S&P Dow Jones Indices

A Division of S&P Global

S&P CoreLogic Case-Shiller Home Price Indices

Methodology

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Introduction

Index Objective

The S&P CoreLogic Case-Shiller Home Price Indices measure the price level of existing single-family homes in the U.S.

The S&P CoreLogic Case-Shiller U.S. National Home Price Index ("the U.S. national index") measures the value of single-family housing within the United States. The index is a composite of single-family home price indices for the nine U.S. Census divisions and is calculated monthly.

The S&P CoreLogic Case-Shiller city indices reflect the average change in home prices in a particular geographic market. The indices are calculated monthly and cover 20 major metropolitan areas (Metropolitan Statistical Areas or MSAs), which are also aggregated to form two composites – one comprising 10 of the metro areas, the other comprising all 20.

Percentage changes in the indices measure percentage changes in housing market prices given a constant level of quality. Changes in the types and sizes of houses or changes in the physical characteristics of houses are specifically excluded from the calculations to avoid incorrectly affecting the index value.

This methodology was created by S&P Dow Jones Indices to achieve the aforementioned objective of measuring the underlying interest of each index governed by this methodology document. Any changes to or deviations from this methodology are made in the sole judgment and discretion of S&P Dow Jones Indices so that the index continues to achieve its objective.

Partnership

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Highlights

The monthly S&P CoreLogic Case-Shiller Home Price Indices use the "repeat sales method" of index calculation – an approach that is widely recognized as the premier methodology for indexing housing prices – which uses data on properties that have sold at least twice, in order to capture the true appreciated value of each specific sales unit.

Please refer to the Repeat Sales Methodology section for details.

The S&P CoreLogic Case-Shiller U.S. National Home Price Index aggregates nine U.S. Census division repeat sales indices using reference periods and estimates of the aggregate value of single-family housing stock for those periods.

Please refer to the U.S. National Index Methodology section for details.

The S&P CoreLogic Case-Shiller Home Price Indices were developed in the 1980s by Professors Karl E. Case and Robert J. Shiller. At the time, Case and Shiller developed the repeat sales pricing technique. This methodology is recognized as the most reliable means to measure housing price movements, and variants of the methodology are used by other home price index publishers, including the Federal Housing Finance Agency (FHFA).

Eligibility Criteria

Inclusions and Exclusions

The S&P CoreLogic Case-Shiller Indices are designed to measure, as accurately as possible, changes in the total value of all existing single-family housing stock. The methodology samples all available and relevant transaction data to create matched sale pairs for pre-existing homes.

The S&P CoreLogic Case-Shiller indices do not sample sale prices associated with new construction, condominiums, co-ops/apartments, multi-family dwellings, or other properties that cannot be identified as single-family.

The factors that determine the demand, supply, and value of housing are not the same across different property types. Consequently, the price dynamics of different property types within the same market often vary, especially during periods of increased market volatility. In addition, the relative sales volumes of different property types fluctuate, so indices that are segmented by property type will more accurately track housing values.

Index Construction

Approaches

The S&P CoreLogic Case-Shiller Home Price Indices are based on observed changes in home prices. They are designed to measure increases or decreases in the market value of residential real estate in 20 defined MSAs and three price tiers – low, middle, and high (see Tables 1 and 1a on the following pages). In contrast, the indices are, specifically, not intended to measure recovery costs after disasters, construction or repair costs, or other such related items.

The indices are calculated monthly, using a three-month moving average algorithm. Home sales pairs are accumulated in rolling three-month periods, on which the repeat sales methodology is applied. The index point for each reporting month is based on sales pairs found for that month and the preceding two months. For example, the December 2005 index point is based on repeat sales data for October, November, and December of 2005. This averaging methodology is used to offset delays that can occur in the flow of sales price data from county deed recorders and to keep sample sizes large enough to create meaningful price change averages.

Index Calculations

To calculate the indices, data are collected on transactions of all residential properties during the months in question. The main variable used for index calculation is the price change between two arms-length sales of the same single-family home. Home price data are gathered after that information becomes publicly available at local recording offices across the country. Available data usually consist of the address for a particular property, the sale date, the sale price, the type of property, and in some cases, the name of the seller, the name of the purchaser, and the mortgage amount.

For each home sale transaction, a search is conducted to find information regarding any previous sale for the same home. If an earlier transaction is found, the two transactions are paired and are considered a "repeat sale." Sales pairs are designed to yield the price change for the same house, while holding the quality and size of each house constant.

All available arms-length transactions for single-family homes are candidates for sale pairs. When they can be identified, transactions with prices that do not reflect market value are excluded from sale pairs. This includes: 1) non-arms-length transactions (e.g., property transfers between family members); 2) transactions where the property type designation is changed (e.g., properties originally recorded as single-family homes are subsequently recorded as condominiums); and 3) suspected data errors where the order of magnitude in values appears unrealistic.

Each sales pair is aggregated with all other sales pairs found in a particular MSA to create the MSA-level index. The 10 and 20 Metro Area Indices are then combined, using a market-weighted average, to create the Composite of 10 and the Composite of 20.

Moreover, each sales pair in each metro area is also allocated to one of three price tiers – low, middle and high – depending on the position of the first price of the pair among all prices occurring during the period of the first sale. Separate data sets of low-price-tier houses, medium-price-tier houses and high-price tier repeat sales pairs are assembled for each metro area. The same repeat sale procedures used to produce the Metro Area Indices are applied to these data sets. The resulting indices are the Low-Tier, Medium-Tier and High-Tier Indices.

The Weighting of Sales Pairs

The indices are designed to reflect the average change in all home prices in a particular geographic market. However, individual home prices are used in these calculations and can fluctuate for a number of reasons. In many of these cases, the change in value of the individual home does not reflect a change in the housing market of that area; it only reflects a change in that individual home. The index methodology addresses these concerns by weighting sales pairs.

Different weights are assigned to different changes in home prices based on their statistical distribution in that geographic region. The goal of this weighting process is to measure changes in the value of the residential real estate market, as opposed to atypical changes in the value of individual homes. These weighting schemes include:

Price Anomalies. If there is a large change in the prices of a sales pair relative to the statistical distribution of all price changes in the area, then it is possible that the home was remodeled, rebuilt, or neglected in some manner during the period from the first sale to the second sale. If there were no physical changes to the property, there may have been a recording error in one of the sale prices, or an excessive price change caused by idiosyncratic, non-market factors. Since the indices seek to measure homes of constant quality, the methodology applies smaller weights to homes that appear to have changed in quality or sales that are otherwise not representative of market price trends.

High Turnover Frequency. Data related to homes that sell more than once within six months are excluded from the calculation of any indices. Historical and statistical data indicate that sales made within a short interval often indicate that one of the transactions 1) is not arms-length, 2) precedes or follows the redevelopment of a property, or 3) is a fraudulent transaction.

Time Interval Adjustments. Sales pairs are also weighted based on the time interval between the first and second sales. If a sales pair interval is longer, then it is more likely that a house may have experienced physical changes. Sales pairs with longer intervals are, therefore, given less weight than sales pairs with shorter intervals.

Initial Home Value. Each sales pair is assigned a weight equal to the first sale price to ensure that the indices track the aggregate/average value of all homes in a market.

Metro Areas

Table 1: Metro Areas for the original 10 S&P CoreLogic Case-Shiller Home Price Indices. These 10 metro areas are used to derive the Composite of 10.

MSA	Represented Counties
Boston-Cambridge-Quincy, MA-NH Metropolitan Statistical Area	Essex MA, Middlesex MA, Norfolk MA, Plymouth MA, Suffolk MA, Rockingham NH, Strafford NH
Chicago-Naperville-Joliet, IL Metropolitan Division	Cook IL, DeKalb IL, Du Page IL, Grundy IL, Kane IL, Kendal IL, McHenry IL, Will IL
Denver-Aurora, CO Metropolitan Statistical Area	Adams CO, Arapahoe CO, Broomfield CO, Clear Creek CO, Denver CO, Douglas CO, Elbert CO, Gilpin CO, Jefferson CO, Park CO
Las Vegas-Paradise, NV Metropolitan Statistical Area	Clark NV
Los Angeles-Long Beach-Santa Ana, CA Metropolitan Statistical Area	Los Angeles CA, Orange CA
Miami-Fort Lauderdale-Pompano Beach, FL Metropolitan Statistical Area	Broward FL, Miami-Dade FL, Palm Beach FL
New York City Area	Fairfield CT, New Haven CT, Bergen NJ, Essex NJ, Hudson NJ, Hunterdon NJ, Mercer NJ, Middlesex NJ, Monmouth NJ, Morris NJ, Ocean NJ, Passaic NJ, Somerset NJ, Sussex NJ, Union NJ, Warren NJ, Bronx NY, Dutchess NY, Kings NY, Nassau NY, New York NY, Orange NY, Putnam NY, Queens NY, Richmond NY, Rockland NY, Suffolk NY, Westchester NY, Pike PA

MSA	Represented Counties
San Diego-Carlsbad-San Marcos, CA Metropolitan Statistical Area	San Diego CA
San Francisco-Oakland-Fremont, CA Metropolitan Statistical Area	Alameda CA, Contra Costa CA, Marin CA, San Francisco CA, San Mateo CA
Washington-Arlington-Alexandria, DC-VA-MD-WV Metropolitan Statistical Area	District of Columbia DC, Calvert MD, Charles MD, Frederick MD, Montgomery MD, Prince Georges MD, Alexandria City VA, Arlington VA, Clarke VA, Fairfax VA, Fairfax City VA, Falls Church City VA, Fauquier VA, Fredericksburg City VA, Loudoun VA, Manassas City VA, Manassas Park City VA, Prince William VA, Spotsylvania VA, Stafford VA, Warren VA, Jefferson WV

Note: The representation of component markets within any S&P CoreLogic Case-Shiller Home Price Index may vary over time depending upon sales activity and the availability of sales data.

Note: the S&P CoreLogic Case-Shiller® New York City Home Price Index is not an MSA. It represents a customized metro area that measures single-family home values in select New York, New Jersey and Connecticut counties with significant populations that commonly commute to New York City for employment purposes. Similarly, the S&P CoreLogic Case-Shiller® Chicago Home Price Index is not an MSA.

Table 1a: Metro Areas for the additional 10 S&P CoreLogic Case-Shiller Home Price Indices. These 10 metro areas, with the 10 in Table 1 above, are used to derive the Composite of 20.

MSA	Represented Counties
Atlanta-Sandy Springs-Marietta, GA Metropolitan Statistical Area	Barrow GA, Bartow GA, Butts GA, Carroll GA, Cherokee GA, Clayton GA, Cobb GA, Coweta GA, Dawson GA, De Kalb GA, Douglas GA, Fayette GA, Forsyth GA, Fulton GA, Gwinnett GA, Haralson GA, Heard GA, Henry GA, Jasper GA, Lamar GA, Meriwether GA, Newton GA, Paulding GA, Pickens GA, Pike GA, Rockdale GA, Spalding GA, Walton GA
Charlotte-Gastonia-Concord, NC-SC Metropolitan Statistical Area	Anson NC, Cabarrus NC, Gaston NC, Mecklenburg NC, Union NC, York SC
Cleveland-Elyria-Mentor, OH Metropolitan Statistical Area	Cuyahoga OH, Geauga OH, Lake OH, Lorain OH, Medina OH
Dallas-Fort Worth-Arlington, TX Metropolitan Statistical Area	Collin TX, Dallas TX, Delta TX, Denton TX, Ellis TX, Hunt TX, Johnson TX, Kaufman TX, Parker TX, Rockwall TX, Tarrant TX, Wise TX
Detroit-Warren-Livonia, MI Metropolitan Statistical Area	Lapeer MI, Livingston MI, Macomb MI, Oakland MI, Saint Clair MI, Wayne MI
Minneapolis-St. Paul-Bloomington, MN-WI Metropolitan Statistical Area	Anoka MN, Carver MN, Chisago MN, Dakota MN, Hennepin MN, Isanti MN, Ramsey MN, Scott MN, Sherburne MN, Washington MN, Wright MN, Pierce WI, Saint Croix WI
Phoenix-Mesa-Scottsdale, AZ Metropolitan Statistical Area	Maricopa AZ, Pinal AZ
Portland-Vancouver-Beaverton, OR-WA Metropolitan Statistical Area	Clackamas OR, Columbia OR, Multnomah OR, Washington OR, Yamhill OR, Clark WA, Skamania WA
Seattle-Tacoma-Bellevue, WA Metropolitan Statistical Area	King WA, Pierce WA, Snohomish WA
Tampa-St. Petersburg-Clearwater, FL Metropolitan Statistical Area	Hernando FL, Hillsborough FL, Pasco FL, Pinellas FL

Note: The representation of component markets within any S&P CoreLogic Case-Shiller Home Price Index may vary over time depending upon sales activity and the availability of sales data.

While the indices are intended to represent all single-family residential homes within a given MSA, data for particular properties or component areas may not be available. Performance of individual properties or counties is not necessarily consistent with the MSA as a whole. The county components of MSAs are subject to change as a result of revisions to metro area definitions by the White House Office of Management and Budget, data insufficiencies, or the availability of new data sources.

Composites

The composite home price indices are constructed to track the total value of single-family housing within its constituent metro areas:

$$Index_{Ct} = \left(\sum_i \left(Index_{it} / Index_{id} \right) \times V_{id} \right) \Big/ Divisor_d$$

where $Index_{Ct}$ is the level of the composite index in period t,

$Index_{it}$ is the level of the home price index for metro area i in period t, and

$Index_{id}$ is the level of the index for metro area i in reference period d, and

V_{id} is the aggregate value of housing stock in metro area i in reference period d.

The $Divisor_d$ is chosen to ensure that the level of the composite index does not change because of changes in the reference period weights (V_{id}).

The reference periods are based on the US Census of Housing. Each reference period is 10 years: 1990-1999, 2000-2009, and 2010-2019.

The composite home price indices are analogous to a cap-weighted equity index, where the aggregate value of housing stock represents the total capitalization of all of the metro areas included in the composite. The numerator of the previous formula is an estimate of the aggregate value of housing stock for all metro areas in a composite index:

$$V_{Ct} = \sum_i \left(Index_{it} / Index_{id} \right) \times V_{id}$$

Calculating Composite Index History

Calculating history for the composite indices requires setting the reference periods and calculating the aggregate value of single-family housing stock in each metro area for those periods. The reference period metro area aggregate values are updated with the metro area home price indices to calculate metro area housing stock values in non-reference periods. For each period, the composite index is equal to the sum of the metro area housing stock values for that period divided by the reference period divisor.

The reference periods for the 10-city composite index are January 1990, January 2000 and March 2014. The reference periods for the 20-city composite index are January 2000 and March 2014. The January 1990 reference period is used for all 10-city composite index calculations between January 1987 and December 1999. The January 2000 reference period is used for all 10- and 20-city composite index calculations between January 2000 and February 2014. All calculations for both composites for any months after February 2014 use the March 2014 reference period.

The housing stock measures used to calculate the aggregate value of single-family housing for both the January 1990 and January 2000 reference periods are the U.S. Decennial Census counts for the metro areas. The housing stock measures used to calculate the aggregate value of single-family housing for the March 2014 reference period are the 2012 5-year sample counts from the American Community Survey, which are centered on 2010. The reference period values of single-family housing stock, average single-family housing prices, and the aggregate value of housing stock are provided in tables 2, 3, 4, 2a, 3a and 4a, on the following pages.

Table 2: Single-Family Housing Stock (units) for the 10-City Composite

	1990	2000	2010
Boston	834,851	926,956	1,010,192
Chicago	1,347,250	1,567,442	1,776,011
Denver	480,023	598,679	725,943
Las Vegas	155,741	321,801	532,152
Los Angeles	2,284,576	2,449,838	2,599,395
Miami	892,931	1,116,437	1,281,940
New York	3,390,191	3,772,351	3,993,438
San Diego	554,821	628,531	705,280
San Francisco	867,454	947,910	1,029,903
Washington DC	1,036,528	1,249,060	1,470,049

Source: U.S. Census Bureau

Table 3: Average Value of Single-Family Housing (US$, thousands) for the 10-City Composite

	1990	2000	2010
Boston	192	299	402
Chicago	138	212	289
Denver	97	230	300
Las Vegas	107	172	182
Los Angeles	284	323	510
Miami	136	167	285
New York	205	270	465
San Diego	221	328	471
San Francisco	290	465	565
Washington DC	204	235	421

Source: CoreLogic

Table 4: Aggregate Value of Single-Family Housing Stock (US$, millions) for the 10-City Composite

	1990	2000	2010
Boston	160,291	277,160	406,097
Chicago	185,921	332,298	513,267
Denver	46,562	137,696	217,783
Las Vegas	16,664	55,350	96,852
Los Angeles	648,820	791,298	1,325,691
Miami	121,439	186,445	365,353
New York	694,989	1,018,535	1,856,949
San Diego	122,615	206,158	332,187
San Francisco	251,562	440,778	581,895
Washington DC	211,452	293,529	618,891
Divisor	2,989,671	3,739,247	3,480,688

Source: CoreLogic

Table 2a: Single-Family Housing Stock (units) for the 20-City Composite

	2000	2010
Boston	926,956	1,010,192
Chicago	1,567,442	1,776,011
Denver	598,679	725,943
Las Vegas	321,801	532,152
Los Angeles	2,449,838	2,599,395
Miami	1,116,437	1,281,940
New York	3,772,351	3,993,438
San Diego	628,531	705,280
San Francisco	947,910	1,029,903
Washington DC	1,249,060	1,470,049
Atlanta	1,133,333	1,558,975
Charlotte NC	381,179	532,081
Cleveland	630,903	674,367
Dallas	1,272,865	1,672,174
Detroit	1,342,871	1,446,191
Minneapolis	819,651	973,551
Phoenix	860,573	1,253,604
Portland OR	521,592	621,776
Seattle	788,452	930,770
Tampa	676,744	829,161

Source: U.S. Census Bureau

Table 3a: Average Value of Single-Family Housing Stock (US$, thousands) for the 20-City Composite

	2000	2010
Boston	299	402
Chicago	212	289
Denver	230	300
Las Vegas	172	182
Los Angeles	323	510
Miami	167	285
New York	270	465
San Diego	328	471
San Francisco	465	565
Washington DC	235	421
Atlanta	182	218
Charlotte NC	181	244
Cleveland	144	175
Dallas	163	201
Detroit	189	122
Minneapolis	179	218
Phoenix	178	191
Portland OR	194	292
Seattle	259	397
Tampa	115	183

Source: CoreLogic

Table 4a: Aggregate Value of Single-Family Housing (US$, millions) for the 20-City Composite

	2000	2010
Boston	277,160	406,097
Chicago	332,298	513,267
Denver	137,696	217,783
Las Vegas	55,350	96,852
Los Angeles	791,298	1,325,691
Miami	186,445	365,353
New York	1,018,535	1,856,949
San Diego	206,158	332,187
San Francisco	440,778	581,895
Washington DC	293,529	618,891
Atlanta	206,267	339,857
Charlotte NC	68,993	129,828
Cleveland	90,850	118,014
Dallas	207,477	336,107
Detroit	253,803	176,435
Minneapolis	146,718	212,234
Phoenix	153,182	239,438
Portland OR	101,189	181,559
Seattle	204,209	369,516
Tampa	77,826	151,736
Divisor	5,249,761	5,137,802

Source: CoreLogic

The aggregate value of single-family housing stock in each metro area was found by multiplying the U.S. Census or American Community Survey counts of units (S_{id}) by estimates of average single-family housing prices (P_{id}), calculated by CoreLogic:

$$V_{i(1990)} = S_{i(1990)} \ x \ P_{i(1990)}$$

$$V_{i(2000)} = S_{i(2000)} \ x \ P_{i(2000)}$$

$$V_{i(2010)} = S_{i(2010)} \ x \ P_{i(2010)}$$

Relative Weights

The relative contribution of a metro area index to a composite index can be found by dividing its weight by the sum of the weights for all metro areas included in the composite. For the months between January 2000 and February 2014, the reference period divisors for the 10-city and 20-city composites are equal to the sum of the metro area weights, so the levels of the composite index points can be calculated directly by summing the products of each metro area's index value and weight and dividing the resulting sum by the 2000 divisor. For months outside of this range, however, it is not possible to use this simple method to calculate the levels of the composite indices.

However, the relative weight of each metro area does measure how much month-to-month changes in its index values contribute to month-to-month changes in the composite index values. The 1990 relative weights measure the contribution of each metro area to a composite index for any period up to and including December 1999. The 2000 relative weights measure metro area contributions between January 2000 and February 2014. The metro area contributions for March 2014 and afterward are measured by the 2010 relative weights. The relative weights for the 10-city and 20-city composite indices are shown in the following tables.

Table 5: Relative Metro Area Weights for the 10-City Composite

	1990	2000	2010
Boston	0.0652	0.0741	0.0643
Chicago	0.0756	0.0889	0.0813
Denver	0.0189	0.0368	0.0345
Las Vegas	0.0068	0.0148	0.0153
Los Angeles	0.2637	0.2116	0.2099
Miami	0.0494	0.0499	0.0579
New York	0.2825	0.2724	0.2941
San Diego	0.0498	0.0551	0.0526
San Francisco	0.1022	0.1179	0.0921
Washington DC	0.0859	0.0785	0.0980

Source: CoreLogic

Table 5a: Relative Metro Area Weights for the 20-City Composite

	2000	2010
Boston	0.0528	0.0474
Chicago	0.0633	0.0599
Denver	0.0262	0.0254
Las Vegas	0.0105	0.0113
Los Angeles	0.1507	0.1547
Miami	0.0355	0.0426
New York	0.1940	0.2167
San Diego	0.0393	0.0388
San Francisco	0.0840	0.0679
Washington DC	0.0559	0.0722
Atlanta	0.0393	0.0397
Charlotte NC	0.0131	0.0151
Cleveland	0.0173	0.0138
Dallas	0.0395	0.0392
Detroit	0.0483	0.0206
Minneapolis	0.0279	0.0248
Phoenix	0.0292	0.0279
Portland OR	0.0193	0.0212
Seattle	0.0389	0.0431
Tampa	0.0148	0.0177

Source: CoreLogic

Change of Data Sources and Divisors

The sources for sale transaction data were changed to sources used by CoreLogic, Inc. beginning with the March 2014 update of the S&P CoreLogic Case-Shiller indices. Since the repeat sale pair samples collected from CoreLogic sources are not identical to samples collected from prior sources[1], divisors are used to prevent any breaks in the index series. The divisors applied to index points estimated for March 2014 and all months afterward are listed below. The divisors are calculated by calculating the index value for February 2014 with the old data source and the new data source separately. If the change in the data source increases the index level for February 2014 by 5%, the divisor is set to 1.05 and the index based on the new data source is divided by 1.05 for March 2014 and all subsequent months. This prevents a jump in the index and preserves the month-to-month percentage changes.

[1] Although there is substantial overlap between the pair samples collected from prior data sources and CoreLogic sources, there are differences in the samples due to differences in the procedures used to collect individual deed records, processes used to identify non-arms-length transactions, and the methods used to translate and standardize deed information.

Table 5b: Divisors for Metro Area Indices

Single-Family Indices:				
	Aggregate	**Low Tier**	**Middle Tier**	**High Tier**
Boston	1.0164	1.0341	1.0143	1.0126
Chicago	1.0192	1.0091	1.0106	1.0106
Denver	1.0442	1.1143	1.0391	1.0335
Las Vegas	1.0303	1.0508	1.0149	1.0225
Los Angeles	1.0543	1.0630	1.0273	1.0473
Miami	1.0095	0.9897	1.0100	1.0027
New York	1.0265	1.0420	1.0249	1.0258
San Diego	1.0341	1.0427	1.0275	1.0249
San Francisco	1.0871	1.0766	1.0610	1.0235
Washington DC	1.0148	1.0497	1.0191	1.0053
Atlanta	1.0924	1.1004	1.0749	1.0541
Charlotte NC	1.0359	No tier indices		
Cleveland	1.0652			
Dallas	NA[2]			
Detroit	1.1246			
Minneapolis	1.0748	1.1712	1.0855	1.0477
Phoenix	1.0814	1.1590	1.0463	1.0525
Portland OR	1.0167	1.0675	1.0058	1.0218
Seattle	1.0329	1.0920	1.0264	1.0164
Tampa	0.9744	1.0023	0.9663	0.9594
Condominium Indices:				
	Aggregate	**Low Tier**	**Middle Tier**	**High Tier**
Boston	1.0428	No tier indices		
Chicago	1.0596			
Los Angeles	1.0301			
New York	1.1013			
San Francisco	1.0092			

Source: CoreLogic

[2] The source for Dallas sale transaction data is unchanged.

Index Construction Process

The S&P CoreLogic Case-Shiller Home Price Indices are based on observed changes in individual home prices. The main variable used for index calculation is the price change between two arms-length sales of the same single-family home. Home price data are gathered after that information becomes publicly available at local deed recording offices across the country. For each home sale transaction, a search is conducted to find information regarding any previous sale for the same house. If an earlier transaction is found, the two transactions are paired and are considered a “sale pair”. Sale pairs are designed to yield the price change for the same house, while holding the quality and size of each house constant.

The S&P CoreLogic Case-Shiller Home Price Indices are designed to reflect the average change in market prices for constant-quality homes in a geographic market and price tier, in the case of the three tier indices. The sale pairing process and the weighting used within S&P CoreLogic Case-Shiller Home Price Indices’ repeat sales index model ensure that the indices track market trends in home prices by ignoring or down-weighting observed price changes for individual homes that are not market driven and/or occur because of idiosyncratic physical changes to a property or a neighborhood. Sale prices from non-arms-length transactions, where the recorded price is usually below market value, are excluded in the pairing process or are down-weighted in the repeat sales model. Pairs of sales with very short time intervals between transactions are eliminated because observed price changes for these pairs are much less likely to be representative of market trends. Idiosyncratic changes to properties and/or neighborhoods are more likely to have occurred between sales with longer transaction intervals, so these pairs are down-weighted in the repeat sales index model if they are not eliminated during the sale pairing process.

Pairing Sales and Controlling Data Quality

The automated sale pairing process is designed to collect arms-length, repeat sales transactions for existing, single-family homes. This process collects as many qualifying sale prices as possible, ensuring that large, statistically representative samples of observed price changes are used in the S&P CoreLogic Case-Shiller Home Price Indices’ repeat sales model. In an arms-length transaction, both the buyer and seller act in their best economic interest when agreeing upon a price. When they can be identified from a deed record[3], non-arms-length transactions are excluded from the pairing process. The most typical types of non-arms-length transactions are property transfers between family members and repossessions of properties by mortgage lenders at the beginning of foreclosure proceedings. Subsequent sales by mortgage lenders of foreclosed properties are included in repeat sale pairs, because they are arms-length transactions.

The pairing process is also designed to exclude sales of properties that may have been subject to substantial physical changes immediately preceding or following the transaction. Furthermore, since a property must have two recorded transactions before it can be included as a repeat sale pair, newly constructed homes are excluded from the index calculation process until they have been sold at least twice. Deed records do not usually describe the physical characteristics of properties (other than the size and alignment of land parcels). However, other items listed on the deed record can be used to identify properties that may have been subject to substantial physical changes.[4] Deeds that have been marked as transfers of land with no improvements (i.e., no structures) are excluded. Transactions where the seller may be a real estate developer (based on the seller’s name) are also excluded, since it is likely that this is

[3] A deed record may directly indicate that a transaction is not arms-length. In other cases, it is possible to identify non-arms-length transactions by comparing the surnames of the buyer and seller (transfers between family members) or by checking if the “buyer” is a mortgage lender (repossessions of properties before a foreclosure auction). Local deed recorders and property data vendors differ in how often and consistently they collect and record information that can be used to identify non-arms-length transactions.

[4] Local deed recorders and property data vendors differ in how often and consistently they collect and record information that can be used to identify properties that have experienced substantial physical changes.

the sale of a newly constructed home built on a previously vacant or occupied lot or a rebuilt existing home.

Finally, sales that occur less than six months after a previous sale are excluded, primarily because single real estate transactions often have duplicate or multiple deed records[5] due to the procedures used by local deed recorders and property data vendors. It is also more likely that in cases with a very short intervals between sales that: (1) one of the transactions is non-arms-length (e.g., a transfer between family members before selling a property), (2) the property has undergone substantial physical changes (e.g., a developer has purchased and quickly sold a rebuilt property), or (3) one of the transactions is a fraudulent transaction (a “property flip”).

Although the number of excluded transactions will vary from market to market, depending on how much detailed information is available in recorded deeds, usually less than 5% of non-duplicate transaction records are identified as non-arms-length and are removed as possible pairing candidates. Similarly, typically less than 5% of non-duplicate transaction records are preceded by another transaction within the last six months. The percentage of properties identified as either new construction or rebuilt existing homes depends on local market conditions, since construction activity is cyclical and related to the strength of the market’s economy, the overall age and condition of the existing housing stock, and the balance between housing supply and demand. Depending on these factors and the completeness of deed information, the percentage of sales identified and eliminated from the pairing process because there may have been substantial physical changes to the property usually ranges from 0% to 15%.

The Division of Repeat Sales Pairs into Price Tiers[6]

For the purpose of constructing the three tier indices, price breakpoints between low-tier and middle-tier properties and price breakpoints between middle-tier and upper-tier properties are computed using all sales for each period, so that there are the same number of sales, after accounting for exclusions, in each of the three tiers. The breakpoints are smoothed through time to eliminate seasonal and other transient variation. Each repeat-sale pair is then allocated to one of the three tiers depending on first sale price, resulting in a repeat sales pairs data set divided into thirds. The same methods used for the Metro Area Indices are applied separately to each of these three data sets to produce the Low-Tier, Medium-Tier and High-Tier Indices.

Note that the allocation into tiers is made according to first sale price. Individual properties may shift between price tiers from one sale date to the next. We use only the tier of the first sale, ignoring the tier of the second sale. This allocation was chosen so that each of the tier indices closely represents a portfolio of homes that could be constructed on each date using information actually available on that date. Thus, the tier indices are essentially replicable by forming a portfolio of houses in real time. The Low-Tier index for a metro area is an indicator of a strategy of buying homes falling in the bottom third of sale prices (while the High Tier Index as an indicator of a strategy of buying homes in the top third of sale prices) and holding them as investments for as long as the homeowner lived in the home. The trend of home price indices in each of the three tiers reflects the outcome of such an investment strategy.

A “value effect” has been noted in the tier indices: low-tier indices have typically appreciated somewhat more than high-tier indices. Part of this value effect may be analogous to the effect that motivates value-investing strategies in the stock market. Individual homes’ prices have shown some tendency to mean revert, so purchasing low-priced homes may have been an overall good investment strategy. We do not know whether this value effect will continue into the future, and the value effect has not been stable through time even in the historic sample that we have observed.

[5] The same transaction date may be listed on duplicate deed records. Duplicate records for a single transaction may contain transaction dates that are weeks apart, depending on the recording processes used at local deed offices and the collection procedures used by property data vendors. Requiring transaction dates to be at least six months apart prevents these duplicate records from being used as sale pairs.

[6] See Karl E. Case and Robert J. Shiller, “A Decade of Boom and Bust in Prices of Single Family Homes: Boston and Los Angeles, 1983 to 1993”, New England Economic Review, March/April 1994, pp. 39-51.

The high-tier indices will tend to lie closer to the aggregate indices than do the low-tier indices. This is as we would expect, since the aggregate indices are value-weighted and hence the high-tier repeat sales figure more prominently in the aggregate indices.

The Weighting of Sale Pairs

Although non-arms-length transactions and sales of physically altered properties are discarded during the pairing process, it is not possible to identify all of these sales based on the information available from deed records. Furthermore, the price changes observed for individual homes may be the result of non-market, idiosyncratic factors specific to a property (which cannot be identified from the deed information) or a property's neighborhood. For example, a buyer was in a special hurry to buy and paid too much, boosting the value of nearby properties relative to the market, or an individual property may have not been well maintained, reducing its value relative to the market. Finally, errors in recorded sale prices may cause a particular sale pair to mismeasure the actual price change of an individual property.

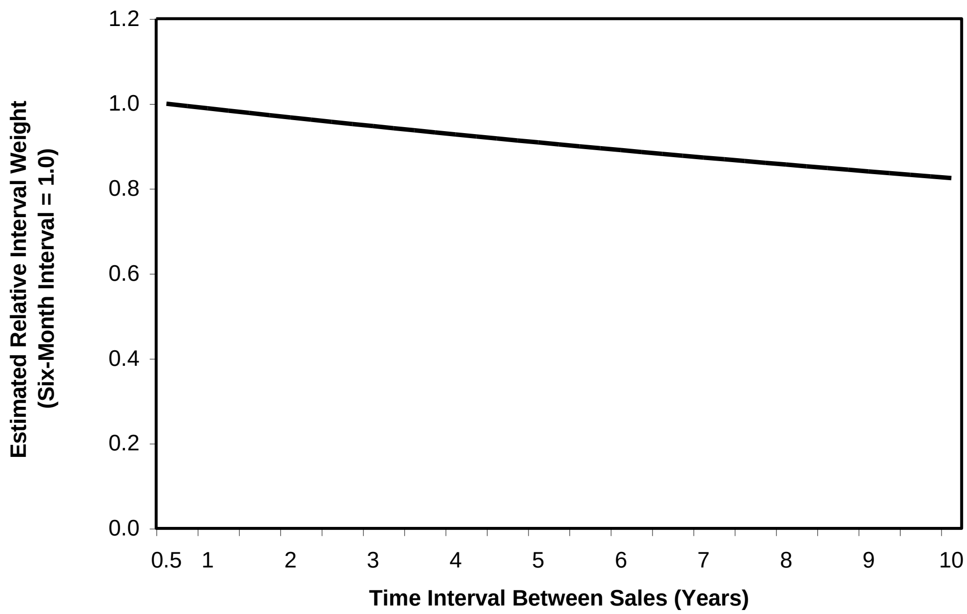
To account for sale pairs that include anomalous prices or that measure idiosyncratic price changes, the repeat sales index model employs a robust weighting procedure. This automated, statistical procedure mitigates the influence of sale pairs with extreme price changes. Each sale pair is assigned a weight of one (no down-weighting) or a weight less than one but greater than zero, based on a comparison between the price change for that pair and the average price change for the entire market. The degree to which sale pairs with extreme price changes are down-weighted depends on the magnitude of the absolute difference between the sale pair price change and the market price change. No sale pair is eliminated by the robust weighting procedure (i.e., no pair is assigned a zero weight) and only sale pairs with extreme price changes are down-weighted. Although the number of sale pairs that are down-weighted depends on the statistical distribution of price changes across all of the sale pairs, in large metro area markets, typically 85% to 90% of pairs are assigned a weight of one (no down-weighting), 5% to 8% are assigned a weight between one and one-half, and 5% to 8% are assigned a weight between one-half and zero.

The S&P CoreLogic Case-Shiller Home Price Indices' repeat sales model also includes an interval weighting procedure that accounts for the increased variation in the price changes measured by sale pairs with longer time intervals between transactions. Over longer time intervals, the price changes for individual homes are more likely to be caused by non-market factors (e.g., physical changes, idiosyncratic neighborhood effects). Consequently, sale pairs with longer intervals between transactions are less likely to accurately represent average price changes for the entire market.

The interval weights are determined by a statistical model within the repeat sales index model that measures the rate at which the variance between index changes and observed sale pair price changes increases as the time interval between transactions increases (time-between-sales variance). It is also assumed that the two sale prices that make up a sale pair are imprecise, because of mispricing decisions made by homebuyers and sellers at the time of a transaction. Mispricing variance occurs because buyers and sellers have imperfect information about the value of a property. Housing is a completely heterogeneous product whose value is determined by hundreds of factors specific to individual homes (e.g., unique physical attributes; location relative to jobs, schools, shopping; neighborhood amenities). The difficulty in assigning value to each of these attributes, especially when buyers and sellers may not have complete information about each factor, means that there is significant variation in sale prices, even for homes that appear to be very similar.

The interval weights in the repeat sales model are inversely proportional to total interval variance, which is the sum of the time-between-sale variance and the mispricing variance. A statistical model within the repeat sales model is used to estimate the magnitudes of the two components of total interval variance. The interval weights introduce no bias into the index estimates, but increase the accuracy of the estimated index points.[7]

The graph on the following page shows estimated interval weights for a large, representative metro area market (relative to the weight for a sale pair with a six-month interval between transactions):



For large metro area markets, the interval weights for sale pairs with ten-year intervals will be 20% to 45% smaller than for sale pairs with a six-month interval.

[7] More technically, the interval weights correct for heteroskedastic (non-uniform) error variance in the sale pair data. These corrections for heteroskedasticity reduce the error of the estimated index points, but do not bias the index upwards or downwards. See Case, K.E. and R.J. Shiller (1987) "Prices of Single-Family Homes Since 1970: New Indices for Four Cities" New England Economic Review, pp. 45-56 for a discussion of the heteroskedastic error correction model used in the Case-Shiller repeat sales index model.

Repeat Sales Methodology

Introduction

The S&P CoreLogic Case-Shiller Home Price Indices are calculated using a Robust Interval and Value-Weighted Arithmetic Repeat Sales algorithm (Robust IVWARS). Before describing the details of the algorithm, an example of a Value-Weighted Arithmetic repeat sales index is described below. In the next section, the value-weighted arithmetic model is augmented with interval weights, which account for errors that arise in repeat sale pairs due to the length of time between transactions. The final section describes pre-base period, simultaneous index estimation and post-base period, chain-weighted index estimation.

Value-Weighted Arithmetic Repeat Sales Indices[8]

Value-weighted arithmetic repeat sales indices are estimated by first defining a matrix *X* of independent variables which has *N* rows and *T*−1 columns, where *N* is the number of sale pairs and *T* is the number of index periods. The elements of the *X* matrix are either prices or zeroes (element *n,t* of the matrix will contain a price if one sale of pair *n* took place in period *t*, otherwise it will be zero). Next, an *N*-row vector of dependent variables, *Y*, is defined, with the price level entered in rows where a sale was recorded during the base period for the index and zeros appear in all other rows. If we define a vector of regression coefficients, β, which has *T*−1 rows, then an arithmetic index can be calculating by estimating the coefficients of the basic regression model: $Y = X\beta + U$, where U is a vector of error terms. The levels of the value-weighted arithmetic index are the <u>reciprocals</u> of the estimated regression coefficients, $\hat{\beta}$.

A simple example illustrates the structure of the regression model used to estimate value-weighted arithmetic index points. Suppose that we have sale pair information for 5 properties (a sale pair is two recorded sales for the same property) for transactions that occurred in 3 time periods (t = 0, 1, 2). Let P_{nt} be the sale price for pair *n* recorded during period *t*.

Then, for this example, suppose we have the following matrix of independent variables and vector of dependent variables:

$$X = \begin{bmatrix} P_{11} & 0 \\ P_{21} & 0 \\ 0 & P_{32} \\ 0 & P_{42} \\ -P_{51} & P_{52} \end{bmatrix}, \quad Y = \begin{bmatrix} P_{10} \\ P_{20} \\ P_{30} \\ P_{40} \\ 0 \end{bmatrix}$$

In this example, *t*=0 is specified to be the base period, so the first sale pair (*n*=1) describes a property that was sold during the base period and the first period after the base period (*t*=1). Similarly, the fifth sale pair (*n*=5) describes a property that was sold in both the first and second index periods.

Because home prices are measured with errors, the matrix of independent variables is stochastic, and likely to be correlated with the vector of error terms, *U*. Therefore, in order to estimate consistent estimates of the model coefficients, β, we use an instrumental variables estimator, $\beta = (Z'X)^{-1}Z'Y$, where Z is a matrix with *N* rows and *T*−1 columns that indicates when the sales for each property occurred. The Z matrix is constructed by replacing the positive or negative price levels in *X* with 1 or –1, respectively.

[8] The example in this section is taken from Shiller, R.J. (1993) *Macro Markets*, Clarendon Press, Oxford, pp. 146-149.

For our example, the matrix of instrumental variables looks like this:

$$Z = \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 1 \\ -1 & 1 \end{bmatrix}$$

The OLS normal equations for this example (using the instrumental variables estimator) are:

$$\hat{\beta}_1^{-1} = Index_1 = \frac{P_{11} + P_{21} + P_{51}}{P_{10} + P_{20} + \hat{\beta}_2 P_{52}}$$

$$\hat{\beta}_2^{-1} = Index_2 = \frac{P_{32} + P_{42} + P_{52}}{P_{30} + P_{40} + \hat{\beta}_1 P_{51}}$$

Notice that the index level for the first period is equal to the aggregate change in the value of all properties that were sold in period 1 ($\hat{\beta}_2 P_{52}$ is the second period price of property 5 discounted back to the base period). Similarly, the index level for the second period is equal to the aggregate change in the value (from the base period) of all properties sold in period 2 ($\hat{\beta}_1 P_{51}$ is the first period price of property 5 discounted back to the base period).[9] Also notice that the estimated value of each index point is conditional on the estimated value of the other index point. In this model formulation, the index points are estimated simultaneously. That is, the value of each estimated index point is conditional of the values of all other index point estimates.

This example also illustrates that the price indices are value-weighted. Each index point is found by calculating the aggregate change in the value of properties sold during that point's time period. So, each sale pair is weighted by the value of its first sale price. Value weighting ensures that the S&P CoreLogic Case-Shiller Home Price Indices track the aggregate value of a residential real estate market. Value-weighted repeat sales indices are analogous to capitalization-weighted stock market indices. In both cases, if you hold a representative portfolio (of houses or stocks), both types of indices will track the aggregate value of that portfolio.

Interval and Value-Weighted Arithmetic Repeat Sales Indices [10]

The value-weighted arithmetic repeat sales model described above assumes that the error terms for each sale pair are identically distributed. However, in practice, this is unlikely to be the case, because the time intervals between the sales in each pair will be different. Over longer time intervals, the price changes for an individual home are more likely to be caused by factors other than market forces. For example, a home may be remodeled, rooms added, or it may be completely rebuilt. Some properties are allowed to deteriorate, or, in extreme cases, are abandoned. In these situations, price changes are driven mostly by modifications to the physical characteristics of the property, rather than changes in market value.

Consequently, sale pairs with longer time intervals will tend to have larger pricing errors than pairs with shorter time intervals (i.e., the value-weighted arithmetic repeat sales regression model has heteroskedastic errors). We can control for heteroskedastic errors, thereby increasing the precision of the index estimates, by applying weights to each of the sale prices before estimating the index points.

[9] Note: CoreLogic Case-Shiller normalizes all indices so that their base period value equals 100. So, in the preceding example, $Index_0$ = 100 and the gross changes in aggregate value from the base period ($Index_1$ and $Index_2$) are multiplied by 100.

[10] This extension of the example to include weights to control for heteroskedastic errors is given in Shiller, R.J. (1993) *Macro Markets*, Clarendon Press, Oxford, p. 149. The description of the sources of pricing errors appears in Case, K.E. and R.J. Shiller (1987) "Prices of Single-Family Homes Since 1970: New Indices for Four Cities" *New England Economic Review*, pp. 45-56.

Returning to the example from the previous section, we apply a weight, W_n, to pair n:

$$\hat{\beta}_1^{-1} = Index_1 = \frac{w_1 P_{11} + w_2 P_{21} + w_5 P_{51}}{w_1 P_{10} + w_2 P_{20} + w_5 \hat{\beta}_2 P_{52}}$$

$$\hat{\beta}_2^{-1} = Index_2 = \frac{w_3 P_{32} + w_4 P_{42} + w_5 P_{52}}{w_3 P_{30} + w_4 P_{40} + w_5 \hat{\beta}_1 P_{51}}$$

The weight applies to the sale pair, so for each property, the same weight is applied to both prices in the pair.

To explicitly account for the interval-dependent heteroskedasticity of the errors in the sale pairs, assume that the error vector has the following structure:

$$U_n = e_{nt(2)} - e_{nt(1)}$$

where $e_{nt(1)}$ is the error in the first sale price of pair n and $e_{nt(2)}$ is the error in the second sale price. Furthermore, assume that the error in any sale price comes from two sources: 1) mispricing at the time of sale (mispricing error) and 2) the drift over time of the price of an individual home away from the market trend (interval error). Mispricing error occurs because homebuyers and sellers have imperfect information about the value of a property, so sale prices will not be precise estimates of property values at the time of sale. Interval error occurs for the reasons outlined above -- over longer time intervals, the price changes for an individual home are more likely to be caused by factors other than market forces (e.g., physical changes to a property). So, define the error for any single price as:

$$e_{nt} = h_{nt} + m_n$$

where h_{nt} is the interval error for pair n and m_n is the mispricing error.

Mispricing errors are likely to be independent, both across properties and time intervals, and can be represented by an identically distributed white-noise term: $m \sim Normal(0, \sigma_m^2)$ where σ_m^2 is the variance of the mispricing errors. The interval errors are assumed to follow a Gaussian random walk, so $\Delta h \sim Normal(0, \sigma_h^2)$ and the variance of the interval error increases linearly with the length of the interval between sales. Consequently, the variance of the combined mispricing and interval errors for any sale pair may be written as: $2\sigma_m^2 + I_n \sigma_h^2$ where I_n is the time interval between sales for pair n.

If the errors of the value-weighted arithmetic repeat sales model have this heteroskedastic variance structure, then more precise index estimates can be produced by estimating a weighted regression model, $\beta = (Z'\Omega^{-1}X)^{-1} Z'\Omega^{-1}Y$, where Ω is a diagonal matrix containing the combined mispricing and interval error variance for each sale pair. Since Ω is unknown, the interval and value-weighted arithmetic repeat sales model is estimated using a three-stage procedure. First, the coefficients of the value-weighted arithmetic repeat sales model are estimated. Second, the residuals from this model are used to estimate Ω. Finally, the interval and value-weighted arithmetic repeat sales index is estimated by plugging $\hat{\Omega}$ into the weighted regression estimator.

Returning to our example, the terms of the error variance matrix act as the weights that control for the presence of mispricing and heteroskedastic interval errors:

$$\omega_n^{-1} = w_n$$

where ω_n^{-1} is the reciprocal of the n^{th} diagonal term in the error variance matrix, Ω.[11]

Pre-Base and Post-Base Index Estimation[12]

The base period of the tradable S&P CoreLogic Case-Shiller Home Price Indices is January 2000, where the index point is set equal to 100.0. All index points prior to the base period are estimated simultaneously using the weighted regression model described above. The estimation is simultaneous because all of the estimated index points (or $\hat{\beta}_t^{-1}$) are conditional on the estimates of all other index points.

After the base period, the index points are estimated using a chain-weighting procedure in which an index point is conditional on all <u>previous</u> index points, but independent of all <u>subsequent</u> index points. The purpose of the post-base, chain-weighting procedure is to limit revisions to recently estimated index points while maintaining accurate estimates of market trends.

Returning to our example, the post-base, chain-weighting procedure can be illustrated by modifying the matrices of independent and dependent variables. Suppose that the index point for first period, $\hat{\beta}_1^{-1}$, has already been estimated.

This means the matrices used for estimating the robust interval and value-weighted arithmetic repeat sales model can be re-written as:

$$X = \begin{bmatrix} 0 \\ 0 \\ P_{32} \\ P_{42} \\ P_{52} \end{bmatrix}, \quad Y = \begin{bmatrix} \hat{\beta}_0 P_{10} \\ \hat{\beta}_0 P_{20} \\ \hat{\beta}_0 P_{30} \\ \hat{\beta}_0 P_{40} \\ \hat{\beta}_1 P_{51} \end{bmatrix}, \quad Z = \begin{bmatrix} 0 \\ 0 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

Since the first index point has already been estimated, the columns in X and Z that correspond to the first index period can be dropped. The normal equation for the second period index point, β_2^{-1}, using the weighted regression model is:

$$\hat{\beta}_2^{-1} = Index_2 = \frac{w_3 P_{32} + w_4 P_{42} + w_5 P_{52}}{w_3 \hat{\beta}_0 P_{30} + w_4 \hat{\beta}_0 P_{40} + w_5 \hat{\beta}_1 P_{51}}$$

[11] CoreLogic augments the interval and value-weights with a robust weighting procedure. This procedure mitigates the influence of sale pairs with extreme price changes (which are more likely to result from physical changes to properties or data errors, rather than market forces). Sale pairs with very large price changes (positive or negative, relative to the market trend) are down-weighted to prevent them from adding error to the index estimates.

[12] See Shiller, R.J. (1993) *Macro Markets*, Clarendon Press, Oxford, pp. 195-199 for a discussion of chain-weighted repeat sales indices.

Again, as for the simultaneous index estimation procedure, the index level for the second period is equal to the aggregate change in the value (from the base period) of all properties sold in period 2 ($\hat{\beta}_1 P_{51}$ is the first period price of property 5 discounted back to the base period, and $\hat{\beta}_0$ = 1.0 by definition), but with a robust interval-weight attached to each sale pair. The example of post-base index estimation can be generalized as:

$$Index_t = \frac{\sum_{n \in t} w_n P_{n\tau(2,n)}}{\sum_{n \in t} w_n P_{n\tau(1,n)} \Big/ Index_{\tau(1,n)}}$$

where $\tau(2,n)$ is the period of the second sale, $\tau(1,n)$ is the period of the first sale, and $n \in t$ indicates the set of pairs with second sales in period *t.*

To compute three-month moving average indices, the *n*th sale pair is used in the above formulas as if it were three sale pairs with the same weight w_n, n_1 with dates $\tau(1,n)$ and $\tau(2,n)$, n_2 with dates $\tau(1,n) + 1$ and $\tau(2,n) + 1$, and n_3 with dates $\tau(1,n) + 2$ and $\tau(2,n) + 2$.

U.S. National Index Methodology

Introduction

The S&P CoreLogic Case-Shiller U.S. National Home Price Index ('the U.S. national index') tracks the value of single-family housing within the United States. The index is a composite of single-family home price indices and FHFA data for the nine U.S. Census divisions:

$$Index_{US\,t} = \left(\sum_i \left(Index_{i\,t} \big/ Index_{i\,d} \right) \times V_{i\,d} \right) \Big/ Divisor_d$$

where $Index_{US,t}$ is the level of the US National index in period t,

$Index_{it}$ is the level of the home price index for Census division i in period t, and

$Index_{id}$ is the level of the index for Census division i in reference period d, and

V_{id} is the aggregate value of housing stock in Census division i in reference period d.

The reference periods are based on the US Census of Housing. Each reference period is ten years: 1990-1999, 2000-2009, 2010-2019.

The $Divisor_d$ is chosen to ensure that the level of the composite index does not change because of changes in the reference period weights (V_{id}).

Calculating U.S. National Index History

Calculating historical estimates of the U.S. national index requires setting the reference periods and estimating of the aggregate value of single-family housing stock in each Census division for those periods. The reference period Census division aggregate values are updated with the Census division price indexes to calculate Census division housing stock values in non-reference periods. For each period, the composite index is equal to the sum of the Census division housing stock values for that period divided by the reference period divisor.

The reference periods are January 1990, January 2000, and January 2010. The decennial U.S. Census provided estimates of the aggregate value of single-family housing units for the Census divisions for 1990 and 2000. Estimates of the aggregate value of single-family housing for 2010 were taken from the American Community Survey. The aggregate value estimates by Census division are listed in Table 6.

The aggregate value estimates and divisor for the January 1990 reference period were used to calculate composite index data for the period from January 1975 to December 1999. The January 2000 reference period estimates were used to calculate data from January 2000 until December 2009. The January 2010 reference period estimates are used to calculate index data from January 2010 until the present. The *Divisors* for these reference periods are set so that the composite index equals 100.0 in January 2010. The national index is then rebased, so that it equals 100.0 in January 2000, to maintain consistency with the metro area and metro area composite indexes.

Table 6: Aggregate Value of Single-Family Housing Stock (US$)

	1990	2000	2010
North Central	765,418,398,000	1,528,000,592,500	2,137,949,847,500
East South Central	224,148,387,500	448,817,717,500	733,666,571,000
Middle Atlantic	975,073,121,500	1,322,860,220,000	2,488,150,340,900

Mountain	248,195,528,000	659,289,495,000	1,254,997,320,900
New England	467,867,938,500	618,272,542,500	1,161,281,404,200
Pacific	1,397,627,457,000	2,140,886,697,500	4,111,981,534,400
South Atlantic	924,261,612,000	1,691,801,012,500	3,383,979,252,300
West North Central	294,495,739,500	578,345,765,000	970,117,448,200

	1990	2000	2010
West South Central	384,583,746,000	700,764,790,000	1,310,808,810,400
Divisor	10,765,643,970,234	14,049,409,871,541	17,552,932,529,800

Source: U.S. Census Bureau

Updating the U.S. National Index

When new estimates of the aggregate value of single-family housing units from either the U.S. Census or the American Community Survey (or another, accurate and widely accepted source for this data) become available, new reference period estimates of aggregate value may be used for calculating updates to the U.S. national home price index.

Adding Reference Period Weights

If new estimates of the aggregate value of single-family housing units by division are chosen to be employed, a new set of reference period weights used for the calculation of the U.S. national index will be created and a new reference period (d) will be added. The divisors for all reference periods may be reset to reflect the addition of new reference period weights.

Index Maintenance

Updating the Composite Indices

Going forward, the 2010 reference period measures of the value of aggregate housing stock will be used for calculating monthly updates of the composite home price indices, until new Census counts of single-family housing units (or another accurate and widely accepted source for this data) become available.

Adding Reference Period Weights

New reference period weights used in the calculation of the composite indices may be added when new metro area counts of single-family housing units become available.[13] A new divisor will be calculated to ensure that the level of the composite indices do not change due to the addition of new reference period weights. The base period of the composite indices (i.e., the period where the index equals 100.0) will remain the same as the base period of the individual metro area home price indices.

Seasonal Adjustment

The S&P CoreLogic Case-Shiller home price indexes are calculated on a non-seasonally adjusted (NSA) basis, so they include the effects of seasonal fluctuations on each market's price level. Seasonally adjusted (SA) versions of the NSA indexes are also provided to track market price trends with seasonal fluctuations removed. The seasonally adjusted indexes are calculated by applying the U.S. Census Bureau's X-13ARIMA-SEATS seasonal adjustment program to the NSA indexes.

Revisions

With the calculation of the latest index data point, each month, revised data may be computed. Index data points are subject to revision as new sales transaction data becomes available. Although most sale transactions are recorded and collected expeditiously, some sale prices for the period covered by the index may have not yet been recorded at the time of the calculation.[14] When this information becomes available, the corresponding index data points are revised to maximize the accuracy of the indices. Index revisions for additional transactional data are limited to the last 24-months. The full history is subject to revision for changes in seasonal factors for all seasonally adjusted indices and FHFA data for the U.S. national index.

Base Date

The indices have a base value of 100 on January 2000.

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[13] The U.S. Census counts of single-family housing units by metro area are typically available two to three years after the completion of the decennial Census survey.

[14] Generally, more than 85% of the sales data for the latest index period are available when the indices are calculated. However, the completeness of the sales data for each update period and metro area will differ depending on real estate market conditions and the efficiency of the public recording and collection of sales deed records.

Index Governance

Index Committee

The S&P CoreLogic Case-Shiller Home Price Indices are maintained and governed by the S&P CoreLogic Case-Shiller Index Committee. The Index Committee members are drawn from S&P Dow Jones Indices, CoreLogic and leading industry experts; S&P Dow Jones Indices designates the Index Committee Chairman.

The Index Committee has complete discretion to determine how the indices are calculated. In addition, the Index Committee may revise index policy covering rules for selecting houses to be considered for the index and extraordinary events, such as natural disasters, that may result in special consideration in the index in any given month.

S&P Dow Jones Indices' Index Committees reserve the right to make exceptions when applying the methodology if the need arises. In any scenario where the treatment differs from the general rules stated in this document or supplemental documents, clients will receive sufficient notice, whenever possible.

S&P Dow Jones Indices considers information about changes to the S&P CoreLogic Case-Shiller Home Price Indices and related matters to be potentially market moving and material. Therefore, all Index Committee discussions are confidential.

Quality Assurance

S&P Dow Jones Indices maintains quality assurance processes and procedures for the calculation and maintenance of its indices that include a regularly scheduled meeting to review incidents or errors, if any, that occurred during the previous week and identify causes, determine repetitive issues and evaluate whether any long-term changes are necessary (e.g., a change in process). Incidents and errors are tracked through S&P Dow Jones Indices' internal system and significant matters are escalated, requiring, at times, an ad hoc meeting of the same group.

Internal Reviews of Methodology

Annual Review Process. In addition to its daily governance of indices and maintenance of index methodologies, at least once within any 12-month period, the Index Committee reviews each index methodology to ensure the indices continue to achieve the stated objective, and that the data and methodology remain effective. The annual review process includes the gathering of information on the appropriateness, representativeness, and effectiveness of the index methodology from colleagues responsible for commercializing the indices. In the case that a Methodology is reviewed off cycle from the annual review, the Index Committee reserves the right to cancel the Annual Review if the requested review covers all the relevant issues.

Consultation with Stakeholders. S&P Dow Jones Indices consults with stakeholders through continuous communication through its Product Management and Client Relations Teams. Additionally, in connection with its maintenance of index methodologies, the Index Committee may at times consult with investors, market participants, security issuers included in or potentially included in an index, or investment and financial experts. Typical consultations may include:

- Meetings of Advisory Panels where market participants, investors and financial experts are invited to attend
- Surveys by mail, email or telephone

- Conference calls, or
- Face-to-face meetings

Stakeholders also have the ability to provide S&P Dow Jones Indices with input on its indices by contacting a representative of S&P Dow Jones Indices via phone, email, or by completing a Client Services Request Form available on the S&P Dow Jones Indices Web site at *http://us.spindices.com/feedback/client-services*. All requests are reviewed and responded to by the S&P Dow Jones Indices Client Services team.

Complaints Procedure. For any inquiry, comment, or complaint regarding the indices governed by this methodology, a Client Services Form can be found at *http://us.spindices.com/feedback/client-services*.

Index Policy

Announcements

Announcements of index levels are made at 9:00 AM Eastern Time, on the last Tuesday of each month. Press releases are posted at *www.spglobal.com/spdji/*, and are released to major news services.

There is no specific announcement time for the S&P CoreLogic Case-Shiller Home Price Indices except for the monthly release of index levels, as indicated above.

Holiday Schedule

The indices are published on the last Tuesday of each month. In the event this falls on a holiday, the data will be published at the same time on the next business day.

Restatement Policy

Each month, in addition to contract settlement indices for the latest reported month, S&P Dow Jones Indices will publish restated data for each Metro Area and the Composite indices.

Restated data will be made available for the prior 24-months or 8-quarters of reported data. Home price data are often staggered, due to the reporting flow of sales price data from individual county deed recorders. Data are restated to take advantage of additional information on sales pairs found each month. Consequently, new data received in the current month may result in a new sales pair previously unreported during the last 24 months, creating a new pair and providing additional data, resulting in a restatement. Experience shows that these restatements tend to be moderate and almost non-existent in periods older than two years.

Calculations and Data Disruptions

If a data source required for index calculation is unable to provide required data S&P Dow Jones Indices may decide to delay or not publish an index.

Expert Judgment

Use of Expert Judgment[15] for the indices governed by this methodology may be employed in:

a) Actions by the Index Committee to determine if an index value is sufficiently exceptional to warrant exclusion or re-computation, and/or

b) Re-statements.

Data Hierarchy

Data used for the indices governed by this methodology may include derived prices using actual transactions in repeat sales algorithm, with exclusions according to the methodology criteria.

[15] Expert Judgment specifically and exclusively refers to S&P Dow Jones Indices' exercise of discretion with respect to its use of data in determining an index in the following context: Expert Judgment includes extrapolating data from prior or related transactions, adjusting data for factors that might influence the quality of data such as market events or impairment of a buyer or seller's credit quality, or weighing firm bids or offers greater than a particular concluded transaction. Other areas of discretion, such as methodology changes, are not, for the purposes of this document, considered Expert Judgment.

Contact Information

For any questions regarding an index, please contact: index_services@spglobal.com.

Index Dissemination

The S&P CoreLogic Case-Shiller Home Price Indices will be published monthly, on the last Tuesday of each month at 9:00 AM Eastern Time.

Tickers

The table below lists headline indices covered by this document. All versions of the below indices that may exist are also covered by this document. Please refer to the *S&P DJI Methodology & Regulatory Status Database* for a complete list of indices covered by this document.

Underlying Cash Index	BBG	RIC
Boston	SPCSBOS	.SPCSBOS
Chicago	SPCSCHI	.SPCSCHI
Denver	SPCSDEN	.SPCSDEN
Las Vegas	SPCSLV	.SPCSLV
Los Angeles	SPCSLA	.SPCSLA
Miami	SPCSMIA	.SPCSMIA
New York	SPCSNY	.SPCSNY
San Diego	SPCSSD	.SPCSSD
San Francisco	SPCSSF	.SPCSSF
Washington, D.C.	SPCSWDC	.SPCSWDC
Composite of 10	SPCS10	.SPCS10
Atlanta	SPCSATL	.SPCSATL
Charlotte	SPCSCHAR	.SPCSCHAR
Cleveland	SPCSCLE	.SPCSCLE
Dallas	SPCSDAL	.SPCSDAL
Detroit	SPCSDET	.SPCSDET
Minneapolis	SPCSMIN	.SPCSMIN
Phoenix	SPCSPHX	.SPCSPHX
Portland	SPCSPORT	.SPCSPORT
Seattle	SPCSSEA	.SPCSSEA
Tampa	SPCSTMP	.SPCSTMP
Composite of 20	SPCS20	.SPCS20
U.S. National	SPCSUSA	.SPCSUSA
Futures and Options	**BBG**	**RIC**
Boston	COA	BOS
Chicago	CVA	CHI
Denver	CXA	DEN
Las Vegas	CYA	LAS
Los Angeles	DLA	LAX
Miami	DQA	MIA
New York	DXA	NYM
San Diego	DZA	SDG
San Francisco	EFA	SFR
Washington, D.C.	EJA	WDC
Composite of 10	CGA	CUS

Web site

Historical index data are published on S&P Dow Jones Indices' Web site, *www.spglobal.com/spdji/*.

Appendix I – Additional Indices

CoreLogic calculates additional indices for S&P Dow Jones Indices. These are available on request. For more information, please contact S&P Dow Jones Indices at *index_services@spglobal.com*.

The following measure single-family home prices with the exception of the Miami-Fort Lauderdale-Pompano Beach, FL Metropolitan Statistical Area and the San Diego-Carlsbad-San Marcos, CA Metropolitan Statistical Area, which measure condominium prices.

Metropolitan Area	State / County Representation
Cape Coral-Fort Myers, FL Metropolitan Statistical Area	Lee FL
Miami-Fort Lauderdale-Pompano Beach, FL Metropolitan Statistical Area	Broward FL, Miami-Dade FL, Palm Beach FL
Naples-Marco Island, FL Metropolitan Statistical Area	Collier FL
North Port-Bradenton-Sarasota, FL Metropolitan Statistical Area	Manatee FL, Sarasota FL
Oxnard-Thousand Oaks-Ventura, CA Metropolitan Statistical Area	Ventura CA
Riverside-San Bernardino-Ontario, CA Metropolitan Statistical Area	Riverside CA, San Bernardino CA
San Diego-Carlsbad-San Marcos, CA Metropolitan Statistical Area	San Diego CA
San Jose-Sunnyvale-Santa Clara, CA Metropolitan Statistical Area	San Benito CA, Santa Clara CA
Santa Barbara-Santa Maria-Goleta, CA Metropolitan Statistical Area	Santa Barbara CA
Santa Rosa-Petaluma, CA Metropolitan Statistical Area	Sonoma CA
Vallejo-Fairfield, CA Metropolitan Statistical Area	Solano CA

Appendix II – Methodology Changes

Methodology changes since January 1, 2015, are as follows:

Change	Effective Date (After Close)	Methodology	
		Previous	Updated
Index Name Change	07/26/2016	The index name was S&P/Case-Shiller Home Price Index.	The index name is S&P CoreLogic Case-Shiller Home Price Index.

Disclaimer

Performance Disclosure/Back-Tested Data

Where applicable, S&P Dow Jones Indices and its index-related affiliates ("S&P DJI") defines various dates to assist our clients by providing transparency. The First Value Date is the first day for which there is a calculated value (either live or back-tested) for a given index. The Base Date is the date at which the index is set to a fixed value for calculation purposes. The Launch Date designates the date when the values of an index are first considered live: index values provided for any date or time period prior to the index's Launch Date are considered back-tested. S&P DJI defines the Launch Date as the date by which the values of an index are known to have been released to the public, for example via the company's public website or its data feed to external parties. For Dow Jones-branded indices introduced prior to May 31, 2013, the Launch Date (which prior to May 31, 2013, was termed "Date of introduction") is set at a date upon which no further changes were permitted to be made to the index methodology, but that may have been prior to the Index's public release date.

Please refer to the methodology for the Index for more details about the index, including the manner in which it is rebalanced, the timing of such rebalancing, criteria for additions and deletions, as well as all index calculations.

Information presented prior to an index's launch date is hypothetical back-tested performance, not actual performance, and is based on the index methodology in effect on the launch date. However, when creating back-tested history for periods of market anomalies or other periods that do not reflect the general current market environment, index methodology rules may be relaxed to capture a large enough universe of securities to simulate the target market the index is designed to measure or strategy the index is designed to capture. For example, market capitalization and liquidity thresholds may be reduced. In addition, forks have not been factored into the back-test data with respect to the S&P Cryptocurrency Indices. For the S&P Cryptocurrency Top 5 & 10 Equal Weight Indices, the custody element of the methodology was not considered; the back-test history is based on the index constituents that meet the custody element as of the Launch Date. Also, the treatment of corporate actions in back-tested performance may differ from treatment for live indices due to limitations in replicating index management decisions. Back-tested performance reflects application of an index methodology and selection of index constituents with the benefit of hindsight and knowledge of factors that may have positively affected its performance, cannot account for all financial risk that may affect results and may be considered to reflect survivor/look ahead bias. Actual returns may differ significantly from, and be lower than, back-tested returns. Past performance is not an indication or guarantee of future results.

Typically, when S&P DJI creates back-tested index data, S&P DJI uses actual historical constituent-level data (e.g., historical price, market capitalization, and corporate action data) in its calculations. As ESG investing is still in early stages of development, certain datapoints used to calculate certain ESG indices may not be available for the entire desired period of back-tested history. The same data availability issue could be true for other indices as well. In cases when actual data is not available for all relevant historical periods, S&P DJI may employ a process of using "Backward Data Assumption" (or pulling back) of ESG data for the calculation of back-tested historical performance. "Backward Data Assumption" is a process that applies the earliest actual live data point available for an index constituent company to all prior historical instances in the index performance. For example, Backward Data Assumption inherently assumes that companies currently not involved in a specific business activity (also known as "product involvement") were never involved historically and similarly also assumes that companies currently involved in a specific business activity were involved historically too. The Backward Data Assumption allows the hypothetical back-test to be extended over more historical years than would be feasible using only actual data. For more information on "Backward Data Assumption" please refer to the FAQ. The methodology and factsheets of any index that employs backward assumption in the back-tested history will explicitly state so. The methodology will include an Appendix with a table setting forth the specific data points and relevant time period for which backward projected data was used. Index returns shown do not represent the results of actual trading of investable assets/securities. S&P DJI maintains the index and calculates the index levels and performance shown or discussed but does not manage any assets.

Index returns do not reflect payment of any sales charges or fees an investor may pay to purchase the securities underlying the Index or investment funds that are intended to track the performance of the Index. The imposition of these fees and charges would cause actual and back-tested performance of the securities/fund to be lower than the Index performance shown. As a simple example, if an index returned 10% on a US $100,000 investment for a 12-month period (or US $10,000) and an actual asset-based fee of 1.5% was imposed at the end of the period on the investment plus accrued interest (or US $1,650), the net return would be 8.35% (or US $8,350) for the year. Over a three-year period, an annual 1.5% fee taken at year end with an assumed 10% return per year would result in a cumulative gross return of 33.10%, a total fee of US $5,375, and a cumulative net return of 27.2% (or US $27,200).

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