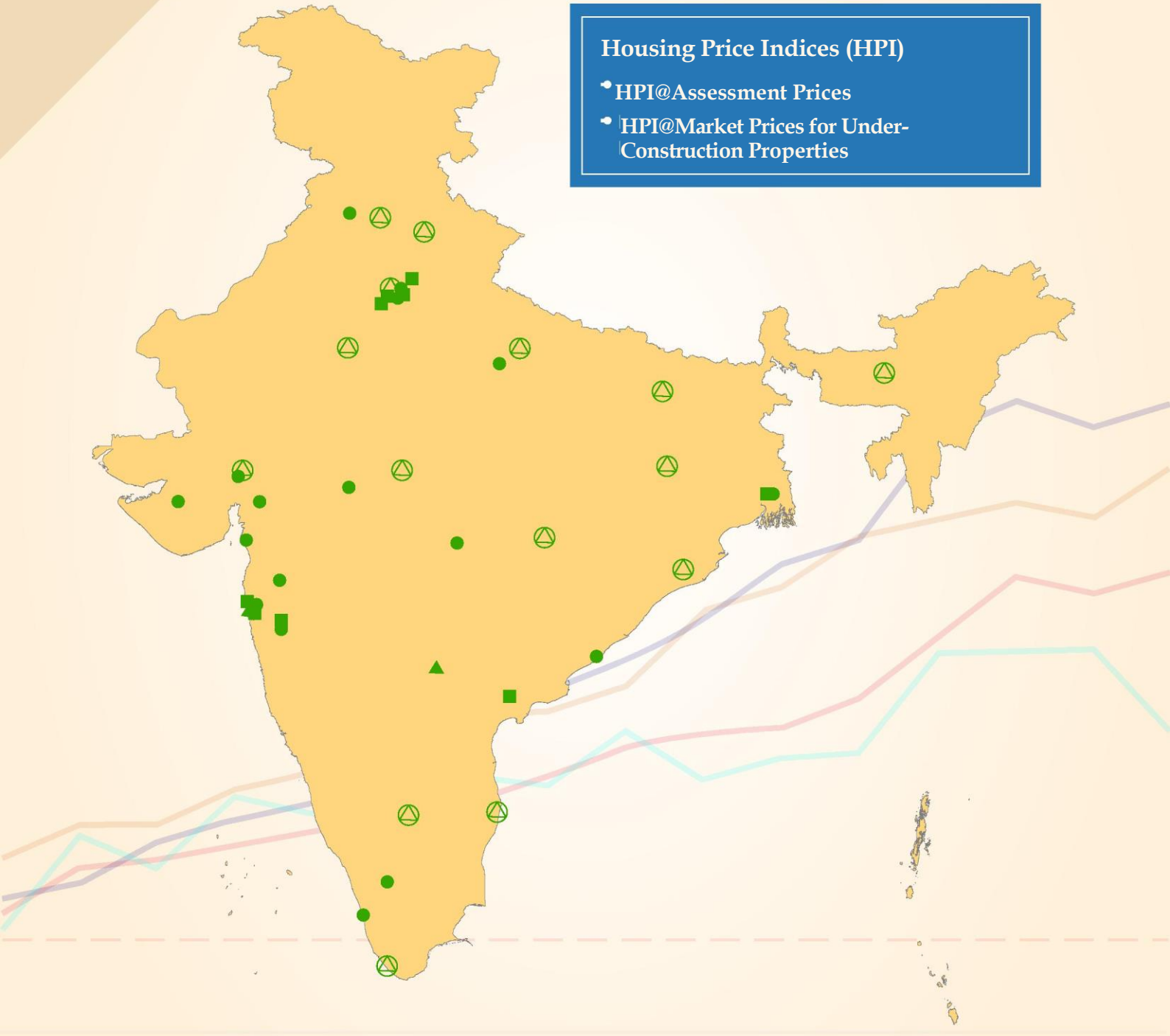
राष्ट्रीय आवास बैंक
NATIONAL HOUSING BANK

WHITE PAPER ON
NHB RESIDEX METHODOLOGY

Housing Price Indices (HPI)

- HPI@Assessment Prices
- HPI@Market Prices for Under-Construction Properties



2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020







COMPOSITION OF NHB RESIDEX TECHNICAL ADVISORY COMMITTEE AS ON JULY 15, 2020

1 Government of India

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1.2 Shri Dinesh Kapila, Economic Adviser (Housing), Ministry of Housing and Urban Affairs
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3.1 Shri Shreekant, Chief General Manager-REHBU, State Bank of India (SBI)
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6 Experts

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7 National Housing Bank

7.1 Shri V Rajan, General Manager

The White Paper on NHB RESIDEX Methodology is approved by the NHB RESIDEX Technical Advisory Committee (TAC)

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LIST OF ABBREVIATIONS

CPI	Consumer Price Index
CSO	Central Statistics Office
GDP	Gross Domestic Product
GOI	Government of India
HFC	Housing Finance Company
HPI	Housing Price Index
RBI	Reserve Bank of India
TAC	Technical Advisory Committee
WPI	Wholesale Price Index
sq.m.	Square Metre
sq.ft.	Square Feet

1. Introduction

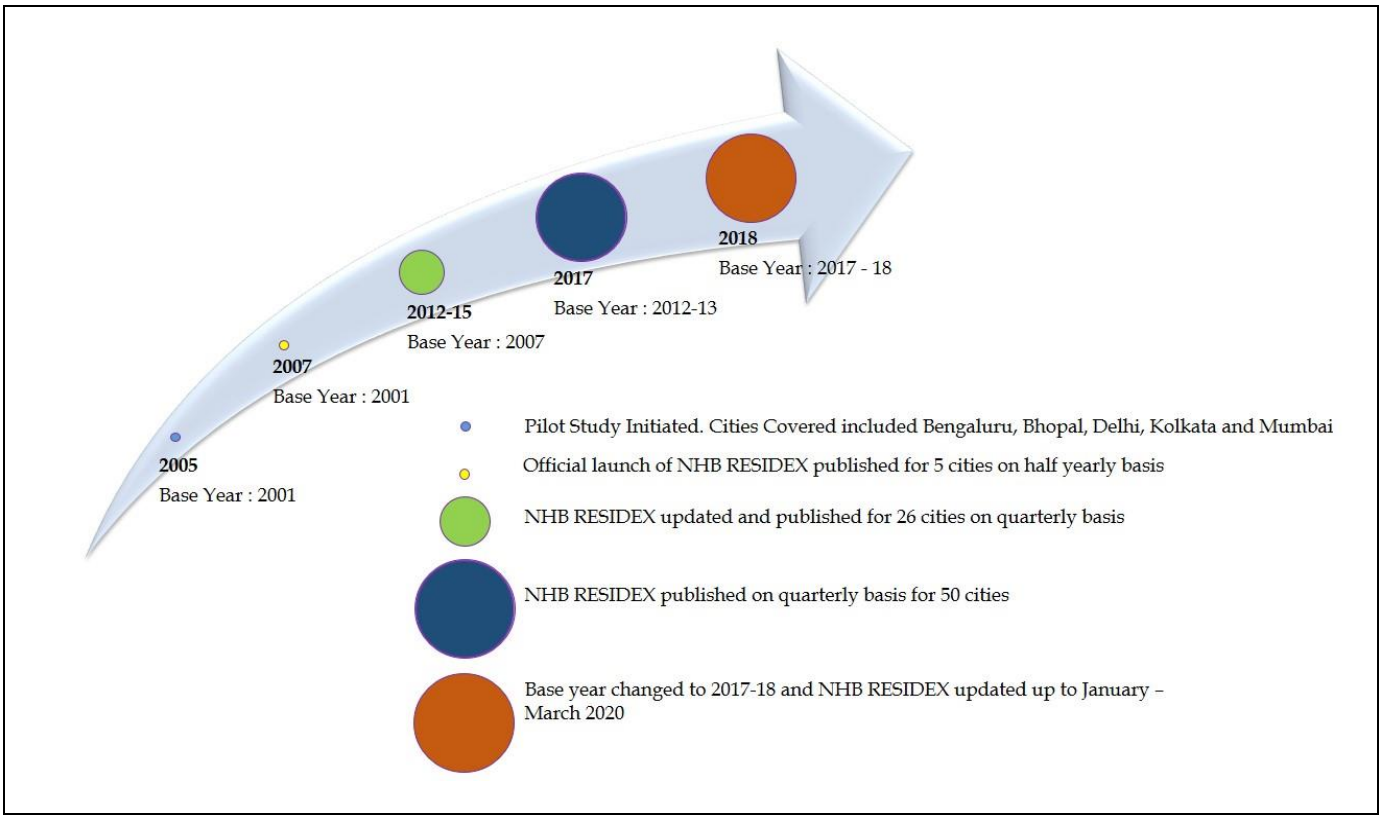
1.1 Brief on NHB RESIDEX

NHB RESIDEX, India's first official housing price index (HPI), was launched in July, 2007, to track the movement in prices of residential properties in select cities on quarterly basis, taking 2007 as the base year. With a view to reflect the current macroeconomic scenario, NHB RESIDEX has been revamped to include cluster of indices with updated base year, revised methodology and automated processes.

The revamped NHB RESIDEX is also wider in its geographic coverage and captures two housing price indices viz. HPI@Assessment Prices for 50 cities and HPI@Market Prices for Under Construction Properties for 50 cities. The HPI@Assessment Prices is based on valuation data of residential properties received from Banks and HFCs, while HPI@Market Prices for Under-Construction Properties is based on data of unsold stock collected through market survey which shall also be collected from project financing details of Banks and HFCs. Currently, the index/price movement has been updated for the HPIs constructed under NHB RESIDEX for the quarter ended March, 2020.The coverage is spread across 21 states in India, including 18 State/UT capitals and 33 smart cities. NHB RESIDEX also includes Composite HPI@Assessment Prices and Composite HPI@Market Prices for Under Construction Properties for 50 cities each.

Till March 2018, above HPIs tracked the movement in prices of residential properties on a quarterly basis, taking FY 2012-13 as the base year. From the April-June, 2018 quarter the base year has been shifted to FY 2017-18. The housing prices are classified on the basis of carpet area size at city level (INR/sq.ft.) for units under three product category levels namely <=60 sq.m., >60 & <=110 sq.m., and >110 sq.m. The indices are computed using Laspeyres Methodology, followed by calculation of a four Quarter Weighted Moving Average with application of dynamic weights at product category level and static new base year weights on the weighted moving average product category level prices, across all the quarters starting from the new base year.

1.2 Evolution of NHB RESIDEX



1.3 Methodology used for NHB RESIDEX

This paper discusses in detail the various stages of computation as well as the methodology used for the computation of *Housing Price Indices*, namely, *HPI@Assessment Prices* and *HPI @Market Prices for Under-Construction Properties*. It further explains the calculation of *the Margin of Error* (MoE).

The Paper is divided into the following sections:

- Preparation and Publication of HPIs
  HPI@Assessment Prices and HPI@Market Prices for Under-Construction Properties, after calculation of indices and the application of *Margin of Error* (MoE)[1]
- Preparation and Publication of Composite HPIs
- Shifting of Base Year
- Linking Factors

[1] Margin of Error is calculated in the case of HPI@Assessment Prices.

2. Preparation and Publications of HPIs

HPI@Assessment Prices and HPI@Market Prices for Under-Construction Properties, after calculation of indices and the application of Margin of Error (MoE)

2.1. HPI @Assessment Prices

Data for computation of HPI @Assessment Prices, sourced from Banks & Housing Finance Companies (HFCs), is based on the valuation undertaken by them at the time of loan origination. The calculation of HPI@Assessment Prices is explained through the following steps:

- Data Collection
- Data Segregation & Data Cleaning
- Regional Segmentation
- Application of Techniques for identification of Outliers
- Product Level Price Calculations
- Computation of Index: Application of Laspeyres Method
- Arriving at HPI@ Assessment Prices at City level
- Smoothing of HPI
- Application of Margin of Error
- Approval of HPI@ Assessment Prices by TAC
- Publication of HPI@ Assessment Price

2.1.1 Data Collection

To calculate HPI@Assessment Prices, Assessment Price Data is collected from Banks/Housing Finance Companies (HFCs) in a data sheet containing the following fields: Type of Property (e.g. Apartment, land, independent house, etc.), Property Area, Type of Area (e.g. Super Built up area, Carpet Area, etc.), Unit of area measurement, Property Address, Name of the City, Pin Code, Type of Transaction (Resale, New Property, Under-Construction property, etc.), Date of Valuation, Market Value of entire Property (Land+ Building), Unit of Market Value measurement.

2.1.2 Data Segregation & Data Cleaning

Processing of valuation data for computing *HPI@Assessment Prices* is done as under:

In the case of *HPI@Assessment Prices,* quality check of all necessary fields in the data sheet is carried out through the following steps:

- Rejection of records with fields having Missing/Incomplete/Incorrect Values

- Checking the completeness and correctness of Property Address
- Maintaining data consistency in the related address fields like Property Address, City and Pin Code
- Extracting Pin Code and City from Property Address, wherever such values are missing/invalid in the respective column
- Conversion of type of area into Carpet Area from Super Built-up Area and Built-up Area

$$\text{Carpet Area (psf)} = \frac{\text{Property Area} * \text{Unit Conversion Factor}}{\text{Area Size type conversion Factor}}$$

- Standardizing the 'Date of Valuation' (in single format), and considering the current quarter as well as the previous two quarters for this purpose. Other dates considered as "*Date of Valuation does not belong to the current Quarter*"
- Conversion of all Market Values to INR
- Conversion of Property Area to sq.ft. from sq.m.
- Mapping of Pin Code to City and Property Address to Pin Code, wherever possible, with the help of the Pin Code Master

2.1.3 Regional Segmentation

For the purpose of NHB RESIDEX, regional segmentation has been done for cities having Municipal Corporations/Councils/Development authorities with substantial zone-wise transactions. The regional segmentation has been conducted by giving preference to administrative/planning boundaries wherever available. In the case of smaller cities where the administrative boundaries are not available or cities where these boundaries are too fragmented, the real estate prices, contiguous area and demographic setting have been taken as proxies to define homogeneity in the area to sub-divide a city into sub-urban areas or zones.

At the macro level, 95% of the records are found to fall within 2 (Sigma). However, as the boundaries get narrower and regional segment of an old area of a city where there are few or no transactions, the process followed is to continue joining the adjoining boundaries in a manner that the clubbed boundaries represent enough records which qualifies the condition of normal distribution.

2.1.4 Application of Techniques for identification of Outliers

During the process of computation of HPI@Assessment Prices, outliers in the datasets are identified for each Pin Code and product category. Exclusion of outliers based on Carpet Area and Price is carried out based on the criteria given below:

- Carpet Area is below 10 sq.m. or above 1000 sq.m.
- Carpet Area Price per sq.ft. is outside the acceptable limits defined for all cities and Mumbai (separately). For all cities, except Mumbai, the acceptable range for Carpet Area Price per sq.ft. is ₹ 1,500 to ₹ 40,000. For Mumbai, it is ₹ 4,000 to ₹ 2,00,000 per sq.ft.
- Price Outliers are identified using the Inter-Quartile Range (IQR) method.

Elimination of Outliers, before the computation of *HPI@Assessment Prices,* is a two-step process explained by the following example:

1st Level Elimination

Price Outliers for Mumbai (Red Line)

< ₹ 4,000 > ₹ 2 lakh

Price Outliers for Other Cities (Red Line)

< ₹ 1,500 Price > ₹ 40,000

2nd Level Elimination

Inter-Quartile Range (IQR) method is applied at Pin Code level for every city every quarter; it is calculated as the difference between the upper (Q_3)[2] and lower (Q_1)[3] quartiles.

IQR = 3rd Quartile – 1st Quartile

Inter-Quartile range is Q_3-Q_1. Given this, the Minimum acceptable price is 1st Quartile – 1.5*IQR while the Maximum acceptable price is 3rd Quartile + 1.5*IQR.

Assessment Records, having prices less than the Minimum acceptable price, are considered as Lower Price Outliers at Pin Code level and similarly Assessment Records, having prices greater than the Maximum acceptable price, are considered as Upper Price Outliers at Pin Code level.

2.1.5 Product Level Price Calculations

Product level Prices for *HPI@Assessment Prices* are calculated using *Median Formula* for the product levels given below:

1. Less than or Equal to 60 sq.m.
2. Greater than 60 sq.m. and Up to 110 sq.m.
3. Greater than 110 sq.m.

[2] Median of the n largest values in dataset.
[3] Median of the n smallest values in dataset.

2.1.6 Computation of Index: Application of Laspeyres Method

Laspeyres Method uses quantity (Q_{0i}) of base year to compute the price trend. For, *HPI@Assessment Prices*, the financial year 2012-13 has been considered as the base year for the HPI calculation till Mar-18, which has been changed to 2017-18 for HPI calculation from Jun-18 onwards. To calculate the average quantity during the base year (Q_{0i}), the average of quarterly transactions, using the simple average method during the base year for each product, have been considered.

In the case of *HPI@Assessment Prices*, Q_{0i} indicates the average quarterly transactions during the base year for each product. Q_{0i} is the percentage of transactions for each product to the total number of transactions for all products. P_{0i} is the simple average of product level prices of all the four quarters of the base year.

2.1.7 Arriving at HPI@Assessment Prices at City level

HPI@Assessment Prices is calculated using the Laspeyres Formula:

$$HPI = \frac{\sum_{i=1}^{n} P_{1i}Q_{0i}}{\sum_{i=1}^{n} P_{0i}\ Q_{0i}} X100$$

Where,

P_{0i} = Median Price of ith product in the base period
Q_{0i} = Number of transactions of ith product in the base period
P_{1i} = Median Price of ith product in the current period
n = Number of product types

2.1.8 Smoothing of HPI@Assessment Prices

This process removes random variations and helps to get the actual market trends and cyclical components. A four-quarter moving average is used to calculate the carpet price for all product categories each quarter, which removes the impact of any seasonal variation in the data. The first product level price value comes for the 4th quarter by taking average of the first 4 quarters. The product level price so derived is multiplied by the no. of transactions in the case of HPI@Assessment Prices. After the calculation of four quarter moving average Product level prices, four quarter moving average Composite Price and four quarter moving average HPI@ Assessment Prices are calculated using the Laspeyres Formula as explained above.

2.1.9 Margin of Error

The margin of error is calculated on a dynamic basis with a benchmark of 200 records in each product category for each city and to go back up to four quarters, and if records are less than 200 then would go back further four quarters and this will continue till Jun. 2012.

To calculate the margin of error for Product level prices, the estimated standard deviation (S) and sample size (n) are required.

Margin of Error = Critical value * $\frac{S}{\sqrt{n}}$

Since data has pooled for Four quarters, to estimate the standard deviation of prices we need to calculate the pooled standard deviation.

Step 1: Calculate the Pooled Standard Deviation

Pooled Standard Deviation:

Formula: Here, the categories are Quarter = i = 1, 2, …, k then the pooled standard deviation $\sqrt{S_p^2}$ can be computed by the weighted average.

$$\sqrt{S_p^2} = \sqrt{\frac{\sum_{i=1}^{k}(n_i - 1)S_i^2}{\sum_{i=1}^{k}(n_i - 1)}}$$

Where,

n_i is the count of usable records in i^{th} Quarter and S_i^2 is sample variance of the log prices of usable records in i^{th} Quarter.

$$S_i^2 = \frac{\sum_{j=1}^{m}\left(X_j - \bar{X}_j\right)^2}{(n_i - 1)}$$

Where, j = 1, 2, …, m

And X_j is the log price of the j^{th} property in i^{th} quarter and $\bar{X}_j$ is average log prices of all properties in the i^{th} quarter. Since, the distribution of property prices is positively skewed, we are using the log of property prices for the calculation purpose.

Step 2: Calculate Pooled Standard Error

Pooled Standard Error = $\frac{\sqrt{S_p^2}}{\sqrt{\sum_{i=1}^{j} n_i}}$

Step3: Calculate Margin of Error

Margin of Error = Critical value * Standard Error, Where, Critical Value (z value) = 1.96 for a confidence level of 95%.

The MoE is not calculated for all cities because of inadequate or too few data. Further, MoE for smaller cities having less data are not published on the website. In other words, the city-wise and product-wise MoE calculations are not disseminated if transactions are less than 200 along with notes or Margin of Error is greater than 5%.

2.1.10 Approval of HPI@Assessment Prices by TAC

Upon calculation, the quarterly index relating to HPI@Assessment Prices for 50 cities is presented to all the TAC members every quarter by the Liases Foras and National Housing Bank to seek their feedback and approval.

2.1.11 Publication of HPI@Assessment Prices

Once all the TAC Members give their feedback and approval to publish, the Indices are placed in the public domain through their publication on the National Housing Bank's website.

2.2 HPI@Market Prices for Under-Construction Properties

Data on Under-Construction Properties across 50 cities are collected from brokers, developers, builders, etc. through market/field surveys. The projects are identified via secondary sources and then geo-mapped to ensure that all under-construction projects in the cities are duly covered. Post this, field survey is conducted with surveyors visiting the identified projects. The data collated include units of unsold stock, their prices and construction status of each project. The data are updated every quarter. The price considered for computation is the base price which the developer offers to the consumer that excludes charges for floor rise, preferred location charge, car parking, government dues, etc.

The calculation of HPI@Market Price for Under-Construction Properties is explained through the following steps:

- Data Collection
- Data Segregation
- Regional Segmentation
- Product Level Price Calculations
- Computation of Index: Application of Laspeyres Method
- Arriving at HPI@Market Prices at City level
- Smoothing of HPI@Market Prices
- Approval of HPI@Market Prices by TAC
- Publication of HPI@Market Prices

2.2.1 Data Collection

To calculate HPI@Market Prices for Under-Construction Properties, the data are collected through market surveys from builders/developers, etc. and maintained in a format containing the following fields: FY Quarter, City Name, Project Name, Project Address, Locality, Pin Code, Unsold Stock, Type of Area, Property Area in terms of carpet area square feet (sq.ft.) and square meter (sq.m.), Product Type, Market value of unit, Carpet Area Rate Per sq.ft.

2.2.2 Data Segregation

Processing of valuation data for computing HPI@Market Prices for Under-Construction Properties is done as under:
Quality Compliance of all required/collected fields including Property Type, Apartment Size, Market Price, Project GPS Coordinates, Saleable to Carpet Ratio of Apartment and Pin Code is done.
Only Unaltered Error Free data is used for computation of the Index. In the case of *HPI@Market Prices for Under-Construction Properties*, the process involves identification and correction of Apartment Price Outliers at different Levels:

- Locality Level
- Suburb Level
- City Level

Quality Compliance of GPS coordinates is done and processing is done for the projects which are in City confinement.

2.2.3 Regional Segmentation

For the purpose of NHB RESIDEX, regional segmentation has been conducted by giving preference to administrative/planning boundaries wherever available. In the case of smaller cities where the administrative boundaries are not available or cities where these boundaries are too fragmented, the real estate prices, contiguous area and demographic setting have been taken as proxies to define homogeneity in the area to sub-divide a city into sub-urban areas or zones.
At the macro level, 95% of the records are found to fall within 2 (Sigma). However, when the boundaries get narrower and/or there are few or no transactions, for instance, in old areas of a city, the process followed for the purpose of regional segmentation is to continue joining the adjoining boundaries in a manner that the clubbed boundaries represent enough records which satisfies the condition of normal distribution.

2.2.4 Product Level Price Calculations

For assessing product level prices for HPI@Market Prices of Under-Construction Properties, the weighted average price methodology is used. The reason for the difference in methodology is due to the difference in data structure. The lender valuation data consists of price of each unit transacted, while under-construction data consists of prices for unsold units at the building level.
Prices are calculated using the Weighted Average Price Formula for the product levels given below:

1. Less than or Equal to 60 sq.m.
2. Greater than 60 sq.m. and Up to 110 sq.m.
3. Greater than 110 sq.m.

2.2.5 Computation of Index: Application of Laspeyres Method

Laspeyres Method uses quantity (Q_{0i}) of base year to compute the price trend. For, *HPI@Market Prices for Under-Construction Properties*, the financial year 2012-13 has been considered as the base year for the HPI calculation till Mar-18, which has been changed to 2017-18 for HPI calculation from Jun-18 onwards. To calculate average quantity during the base year (Q_{0i}), the four quarter average of unsold stock, using the simple average method during the base year for each product, has been considered.

In the case of HPI@Market Prices for Under-Construction Properties, Q_{0i} indicates the average quarterly unsold stock during the base year for each product.

Q_{0i} is the percentage of unsold stock for each product to the total unsold stock for all products in the base year.
P_{0i} is the simple average of product level prices of all the four quarters of the base year.

2.2.6 Arriving at HPI@Market Prices at City level

HPI@Market Prices for Under-Construction Properties is calculated using the Laspeyres method:

$$\text{HPI} = \frac{\sum_{i=1}^{n} P_{1i} Q_{0i}}{\sum_{i=1}^{n} P_{0i}\ Q_{0i}} X100$$

Where,
P_{0i} = weighted average price of ith product in the base period
Q_{0i} = Number of Unsold stock of ith product in the base period
P_{1i} = weighted average Price of ith product in the current period
n = Number of product types

2.2.7 Smoothing of HPI@Market Prices for Under-Construction Properties

This process removes random variations and helps to get the actual market trends and cyclical components.

A four-quarter moving average is used to calculate HPI, which removes the impact of any seasonal variation in the data. The carpet price for each product category every quarter is multiplied by the number of unsold units in that product category and the sum so derived is divided by the total number of unsold stock of that product in the four qtrs. The first product level price value comes for the 4th quarter by taking average of the first 4 numbers. After the calculation of four quarter moving average product level prices, four quarter moving average Composite Price and four quarter moving average HPI@Market Prices are calculated using the Laspeyres Formula as explained above.

2.2.8 Approval of HPI@Market Prices by TAC

Upon calculation, the quarterly Index relating to HPI@Market Prices for Under-Construction Properties for 50 cities is presented to all the TAC members every quarter by the Liases Foras and National Housing Bank to seek their feedback and approval.

2.2.9 Publication of HPI

Once all the TAC Members give their feedback and approval to publish, the Indices are placed in the public domain through their publication on the National Housing Bank's website.

3. Preparation and Publication of Composite HPIs

Post determination of HPIs for 50 cities, the Composite 50-city HPIs are computed by assigning weights, based on population of 50 cities as per CENSUS 2011, to city-level HPIs, as under:

$$Composite\ 50\ City\ HPI = \frac{\sum_{i=1}^{n}(HPI_{1i} * Pop_{i(2011)})}{\sum_{i=1}^{n} Pop_{2011}}$$

Wherein,
HPI_{1i} = *HPI of* i^{th} *city in current period*
$Pop_{i\ (2011)}$ = i^{th} *City Population as per Census 2011*
n = *number of cities (50)*

4. Shifting of Base Year

As market dynamics changes every year, to make it current and relevant, Base year revision of the HPIs is envisaged every five years. In line with the Base year revision, a new series of NHB RESIDEX will get launched every five years. Currently, the new base year is FY 2017-18.

5. Linking Factor to inter-link the different base years

NHB, in the Request for Proposal (RFP), mandated that the base year for the indices shall be shifted every 5 years automatically to make it current and relevant. Government of India has proposed to shift the base year for Gross Domestic Product (GDP) and Index of Industrial Production (IIP) to 2017-18 and Consumer Price Index (CPI) to 2018. The implementation of structural reform processes such as Real Estate (Regulation and Development) Act, 2016, withdrawal of higher denomination notes of ₹500 and ₹1,000 in 2016 and introduction of Goods and

Services Tax (GST) in 2018 have helped to streamline the real estate activity in the country.

Linking factors are the conversion coefficients (multipliers) linking two or more indices prepared on the basis of different base years. Since the base year for the NHB RESIDEX has been shifted from FY 2012-13 to FY 2017-18, presented below are the linking factors (forward linking and backward linking) for the indices built on FY 2012-13 as the base year and FY 2017-18 as the base year.

- Ratio Method is used to calculate Linking Factor

$$\text{Forward Linking Factor} = \frac{HPI\ Base\ Year\ FY\ 2012-13}{HPI\ Base\ Year\ FY\ 2017-18}$$

$$\text{Backward Linking Factor} = \frac{HPI\ Base\ Year\ FY\ 2017-18}{HPI\ Base\ Year\ FY\ 2012-13}$$

****

The document has been prepared by M/s Liases Foras Real Estate Rating and Research Pvt. Ltd.in consultation with the Market Research Consultancy & Policy Department of the National Housing Bank.

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2. Preparation and Publication of HPI

2.1 HPI@Assessment Price

2.1.1 Carpet Area calculation

$$\text{Carpet Area (psf)} = \frac{\text{Property Area} \ * \ \text{Unit Conversion Factor}}{\text{Area Size type conversion Factor}}$$

Property Area Type may be received as 'Super Built up Area', 'Built up Area' or 'Carpet Area'.

If Property Area Type is 'Carpet Area', then no conversion is required.

If Property Area Type is 'Built up Area' and is 1000 square feet, then it is converted into Carpet Area as follows:

$$\frac{1000 \text{ (Built up Area)} \ * \ 1}{1.2} = 833 \ sq.ft. \ (Carpet \ Area)$$

If Property Area Type is 'Super Built up Area' and is 1000 square feet, then its conversion into Carpet Area is as under:

$$\frac{1000 \text{ (Super Built up Area)} \ * \ 1}{1.45} = 690 \ sq.ft. \ (Carpet \ Area)$$

For Property Area Type 'Built up Area', conversion factor is considered to be the same for all the cities and product types while for 'Super Built up Area', conversion factor for Mumbai is 1.65, while for other cities it is 1.45.

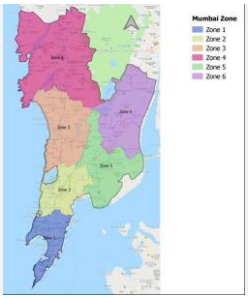
2.1.2 Regional Segmentation

India being a unity in diversity, different cities have different layers of segmentation. However, we have selected four common segmentations prevalent across cities. The regional segmentation approach should be such that the price can be computed at any selection of boundary, macro to micro level.

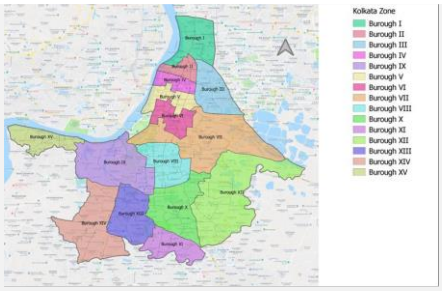
Regional segmentation is a division of a city's boundary into multiple sub-sections. A city can be sub-divided based upon multiple factors like administrative divisions, electoral wards, planning wards, infrastructure circuit, congruency in terms of a particular parameter like real estate prices, etc.

Following these broad norms, Mumbai has been divided into Six Zones, while Kolkata has been divided into 15 Zones. Similarly, other cities have been divided into Municipal Zones; the number of Municipal Zones differ from city to city.

Below are the Graphical representation of the regional segmentation of Mumbai and Kolkata:



Mumbai



Kolkata

2.1.3 Application of Techniques for identification of Outliers

The inter-quartile range (IQR) is used to identify outliers in price data. The IQR of a set of values is calculated as the difference between the upper (Q_3) and lower (Q_1) quartiles. Outliers are defined as observations that fall below Q_1-1.5*IQR or above Q_3+1.5*IQR. For instance, if we have total 33 units in a given Pin Code and Market Value of Carpet Prices per sq.ft. for these units (33) are 7315, 6451, 6663, 11086, 12493, 11611, 11606, 17310, 12943, 15568, 11479, 11297, 10429, 14239, 13901, 14691, 13380, 15025, 10426, 16617, 15121, 12426, 12478, 10392, 10272, 17905, 12877, 16117, 16586, 28741, 33931, 28044, 31295 then the outliers using the IQR method are identified as under:
Median Value or 2nd Quartile (50% Percentile) of above data set = 12,943
The 1st Quartile and 3rd Quartile, based on the above data are as under:
1st Quartile (25th Percentile exclusive) = 11,191 and
3rd Quartile (75th Percentile exclusive) = 16,351
IQR = 5,160
Minimum Acceptable price = 11,191 – (1.5*5,160) = ₹ 3,451 per sq.ft.
Maximum Acceptable price= 16,351 + (1.5*5,160) = ₹ 24,091 per sq.ft.
Thus, in this example, Four Records turn out to be Upper Outliers and are not used for the computation of HPI@Assessment Prices.

2.1.4 Product Level Price Calculations for HPI@Assessment Prices

Median Method is used to calculate Product Level Prices for three product categories at city level. For instance, in case we have 14 records relating to Carpet Prices per sq.ft. for the Product category, "*Less than or equal to 60 sq.m.*" for any given city- 7315, 6451, 6663, 11086, 12493, 11611, 11606, 17310, 12943, 15568, 11479, 11297, 10429, 14239, Product Level Price, using the Median Method, works out to ₹ 11,543 per sq.ft.

Similarly, Product Level prices are calculated for the other two product categories using the Median Method.

2.1.5 Determination of base year prices & quantities

Laspeyres Method uses quantity (Q) of base year to compute the price trend. For both indices *viz.*, HPI@Assessment Price and HPI@Market Prices for under-construction properties, the financial year 2017-18 has been considered as the base year.

To calculate the average quantity during the base year (Q_0), a simple average of quarterly records pertaining to number of transactions during FY 2017-2018 for each product has been considered. Q_0 is a percentage of records for each product against the total number of records in the base year 2017-18. For HPI@Market Prices for Under-Construction Properties, the average of unsold stock during the four quarters of 2017-18 has been considered to compute Q_0.

Determination of Q_0 for HPI@Assessment Prices of Bengaluru:

Product Level Categories	Number of Transactions					Q_0 for FY 2017-18
	Jun-17	Sep-17	Dec-17	Mar-18	Average for FY 2017-18	
<=60 sq.m.	42	38	33	49	40.5	0.0478
>60 sq.m. and <=110 sq.m.	423	469	507	609	502	0.5929
>110 sq.m.	261	310	294	352	304.25	0.3593

The average base year prices are multiplied by these weights to calculate P_0Q_0.

To calculate average prices for the base year (P_0), a simple average of product level prices for four quarters viz., June 2017, September 2017, December 2017 and March 2018 has been considered.

Determination of P_0 for HPI@Assessment Prices of Bengaluru.

Product Level Prices for HPI computation (Figures in INR/ sq.ft.)			
Quarter /Year	<=60 sq.m. ≈ 646 sq.ft.	>60 sq.m. and <=110 sq.m.≈ >646 sq.ft. and <=1083 sq.ft.	>110 sq.m. ≈ > 1083 sq.ft.
Jun-17	3,732	4,271	5,008
Sep-17	3,688	4,510	5,293
Dec-17	4,223	4,586	5,129
Mar-18	4,028	4,607	5,463
Average (P_0)	3,918	4,494	5,223

Determination of P_0Q_0 for HPI@Assessment Prices of Bengaluru

Product Level	P_0 for FY 2017-18 (a)	Q_0 for FY 2017-18 (b)	P_0Q_0 (a*b)
<=60 sq.m.	3,918	0.0478	187.28
>60 sq.m. and <=110 sq.m.	4,494	0.5929	2664.49
>110 sq.m.	5,223	0.3593	1876.62
Total		1.0000	4728.39

2.1.6 Arriving at HPI@Assessment Prices at City level

For the three product categories, base year/current prices and weights for a given city are given below:

Product Category	Base Year Price	Current Quarter Price	Weights[4]
<=60 sq.m.	3,918	4,747	0.0478
>60 sq.m. and <=110 sq.m.	4,494	5,380	0.5929
>110 sq.m.	5,223	6,439	0.3593

The HPI@Assessment Prices is then calculated as under:

$$\text{HPI} = \frac{(4747*0.0478)+(5380*0.5929)+(6439*0.3593)}{(3918*0.0478)+(4494*0.5929)+(5223*0.3593)} * 100 = \mathbf{121}$$

2.1.7 Smoothing of HPI@Assessment Prices

The four quarter moving average of product level prices helps to smooth out the HPI@Assessment prices series. The four quarter moving average of product level prices is computed by applying dynamic weights based on the number of transactions at product category level. This is explained as under:
Suppose that there are 'n' time periods denoted by t1, t2, t3…..tn; the corresponding values of the Y variable (product prices) are Y1,Y2,Y3,…,Yn and the corresponding no. of transactions are W1,W2,W3…..Wn.

Since we have a quarterly time series, we set M, the size of the "smaller set" equal to 4. Then the average of the first 4 quarterly numbers is calculated as follows:

$$\frac{Y1W1 + Y2W2 + Y3W + Y4W4}{W1 + W2 + W3 + W4} = M4$$

[4] Percentage of number of transactions of i^{th} product to the total number of transactions of all products in the base year

This smoothing process is continued by advancing one period and calculating the average of next four quarters, dropping the first quarter.
After the calculation of these Moving Average product level prices, the static base year transactional weights are used on these product level prices to arrive at the composite city level price which is then used for index computation.

e.g.: For Product category "<=60 sq.m." and Ahmedabad City

Quarter (t)	Variable (Y)	No. of Transactions	Four quarter Moving Average
17-18 Q1	2,975	1,197	
17-18 Q2	3,309	1,229	
17-18 Q3	3,600	1,507	
17-18 Q4	3,629	1,289	$\frac{(2975*1197)+(3309*1229)+(3600*1507)+(3629*1289)}{(1197+1229+1507+1289)}$
18-19 Q1	3,840	2,035	$\frac{(3309*1229)+(3600*1507)+(3629*1289)+(3840*2035)}{(1229+1507+1289+2035)}$
18-19 Q2	4,020	2,622	$\frac{(3600*1507)+(3629*1289)+(3840*2035)+(4020*2622)}{(1507+1289+2035+2622)}$
18-19 Q3	4,200	2,436	$\frac{(3629*1289)+(3840*2035)+(4020*2622)+(4200*2436)}{(1289+2035+2622+2436)}$
18-19 Q4	4,187	2,500	$\frac{(3840*2035)+(4020*2622)+(4200*2436)+(4187*2500)}{(2035+2622+2436+2500)}$

Thus, the Four Quarter moving average prices for Product category "<=60 sq.m."so calculated are given below:

Quarter (t)	Four Quarter moving average Price (per sq.ft.)
17-18 Q4	3,395
18-19 Q1	3,628
18-19 Q2	3,941
18-19 Q3	4,030
18-19 Q4	4,200

2.1.8 Margin of Error calculation

For City Pune, and for Product category "<=60 sq.m.", to calculate Margin of Error for the quarter Jul-Sep 2019, the usable records from Dec-18 to Sep-19 are considered.

FY QTR	City	Record Count (n_i)	(Record Count-1) ($n_i - 1$)	Standard Deviation (S_i)	Variance S_i^2	$(n_i - 1)S_i^2$
Dec-18	Pune	2031	2030	0.375911	0.141309	286.8568
Mar-19	Pune	2004	2003	0.38518	0.148364	297.1724
Jun-19	Pune	1756	1755	0.420315	0.176665	310.0466
Sep-19	Pune	1410	1409	0.401802	0.161445	227.4757
		$\sum_{i=1}^{j} n_i$	$\sum_{i=1}^{j} (n_i - 1)$			$\sum_{i=1}^{k} (n_i - 1)S_i^2$
		7201	7197			1121.552

Pooled Standard Deviation of the data = $\sqrt{S_p^2} = \sqrt{\frac{\sum_{i=1}^{k}(n_i-1)S_i^2}{\sum_{i=1}^{k}(n_i-1)}}$

Where, $\sum_{i=1}^{k}(n_i-1)S_i^2 = 1121.552$ and $\sum_{i=1}^{j}(n_i-1) = 7197$

Then, Pooled Variance of the data = $S_p^2 = \frac{1121.552}{7197} = 0.155836$

Pooled Standard Deviation = $\sqrt{S_p^2} = \sqrt{0.155836} = 0.394761$

Step 2: Calculate Pooled Standard Error

Pooled Standard Error = $\frac{\sqrt{S_p^2}}{\sqrt{\sum_{i=1}^{j} n_i}}$

$= \frac{\sqrt{0.155836}}{\sqrt{7201}}$

$= \frac{0.394761}{84.85871}$

$= 0.004652$

Pooled Standard Error = 0.004652

Step 3: Calculate Margin of Error

Margin of Error = Critical value * Standard Error

= 1.96 * 0.004652

=0.0091

Margin of Error= 0.91 % for the Product category "<=60 sq.m."

Where, Critical Value (z value) = 1.96 for a confidence level of 95%.

2.2 HPI@Market Prices for Under-Construction Properties

2.2.1 Product Level Prices:

For Example, for a City and for Product category "<=60 sq.m.", there are 5 projects, with carpet prices (psf) and unsold units shown as under:

Project Name	Carpet Price (psf)	Unsold Units
Project 1	6,385	180
Project 2	4,812	86
Project 3	4,449	115
Project 4	4,188	152
Project 5	6,328	122

The Weighted Average Product level price for the product category "<=60 sq.m." is calculated as under:

Carpet Price (psf) = $\frac{(6385*180)+(4812*86)+(4449*115)+(4118*152)+(6328*122)}{180+86+115+152+122}$ = **5,318 per sq.ft.**

Similarly, Product level prices are calculated for the other two categories.

2.2.2 Base Year Price, Base Year Weights, Computation of HPI & Smoothing of HPI Composite 50-City Index for HPI@Market Prices for Under-Construction Properties

As in the case of HPI@Assessment Prices, the computation of HPI@Market Prices for Under-Construction Properties is based on the Laspeyres methodology. The process used for smoothing of HPI and compilation of Composite 50-City Index for HPI@ Market Prices for Under-Construction Properties is similar to that adopted in the case of HPI@Assessment Prices.

3 Preparation and Publication of Composite HPIs

To Calculate Composite 50 city Index, HPI for the city & Population weights are required. The illustration of Composite 8-City Index is given below:

	HPI Index	**Population Weights (as per census 2011)**
Mumbai	114	20.1%
Pune	115	5.1%
Hyderabad	133	10.9%
Bengaluru	122	13.7%
Chennai	106	7.5%
Kolkata	110	7.3%
Ahmedabad	138	9.0%

Composite HPI Index $= ((114 * 20.1\%) + (115 * 5.1\%) + (133 * 10.9\%) + (122 * 13.7\%) + (106 * 7.5\%) + (110 * 7.3\%) + (138 * 9\%)) + (97 * 26.5\%))/1$ **= 114**

4 Shifting of base year

Base year has shifted from FY 2012-13 to FY 2017-18 to make the HPI current and relevant. Linking factors are the conversion coefficients (multipliers) linking two or more indices prepared on shifting the base year. In Future, New Base year will be FY 2022-23.

5 Linking Factor

$$\text{Backward Linking Factor} = \frac{HPI\ Base\ Year\ FY\ 2017-18}{HPI\ Base\ Year\ FY\ 2012-13}$$

Example: For Mumbai

$$\text{Backward Linking Factor} = \frac{139}{100} = \mathbf{1.39}$$