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House Price and Economic Activity in India: A Wavelet Analysis[1]

Swarup Kumar Pal
Department of Statistics and Information Management
Reserve Bank of India, N.S. Road, Kolkata 700001, India
E-mail: skpal@rbi.org.in

Anjana Saha
Department of Statistics and Information Management
Reserve Bank of India, N.S. Road, Kolkata 700001, India
E-mail: asaha@rbi.org.in

Partha Ray*
Economics Group
Indian Institute of Management Calcutta, Joka, D H Road, Kolkata 700104, India
E-mail: pray@iimcal.ac.in / rayparthal@gmail.com

*Corresponding Author

Indian Institute of Management Calcutta, Joka, D.H. Road, Kolkata 700104

URL: http://facultylive.iimcal.ac.in/workingpapers

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House Price and Economic Activity in India: A Wavelet Analysis

Swarup Kumar Pal[2], Anjana Saha[3] & Partha Ray[4]

Abstract: This paper looks into the relationship between house price and economic activity (real GDP) in a major emerging market economy, namely, India. Using continuous wavelet analysis, the dynamic relationship between these two economic variables has been identified. Notwithstanding the period specificity, in general, GDP is seen to have influenced the house price positively. Both consumption and investment transmission channels appear to be operational in house price - GDP relationships, particularly until August 2017. Thereafter, the transmission channel seems to have weakened; this may be due to the lagged effect of demonetization of high-value notes in November 2016.

Keywords: House Price, India, GDP, Wavelet

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[2] Department of Statistics and Information Management, Reserve Bank of India, email: skpal@rbi.org.in.
[3] Department of Statistics and Information Management, Reserve Bank of India, email: asaha@rbi.org.in
[4] Economics Group, India Institute of Management Calcutta, email: pray@iimcal.ac.in.

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1. Introduction

There is an influential view that housing plays a very significant role in the economic system of a country and accounts for a significant portion of its wealth. Perhaps, this is even more true for a young, urbanizing, land-scarce, and emerging economy like India over the last few decades. The Indian housing market has got a fillip from the emergence of retail loans in general and housing loans, in particular, as a major activity of commercial banks and other housing loan institutions. In fact, since the 1990s, there has been a huge clamor for homeownership in India, both as an investment opportunity as well as residential abodes for the moving Indians in search of jobs in various metros.[5]

But how is it so special about housing? Like any other asset price, should not house price be equal to the discounted stream of future housing returns in the long run? If so, rent from a house should be able to capture the opportunity cost/return from owning a house. Why then is it different from any other assets in the investor's portfolio? Two features may be highlighted in particular: (a) supply response to the housing market is very sluggish due to the long gestation period of contracting a house, and (b) information of house price is often less transparent and limited. Thus, the housing market is much more susceptible to macroeconomic shocks than other goods and asset prices (Goodhart and Hofmann 2007). However, how does homeownership influence the real economy? Various channels have been identified in the literature.

A principal channel through which house price may influence real activity runs through its wealth effect on consumption. Any change in house prices will cause a change in residents'

[5] The internal migration in India has been substantial since 2000. Illustratively, the Government of India's Annual *Economic Survey, 2016-17* noted, "A new cohort-based migration metric ….shows that annually inter-state labor mobility averaged 5-6 million people between 2001 and 2011, yielding an inter-state migrant population of about 60 million and an inter-district migration as high as 80 million".

housing wealth, which may affect consumption and investment behavior. For homeowners, an increase in the house prices may lead to refinance or sell their property, or relaxation in the borrowing constraints. Even if they do not refinance or sell their houses, they are expected to consume more due to the higher discounted value of wealth, which is an unrealized wealth effect. Again, for the potential buyer, a rise in house price will result in higher EMI (equated monthly installment) for a future housing loan and higher housing rent, which will influence their investment and consumption decision. Considering the significance of the housing sector, the Government also tries to stabilize the housing market through various housing welfare schemes. In addition, depending on the size of the labor force employed in the government, the Government's expenditure on house rent allowances (HRA) of the public sector employees is a determinant for housing rent. Thus, housing assets may be linked with economic activities (growth), through investment, consumption, and Government expenditure channels.

In particular, the channel through which house price may affect activity is *via* residential investment. An increase in house price increases the value of the house in relation to its construction cost. Accordingly, Tobin's q (i.e., the ratio between a physical asset's market value and its replacement value) goes up for such residential investment and hence investment goes up too (Tobin 1969).

In the real world, the impact of house price on GDP could have significant country-specificity. Apart from the usual business cycle-related factors, the credit market tends to play a key role in the market for housing. After all, given that a house is an expensive and somewhat indivisible asset, the economic agent would require a substantial amount of money to buy and hence would require a loan to ease his or her liquidity constraint.

Since the focus of the paper is on the Indian housing market, a few comments on the Indian economy is in order. Ever since the liberalization of the Indian economy since 1991, India has turned out to be an important emerging market economy (EME) (Ahluwalia 2002).

At the current juncture, India is an important member of the G-20 and with a GDP (at the current market exchange rate) of USD 2.9 trillion in 2019; it is the fifth-largest economy on the earth.

Housing plays a key role in the Indian economy from two key angles. First, the housing sector in India is large. In recent times, the share of "real estate and ownership of dwelling" is around 7 percent of the Indian GDP. Given its population at 1.37 billion in 2019 and a working-age dependency ratio of nearly 50 percent, housing seems to have a huge potential in the Indian economy. Second, given that over the years, India has tilted towards a service-oriented economy (with low employment elasticity of output); housing has emerged as a major source of employment in India. The Government agency, *NITI Aayog*, has estimated the current size of the Indian “real estate sector” as USD 120 billion, employing 55 million people; consequently, it is the second-largest employment-generating sector next to agriculture (Soundararajan et al., 2018).[6]

What has been the relationship between house price and real GDP in India? Has there been any period specificity in this relationship? What are the channels of transmission? The present paper looks into some of these questions for the Indian economy.

The distinguishing features of our paper are three. First, to the best of our knowledge, our study is one of the initial attempts to discern the inter-linkage between the real estate market and economic activity in the context of a major emerging economy, viz., India. Second, methodologically, instead of using the time series model, we have used continuous wavelet analysis to identify the interrelationships and have discerned the association and lead/ lag relationships of the variables over time through wavelet phase difference (along with a

[6] Technically, real estate is an umbrella term that includes "residential housing, commercial offices, trading spaces such as theatres, hotels, and restaurants, retail outlets, industrial buildings such as factories and government buildings" (Government of India, 2002). Throughout the paper, housing and real estate are often used interchangeably.

bootstrap confidence interval to assess the strength of relationships).[7] Finally, the impact of a specific structural phenomenon, viz., demonetization of high-value currency notes in November 2016, on the relationships are also probed.

For expository convenience, the rest of the paper is organized as follows. In section 2, we survey some of the received literature. Section 3 is in the nature of a methodological digression. Sections 4 and 5 discuss data and stylized facts, respectively. Results are discussed in section 6, and some of the extensions and specific issues are taken in Section 7. Concluding observations are presented in section 8.

2. Received Literature

We have already noted that there are multiple channels through which house price may influence the real economy. In general, rising house prices stimulate homeowners' consumption by boosting expected total wealth (Ludwig and Slok, 2002). Any increase in house price may result in relaxation in the borrowing constraint through the collateral channel. Higher property price may lead to higher housing rent. But for the tenant, higher rent may curb their spending (Chamon and Prasad, 2010). Thus, the overall impact of housing assets on the growth of the real economy is ambiguous.

Most of the empirical papers on house price and GDP were developed for the US, where, both kinds of relationships exist. Some study supports that the house price positively influences consumption through the wealth effect (Calomiris et al., 2012); others suggest that an increase in house prices will suppress consumption (Aron et al., 2012). Consumer spending can improve general economic conditions and consequently the housing investment may increase with increasing house prices. However, there is little empirical evidence suggesting

[7] The wavelet analysis can be directly applied to non-stationary time series. Compared to standard and established time-series methods, e.g., linear VAR models, the wavelet transform can capture local events in time and detect time-varying leading effects (Fan and Gençay 2010).

that such an effect exists (Shirvani et al., 2012). While Shirvani et al. (2012) observe a weak effect of consumer spending on house prices for the US economy; Miller et al. (2011) observe that house price significantly affect the growth rate of per capita GDP. Bostic et al. (2009) find a reverse wealth effect by showing that a 10 percent reduction in housing wealth directly reduces real GDP growth by 1 percentage point. Finally, some literature also argues that the link between house prices and growth is due to common factors, such as changes in credit market conditions or expected income growth (Windsor et al 2015). Attanasio et al. (2009) and Iacoviello (2011) find that the co-movement between house prices and consumption is driven by common factors and Long et al. (2016) show that there is no direct effect of house prices on consumption. Zhou et al. (2009) observe that housing wealth has a negative but minor effect on consumption.

Most of these studies use traditional time series techniques such as Vector Auto Regression (VAR), Cointegration, or, Error Correction model. Such approaches assess the linkage between the variables in the time domain in a static way, which assumes that the relationship does not change over time. Granger (1988) points out that the direction and strength of causality may change at diverse frequencies. Balcilar et al. (2010) assert that when structural changes exist, the relationship between series will present instability in different sub-samples. Therefore, a conclusion in the full-sample period is not credible in the presence of breakpoints. Kim and Chung (2016) had used the Markov-switching common factor model to study the role of house price in the US business cycle. The time-varying role of macroeconomic shocks on house prices was studied for the US and UK housing market by Plakandaras et al. (2018) with Bayesian time-varying VAR. Contrary to these, Li et al. (2015) have used continuous wavelet analysis to analyze the co-movement and causality between US housing and the stock market. We have also adopted a similar technique for discerning the dynamic relationship between house price and GDP for India.

The academic literature on housing in India is somewhat scanty. Narendran (2013) had probed into the differences in residential property price across different cities in India. Singh (2015) had looked into various indices of house prices in India and their limitations. More recently, Tiwari and Rao (2016) described the urbanization story of India in different periods after independence and the need for affordable housing. In that sense, our paper is one of the initial attempts to formally study the relationship between house price and the Indian economy.

3. Methodology

We have adopted continuous wavelet analysis for our study and our choice of this particular technique may be justified from the following four considerations.

First, while the variables under study are non-stationary, we could have found a cointegrating relationship and then would have used a suitable VECM type of time series model for data analysis. However, that would be difficult in the presence of several breakpoints in the data because of economic shocks.

Second, alternatively, one could have investigated the importance of different frequency components for the behavior of a variable. However, non-stationary data cannot be analyzed in the frequency domain.

Third, the dynamic change in relationships can be captured through continuous wavelet transformation within a time-frequency space. Because of that, we can analyze non-stationary data through the wavelet technique. As mentioned by Ramsey (2002), "Wavelets are treated as a 'lens' that enables the researcher to explore relationships that previously were unobservable."

Finally, continuous wavelet transformation provides a good working approximation to the problem of the Heisenberg uncertainty principle, to capture the time-varying property of the variable.

To appreciate the results discussed in the paper, a brief discussion of our methodology, following Rösch and Schmidbauer (2018), is in order.

The CWT decomposes a time series using a function called mother wavelet, $\eta(t)$, which is a function of translation (location) and dilation (scale) parameters. [8] The "daughter wavelets" resulting from a mother wavelet $\eta(t)$ are defined as,

(1) $\eta_{\alpha,\beta}(t) = \frac{1}{\sqrt{|\beta|}}\eta\left(\frac{t-\alpha}{\beta}\right)$, $\alpha, \beta \, \varepsilon \, \mathrm{R}, \beta \neq 0$, α and β are location and scale parameter.

CWT of a time series $X(t)$ is defined as,

(2) $W_X(\alpha,\beta) = \int_{-\infty}^{+\infty} X(t)\,\frac{1}{\sqrt{|\beta|}}\,\overline{\eta}\,\left(\frac{t-\alpha}{\beta}\right)\,dt$, where $\overline{\eta}$ denotes the complex conjugate of η. The local amplitude is defined as

(3) $\mathrm{Amp}(\alpha,\beta) = \frac{1}{\sqrt{\beta}}|W_X(\alpha,\beta)|$, and the square of local amplitude is called wavelet power.

CWT is an invertible transformation, as the series can be reconstructed by minimizing the noise as,

(4) $\tilde{X}(t) = \frac{2}{C_\eta}\int_0^{\infty}\int_{-\infty}^{+\infty} W_X(\alpha,\beta)\eta_{\alpha,\beta}(t)\partial\tau\frac{\partial s}{s^2};\; C_\eta = \int_{-\infty}^{+\infty}\frac{|\eta(\omega)|}{|\omega|}d\omega.$

For the bivariate analysis, the cross-wavelet transform of two-time series $X(t)$ and $Y(t)$ in the time-frequency domain is represented as,

(5) $W_{XY}\,(\alpha, \beta) = \; W_X(\alpha, \beta)\,\overline{W}_Y(\alpha, \beta)$,

where, $W_X(\alpha, \beta)$, and $W_Y(\alpha, \beta)$ are the wavelet transform of $X(t)$, and $Y(t)$, respectively, and $\overline{W}_Y(\alpha, \beta)$ denotes the complex conjugate of $W_Y(\alpha, \beta)$.

The cross-wavelet power is defined as the modulus of the cross-wavelet transform,

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[8] Morlet wavelet, $\psi(t) = \pi^{-1/4}e^{i\omega t}e^{-t^2/2}$, where ω is the angular frequency, is used as the mother wavelet for its well-localized properties.

(6) $|W_{XY}(\alpha, \beta)| = \frac{1}{\beta}|W_X(\alpha, \beta)||\overline{W}_Y(\alpha, \beta)|$

It represents the local volatility in time-frequency space and is analogous to usual covariance in the literature.

The basic assumption in wavelet transformation is that the time series is periodic and infinite. However, in real-life problems, we encounter a finite-length time series. Therefore, the endpoints of the time-series are required to be padded with zeros. It leads to the edge effect described as the Cone of Influence (COI) in the power spectrum plot. The power spectrum plot also indicates the contour lines, revealing the significance of joint periodicity.

The cross-correlation between two-time series is measured by wavelet coherency, and is defined as,

(7) $₵_{XY}(\alpha, \beta) = \frac{\mathfrak{s}(W_{XY}(\alpha,\beta))}{\sqrt{[\![\mathfrak{s}(|W_X(\alpha,\beta)|^2)\, \mathfrak{s}(|W_Y(\alpha,\beta)|^2)]\!]}}$ with a smoothing operator $\mathfrak{s}$. Although the magnitude of wavelet coherency lies between 0 and 1, it may be complex-valued. The square of wavelet coherency is defined as wavelet coherence.

Information about the association between two series $X(t)$ and $Y(t)$ in terms of the instantaneous or local phase is determined by the phase difference at each localizing time origin (α) and scale (β), and is defined as,

(8) $\Theta_{X,Y}^{\alpha,\beta} = \tan^{-1}\left(\delta\{\mathfrak{s}\left(W_{XY}(\alpha, \beta)\right)\} \middle| \mathcal{R}\{\mathfrak{s}\left(W_{XY}(\alpha, \beta)\right)\}\right),$

with $\Theta_{X,Y}^{\alpha,\beta} \in [-\pi, \pi]$, where δ and $\mathcal{R}$ are the imaginary and the real parts of the smoothed cross-wavelet transform, respectively. The average phase difference at time t is obtained by integrating over the location and scale parametric space as,

(9) $\Theta_{X,Y} = \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \Theta_{X,Y}^{\alpha,\beta}\, \partial\beta \partial\alpha$

It may be noted that the average phase difference contains information on the dynamic lead-lag relationships and structure of association between the two time series in the following way (Figure 1):

[Figure 1 to come here]

(9a) If $\Theta_{X,Y}$ is zero, the two series have a positive association with no lead-lag relationships (perfectly in-phase), and if it is π (or $-\pi$), the series has a negative association with no lead-lag relationships (perfectly out of phase). If $\Theta_{X,Y} \in (-\pi/2, \pi/2)$, the series is said to be in phase. Further, if $\Theta_{X,Y} \in (\pi/2, \pi)$ or, $\Theta_{X,Y} \in (-\pi, -\pi/2)$, the series are termed as out of phase.

(9b) If $\Theta_{X,Y} \in (0, \pi/2)$, they are associated positively, and X leads Y.

(9c) If $\Theta_{X,Y} \in (-\pi/2, 0)$, they are associated positively, and Y leads X.

(9d) If $\Theta_{X,Y} \in (\pi/2, \pi)$, they are associated negatively, and Y leads X.

(9e) If $\Theta_{X,Y} \in (-\pi, -\pi/2)$, they are associated negatively, and X leads Y.

In our analysis, the average phase difference as in (9), is used to conclude the lead-lag and co-movement structure between house price (and its variants) and real growth.

Traditionally, the Granger causality test is undertaken to discern such direction of causality prevailed between two economic variables. However, the Granger causality test assumes that a single causality prevails throughout the period of the study. On the contrary, the wavelet method is superior because it can assess the strength and direction of causality over frequency and time.

We used classical bootstrap methods to obtain a confidence interval for phase difference (Ge, 2008; Aguiar-Conraria and Soares, 2014; Hanus and Vacha, 2020 for details). Each series was given 5 percent random shock alternatively and was performed the wavelet analysis 1000 times, before constructing a 95 percent confidence interval.

We have used R programming language to compile wavelet coherency, to draw wavelet power spectrum, average coherence, and phase difference plots with WaveletComp R-package.[9] The cross-wavelet power spectrum is computed using Morlet wavelet as the mother wavelet keeping the significance level of contour as 10 percent. For the simulation, we have used 'white noise' as the surrogate time series. The results found are discussed in section 6.

4. Data

Data on the Indian housing market is not necessarily very organized or clean. [10] In fact, it is widely believed that the housing market in India has been marked by the presence of informality.[11] It is also characterized by huge informational asymmetry that has stood in the way hindering the formation of a formal market for real estate (Soundararajan & others, 2018).

Insofar as house price is concerned, there are two sources of data. First, the most important source of house price data is the Reserve Bank of India (RBI), the Central Bank of the country. RBI compiles and publishes quarterly House Price Index (HPI). Currently, the HPI, with the base period as the financial year, 2010-11, is compiled with the official data of property price transactions collected from registration authorities of respective state governments from 10 major cities.[12] The index is well accepted to indicate the movement of house prices in India. However, the index is compiled based on registration data of 10 cities, and there may be issues relating to its representativeness. The HPI data is considered from 2010:Q2 to 2019:Q4 for our study.

Apart from HPI, in India, two other house price indices are being published by the National Housing Bank (NHB), viz., (a) assessment price (NHB-A), and (b) market prices for

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[9] Available at http://www.hs-stat.com/projects/WaveletComp/WaveletComp_guided_tour.pdf

[10] The index on residential property price is the only available information for the Indian housing market. No official indicators for commercial property price and rental price movement are available as of now.

[11] The presence of informality and corruption is well known in the Indian context; see Dutta, Kar & Roy (2013).

[12] Indian financial year runs from April to March, e.g., 2017-18 refers to April 2017 to March 2018.

the under-construction property (NHB-M).[13] The indices NHB-A and NHB-M are considered from 2013:Q2 to 2019:Q3.[14]

All the indices are observed quarterly for a maximum of 35 quarters during our period of study. We are interested in using the Continuous Wavelet technique for the analysis, which performs well if the number of data points is sufficiently large. Hence, the quarterly series are interpolated to get the monthly series using a cubic spline.

We have taken the following macroeconomic variables, viz., (i) Real Gross Domestic Product (at 2011-12 prices) (GDP); (ii) Real Private Final Consumption Expenditure (PFCE); (iii) Real Government Final Consumption Expenditure (GFCE), and (iv) Real Gross Fixed Capital Formation (GFCF). The data is taken from the RBI Database of Indian Economy (DBIE) for the period 2011:Q2 to 2019:Q4. To convert the quarterly variables into monthly, the Denton-Cholette method for interpolation has been chosen, as this method generates disaggregated series while preserving the movement of the original series, thus matching the quarterly aggregates.[15] All the series are adjusted seasonally using X-13 ARIMA for our study.

The period of our study is from April 2011 to December 2019.

5. Some Stylized Facts

Going forward a few features of the Indian real estate market need to be borne in mind. First, the housing loan portfolio of Indian commercial banks was extremely scanty before the 1990s, since when it started picking up. The boom in housing loans has been a phenomenon since the mid-1990s. Furthermore, despite the spurt in housing loan the non-performing loans

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[13] The National Housing Bank (NHB) is an apex level development financial institution for housing finance in India. It was established on July 9, 1988, under the National Housing Bank Act, 1987, and is wholly owned by the Central Government of India. NHB performs three broad functions, viz., regulation, and supervision of Housing Finance Companies (HFCs) financing, promotion, and development.

[14] Incidentally, there is a third index related to the house price, viz., housing component of the Consumer Price Index (CPI); this weights 10.07 percent in the CPI. Since this housing component of CPI represents the rental price, we did not consider it a proxy for house price.

[15] See Sax and Steiner (2013) for a discussion of the methodology of this interpolation method.

originating in the housing sector in India has been rather scanty. Second, the policy of foreign direct investment has been liberalized from time to time. Specifically, 100 percent foreign direct investment into real estate was also introduced in 2005. Third, reported prices in the Indian real estate market until recently were underestimated, as often in the metropolitan areas there was an incidence of part cash payment (sometimes unreported) in tax evaded income.[16] While formal estimates of such unreported cash components are difficult to find, there are accounts of the presence of such tax evaded income – or "black money" as Indians would call it – in real estate transactions (Government of India, 2012). After the demonetization of high-value currency notes in November 2016, there are indications that the extent of under-reporting of house prices could have come down. Fourth, with a huge youth population, an old-age dependency ratio (as a percentage of the working-age population) less than 10 percent, and increasing urbanization, the potential demand for housing has been huge.

A few interesting traits come up from the real GDP growth and HPI inflation is shown in Chart 1.

[Chart 1 to come about here]

First, there has been a sharp fall in HPI inflation from 23.1 percent in June 2011 to 3.0 percent in December 2019 with an average rate of house price inflation of 12.4 percent during this period.

Second, a downward trend in real GDP growth was observed from December 2017 to December 2019. While GDP was growing at the rate of 8.7 percent in December 2017, it was observed to grow by 2.9 percent in December 2019. Moreover, a sharp decline was noticed

[16] In 2020, India's ranking of "registering property" as per Word Bank's Ease of Doing Business Indicators is 154 among 190 countries.

since October 2019, when growth dropped from 6.1 percent to 2.9 percent (Chart 1) in 3 months.

Third, clear cycles can be observed in HPI annual inflation. The average inflation/ growth for each cycle is presented in the table below. The house price inflation and real GDP growth are co-moving after the demonetization period (September 2017 to December 2019).

[Table 1 to come about here]

6. Results and Discussions

To discern the underlying causal relationship between house price and economic activity, we proceed as follows.

First, we have tested for a cointegrating relationship between the variables and look for pairwise Granger causality patterns. Employing the Johansen test, we have checked that, both HPI and GDP are I(1) series and have one cointegrating relationship.[17] The causal relationship between house price and GDP is explored through the bivariate Granger causality test. We have observed significant bi-directional causality.

[Table 2 to come about here]

Second, to explore further, continuous wavelet analysis is done to identify the causal relationships considering the information of time and frequency domain together. We undertake the continuous wavelet analysis of the variable pairs. This produces three sets of distinct outputs: (a) cross-wavelet power spectrum, (b) average coherence, and (c) phase difference. Additionally, in the case of the phase difference diagram, we produced a 95 percent confidence interval through a bootstrap method.

[17] The Johansen test result and an estimated VECM model is presented in Annex Table 1

From the cross power spectrum of HPI and GDP (Chart 2A), significant co-movements are observed for the frequencies above 16-month frequency. Further from the average coherence plot (Chart 2B), high coherence (above 0.85) is observed for the frequencies above 4-month frequency, representing the strength of the relationship. From the average phase difference plot (Chart 2C) with 95 percent bootstrap confidence interval (obtained through Monte Carlo simulation and shown by green (red) line for upper (lower) band) we observe 3 episodes of house price and GDP relationships during the study period.

[Chart 2 to come about here]

- *Episode 1 (April 2011 to February 2012):* House price was positively leading GDP. The relationship thus obtained is stable, as the average phase difference is within the 95 percent confidence interval.
- *Episode 2 (March 2012 to August 2017):* Growth was influencing the house price positively. The findings are consistent as the average phase difference is within the 95 percent confidence interval. Demonetization on November 8, 2016, did not have an immediate impact on this relationship.
- *Episode 3 (September 2017 to December 2019):* During this period, except for the initial 2 months, the growth had a lead-positive impact on house price, similar to Episode 2. However, from February 2019 onwards, the phase difference moves outside the 95 percent confidence interval, making the relationship less stable. It may be noted that during this period there has been a slowdown of growth on account of various local factors (e.g., demonetization or introduction of the new goods and services tax) and global shocks (like US-China trade war or geopolitical tension in the Middle East). In fact, the real growth rate came down from 8.0 percent in September 2017 to 2.9 percent in December 2019 (Chart 1). In addition, a spurt in non-performing assets (NPA) of

Indian public sector banks could have affected growth *via* the credit channel of monetary policy.

Thus, to summarize, there seems to be a positive relationship between house price and real GDP in general with GDP leading house price except for the initial period (Episode 1). In general, rapidly growing income, younger population, cheap housing credit, and mobile labor force - all could have played their roles in this positive relationship between GDP and house prices. The linkage thus obtained is not spurious, since the variables are cointegrated.

Admittedly, the relationship became less stable in Episode 3, perhaps because of the contraction of demand following demonetization and high NPA of banks. Wavelet analysis thus extracts the dynamic relationships between HPI and GDP through the time-frequency domain, which was earlier, unobserved in the time domain with the Granger causality test.

7. Some Extensions

As already noted, the National Housing Bank (NHB) compiles two indices of house price, viz., (a) assessment price (NHB-A), and (b) market prices for under-construction properties (NHB-M). Considering these indices to be the representatives of house price, we have revisited the relationships of these indices with growth and compared the result with that obtained for HPI-real GDP.

7.1 Using NHB Assessment Price Index (NHB-A)

Using NHB-A, we have performed continuous wavelet analysis to obtain time-localized relationships with real growth. We have compared the relationships obtained from average phase difference (Chart 3C) with HPI-GDP linkage for the following episodes:

[Chart 3 to come about here]

- *Episode 2A (June 2013 to August 2017):* Real GDP was influencing the 'NHB Assessment price' positively in this episode, which supports similar relationships between HPI-GDP.
- *Episode 3A (September 2017 to September 2019):* Growth had a lead-positive impact on 'NHB Assessment price' and it supports the similar linkage between 'HPI-GDP'.

Thus, the 'NHB Assessment price-GDP' relationship is found to be in line with the 'HPI-GDP' relationship.

7.2 Using NHB Market Price Index (NHB-M)

Using 'NHB Market price for newly constructed properties' as an indicator of house price, we have performed continuous wavelet analysis with real GDP. The relation thus obtained through phase difference plot (Chart 4C) is compared with 'HPI-GDP' linkage for the following episodes:

[Chart 4 to come about here]

- *Episode 2B (June 2013 to August 2017):* Growth positively impacted 'NHB Market price' from June 2013 to March 2014 and October 2015 to August 2017, supporting HPI-GDP linkage during this period. From April 2014 to September 2015, 'NHB Market price' impacted real growth positively, contradicting the causality relation between HPI-GDP.
- *Episode 3B (September 2017 to September 2019):* GDP influenced 'NHB Market price' positively only during a short interval from December 2018 to June 2019. During this period, a similar 'HPI-GDP' linkage was observed. Otherwise, it is contradicting the HPI-GDP relationship.

Thus, 'NHB Market price for newly constructed properties' and real-GDP relationships partially support the interlinkage as observed for HPI-GDP.

7.3 Channels of Transmission from House Price to GDP

As already explained in section 6, the relationships of House Price and GDP have 3 episodes as obtained through the breakpoints from Chart 2. To identify the transmission channels of house price and GDP, we have performed wavelet analysis for the following pairs, viz., (i) house price (HPI)-consumption (PFCE); (ii) house price (HPI)-government expenditure (GFCE); and (iii) house price (HPI)-investment (GFCF). The results are reported in Charts 5, 6, and 7, respectively.

[Charts 5, 6 and 7 to come about here]

There is distinctiveness in transmission channels in each episode as discussed in table 3. Both consumption and investment are operational with period specificity until August 2017. This is consistent with the contribution of housing as a major driver of economic activity in India – both on account of demand for housing from the households in a young and moving economy like India as well as the key role of housing and construction as a major investment activity (in absence of major manufacturing investment during this period). Starting from September 2017, however, HPI-GDP linkage is not supported by the components of GDP, making the transmission mechanism inconclusive. The delayed impact of policy shocks like demonetization may have distorted the underlying linkage of these variables.

[Table 3 to come about here]

7.4 Has Demonetization of November 2016 Changed the Relationship?

On November 8, 2016 currency notes of denominations of ₹ 1000 and ₹ 500 valued at ₹ 15.4 trillion and constituting 86.9 percent of the value of total notes in circulation, were demonetized. Demonetization led to several changes for the real and financial sectors.

The impact of demonetization could have been through the temporary decline in demand due to a shortage of cash for making payments; particularly given the fact, housing transactions often involved some cash component. Labor-intensive production activities, like real estate and construction, were affected due to a shortage of cash as associated unorganized working forces were required to be paid daily wages in cash. The loss of wage income for workers could have caused a temporary drag on consumption demand.[18]

Nevertheless, the property price increased just after the demonetization for a short period, maybe because of the sudden rise in demand for the secured investment for parking demonetized currency notes. People, who had demonetized currency, may have invested in the real estate until December 30, 2016, as the banks as well as the builders, had accepted the demonetized currency until that time. In addition, potential buyers may have preponed the purchase before the implementation of GST tax reforms from July 1, 2017. As observed in Chart 1, the annual return of the property, which was at 10.5 percent in March 2017, was slashed to 3.0 percent in December 2019 may be due to the persistent impact of demonetization.

From our analysis, it is, thus, observed that the relationship between house price and GDP has a breakpoint in August 2017 (Chart 2C). Considering the components of GDP and its relationships with HPI, we have also observed the breakpoints in August 2017 (HPI-consumption: Chart 5C), (HPI-investment: Chart 7C), (HPI-Govt. expenditure: Chart 6C). Thus, as observed from our study, demonetization may have influenced the relationship between house price and economic activities with a lag of 8 months.

8. Concluding Observations

Given the importance of housing at both micro as well as macro levels, we have tried to probe into the role of house price in Indian real GDP through continuous wavelet analysis.

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[18] Views and opinions on the economic impact of demonetization differed across different areas and income groups. While a survey in Bangalore revealed a 20 percent fall in sales, 73 percent of the market participants felt that demonetization was good for the country (Banerjee and Kala 2019). Using geographic variation in the severity of demonetization, Chodorow-Reich et. al (2019) have shown, "a sharp, temporary decline in currency caused a decline in ATM withdrawals, reduced economic activity, faster adoption of alternative payment technologies, and higher deposit and lower bank credit growth in Indian districts".

Given the limitation of data, we have looked into the pair-wise dynamic causality between house price and GDP. Notwithstanding some degree of period specificity, there seems to be in general a positive relationship between house price and real GDP. We can extract the dynamic causal relationships through wavelet analysis, which was unobserved in pair-wise Granger Causality tests. As regards the channels of transmission, both consumption and investment emerged as the conduits through which house price could have influenced real GDP in India. However, the transmission channels seemed to have become weaker in the post-demonetization period.

Our paper suffers from two sets of limitations. First, our findings are subject to the limitation of the technique of continuous wavelet analysis itself. Theoretically, the technique of continuous wavelet analysis assumes that the time series is periodic and infinite. However, as we worked with finite-length time series, we had to pad the beginning and the end of the time-series with zeros. The area affected by zero-padding is designated as the cone of influence (COI) in the power spectrum, making both ends of the spectrum less significant. Second, the house price indicators in India, as available for our study, are subject to several limitations concerning methodology, coverage, data source, etc. Thus, our findings could be victims of the limitation of data.

Notwithstanding these limitations, our paper sets the context in which house prices may play a significant role in economic activity in a large and young economy like India in the years to come.

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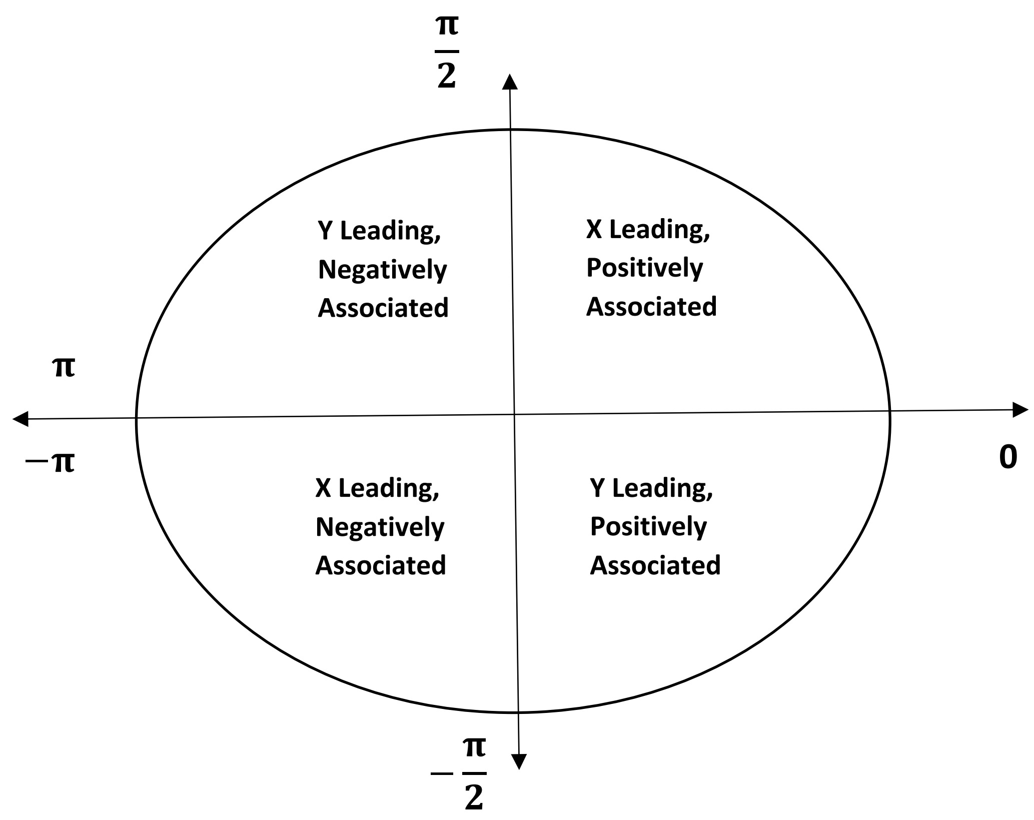
Figure

Figure 1: Phase Difference Diagram



Source: Aguiar-Conraria and Soares (2014)

Tables

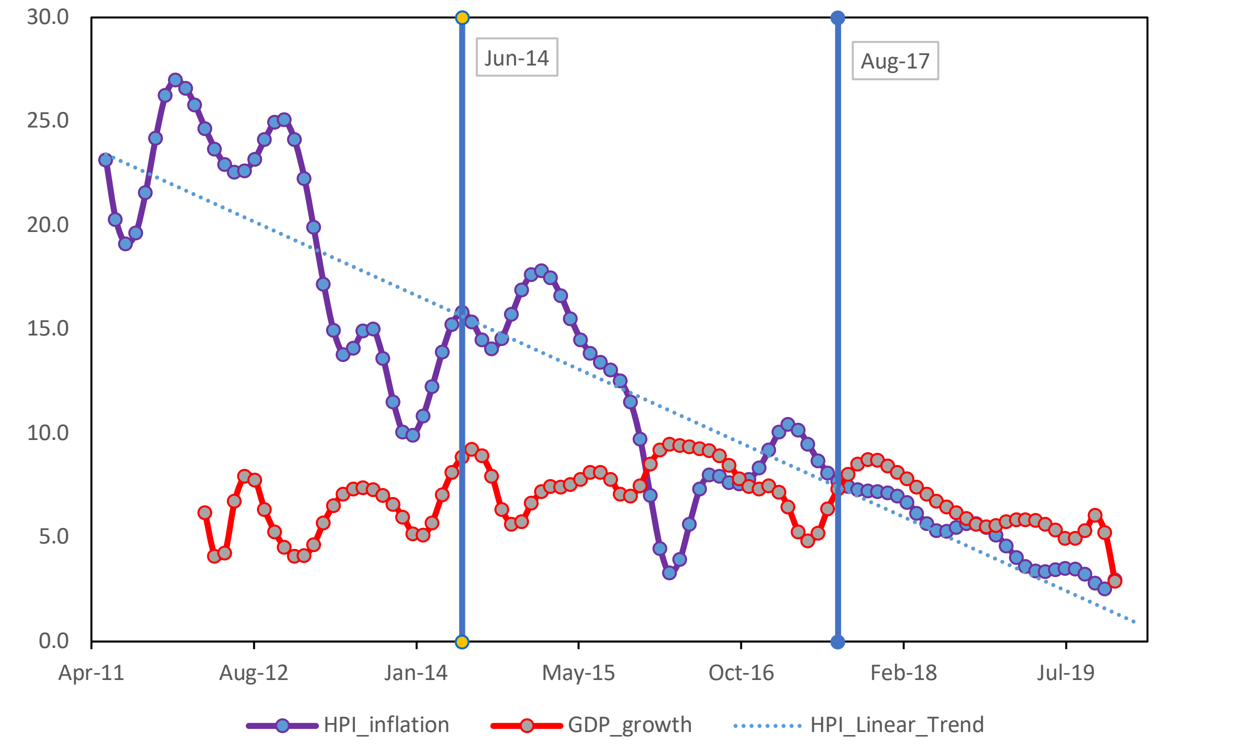
Table 1: Real Growth and House Price Average Inflation			
Cycle	Jun-2011 to Jun-2014	Jul-2014 to Aug-2017	Sep-2017 to Dec-2019
HPI	19.4	11.0	6.6
Real GDP	6.2	7.6	6.4
Source: Authors' Calculation			

Table 2: Pairwise Granger Causality Tests between GDP and House Price		
	Granger's F (df1, df2)	Significance
HPI causes GDP	4.9436 (101, 102)	0.02842
GDP causes HPI	3.9273 (95, 98)	0.01087
Source: Authors' Calculation		

Table 3: Transmission channel of HPI-Real GDP			
Episodes	HPI-Real GDP Relation	Transmission channels	Remarks
Episode 1C `(April 2011 to February 2012)	House price influenced the real GDP positively	House price influenced consumption positively supporting HPI-GDP linkage (Chart 5C)	Consumption is the major transmission channel during this episode
		Investment led house price positively (Chart 7C)	
		Government expenditure led house price positively (Chart 6C)	
Episode 2C (March 2012 to August 2017)	Real GDP had a lead-positive impact on HPI	Investment influenced house price positively supporting HPI-GDP linkage (Chart 7C)	Investment is the major transmission channel during this episode
		House price impacted consumption most of the time (Chart 5C)	
		House price impacted Government expenditure most of the time (Chart 6C)	
Episode 3C (September 2017 to December 2019)	Real GDP had a lead-positive impact on HPI. The phase difference diverged outside the 95 percent confidence interval.	House price impacted the investment positively (Chart 7C)	Transmission channel cannot be concluded
		Consumption influenced house price negatively most of the time (Chart 5C)	
		Government expenditure is in-phase with HPI, making the relationship inconclusive (Chart 6C)	
Source: Authors' inference from Charts 5, 6, and 7.			

Charts

Chart 1: GDP Growth and House Price Inflation (percent per annum)



Source: Handbook on Indian Economy, on line, RBI

Chart 2: Wavelet Analysis of House Price (HPI) and GDP

Chart 2A

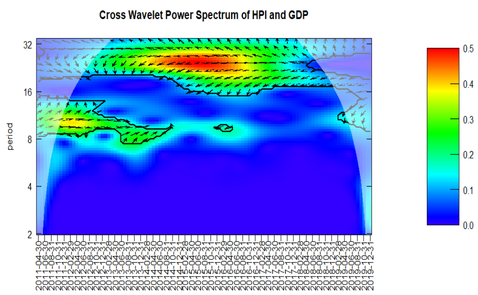


Chart 2B

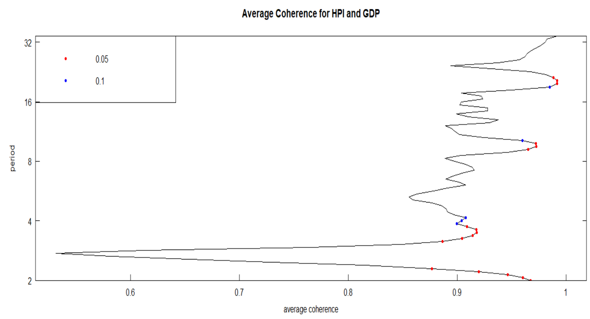


Chart 2C

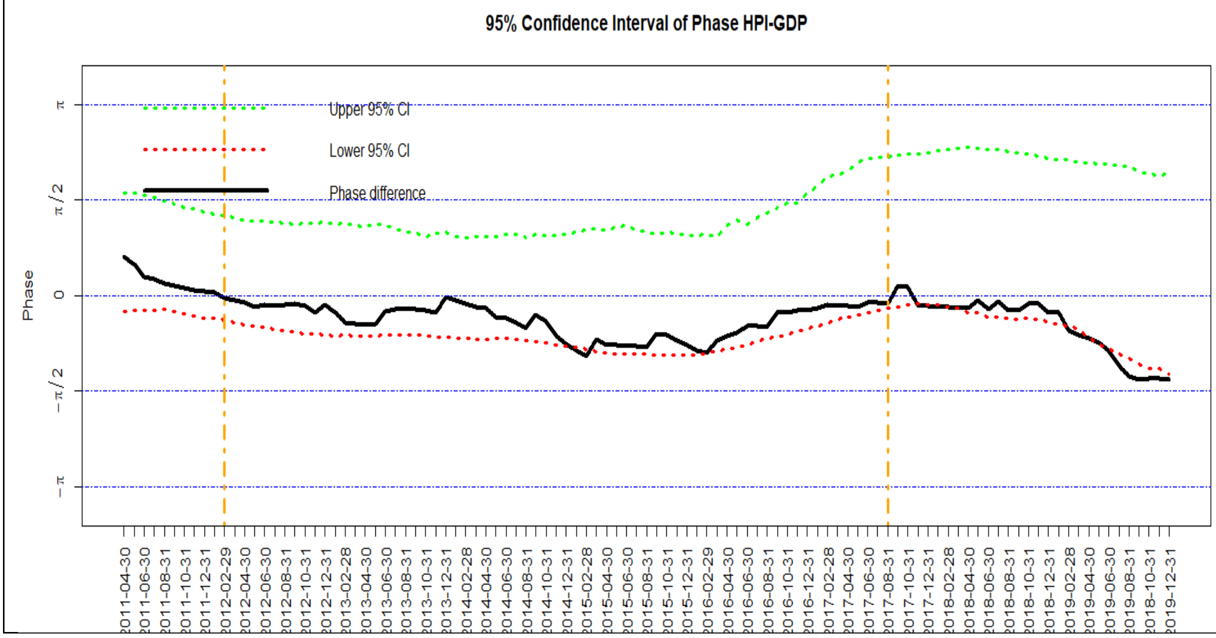


Chart 3: Wavelet Analysis of NHB-A and GDP

Chart 3A

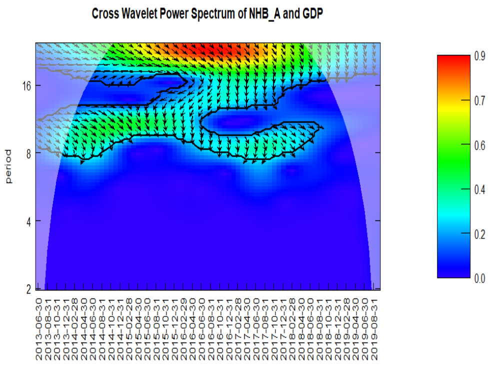


Chart 3B

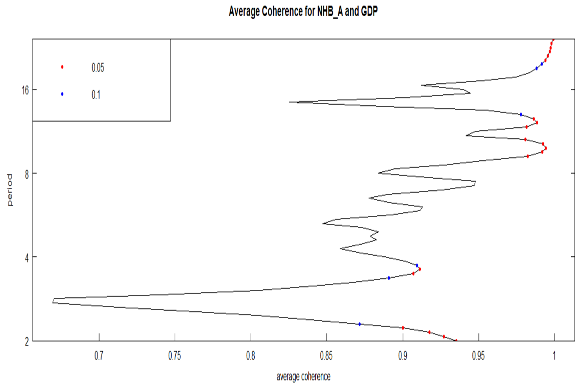


Chart 3C

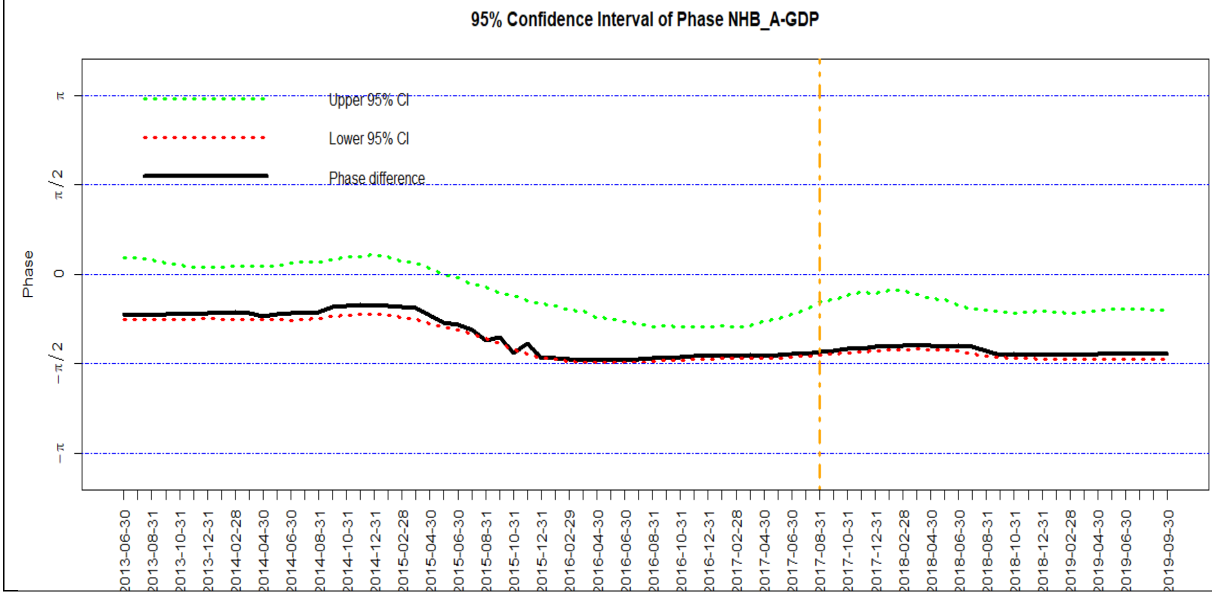


Chart 4: Wavelet Analysis of NHB-M and GDP

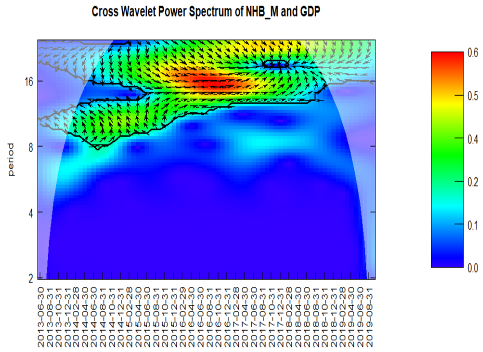
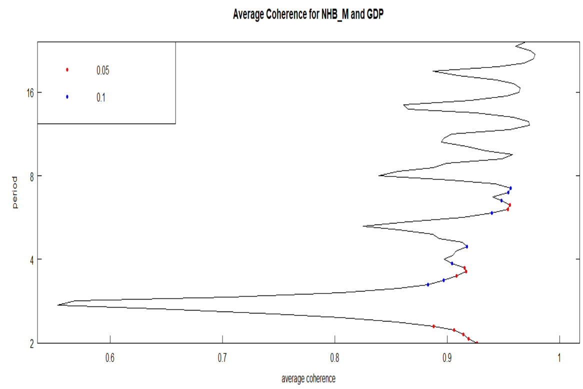
Chart 4A	Chart 4B
	

Chart 4C

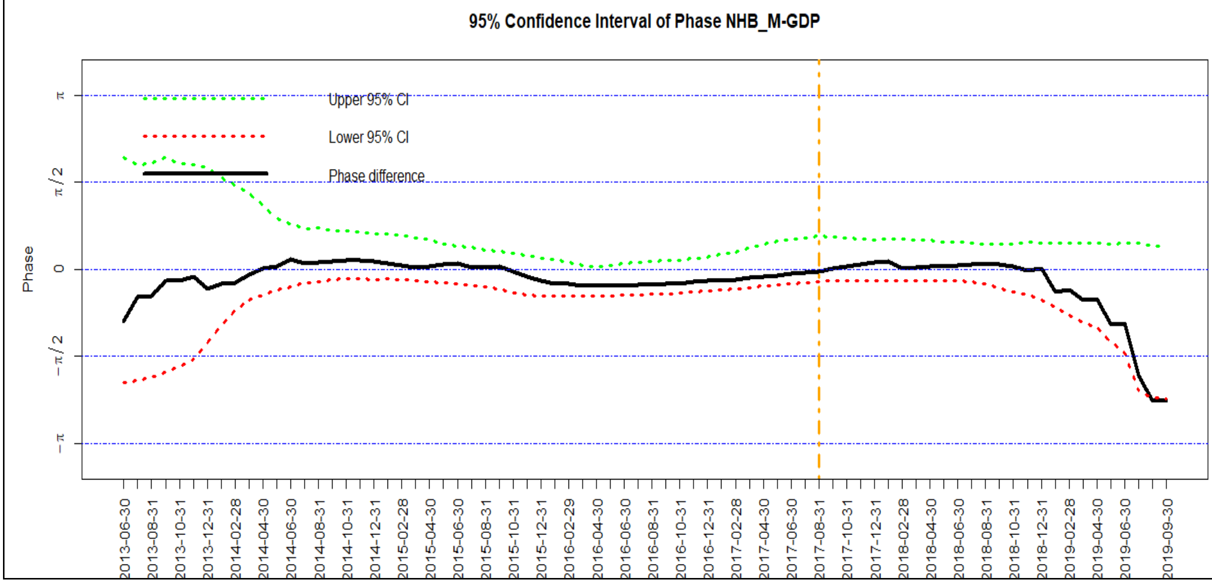


Chart 5: Wavelet Analysis of House Price (HPI) and Private Consumption (PFCE)

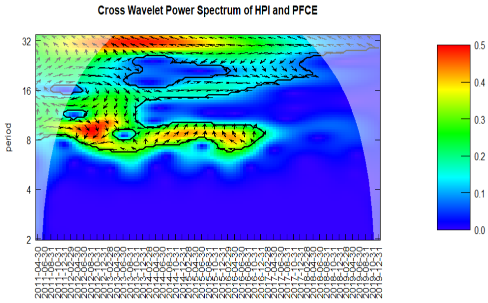
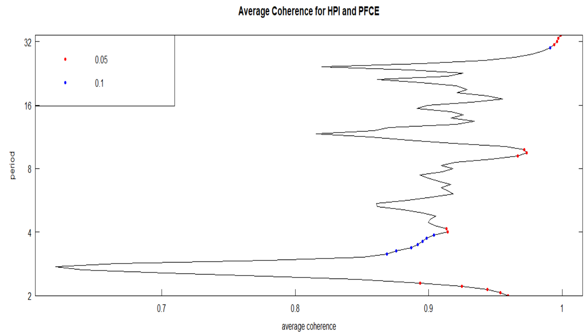
Chart 5A	Chart 5B
	

Chart 5C

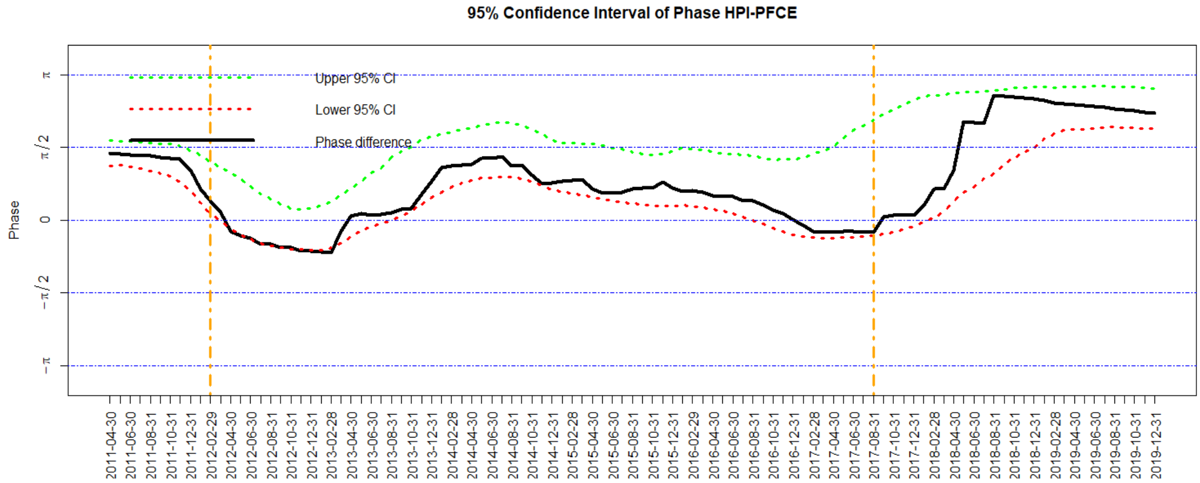


Chart 6: Wavelet Analysis of House Price (HPI) and Government Consumption (GFCE)

Chart 6A

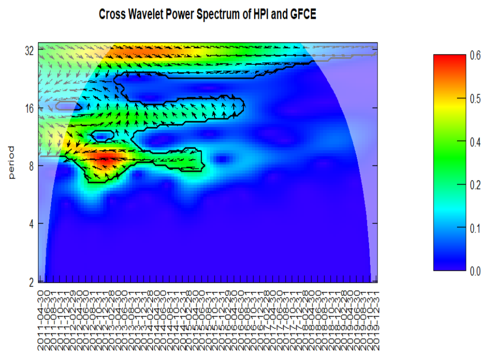


Chart 6B

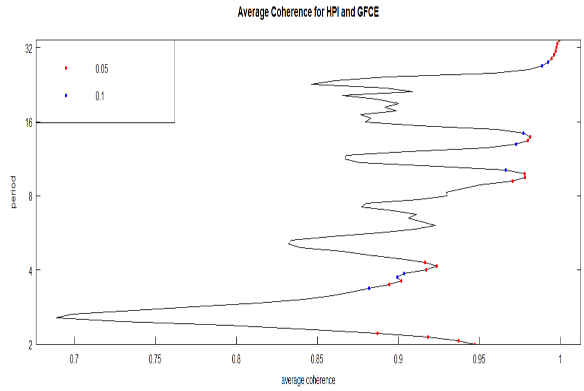


Chart 6C

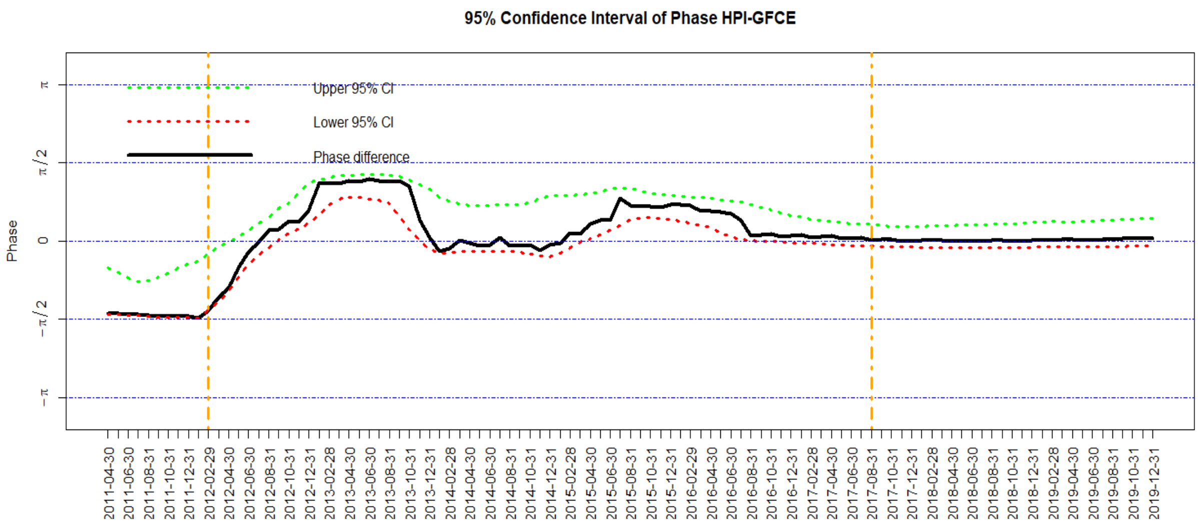


Chart 7: Wavelet Analysis of House Price (HPI) and Investment (GFCF)

Chart 7A

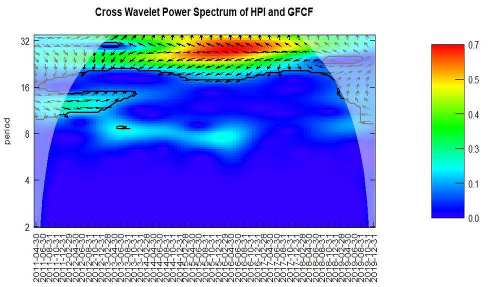


Chart7B

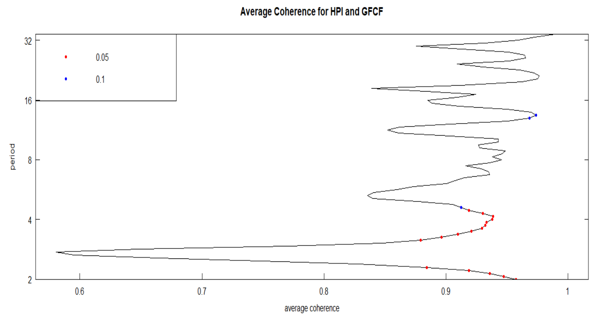
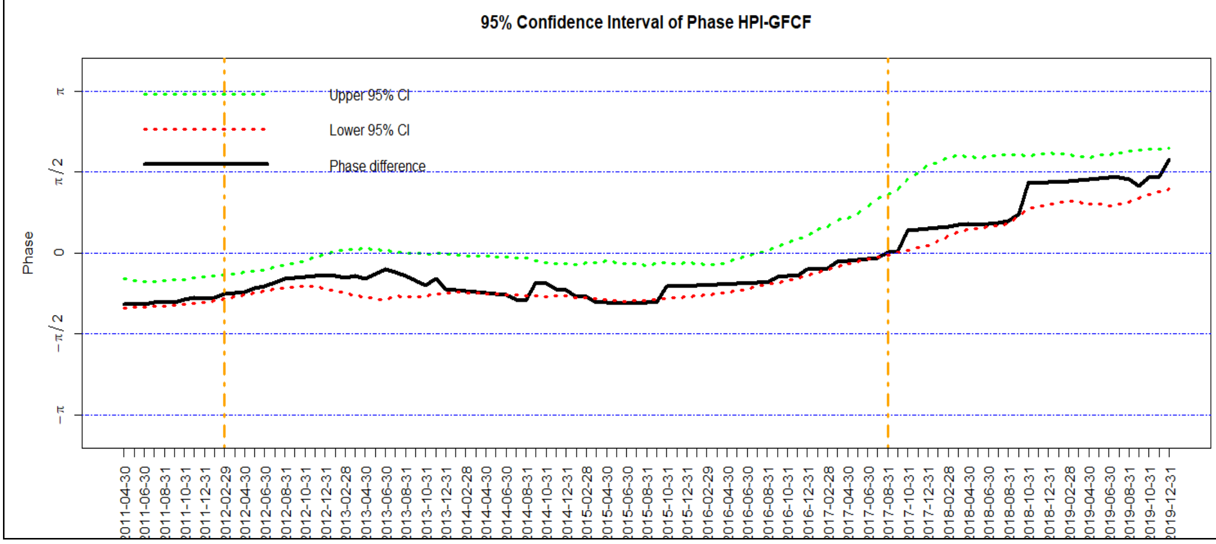


Chart 7C



Annex

Annex Table 1: Johansen Test and Estimated VECM model for HPI(X) and GDP(Y) (Test type: maximal eigenvalue test statistic)				
Eigenvalues	λ_1 = 2.256e-01	λ_2 = 8.965e-02	λ_3 = 1.139e-16	
	Test Statistic	10 % critical value	5 % critical value	1 % critical value
r ≤ 1	9.30	10.49	12.25	16.26
r = 0	25.32	16.85	18.96	23.65

Estimated VECM Model: $ECT_{t-1} = (X_{t-1} - 0.4144Y_{t-1})$

Dependent Variable	X_t	Y_t
ECT	-0.0018(*)	-0.0014
X_{t-1}	2.9164(***)	-0.3105
Y_{t-1}	-0.0637	1.7205(***)
X_{t-2}	-4.2699(***)	0.9916
Y_{t-2}	0.1325	-1.3301(***)
X_{t-3}	3.7708(***)	-1.5438
Y_{t-3}	-0.0556	0.1755
X_{t-4}	-2.0772(***)	1.4038
Y_{t-4}	-0.0313	0.6188(***)
X_{t-5}	0.6196(*)	-0.8302
Y_{t-5}	0.0645	-0.5501(***)
X_{t-6}	-0.0418	0.2791
Y_{t-6}	-0.0503	0.2581(**)

Note:

1. H_0: number of cointegration vectors (r), r = r*, against H_1: number of cointegration vectors r = r*+1.
2. Lag of 6 months was selected through Schwarz Criterion
3. The notation (.), (*), (**) and (***) refers to 10%, 5%, 1% and less than 1% significance level, respectively.

Source: Authors' calculations