1. Introduction- The Freddie Mac House Price Index (FMHPI [SM])

Freddie Mac publishes the monthly index values of the FMHPI[SM] each quarter. Index values are available for the nation as a whole as well as for the 50 states and the District of Columbia, and 367 metropolitan statistical areas (MSAs).

The FMHPI is constructed using a repeat transactions methodology, which has become a common practice in housing research. The FMHPI index is estimated with data including transactions on one-family detached and townhome properties serving as collateral on loans originated between January 1, 1975 and the end of the most recent index month, where the loan has been purchased by Freddie Mac or Fannie Mae.

Section 2 provides an overview of repeat transactions indexes. Section 3 presents a comparison of the FMHPI and other repeat transaction house price indexes. Appendix A provides a more detailed technical specification for the construction of a repeat transactions index.

2. Background- Repeat Transactions Indexes

Freddie Mac first published a repeat transaction home price index in 1994. Since then, repeat transactions methodologies have become accepted practice in the housing and real estate industries. The repeat transactions methodology has practical advantages because the most basic specification utilizes only data on house price transactions associated with property addresses. The minimal data requirement limits the costs associated with data collection across counties, states, and regions. These indexes are calibrated to price appreciation, whereas median or mean price indexes are direct measures of price levels.

Repeat transactions indexes measure price appreciation while holding constant property type and location, by comparing the price of the same property over two or more transactions. By construction, therefore, the repeat transaction requirement excludes new homes. The change in price of a given property measures the underlying rate of appreciation because basic factors such as physical location, climate, housing type, etc., are constant between transactions. Significant renovation or deterioration to a property may, however, lead to higher or lower appreciation, respectively, than what results from the underlying price change of the property as

it existed in the first transaction. The methodology attempts to identify and exclude such outlier properties that may influence the index away from a more accurate estimate of average property appreciation rates. Such outliers include transactions that suggest substantial physical change through renovation or deterioration, and properties that have appreciated at exceptionally large or small rates (perhaps due to data-entry errors), relative to a normal range of appreciation rates.

The basic approach of measuring price differences over time for successive transactions for the same property is the same for all repeat transactions indexes. Methodologies differ, however, according to the market coverage of the transactions sample, the inclusion or exclusion of appraisals for refinance transactions, the choice of geographic weights used to create an aggregate national index, and the details of the econometric specification.[1] These differences explain disparities between index values over time, which can be significant, as methodologies will cause indexes to be more or less sensitive to various aspects of housing market movements.

Appraisal Values

Appraisal values for refinance transactions are included in the estimation of some house price indexes. Historically, appraisal valuations conducted as part of a loan refinance tend to measure value with more error than those completed in conjunction with a home purchase, as the latter benefit from the additional information of the home-buyer's and home-seller's agreed upon sales price. The inclusion of appraisal information for refinance decisions, however, can yield a far larger sample of observed housing values, which can improve the estimation of a house price index, especially at smaller geographic units where sales transactions volumes in a given period may be quite small. The decision whether to include or exclude appraisal valuations, therefore, involves a trade-off between sample size and the accuracy of a given valuation.

Geographic Weights

In practice, repeat transactions indexes are estimated at disaggregated geographic levels such as census regions, states, metropolitan areas, counties, or zip codes. These indexes are then aggregated to a national index, typically by using weights based on the number of housing units or weights based on the aggregate dollar value of the properties. A raw un-weighted average

[1] An example of an econometric difference is the estimation of arithmetic versus geometric indexes. Methodologies will also differ in other details of the statistical estimation, although that discussion is outside the scope of this document.

reflects the relative frequency of transactions in each region in the dataset. Dollar amounts represent the value share of housing, whereas counts of housing units reflect the physical share of housing.

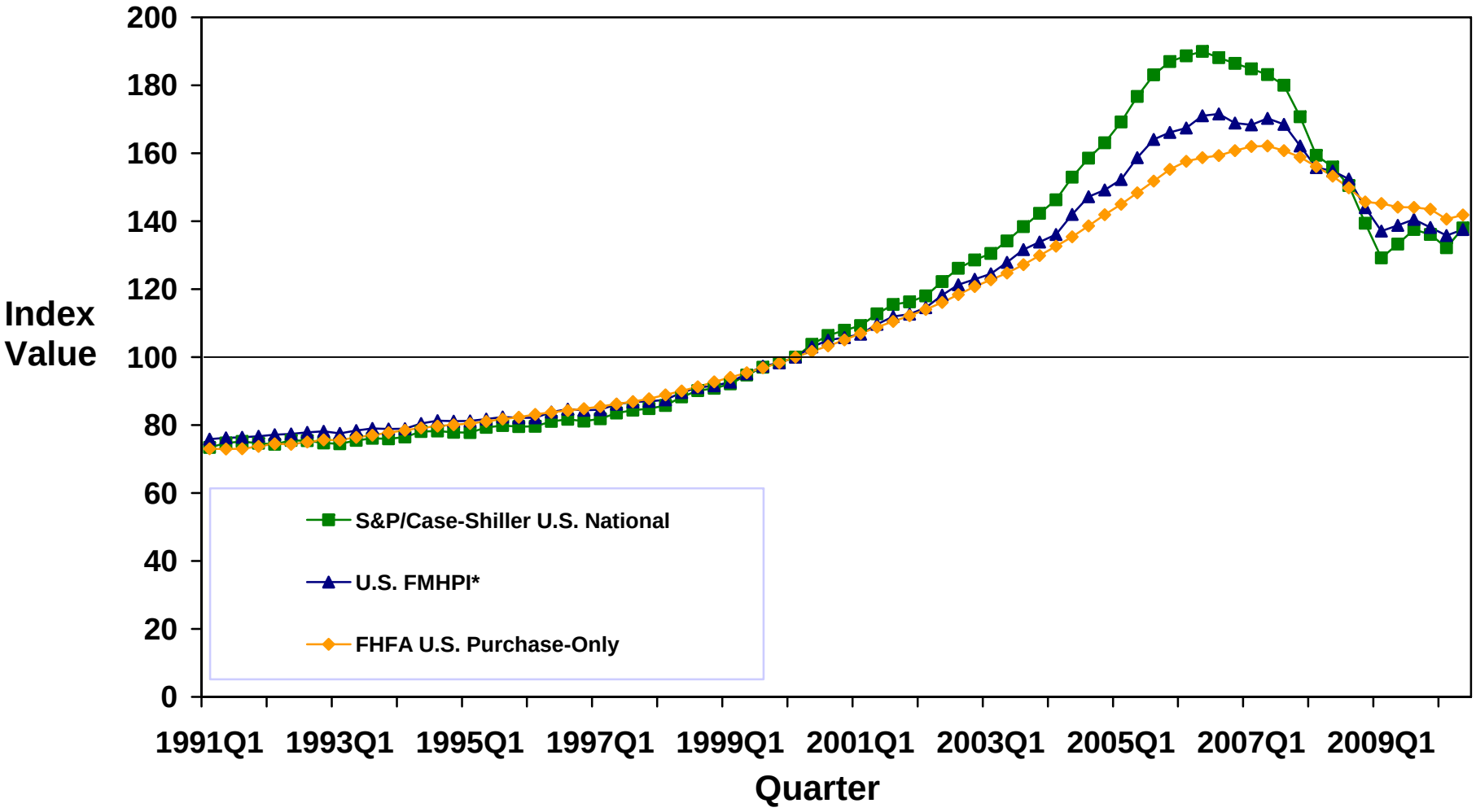
A typical unit-weighting scheme, such as that which the FHFA index employs, assigns weights according to U.S. Census Bureau counts of single-family housing units in each of nine census regions. Geographic weights correct for any over- or under-sampling that may occur in any given region due to fluctuations in transaction volumes in a given period, and results in a measure of the average price appreciation of single-family homes in the United States. This weighting scheme aims to weight appreciation equally for all homes in the country. Consider the case where there is one house in each of two hypothetical regions in the U.S. A $100,000 home in region one appreciates by 5 percent and a $1 million home in region two appreciates by 10 percent over the same time period. Each house is assigned a unit weight of 0.5 and the unit-weighted index will estimate average appreciation of 7.5 percent.

Dollar-weighting is more appropriate for applications that are concerned with relative value shares of properties. A common dollar weight is simply the share of total housing values in each region. Considering the two-home example above, the appreciation of the home in region one will receive a weight of 0.091 and the home in region two will receive a weight of 0.909. The value-weighted index will estimate an average appreciation rate of 9.1 percent.

Comparison of Index Values

Each repeat transactions methodology provides a different estimate of price appreciation. Figure 1 provides a comparison of the FHFA U.S. Purchase Only Index, S&P/Case-Shiller U.S. National Index ®, and U.S. FMHPI.

Repeat Sales House Price Index Comparison, U.S. Aggregate 2000Q1=100



*This graph plots the index values corresponding to the last month in each quarter. December 2000=100 in the publicly available FMHPI.

3. The FMHPI and Other Commonly Referenced House Price Indexes

3.1 The FMHPI

The FMHPI utilizes a dataset, created jointly with Fannie Mae, that forms the basis for the FMHPI as well as the FHFA house price indexes. The primary differences between the FMHPI and other indexes are the inclusion of some appraisal values used for refinance transactions, the choice of geographic weights, the method for identifying outliers, and the use of statistical smoothing to more efficiently estimate indexes at finer geographic levels.

Freddie Mac and Fannie Mae Dataset

In 1992, Freddie Mac and Fannie Mae agreed to create a joint dataset that includes valuation and location data for the combined portfolio of loans that were purchased by either company since January 1975. This dataset is updated monthly with new purchases from the two firms.

Repeat transactions in this dataset are identified as two first-lien mortgages originated on different dates for the same property address, that are financed by loans purchased by either Freddie Mac or Fannie Mae. This sample covers every state, although sampling reflects Freddie Mac and Fannie Mae's collective market coverage and thus is not random across states. Furthermore, data are limited to one-family detached and townhome properties that are financed by first-lien conventional and conforming loans.[2] The FMHPI further excludes planned unit developments (PUDs), condominium, and co-operative properties.

Appraisal Values from Refinancing Transactions

The FMHPI includes appraisal values for some refinance decisions in the data pairs, with the restriction that at least one of the two transactions represents a purchase. In other words, refinance-to-refinance matched pairs are excluded from the calculations. The use of refinance transactions more than quadruples the sample size to over 25 million pairs between 1975 and 2010. Refinance adjustment terms are included in the regression specification to account for the

[2] Freddie Mac and Fannie Mae are authorized to purchase only conforming loans, or loans that fall below certain size limits determined by Congress. For 2008 through 2011, the limit for conforming loans is $417,000 for one-family homes in most areas of the country, although certain high-cost areas face higher limits. For more information on conforming loan limits, see www.fhfa.gov.

possibility that appraisal values might systematically differ from purchase prices. These additional transactions greatly increase the power of estimation, especially at smaller levels of geography.

Geographic Weights

Freddie Mac aggregates the state-level indexes in FMHPI to a national index that is tailored to suit several internal business purposes using weights based on the estimated property value underlying active Freddie Mac loans. Freddie Mac portfolio weights equal the estimated property value underlying active Freddie Mac loans in the one- to four-family portfolio (including PUDs and condominiums) as of December 31 of the previous year. Portfolio weights are recalculated early in each calendar year, according to the prior end-of-year active loan portfolio. Updated weights are then applied to all index values, not just those of the prior year.

The U.S. FMHPI measures the average appreciation of house values within the currently active Freddie Mac portfolio. Freddie Mac encourages users of the FMHPI who are interested in measuring an appreciation rate that better suits their research or business purpose, to construct a national index from the provided state indexes using weights appropriate to their needs.

3.2 The FHFA House Price Indexes

The FHFA publishes two sets of quarterly indexes at the census region, MSA, and national levels: all-transactions indexes that include both purchase and appraisal data, and purchase-only indexes that includes only purchase transactions. The FHFA also publishes a monthly purchase-only index for the nation as a whole and the nine census divisions. The national index is an average of census division indexes, weighted according to census counts of owner-occupied housing.[3] This unit-weighting method can be interpreted to measure the average price appreciation of single-family homes in the United States.

3.3 S&P/Case-Shiller House Price Index

The S&P/Case-Shiller indexes comprise several indexes constructed from data gathered monthly from local recording offices across the country that include only purchase transactions

[3] The FHFA national index is constructed by extrapolating index values from a weighted average of the growth rates of census division indexes, rather than a weighted average of index values. Census division weights are published at www.fhfa.gov.

for single-family housing. S&P publishes the S&P/Case-Shiller indexes for twenty metropolitan regions, as well as a 20-city composite and a 10-city composite national indexes.[4] Monthly indexes are calculated using three-month moving averages. S&P also publishes a quarterly national index, comprised of data from the nine census divisions. Census division indexes are weighted to a national index using the aggregate value of single-family housing stock. The national index thus approximates the average appreciation of the value of the housing stock across the country.[5]

3.4 Other Price Measures

There are several house price measures that are not based on a repeat transaction methodology.

Single-period measures, such as those released by the U.S. Census Bureau or the National Association of Realtors®, report the average or median price for new or existing houses sold in a given period.[6] These measures are sensitive to the mix of properties sold in a given period, including sales of larger or smaller houses or sales volumes in different geographic regions. Growth rates calculated from these measures, as a result, reflect not only price appreciation of houses of a particular type or in a particular location, but also changes in the mix of property types or locations.

Hedonic house price measures are an alternative to single-period transaction and repeat transactions measures. Hedonic models, like that employed by the U.S. Census Bureau's Constant-Quality House Price Index, estimate house price appreciation by measuring changes in average price levels of all houses, while controlling for a subset of housing and location attributes.[7] The U.S. Census Bureau's index is for new homes only and is released quarterly for the nation and four census regions. Despite the intuitive appeal of basing a house price measure on observable characteristics, in practice there are limitations to the use of hedonic measures, largely related to the necessarily broad definitions of geographic market and house price

[4] S&P/Case-Shiller also publishes an index for three tiers of prices in 17 MSAs and a condominium index for 5 MSAs. See http://www.standardandpoors.com/home/en/us.
[5] The aggregate value of housing stock for each metro area is calculated as the total number of units multiplied by the average value of single family housing, as reported by the decennial Census.
[6] See http://www.realtor.org/.
[7] See http://www.census.gov/const/www/constpriceindex.html.

characteristics that are used in the regression, and the costs of collecting the more granular information.

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Appendix A-Index construction detail

The index estimation is based on a simple repeat sales specification, similar to that described in Leventis (2006). The natural logarithm of price for house *i* in period *t*, $\ln P_{it}$, is a function of a log price index for period *t*, β_t, a house-specific factor, H_{it}, and a random disturbance N_{it}:

$$\ln P_{it} = \beta_t + H_{it} + N_{it} \tag{1}$$

The change in log home prices between periods *t* and *s*, where *s* is the period of the first sale, can be written as:

$$\ln(P_{it}) - \ln(P_{is}) = \ln\left(\frac{P_{it}}{P_{is}}\right) = (\beta_t - \beta_s) + (H_{it} - H_{is}) + (N_{it} - N_{is}) \tag{2}$$

Note that one assumption of the repeat sales model is that H_{it} does not vary over time. The intution behind this assumption is that housing characteristics like size, location, and quality, are constant. Thus, $H_{it} = H_{is}$. The change in log home prices can be written compactly as,

$$\ln\left(\frac{P_{it}}{P_{is}}\right) = \sum_{\tau=1}^{T}(\beta_t D_{it} + \varepsilon_{it}) \tag{3}$$

Where, $\varepsilon_{it} = N_{it} - N_{is}$, and

$$D_{i\tau}\begin{cases} = 1 & \text{If second sale is in period t} \\ = -1 & \text{If first sale is in period t, t = s} \\ = 0 & \text{Otherwise} \end{cases}$$

The log price index for each period, β_t, is estimated using an Ordinary Least Squares estimator. The reported index for each time period is $I_t = e^{\hat{\beta}_t}$. [8]

[8] Note that this index implicitly estimates the geometric mean of house price appreciations; $\hat{\beta}_t$ can be written as,

Empirical evidence generally concludes that appraisals tend to overvalue properties. This inflation of home values would overstate appreciation during times of significant refinance activity, and understate appreciation when refinance activity was low. The FMHPI includes time-varying refinance adjustment terms to account for potential differences in valuations for mortgage refinances for both first and second transactions.[9] Modifying equation (3), the refi-adjusted model is:

$$\ln\left(\frac{P_{it}}{P_{is}}\right) = \sum_{t=1}^{T}(\beta_t D_{it} + \varphi_{1t} R_{1it} + \varphi_{2t} R_{2it} + \varepsilon_{it}) \quad (4)$$

Where $R_{nit}\begin{cases}=1 & \text{If the n}^{\text{th}}\text{ transaction of a pair is a refinance, in t}\\ =0 & \text{Otherwise}\end{cases}$

As mentioned in Section 3, the FMHPI non-parametrically estimates the house price index through the use of smoothing techniques.

$$\hat{\beta}_t = \ln\left(\prod_{i\in J_t}\frac{P_{it}}{P_{is}e^{-\hat{\beta}_t}}\right)^{1/n_t}$$

where J_t denotes the set of houses with a repeat sale in *t*. For example, indexes methodologies can include the Goetzmann (2002) modification to approximate the arithmetic mean. This approach modifies the error term to account for the positive correlation between variance and holding periods. S&P/Case-Shiller also estimates an arithmetic mean using a generalized least squares approach. See Graddy, Hamilton, and Campbell (2009), for example, for more detail on error corrections in repeat sales indexes.