia. Based on the empirical testing method of the GFH, this study uses the conventional Fama and Schwert regression method, Johansen and Pesaran cointegration technique and Granger causality models to examine the inflation hedging ability of residential property.

The regression results based on Fama and Schwert (1977) show that only residential properties in China and Russia hedge against expected inflation but fail to hedge against unexpected inflation at a 5% rate of error. Compared to the short run results based on developed economies, the short run results of China and Russia contradict those of Stevenson and Murray (1999) for Ireland, Wurstbauer and Schafers (2015) for the (US), Ganesan and Chiang (1998) for Hong Kong and Li and Ge (2008) for China, but are in agreement with those of Fama and Schwert (1977), Rubens et al. (1989), and Brounen et al. (2014) for the US, and Lee (2013) for Hong Kong. In contrast to China and Russia, the regressions results imply that residential properties in India act in the opposite manner when hedging expected and unexpected inflation. The results contradict those of Upadhyay (2019) who concludes that real estate assets react proportionately to inflation. With regard to the actual inflation model, only residential properties in China provide effective short-term hedge against actual inflation.

The results of the cointegration tests (Johansen, 1988), which range from inflation to residential property, provide strong evidence to support cointegrating relationships in China and India at an error level of 5%. The results suggest that residential property in China and India provide a long-term effective hedge against inflation. Likewise, the results of the ARDL cointegration tests (Pesaran et al. 2001) provide strong evidence to support cointegrating relationships in Russia at an error level of 5%. Overall, the cointegration results indicate that residential property price and inflation are cointegrated for all three EM countries. This relationship confirms that residential properties can offer reliable long-term hedge against inflation. Compared with the more developed economies, this contradicts the findings of Ganesan and Chiang (1998) for Hong Kong, and Stevenson and Murray (1999) for Ireland, but is in agreement with those of Stevenson (2000) for the UK, Anari and Kolari (2002) and Wurstbauer and Schafers (2015) for the US, Lee (2013) for Hong Kong, and Brounen et al. (2014) for the Netherlands. As for the results of the Fisher coefficients, the long-run parameter estimates indicate that the price elasticity of residential property in the long run with respect to the inflation rate is 2.824 for China and 1.320 for India, which is greater than unity for both countries. This suggests that residential properties provide a superior long-term hedge against inflation in China and additional hedge against inflation in India. However, the Fisher coefficient result indicates that the coefficient of residential property against inflation in Russia is 0.960, which is somewhat less than unity. This suggest Russia residential property could be a partial hedge against inflation over the long run.

The causality results are not consistent across the three EMs in this study. This indicates that a significant ECT of 3 is only found with India while insignificant ECTs are found for China and Russia. Therefore, inflation has a lead effect on residential property in India. Moreover, the size of the coefficients on the ECT indicates that the adjustment of property returns to inflation is moderate in India, and also implies that the inflation rate helps to predict and lead residential property returns in India over the long run. The Granger causality results in India is consistent with those of Lee (2013) for Hong Kong and Wurstbauer and Schafers (2015) for the US, but contradict those of Stevenson and Murray (1999) for Ireland, Stevenson (2000) for the UK, Li and Ge (2008) for China and Upadhyay (2019) for India.

While the results of this study support the Fisher hypothesis and provide strong evidence of the inflation-hedging ability of residential property assets for the short run and long-run in China, previous studies on China, including Chu and Sing (2004) and Zhou and Clements (2010), have failed to support the Fisher hypothesis and conclude that residential real estate assets are not a good hedge against inflation. The conflicting results among these different studies on China are mainly attributed to the different time periods of the study, type of property data, different cointegration approaches used and covered period which involves different stages of economic development in China. Compared with this study which uses quarterly data from 2003Q1 to 2019Q3, the data in Chu and Sing (2004) are quarterly (1996 to 2002) for their OLS regression of the short term, and annual data (1996 to 2002) for the Engle and Granger cointegration of the long term. In addition, the data in Zhou and Clements (2010) are monthly from 2000 to 2008 in their ARDL cointegration model. As for the cointegration approach, this study uses the Johansen cointegration approach while Chu and Sing (2004) and Zhou and Clements (2010) use the Engle and Granger and Pesaran approaches, respectively. This indicates that the different results might also be possibly due to the use of different cointegration approaches.

During the sample period of 1996 to 2008 in Chu and Sing (2004) and Zhou and Clements (2010), the real estate market in China was still immature. The development of the Chinese real estate market was a relatively recent phenomenon back then. The secondary market function was not efficient, which restricted the free and rapid adjustment of real estate prices to various macroeconomic shocks. More importantly, China was formally admitted to the WTO in November 2001. Prior to its entry, the real estate markets in China were typically characterized by less informed and less rational local investors in comparison to the developed markets where the role of international institutional investors was more dominant. This characteristic could have produced the contradicting results of the inflation-hedging effectiveness of residential property assets between this study and Chu and Sing (2004) and Zhou and Clements (2010).

The findings in this study have some practical investment and policy implications for residential property and real estate investment trust investors and policy makers. First, investors should differentiate between the impacts of inflation for the short run and long run. The results confirm that residential property investors may experience lower returns as a result of unexpected inflation over the short run in China, India and Russia, although residential properties in those EMs are effective risk management tools to hedge the inflation risk over the long run. Second, investors should understand that residential properties in India and Russia have different inflation-hedging properties compared to China. International property investors should also be aware of the fact that residential properties in India and Russia not only have different risk and return characteristics, but different inflation-hedging properties as opposed to those of China. The unique inflation-hedging characteristic of residential properties in China should also be considered in their investment decision making. Lastly, both the short run and long run results suggest that residential properties in China are an effective investment instrument. In particular, the results imply that investors should overweigh their investment in residential property assets in China during times of continuing and persistent inflation and the more recent global quantitative easing policy.

Recently, relatively long series of data have become available for various types of properties in the EMs. Research on these issues is important to provide further insights and help gain a better understanding of these relationships. Therefore, future research should investigate the inflation hedging effectiveness of various types of property markets, such as luxury house, apartment, office, retail, factory and hotel in other EM countries. The work may also extend this research study and use a panel cointegration approach to empirically test the GFH for all EMs over the long term.

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