Freddie Mac
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December 2005

Freddie Mac Working Paper #05-03

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This paper was produced for the American Real Estate and Urban Economics Association 2005 Annual Meetings, held Philadelphia, PA on January 7-9, 2005.

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The authors are grateful for the research assistance provided by Eric Fesselmeyer.

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# Revision Bias in Repeat-Sales Home Price Indices


## Abstract

Repeat-sales or, more appropriately, repeat-observation home-price indices are the most widely used measures of changes in home values. The two most widely cited of these indices are the Conventional Mortgage Home Price Index (CMHPI) and the OFHEO Home Price Index (OHPI), and both are based on valuations of properties backing loans purchased by Freddie Mac and Fannie Mae. These indices use repeated valuations of the same properties over time to gauge the average change in home prices and suffer from "revision volatility." Revision volatility is a tendency of previously estimated values for prior quarters to change with a new release and is the focus of our study.

The largest source of revision volatility comes from the timing of the loan deliveries to Freddie Mac and Fannie Mae. We reject a theoretical correction in favor of a methodological fix that was adopted on the basis of this research in both the CMHPI and the OHPI. We also examine whether adverse selection by lenders against the two companies is present and find weak evidence at the national level, but not at local levels of aggregation, leading us to believe other forces are at work.

# Revision Bias in Repeat-Sales Home Price Indices

By J.S. Butler, Yan Chang and Amy Crews Cutts

## 1. Introduction

Repeat-sales or, more appropriately, repeat-observation home-price indices are the most widely used measures of changes in home values by researchers, business analysts, regulators and fraud investigators. These indices use regression analysis on repeated mark-to-market valuations – whether from property sales or appraisals – of the same properties over time to gauge the average change in home prices.

Two of the most widely used and cited repeat-observation home-price indices are the Conventional Mortgage Home Price Index (CMHPI) and the Office of Federal Housing Enterprise Oversight (OFHEO) Home Price Index (OHPI). Freddie Mac and Fannie Mae developed the CMHPI jointly in the early 1990s, and Freddie Mac has been continuously publishing the index since the second quarter of 1994. OFHEO developed and began publishing the OHPI in 1996.[1] Both indices use data on one–unit detached and single-family townhome properties serving as collateral on loans purchased by Freddie Mac and Fannie Mae. More than 28 million matched observation-pairs are currently used to estimate the national series of the CMHPI and the OHPI. A third widely used index, developed and marketed by Fiserv CSW, Inc. uses public record data in the estimation of its repeat-observation index.

All three indices use a weighted-repeat-sales methodology developed initially by Bailey, Muth and Nourse (1963), and later improved by Case and Shiller (1987, 1989) and Shiller (1991) and others. The development of the CMHPI in particular is described in Stephens, et al., (1995).

Wang and Zorn (1997) discuss many of the statistical properties of repeat-observation indices and other competing models with an eye towards appropriate use given a particular research question. In their study, they highlight a statistical feature of repeat-observation indices that they called "revision volatility" – the tendency of previously estimated values for prior quarters to change with a new release. Revision volatility stems from both the fact that *any* additional data added to a regression model will affect all of the parameter estimates and the fact

[1] OFHEO's first release of the OHPI was using data from the fourth quarter of 1995.

that there is sampling selection bias present.[2] The goal of our study is to examine more fully the properties of revision volatility and some empirical implications of this volatility.

We use the published CMHPI releases from the first quarter of 1996 through the fourth quarter of 2002 – 27 in all – for our study. We find a pattern of significant revision to prior quarter values, and strong bias in the direction of these revisions. We also examine whether adverse selection by lenders against the two secondary market companies in the delivery of the loans is present and cannot statistically reject the hypothesis at the national level, but do reject it at regional or local levels of aggregation – which leads us to believe other forces are at work.

The results of the work described here, performed in 2003, caused both Freddie Mac and OFHEO to change the way their indices are estimated. Starting with Freddie Mac's publication of the second quarter 2003 CMHPI and OFHEO's first quarter 2004 publication of the OHPI, an additional month of Freddie Mac and Fannie Mae loan-purchase data were added. The change reduced the revision volatility for the prior quarter's value by roughly 83% on average.

## 2. Sources of Bias and Mortgage and Housing Market Peculiarities

Wang and Zorn (1997) describe sampling selection bias in repeat observation indexes as arising from three sources:

> … The first stage of sampling is based on whether or not a house price is observable in a given time period. Only houses with observable prices have any potential of being in the ultimately realized sample. The second stage is sampling among those houses for which prices are actually observed. Finally, a third stage introduces additional sampling as properties for which there is only one price observation are thrown out.

The first stage bias is reduced by the inclusion of appraisals into the database, rather than restricting the sample to purchase transactions, but it is not feasible to appraise every home in every period. The second source is limited by the collection costs of known or estimable prices – although there are purveyors of public record data, not all states allow the dissemination of home purchase price data to third parties, and thus other means such as a survey would have to be employed. The third source affects newer properties more significantly than older properties since the median owner-occupant tenure in a house exceeds 13 years according to the American Housing Survey data – hence newer homes will have fewer transactions than older homes.

[2] See Gatzlaff and Haurin (1994, 1997) and Meese and Wallace (1997) for more on selection bias in repeat-transaction indices.

To these sources, the CMHPI and the OHPI have additional sources of bias due to the nature of the source data, hereafter referred to as the FRE-FNM database. The data are limited by the business activities of Freddie Mac and Fannie Mae, which in turn are limited by the federal charters that created the two companies. Specifically, the loans the two companies may purchase are restricted to investment quality residential mortgages at or below the conforming loan limit. The maximum increase in the conforming loan limit each year is calculated based on the October-to-October change in the average price of homes purchased with a mortgage in the final 5 days of the month as recorded in the Federal Housing Finance Board's Monthly Interest Rate Survey. According to the charters of the two companies, the companies can set their own limits up to this maximum allowable increase, and so "the" conforming limit can vary, although they are usually the same. In Table 1 the conforming loan limits for Freddie Mac, from 1980 through 2005 are shown.

The effect of the loan limits is to eliminate many, but not all, high-priced homes from the sample – a few homeowners do have conforming mortgages on very expensive homes. The restriction on investment quality means that the two companies do very little business in the subprime segment of the market, and studies such as Goldstein (2003) have shown that in many large cities, subprime lending is highly concentrated in particular types of neighborhoods, often distressed, low-income neighborhoods. Hence, the FRE-FNM database will be underrepresented in lower-priced homes. Properties that are mortgaged with an FHA or VA loan are unlikely to be in the sample because those loans already have a full faith and credit guarantee of the U.S. Government. Freddie Mac and Fannie Mae do not offer any additional credit risk benefit to investors in these mortgages. The FHA and VA programs are targeted towards first-time homebuyers and, thus presumably, to lower-income homebuyers, and so this is another reason why the combined FRE-FNM database may be underrepresented in lower-priced homes.

The real estate sales market has its own peculiarities that can create bias in a repeat-observation index. For example, a new home offered by a builder is, currently, usually built only if a contract with a buyer is in place. The "sales" price of the home is actually a delivery price upon completion and may change over the time the home is being built to reflect the choices made by the buyer regarding different builder options and perhaps changes in building material costs over time. However, the land cost of the new home is set at the time of the building contract. Thus the price actually paid by the buyer at closing (completion) will reflect the cost of construction as well as the initial land cost, but not the appreciation in the land that has occurred while the home was being built. Lenders may require an appraisal for the mortgage, but that

value will only be used on the loan documents to verify the loan-to-value ratio, and hence will only be revealed to Fannie Mae or Freddie Mac if the appraised price is lower than the price actually paid. The effect of this is to increase the observed change in price between the time the buyer took possession of the home and the next refinance of the mortgage or sale of the property from what it would have been had the land appreciation been fully valued at closing.

### 3. Observations on the CMHPI

Every quarter Freddie Mac publishes the CMHPI as well as calculated growth rates based on the indexes, one of which is the quarterly growth rate, which is calculated as:

$$g_{t,\tau} = \left( \frac{CMHPI_{t,\tau}}{CMHPI_{t-1,\tau}} - 1 \right) * 100, \quad (1)$$

where $\tau$ is the publishing quarter and $t$ is the quarter for which the growth rate is calculated.

We focus our revision discussion on this growth rate because it illustrates all of the issues relating to revision volatility and any other growth rates calculated from the CMHPI will be similarly affected. The value of the CMHPI in research or business application stems from the growth rates calculated from it – the index values of the CMHPI are themselves irrelevant since they are not tied to a baseline level of prices, but instead are set such that the value in first quarter of 1987 equals 100.

Table 2 lists the initial published value of the quarterly growth rate of the national CMHPI series at the end of each column (t=1996Q1, 1996Q2,…, 2002Q4), and the subsequent revised values of the growth rate of the same quarter in quarters that follow across the rows ($\tau$=0, 1, 2, 3,…, n). We define revision as

$$r_{t,\tau} = g_{t,\tau} - g_{t,\tau-1}, \quad (2)$$

and the subsequent revised values reported in the rows of Table 2 can then be specified as

$$g_{t,\tau} = g_{t,0} + \sum_{j=1}^{\tau} r_{t,j}. \quad (3)$$

Therefore, all the values first published line up on the diagonal; all the first revised values, i.e., growth rate for the quarter published in the next quarter's release, are on the slant line immediately above; all the second revisions are immediately above the first revisions, etc.

Figure 1 plots out the series of initial and revised published values of the national CMHPI series by release quarter, $g_{t,\tau}$. Figure 2 shows the revisions in subsequent quarters relative to the

previous quarter's release, i.e., $r_{t,\tau}$. Most of the first revisions, 24 out of 27, in the 1996Q1 to 2002Q4 period are positive in sign, and only three are negative. The magnitude of subsequent revisions declines as more quarters pass by. While it is natural for the index designed as such to revise its historical values with each new publication, presumably the revisions should be random in nature and center around zero if the index is an unbiased estimate of the population growth rate. This is contrary to what we observe here, which are overwhelmingly positive revision, especially the first revisions. This phenomenon has caught the attention and raised inquiries of many parties, OFHEO, the Fed, and us included.

Theoretically, the source of the revision each quarter is that additional data are entered as inputs for the calculation of the CMHPI. The parameters thus calculated are revised each time new information is uncovered. But as mentioned before, if the new information does not materially differ from what was obtained in the publishing quarter, and enters the CMHPI subsequently in a random fashion, the revision it causes should be pure noise. We attempt to explain the observed revision bias by investigating the two main reasons for mortgages originated in the same quarter to come into the index in subsequent quarters.

The first explanation is that there is a natural time lapse between the origination of a loan and its sale and delivery to Freddie Mac or Fannie Mae by the lender. Therefore, home valuations enter the index with a delay, so sales near the end of a quarter might not come into the index until the following quarter or possibly the second following quarter. We examine the timing of deliveries of loans to Freddie Mac relative to their origination date, the date that determines which release quarter the home valuation will be used in, in Table 3 for a sample of CMHPI publication quarters.

The first three columns after the release date indicate that the published release quarter index and growth rates are based on data heavily loaded towards the early part of the quarter, with between 3 and 10 percent of the data coming from the last month of the quarter. The next cluster of shares reports how the release-quarter loan purchases are distributed over the quarter immediately following the CMHPI release, and the majority (between 60 and 75 percent) of these property valuations are from the last month of the release quarter – hence revision due to the timing of the delivery of the data for the release quarter is expected.

The last section of Table 3 reports what share of all loan deliveries for a release quarter occur by the end of the release quarter, and by the end of one month, one quarter and two quarters after initial publication. Generally, between 40 and 65 percent of all data for a release

quarter will have been delivered to Freddie Mac and Fannie Mae by the end of the release quarter, the date at which the CMHPI data are pulled from the databases of the two companies. One month later, the coverage increases to between 65 and 89 percent of total, and by the end of the third month following initial release, coverage increases to between 83 and 98 percent.[3]

In summary, Table 3 shows that a typical CMHPI release is based on only half of the information about the current quarter, and it is concentrated in the first half or one-third of the quarter. In a market in which house prices are rising, the quarterly growth rate that is calculated as in Equation 1 will be biased downwards – homes that transact later in the quarter will have another 45 to 60 days of appreciation time behind them, and will therefore be worth more than the homes that entered the sample in the early part of the quarter, and the effect will be more pronounced in very fast appreciating (or depreciating) environments. Hence a more accurate way to calculate the quarterly growth rate would be to adjust the data, perhaps by exponentiation, to take into account the compounding of the appreciation.[4] Such a mathematical adjustment would assume that the growth rate would be constant throughout the quarter, which, given the variation in quarterly growth rates and monthly sales data from the National Association of Realtors, does not seem likely. We investigate what the data have to say on this below. Later in the paper we also explore an alternative fix to this problem.

The second explanation is what we call an 'adverse-selection' bias. Lenders can choose to place loans with Freddie Mac and Fannie Mae that, while underwritten to the standards of the two companies, may be less desirable to the lenders for some reason, or may be loans on houses in areas with slow or even falling home values. In general, this is not a characteristic of loans sold to the two secondary market companies. Most lenders sell almost their entire portfolios of conventional, conforming mortgages on a regular monthly basis as the loans are originated. But many lenders also hold loans in their portfolio that are eligible for sale to the GSEs but are desirable to the lender, such as short-term, adjustable-rate mortgages. However, local market conditions can change, causing the lender to rethink whether they want to continue to hold those portfolio mortgages. Loans that are sold with a prolonged time lag, which enter the index post release and whose desirability lenders have more time to study and consider are subject to this

[3] We have to be careful interpreting the total delivery shares of more recent release dates, as Freddie Mac and Fannie Mae may still purchase significant numbers of loans originated in the quarters. That likelihood decreases rapidly over time, especially with the heavy refi activity that has happened over the past 4 years (removing older loans from the total market loan inventory from which Freddie Mac and Fannie Mae may purchase) but is not yet trivial for 2002.

[4] By quarterization we mean an adjustment similar to when a quarterly growth rate is annualized by taking one plus the growth rate to the fourth power.

selection bias. In this case the index will be lowered in later quarters with the influx of selective slow-growth properties, and we will see a negative revision in pattern in later quarters.

## 4. What Can We Learn from the Revision Patterns

### *4.1 National Series*

Both the explanations we offered in the previous section lead to hypotheses about the revisions that can be tested. We constructed a revision series based on national CMHPI data as the base of our tests. Our sample period is 1996Q1 through 2002Q4. Our starting quarter is the first quarter of 1996 since it is the earliest data from the CMHPI that is available electronically; thus the revision of 1996Q1 growth rate published in the second quarter of 1996 is the first legitimate "first revision" under our definition. The last quarter of 2002 is our cutoff point because modifications were introduced to the CMHPI in 2003. We expanded our database to allow for loans originated prior to 1975 to enter into the computation for the first time in the first quarter of 2003, and the in second quarter of 2003 the CMHPI adopted the method proposed in this paper to reduce the revision bias. This yields us 27 first revisions, 26 second revisions, 25 third revisions, and 24 fourth revisions. Table 4 contains the summary statistics for the initial release quarter quarterly growth rates and the first four revisions.

The mean quarterly growth rate during the period is 1.252 percent, and at the same time, the mean of first revisions, $r_{t,1}$, is 0.212, or 21 basis points. The estimated mean of first revisions is significantly different from zero. The second, third, and fourth revisions have smaller mean values, between 5 and 7 basis points, and are all statistically different from zero; the fifth revision is statistically different from zero, but it is also negative on average. The growth rates are positively and significantly autocorrelated, as are first revisions. However, there is no autocorrelation present in second and later revisions.

We first examine the 'partial quarter' data effect on the revisions. Our assumptions about this effect can be summarized by the following hypotheses:

*Hypothesis 1: The first revision is positively correlated with the growth rate of housing prices.*

*Hypothesis 2: The first revision is negatively correlated with the share of total release quarter observations that are used in the release quarter calculation*

*Hypothesis 3: The first revision is positively correlated with the share of total release quarter observations that are added in the first quarter following release.*

Hypothesis 1 is derived from the idea that if house prices are increasing throughout a quarter, then the fact that the initial estimate of the quarterly growth rate is estimated on data that

come primarily from the beginning of the quarter, then the home values added during the first revision will have had a longer appreciation time and thus will be higher in price than those from the start of the quarter. It is the effect of compounding of the growth rate that we are testing. In both the national CMHPI series and the regional series that we examine, home values were increasing over the entire period of our study.

The results of our regression analysis used to test these hypotheses are shown in Table 5. We find no statistical support for Hypothesis 1 – in all model specifications, the sign on the estimated coefficient is positive but statistically insignificant. This suggests that the compounding effect is mitigated by monthly variation in the growth rates over the quarter in combination with the data distribution problems associated with lagged loan deliveries.

Hypothesis 2 was tested in model specifications 2, 4 and 5, and we also find no statistical support for this hypothesis – the estimated coefficients were all positive, rather than negative. Hypothesis 3 has the strongest support in our regression analysis – in all three specifications we examined the estimated coefficient was positive and statistically significant at the 10% or lower levels. In the last specification, model 5 in Table 5, we considered the effect of the distribution of the observations over the months within the release quarter and the quarter immediately following. We got the contradictory result that the more observations in the second month of the release quarter that were added in the following quarter decreased the level of revision with weak significance of the estimated coefficient. In sum, we conclude from these regression results that a mathematical fix to the revision problem, such as exponentiation of the growth rate, to compensate for delivery lag for observations later in the release quarter is infeasible.

We also examined whether there is information in the first revision that can help predict the direction or magnitude of the second revisions and later revisions, whether the second revision predicts the third and so on. Specifically we test the following.

*Hypothesis 4: The second and later revisions are negatively correlated with the growth rate of housing prices,* $g_{t,0}$.

*Hypothesis 5: The second and later revisions are not correlated with the level of prior revisions*.

We present the regression results for the national CMHPI series in Table 6. For second revisions, we find no statistical support for either hypothesis – the second revision is positively and significantly correlated with level of the initial estimate of the quarterly growth rate at the 5% level of significance and negatively and significantly correlated with the first revision at the 10% level of significance. The third revision is not significantly correlated with the growth rate, but is positively and almost significantly correlated (11% level) with the first revision and is

positively and significantly correlated with the level of the second revision (1% level). Lastly, the fourth revision is negatively and significantly correlated with the initially published growth rate (1% level), and negatively correlated with the second revision (5% level) and positively correlated with the third revision (1% level).

Hypothesis 4 is looking for indication of adverse selection bias in the delivery of loans after the release/origination quarter. Note that from Table 4, the mean third and fourth revisions are positive, suggesting no adverse selection bias. However, from our regressions in Table 6, at the national level, we find evidence statistically that adverse selection occurs in the delivery of loans to Freddie Mac and Fannie Mae – that is, loans that are sold to the two secondary market companies more than six months after origination have slower house-price appreciation than those loans delivered within six months of origination. We cannot tell from these regressions the circumstances under which these loans are sold to the two companies – is it because they are from special deals and the two companies wanted to see demonstrated performance before they purchased them or was it because there were changes in local market conditions that caused the lenders to liquidate some or all of their portfolios and lay off credit risk.

### *4.2 Regional Series*

To find whether the results we obtained at the national level are present in more detailed series, we applied the tests to the regional CMHPI indexes. We repeated the regressions we performed at the national level on the nine census division indexes and selected state indexes for Hypotheses 1, 2 and 3 in Table 7.

Just as we found for the national series regression on first revisions, we again find no strong pattern in support of any of our first three hypotheses. So we conclude that a mathematical fix to the first revision problem is not a good idea.

In Tables 8 and 9 we examine the adverse selection issue in more detail at the regional level. We find some evidence in support of the adverse selection bias hypothesis, particularly in regions and states in which average home price appreciation has been at or below the national average for much of our sample period. Although the national regression coefficient is insignificant, we found in Table 4 that the mean fifth revision at the national level was negative, so here the growth rate has little additional explanatory power.

## 5. Fixing First Revisions (and Conclusions)

The problem with a consistent pattern of upward revisions in the CMHPI and the OHPI is that researchers, policy makers and regulators and business analysts use these indices to make decisions and market forecasts. If the data on which those decisions are made are both lagged and biased, poor decisions may be made. An example of importance to OFHEO, Freddie Mac and Fannie Mae is that the OHPI is used to determine whether Fannie and Freddie are adequately capitalized under the risk-based capital rule established by OFHEO. If the OHPI were to show a severe slowing, or even decline, in house price growth rates in its public release, requiring that both companies hold larger capital stocks as a result, and that growth rate was then revised significantly upward in the following quarter, it could impose significant capital costs on the companies and cause reputation risk to the regulator.

Since we determined that a mathematical fix to the revision problem was neither easy nor likely to be correct, we looked at another alternative. Over the years since Freddie Mac and Fannie Mae first negotiated a deal to jointly develop the CMHPI, significant advances have been made in data storage and processing. Because of these advances, it is now possible to keep the same publication schedule (roughly 65 days after quarter's end) but add an additional month of loan purchase data from both Freddie Mac and Fannie Mae in the estimation of the release quarter index values. Starting with the second quarter of 2003, we did exactly that in the CMHPI release and in the first quarter release for 2004, OFHEO also added an additional month of loan purchase data into its OHPI data.

The results on the first revision are shown in Table 10. In the national series of the CMHPI, the change in the data sample reduced the average revision over the 6 quarters the change has been in effect by 83 percent. The average revision would have been 72 basis points had the change not been made, and instead it has averaged just 12 basis points since the change.

In the regional series we see a similar impact. The Pacific series shows the most dramatic change, with the average revision falling from 137 basis points down to just 18, an 87 percent reduction in the average level of the first revision. The smallest improvement has occurred in the Mid Atlantic states, which would have had an average revision of 98 basis points without the change, but saw a 63 percent drop in the average revision to 36 basis points.

It is too early to see what impact the data change may have on later revisions. We conjecture that the correlation between the first and later revisions will be smaller.

The issue of adverse selection bias has some support in our results, but the effects are small since about 90 to 95 percent of the total loans from a release quarter are delivered within the first six months after the quarter ends, the average revision one year out is still positive, and later revisions are small in magnitude. ♦

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**Figure 1. Cumulative Revisions of National CMHPI Quarterly Growth Rates**

$$g_{t,\tau} = g_{t,0} + \sum_{j=1}^{\tau} r_{t,j}$$

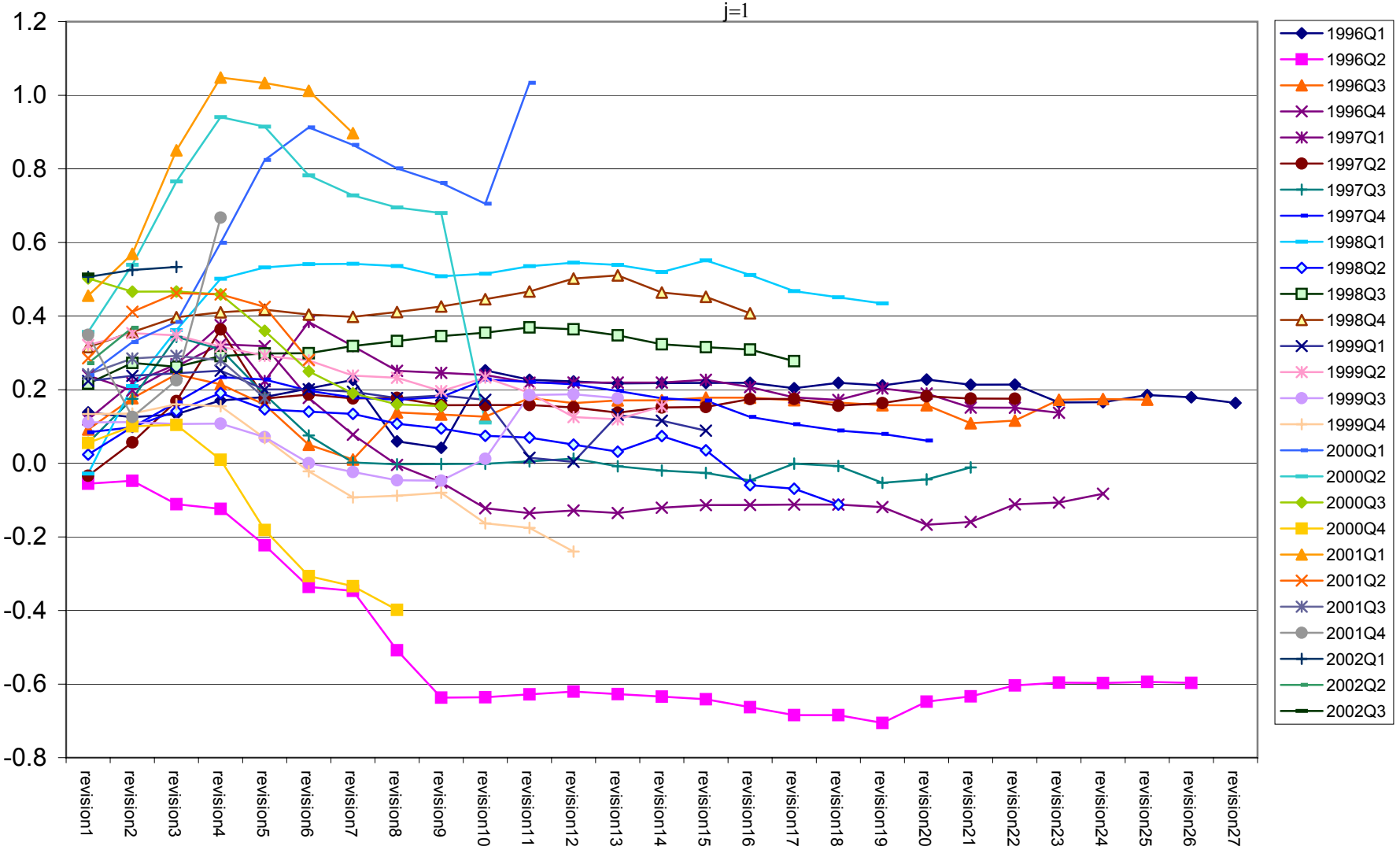
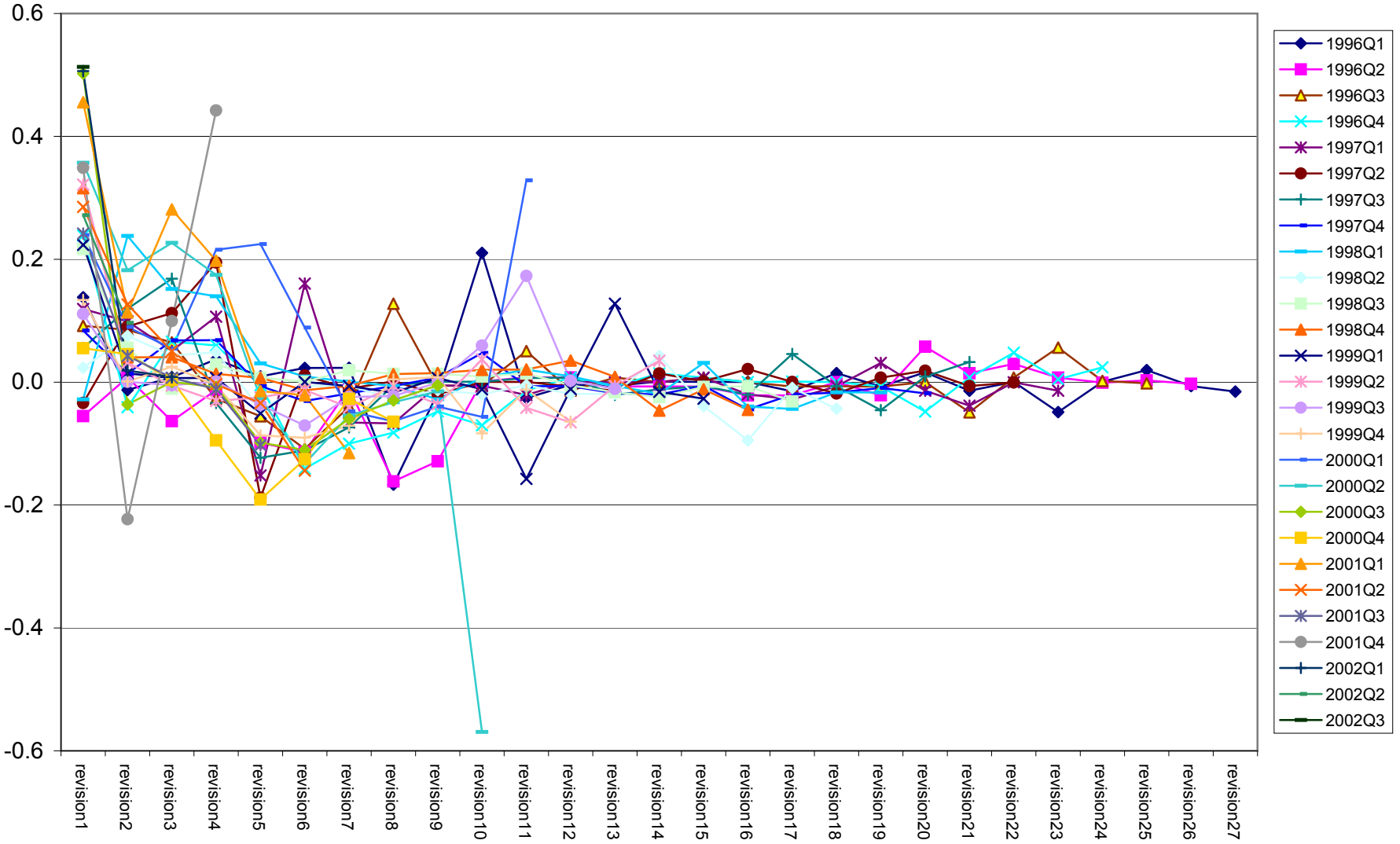


**Figure 2. Successive Revisions of National CMHPI Quarterly Growth Rates**

$$r_{t,\tau} = g_{t,\tau} - g_{t,\tau-1}$$



## *Table 1. Freddie Mac Conforming Loan Limits For First-Lien Mortgages on One-Unit Single-Family Residential Properties*

| Year | Limit | Year | Limit |
|---|---|---|---|
| 1980 | 93,750 | 1992 | 202,300 |
| 1981 | 98,500 | 1993-95 | 203,150 |
| 1982 | 107,000 | 1996 | 207,000 |
| 1983 | 108,300 | 1997 | 214,600 |
| 1984 | 114,000 | 1998 | 227,150 |
| 1985 | 115,300 | 1999 | 240,000 |
| 1986 | 133,250 | 2000 | 252,700 |
| 1987 | 153,100 | 2001 | 275,000 |
| 1988 | 168,700 | 2002 | 300,700 |
| 1989 | 187,600 | 2003 | 322,700 |
| 1990 | 187,450 | 2004 | 333,700 |
| 1991 | 191,250 | 2005 | 359,650 |

NOTE: The first-lien mortgage loan limit is 50 percent higher in Alaska, Hawaii, and Guam (and the U.S. Virgin Islands as of 1/1/93). The second-lien mortgage limit is half the 1-unit first-lien mortgage limit.
Source: Freddie Mac

## *Table 2. CMHPI Quarterly Growth Rates by Quarter of Publication*

| Reference Quarter t | Publishing Quarter τ | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1996 Q1 | 1996 Q2 | 1996 Q3 | 1996 Q4 | 1997 Q1 | 1997 Q2 | 1997 Q3 | 1997 Q4 | 1998 Q1 | 1998 Q2 | 1998 Q3 | 1998 Q4 | 1999 Q1 | 1999 Q2 | 1999 Q3 | 1999 Q4 | 2000 Q1 | 2000 Q2 | 2000 Q3 | 2000 Q4 | 2001 Q1 | 2001 Q2 | 2001 Q3 | 2001 Q4 | 2002 Q1 | 2002 Q2 | 2002 Q3 | 2002 Q4 |
| **1996Q1** | 1.08 | 1.22 | 1.21 | 1.22 | 1.25 | 1.26 | 1.29 | 1.31 | 1.14 | 1.12 | 1.33 | 1.31 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.29 | 1.30 | 1.29 | 1.31 | 1.30 | 1.30 | 1.25 | 1.25 | 1.27 | 1.26 | 1.25 |
| **1996Q2** | | 1.01 | 0.96 | 0.97 | 0.90 | 0.89 | 0.79 | 0.68 | 0.67 | 0.51 | 0.38 | 0.38 | 0.39 | 0.39 | 0.39 | 0.38 | 0.37 | 0.35 | 0.33 | 0.33 | 0.31 | 0.37 | 0.38 | 0.41 | 0.42 | 0.42 | 0.42 | 0.42 |
| **1996Q3** | | | 0.42 | 0.51 | 0.59 | 0.66 | 0.63 | 0.57 | 0.47 | 0.43 | 0.55 | 0.55 | 0.54 | 0.59 | 0.58 | 0.59 | 0.59 | 0.59 | 0.59 | 0.59 | 0.58 | 0.57 | 0.57 | 0.52 | 0.53 | 0.59 | 0.59 | 0.59 |
| **1996Q4** | | | | 0.97 | 1.21 | 1.17 | 1.24 | 1.30 | 1.29 | 1.15 | 1.05 | 0.97 | 0.92 | 0.85 | 0.84 | 0.85 | 0.84 | 0.85 | 0.86 | 0.86 | 0.86 | 0.86 | 0.85 | 0.81 | 0.81 | 0.86 | 0.87 | 0.89 |
| **1997Q1** | | | | | 0.84 | 0.96 | 1.06 | 1.11 | 1.21 | 1.06 | 1.22 | 1.16 | 1.09 | 1.08 | 1.08 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.04 | 1.02 | 1.01 | 1.04 | 1.03 | 0.99 | 0.99 | 0.97 |
| **1997Q2** | | | | | | 0.78 | 0.75 | 0.84 | 0.95 | 1.15 | 0.96 | 0.97 | 0.96 | 0.96 | 0.94 | 0.94 | 0.94 | 0.93 | 0.92 | 0.93 | 0.94 | 0.96 | 0.96 | 0.94 | 0.95 | 0.97 | 0.96 | 0.96 |
| **1997Q3** | | | | | | | 1.49 | 1.54 | 1.66 | 1.83 | 1.80 | 1.67 | 1.56 | 1.49 | 1.48 | 1.48 | 1.49 | 1.49 | 1.50 | 1.48 | 1.47 | 1.46 | 1.44 | 1.49 | 1.48 | 1.43 | 1.44 | 1.48 |
| **1997Q4** | | | | | | | | 1.30 | 1.39 | 1.40 | 1.47 | 1.54 | 1.53 | 1.50 | 1.48 | 1.48 | 1.48 | 1.53 | 1.53 | 1.52 | 1.50 | 1.48 | 1.47 | 1.43 | 1.41 | 1.39 | 1.38 | 1.37 |
| **1998Q1** | | | | | | | | | 1.00 | 0.97 | 1.21 | 1.36 | 1.50 | 1.53 | 1.54 | 1.54 | 1.54 | 1.51 | 1.52 | 1.54 | 1.55 | 1.54 | 1.52 | 1.55 | 1.51 | 1.47 | 1.45 | 1.43 |
| **1998Q2** | | | | | | | | | | 1.02 | 1.04 | 1.11 | 1.16 | 1.21 | 1.16 | 1.16 | 1.15 | 1.12 | 1.11 | 1.09 | 1.09 | 1.07 | 1.05 | 1.09 | 1.05 | 0.96 | 0.95 | 0.90 |
| **1998Q3** | | | | | | | | | | | 1.19 | 1.41 | 1.46 | 1.45 | 1.48 | 1.49 | 1.49 | 1.51 | 1.52 | 1.54 | 1.54 | 1.56 | 1.55 | 1.54 | 1.51 | 1.51 | 1.50 | 1.47 |
| **1998Q4** | | | | | | | | | | | | 0.81 | 1.13 | 1.17 | 1.21 | 1.22 | 1.23 | 1.22 | 1.21 | 1.22 | 1.24 | 1.26 | 1.28 | 1.31 | 1.32 | 1.28 | 1.26 | 1.22 |
| **1999Q1** | | | | | | | | | | | | | 1.05 | 1.27 | 1.28 | 1.29 | 1.30 | 1.25 | 1.25 | 1.24 | 1.22 | 1.23 | 1.22 | 1.06 | 1.05 | 1.18 | 1.16 | 1.13 |
| **1999Q2** | | | | | | | | | | | | | | 1.34 | 1.66 | 1.69 | 1.69 | 1.66 | 1.63 | 1.62 | 1.58 | 1.57 | 1.54 | 1.57 | 1.53 | 1.47 | 1.46 | 1.50 |
| **1999Q3** | | | | | | | | | | | | | | | 1.76 | 1.87 | 1.87 | 1.87 | 1.87 | 1.83 | 1.76 | 1.73 | 1.71 | 1.71 | 1.77 | 1.94 | 1.95 | 1.94 |
| **1999Q4** | | | | | | | | | | | | | | | | 1.56 | 1.69 | 1.69 | 1.72 | 1.71 | 1.62 | 1.53 | 1.46 | 1.47 | 1.48 | 1.39 | 1.38 | 1.32 |
| **2000Q1** | | | | | | | | | | | | | | | | | 1.25 | 1.48 | 1.57 | 1.63 | 1.84 | 2.07 | 2.16 | 2.11 | 2.05 | 2.01 | 1.95 | 2.28 |
| **2000Q2** | | | | | | | | | | | | | | | | | | 1.69 | 2.05 | 2.23 | 2.46 | 2.63 | 2.61 | 2.47 | 2.42 | 2.39 | 2.37 | 1.80 |
| **2000Q3** | | | | | | | | | | | | | | | | | | | 1.77 | 2.27 | 2.23 | 2.23 | 2.23 | 2.13 | 2.02 | 1.96 | 1.93 | 1.92 |
| **2000Q4** | | | | | | | | | | | | | | | | | | | | 2.03 | 2.09 | 2.13 | 2.14 | 2.04 | 1.85 | 1.73 | 1.70 | 1.63 |
| **2001Q1** | | | | | | | | | | | | | | | | | | | | | 1.77 | 2.22 | 2.33 | 2.62 | 2.81 | 2.80 | 2.78 | 2.66 |
| **2001Q2** | | | | | | | | | | | | | | | | | | | | | | 1.69 | 1.98 | 2.10 | 2.15 | 2.15 | 2.11 | 1.97 |
| **2001Q3** | | | | | | | | | | | | | | | | | | | | | | | 1.62 | 1.86 | 1.91 | 1.91 | 1.90 | 1.80 |
| **2001Q4** | | | | | | | | | | | | | | | | | | | | | | | | 0.33 | 0.68 | 0.46 | 0.56 | 1.00 |
| **2002Q1** | | | | | | | | | | | | | | | | | | | | | | | | | 1.40 | 1.91 | 1.93 | 1.94 |
| **2002Q2** | | | | | | | | | | | | | | | | | | | | | | | | | | 1.84 | 2.12 | 2.21 |
| **2002Q3** | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.79 | 1.30 |
| **2002Q4** | | | | | | | | | | | | | | | | | | | | | | | | | | | | 0.96 |

Source: Authors' calculations based on Conventional Mortgage Home Price Index. See www.FreddieMac.com/finance/cmhpi.

## *Table 3. Share of All CMHPI Loan Pairs Originated by Market and Purchased by Freddie Mac in CMHPI Release Quarter*

| | Share of Freddie Mac Release Quarter Loan Purchases Occurring in Month* | | | Share of Freddie Mac Release Quarter Loan Purchases Occurring in Month* | | | Share of Total Freddie Mac Release Quarter Loan Purchases Delivered by End of | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Release Quarter | 1 of Release Quarter | 2 of Release Quarter | 3 of Release Quarter | 1 of Quarter after Release Quarter | 2 of Quarter after Release Quarter | 3 of Quarter after Release Quarter | Release Quarter | 1st Month After Release | 1st Quarter After Release | 2nd Quarter After Release |
| 1996-01 | 49.22 | 44.77 | 6.02 | 3.21 | 28.59 | 68.19 | 49.31 | 78.67 | 92.95 | 94.05 |
| 1996-02 | 61.33 | 35.24 | 3.44 | 7.49 | 28.92 | 63.59 | 52.64 | 77.85 | 88.83 | 91.08 |
| 1996-03 | 59.10 | 37.49 | 3.41 | 5.14 | 31.36 | 63.50 | 50.09 | 77.62 | 89.80 | 91.00 |
| 1996-04 | 55.57 | 38.34 | 6.08 | 3.34 | 24.15 | 72.52 | 47.79 | 78.32 | 91.27 | 94.04 |
| 1998-01 | 41.20 | 51.05 | 7.75 | 2.31 | 28.16 | 69.52 | 43.07 | 75.94 | 91.59 | 95.37 |
| 1998-02 | 61.07 | 34.30 | 4.64 | 8.28 | 25.92 | 65.80 | 51.03 | 77.27 | 89.68 | 93.57 |
| 1998-03 | 58.56 | 36.77 | 4.67 | 6.38 | 27.04 | 66.57 | 51.32 | 77.90 | 93.09 | 94.28 |
| 1998-04 | 58.73 | 35.78 | 5.50 | 5.42 | 29.80 | 64.79 | 50.09 | 76.95 | 91.44 | 93.11 |
| 2000-01 | 53.49 | 42.28 | 4.22 | 5.93 | 21.01 | 73.06 | 40.54 | 65.67 | 83.49 | 88.39 |
| 2000-02 | 53.49 | 42.66 | 3.85 | 4.80 | 26.08 | 69.12 | 43.99 | 68.96 | 88.51 | 93.71 |
| 2000-03 | 57.46 | 39.67 | 2.87 | 4.60 | 32.63 | 62.77 | 48.66 | 78.61 | 94.65 | 96.29 |
| 2000-04 | 61.31 | 36.30 | 2.40 | 3.81 | 31.44 | 64.74 | 49.68 | 79.67 | 95.86 | 97.46 |
| 2002-01 | 61.36 | 32.81 | 5.84 | 7.05 | 25.29 | 67.66 | 58.43 | 88.79 | 96.51 | 98.36 |
| 2002-02 | 54.40 | 40.22 | 5.38 | 2.74 | 25.27 | 72.00 | 57.53 | 86.58 | 97.43 | 99.20 |
| 2002-03 | 41.68 | 48.94 | 9.38 | 3.67 | 25.01 | 71.32 | 47.31 | 82.70 | 97.85 | 99.22 |
| 2002-04 | 54.69 | 37.83 | 7.49 | 6.40 | 22.67 | 70.93 | 64.24 | 85.61 | 97.58 | 99.13 |

Source: Authors' calculations on Freddie Mac and Fannie Mae data used for estimation of the Conventional Mortgage Home Price Index

## *Table 4. Summary Statistics of National Series CMHPI Data*

| | Description | Sample Size | Mean | Standard Deviation | Mean t-Value | Auto-correlation Factor | Auto-Correlation t-Value |
|---|---|---|---|---|---|---|---|
| $g_{t,0}$ | Initially Published Quarterly Growth Rate $[(CMHPI_t/CMHPI_{t-1})-1]*100$ | 27 | 1.252 | 0.444 | 14.65 | 0.354 | 1.86 |
| $r_{t,1}$ | 1st Revsion to Quarterly Growth Rate $(g_{t,1}-g_{t,0})$ | 27 | 0.212 | 0.168 | 6.59 | 0.399 | 2.03 |
| $r_{t,2}$ | 2nd Revsion to Quarterly Growth Rate $(g_{t,2}-g_{t,1})$ | 26 | 0.049 | 0.085 | 2.93 | 0.019 | 0.09 |
| $r_{t,3}$ | 3rd Revsion to Quarterly Growth Rate $(g_{t,3}-g_{t,2})$ | 25 | 0.058 | 0.079 | 3.67 | -0.002 | -0.01 |
| $r_{t,4}$ | 4th Revsion to Quarterly Growth Rate $(g_{t,4}-g_{t,3})$ | 24 | 0.063 | 0.117 | 2.64 | -0.130 | -0.44 |
| $r_{t,5}$ | 5th Revsion to Quarterly Growth Rate $(g_{t,5}-g_{t,4})$ | 23 | -0.046 | 0.086 | -2.57 | 0.107 | 0.63 |

Source: Authors' calculations on Conventional Mortgage Home Price Index, 1Q1996-4Q2002.

# *Table 5: National CMHPI Series First Revision Regressions*

**Dependent Variable: First Revision of Index Quarterly Growth Rate**

| | Model | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | |
| Variable | Parameter | t-Value | Parameter | t-Value | Parameter | t-Value | Parameter | t-Value | Parameter | t-Value |
| Intercept | 0.128 | 1.30 | 0.065 | 0.18 | -0.357 | -1.34 | -1.477 | -2.36 | 1.091 | 0.65 |
| Level of quarterly growth rate in release quarter *t* ($g_{t,t}$) | 0.067 | 0.91 | 0.067 | 0.88 | 0.059 | 0.83 | 0.048 | 0.71 | 0.025 | 0.32 |
| Share of total GSE purchases of loans originated in release quarter that were purchased by of end of release quarter *t* ($p_{t,t}$) | | | 0.129 | 0.19 | | | **1.511** | **1.95** | 0.767 | 0.68 |
| Share of total GSE purchases of loans originated in release quarter that were purchased during the quarter following release quarter *t* [($p_{t,t+1}$)-($p_{t,t}$)] | | | | | **1.173** | **1.94** | **2.088** | **2.82** | **5.496** | **2.40** |
| Share of release quarter loans used in release publication that were from second month of the release quarter t | | | | | | | | | 5.251 | 1.47 |
| Share of release quarter loans used in release publication that were from third month of the release quarter t | | | | | | | | | 2.012 | 0.55 |
| Share of release quarter loans in first revision publication that were from second month of the release quarter t | | | | | | | | | **-10.119** | **-1.76** |
| Share of release quarter loans in first revision publication that were from third month of the release quarter t | | | | | | | | | -7.007 | -1.50 |
| R-Square | 0.03 | | 0.03 | | 0.16 | | 0.28 | | 0.40 | |
| Adjusted R-Square | -0.01 | | -0.05 | | 0.09 | | 0.19 | | 0.18 | |
| Sample Size | 27 | | 27 | | 27 | | 27 | | 27 | |

Source: Authors' calculations on Conventional Mortgage Home Price Index, 1Q1996-4Q2002.

## *Table 6: National CMHPI Series Second and Later Revision Regressions*

| **Dependent Variable** | Second Revision of Quarterly Growth Rate $r_{t,2}$ | | Second Revision of Quarterly Growth Rate $r_{t,2}$ | | Third Revision of Quarterly Growth Rate $r_{t,3}$ | | Third Revision of Quarterly Growth Rate $r_{t,3}$ | | Fourth Revision of Quarterly Growth Rate $r_{t,4}$ | | Fourth Revision of Quarterly Growth Rate $r_{t,4}$ | | Fourth Revision of Quarterly Growth Rate $r_{t,4}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Independent Variables** | Parameter | t-Value | Parameter | t-Value | Parameter | t-Value | Parameter | t-Value | Parameter | t-Value | Parameter | t-Value | Parameter | t-Value |
| Intercept | 0.075 | 2.79 | -0.003 | -0.07 | 0.009 | 0.35 | 0.042 | 0.96 | 0.199 | 2.97 | 0.042 | 1.27 | 0.139 | 2.72 |
| Level of quarterly growth rate in release quarter *t* ($g_{t,t}$) | | | **0.071** | **1.87** | | | -0.034 | -0.93 | **-0.110** | **-2.15** | | | **-0.099** | **-2.34** |
| Level of first revision to quarterly growth rate ($r_{t,1}$) | -0.13 | -1.23 | **-0.185** | **-1.76** | 0.133 | 1.46 | 0.165 | 1.69 | | | -0.063 | -0.47 | 0.060 | 0.45 |
| Level of second revision to quarterly growth rate ($r_{t,2}$) | | | | | **0.478** | **2.79** | **0.537** | **2.94** | | | **-0.758** | **-2.98** | **-0.521** | **-2.07** |
| Level of third revision to quarterly growth rate ($r_{t,3}$) | | | | | | | | | | | **1.159** | **4.17** | **1.026** | **3.98** |
| R-Square | 0.06 | | 0.18 | | 0.28 | | 0.31 | | 0.17 | | 0.50 | | 0.61 | |
| Adjusted R-Square | 0.02 | | 0.11 | | 0.21 | | 0.21 | | 0.14 | | 0.43 | | 0.53 | |
| Sample Size | 26 | | 26 | | 25 | | 25 | | 24 | | 24 | | 24 | |

Source: Authors' calculations on Conventional Mortgage Home Price Index, 1Q1996-4Q2002.

# *Table 7: Regional CMHPI Series Revision Regressions*

## Dependent Variable: First Revision of Index Quarterly Growth Rate

| | *Independent Variables* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Intercept | | Level of quarterly growth rate in release quarter t ($g_{t,0}$) | | Share of total GSE purchases of loans originated in release quarter that were purchased by of end of release quarter t ($p_{t,0}$) | | Share of total GSE purchases of loans originated in release quarter that were purchased during the quarter following release quarter t [$(p_{t,1})-(p_{t,0})$] | | | |
| **Region** | Parameter | t-Value | Parameter | t-Value | Parameter | t-Value | Parameter | t-Value | R-Square | Adjusted R-Square |
| **United States** | -1.477 | -2.36 | 0.048 | 0.71 | **1.511** | **1.95** | **2.088** | **2.82** | 0.28 | 0.19 |
| **New England** | -1.377 | -0.90 | **0.088** | **1.76** | 1.907 | 1.06 | 1.330 | 0.84 | 0.18 | 0.07 |
| Massachusetts | -0.796 | -0.50 | **0.083** | **1.93** | 1.367 | 0.76 | 0.542 | 0.34 | 0.18 | 0.08 |
| **Mid Atlantic** | -1.481 | -1.05 | **0.112** | **1.82** | 1.180 | 0.69 | 2.461 | 1.59 | 0.26 | 0.16 |
| New Jersey | -1.525 | -0.80 | 0.014 | 0.17 | 2.412 | 1.01 | 1.442 | 0.70 | 0.06 | -0.07 |
| Pennsylvania | -2.368 | -0.92 | **-0.354** | **-3.09** | 2.453 | 0.79 | 3.771 | 1.32 | 0.30 | 0.21 |
| **South Atlantic** | -1.371 | -2.47 | -0.136 | -1.71 | **1.698** | **2.35** | **2.312** | **2.80** | 0.31 | 0.22 |
| Georgia | -1.673 | -1.71 | -0.102 | -1.28 | **1.875** | **1.67** | **2.529** | **2.12** | 0.26 | 0.17 |
| South Carolina | 0.302 | 0.57 | **-0.413** | **-5.94** | -0.692 | -1.02 | **1.732** | **1.89** | 0.62 | 0.57 |
| Virginia | -1.581 | -1.54 | 0.012 | 0.11 | **2.608** | **1.81** | 1.493 | 0.99 | 0.15 | 0.04 |
| **East South Central** | 0.220 | 0.42 | **-0.234** | **-4.37** | 0.054 | 0.09 | 0.235 | 0.36 | 0.46 | 0.40 |
| Kentucky | 0.096 | 0.14 | **-0.356** | **-4.65** | **1.610** | **2.21** | -0.880 | -0.90 | 0.58 | 0.52 |
| Tennessee | 1.445 | 1.43 | **-0.319** | **-2.93** | **-2.012** | **-1.59** | -0.090 | -0.07 | 0.30 | 0.21 |
| **West South Central** | -1.800 | -1.58 | -0.098 | -1.22 | 1.566 | 1.33 | **2.950** | **2.16** | 0.23 | 0.12 |
| Texas | 0.520 | 0.47 | -0.066 | -0.91 | -0.934 | -0.81 | 0.518 | 0.38 | 0.11 | 0.00 |
| **West North Central** | -3.481 | -2.73 | -0.051 | -0.57 | **4.276** | **3.11** | **3.693** | **2.52** | 0.34 | 0.25 |
| Minnesota | -1.615 | -0.63 | 0.010 | 0.13 | 2.039 | 0.75 | 1.760 | 0.66 | 0.03 | -0.10 |
| Kansas | 1.369 | 1.24 | -0.153 | -1.70 | -1.000 | -0.77 | -1.201 | -0.83 | 0.12 | 0.00 |
| **East North Central** | 0.218 | 0.39 | **-0.225** | **-3.47** | 0.289 | 0.45 | 0.168 | 0.22 | 0.44 | 0.37 |
| Ohio | -0.186 | -0.42 | **-0.180** | **-2.46** | -0.253 | -0.46 | **1.419** | **2.13** | 0.44 | 0.37 |
| Indiana | -1.007 | -1.20 | **-0.190** | **-1.98** | 0.984 | 0.87 | **2.018** | **1.62** | 0.28 | 0.19 |
| **Mountain** | -0.097 | -0.07 | -0.077 | -0.78 | -0.167 | -0.11 | 1.071 | 0.73 | 0.10 | 0.03 |
| Colorado | 1.759 | 0.87 | -0.013 | -0.12 | -1.609 | -0.75 | -1.182 | -0.57 | 0.03 | -0.10 |
| Arizona | -0.161 | -0.10 | -0.030 | -0.23 | 1.352 | 0.74 | -0.283 | -0.17 | 0.09 | -0.03 |
| **Pacific** | 0.821 | 0.69 | **0.151** | **1.98** | -1.091 | -0.76 | -0.662 | -0.47 | 0.20 | 0.10 |
| California | 1.967 | 1.96 | **0.100** | **2.04** | **-2.147** | **-1.77** | -1.840 | -1.51 | 0.25 | 0.15 |

Note: Sample size in all cases equals 27. Source: Authors' calculations on Conventional Mortgage Home Price Index, 1Q1996-4Q2002.

## *Table 8: Regional CMHPI Series Revision Regressions*

### Dependent Variable: Fourth Revision of Index Quarterly Growth Rate ($r_{t,4}$)

| | ***Independent Variables*** | | | | | |
|---|---|---|---|---|---|---|
| | Intercept | | Level of quarterly growth rate in release quarter t ($g_{t,0}$) | | | |
| **Region** | Parameter | t-Value | Parameter | t-Value | R-Square | Adjusted R-Square |
| **United States** | 0.199 | 2.97 | **-0.11** | **-2.15** | 0.17 | 0.14 |
| **New England** | 0.067 | 0.98 | 0.002 | 0.06 | 0.00 | -0.05 |
| Massachusetts | 0.088 | 1.40 | -0.007 | -0.25 | 0.00 | -0.04 |
| **Mid Atlantic** | 0.112 | 1.72 | -0.030 | -0.63 | 0.02 | -0.03 |
| New Jersey | 0.048 | 0.67 | -0.007 | -0.16 | 0.00 | -0.04 |
| Pennsylvania | 0.001 | 0.02 | -0.019 | -0.42 | 0.01 | -0.04 |
| **South Atlantic** | 0.094 | 1.00 | -0.033 | -0.47 | 0.01 | -0.04 |
| Georgia | 0.165 | 1.59 | **-0.094** | **-1.44** | 0.09 | 0.04 |
| South Carolina | 0.129 | 1.18 | -0.054 | -0.68 | 0.02 | -0.02 |
| Virginia | 0.102 | 1.28 | -0.051 | -0.90 | 0.04 | -0.01 |
| **East South Central** | 0.128 | 1.52 | **-0.123** | **-1.77** | 0.12 | 0.09 |
| Kentucky | -0.055 | -0.62 | 0.048 | 0.66 | 0.02 | -0.02 |
| Tennessee | 0.044 | 0.43 | -0.020 | -0.24 | 0.00 | -0.04 |
| **West South Central** | 0.057 | 0.90 | -0.034 | -0.59 | 0.02 | -0.03 |
| Texas | 0.115 | 1.81 | -0.053 | -1.03 | 0.05 | 0.00 |
| **West North Central** | 0.293 | 3.76 | **-0.135** | **-2.54** | 0.23 | 0.19 |
| Minnesota | 0.192 | 1.92 | **-0.083** | **-1.56** | 0.10 | 0.06 |
| Kansas | 0.124 | 2.23 | **-0.100** | **-2.50** | 0.22 | 0.19 |
| **East North Central** | 0.186 | 4.51 | **-0.109** | **-3.60** | 0.37 | 0.34 |
| Ohio | 0.183 | 2.05 | **-0.136** | **-1.96** | 0.15 | 0.11 |
| Indiana | 0.220 | 2.74 | **-0.187** | **-2.76** | 0.26 | 0.22 |
| **Mountain** | 0.182 | 2.01 | **-0.133** | **-1.87** | 0.14 | 0.10 |
| Colorado | 0.198 | 2.20 | **-0.109** | **-2.09** | 0.17 | 0.13 |
| Arizona | 0.370 | 2.11 | -0.179 | -1.24 | 0.07 | 0.02 |
| **Pacific** | 0.173 | 2.05 | -0.039 | -0.76 | 0.03 | 0.00 |
| California | 0.101 | 1.55 | -0.007 | -0.22 | 0.00 | -0.04 |

Note: Sample size in all cases equals 24. Source: Authors' calculations on Conventional Mortgage Home Price Index, 1Q1996-4Q2002.

# Table 9: Regional CMHPI Series Revision Regressions

## Dependent Variable: Fifth Revision of Index Quarterly Growth Rate ($r_{t,5}$)

| | *Independent Variables* | | | | | |
|---|---|---|---|---|---|---|
| | Intercept | | Level of quarterly growth rate in release quarter t ($g_{t,0}$) | | | |
| **Region** | Parameter | t-Value | Parameter | t-Value | R-Square | Adjusted R-Square |
| **United States** | -0.015 | -0.24 | -0.024 | -0.53 | 0.01 | -0.03 |
| **New England** | 0.025 | 0.73 | **-0.034** | **-1.94** | 0.15 | 0.11 |
| Massachusetts | 0.055 | 1.37 | **-0.043** | **-2.39** | 0.21 | 0.18 |
| **Mid Atlantic** | 0.033 | 0.72 | -0.013 | -0.41 | 0.01 | -0.04 |
| New Jersey | 0.087 | 1.19 | -0.037 | -0.82 | 0.03 | -0.01 |
| Pennsylvania | 0.156 | 2.63 | **-0.081** | **-1.92** | 0.15 | 0.11 |
| **South Atlantic** | -0.141 | -1.80 | 0.050 | 0.86 | 0.03 | -0.01 |
| Georgia | 0.244 | 2.88 | **-0.155** | **-2.94** | 0.29 | 0.26 |
| South Carolina | 0.186 | 1.84 | **-0.170** | **-2.32** | 0.20 | 0.17 |
| Virginia | 0.031 | 0.20 | -0.039 | -0.36 | 0.01 | -0.04 |
| **East South Central** | 0.053 | 1.47 | **-0.104** | **-3.55** | 0.38 | 0.35 |
| Kentucky | 0.241 | 2.85 | **-0.256** | **-3.69** | 0.39 | 0.36 |
| Tennessee | -0.103 | -1.40 | 0.027 | 0.47 | 0.01 | -0.04 |
| **West South Central** | -0.096 | -1.28 | 0.036 | 0.55 | 0.01 | -0.03 |
| Texas | -0.041 | -0.55 | 0.018 | 0.30 | 0.00 | -0.04 |
| **West North Central** | -0.034 | -0.41 | -0.019 | -0.35 | 0.01 | -0.04 |
| Minnesota | 0.083 | 0.67 | -0.056 | -0.87 | 0.03 | -0.01 |
| Kansas | 0.033 | 0.50 | **-0.114** | **-2.51** | 0.23 | 0.19 |
| **East North Central** | 0.064 | 1.36 | **-0.061** | **-1.81** | 0.14 | 0.09 |
| Ohio | 0.185 | 1.93 | **-0.159** | **-2.19** | 0.19 | 0.15 |
| Indiana | -0.036 | -0.62 | 0.008 | 0.17 | 0.00 | -0.05 |
| **Mountain** | -0.286 | -2.23 | **0.181** | **1.83** | 0.14 | 0.10 |
| Colorado | 0.153 | 1.46 | **-0.083** | **-1.40** | 0.09 | 0.04 |
| Arizona | -0.152 | -1.20 | 0.083 | 0.81 | 0.03 | -0.02 |
| **Pacific** | -0.034 | -0.51 | -0.013 | -0.34 | 0.01 | -0.04 |
| California | -0.025 | -0.50 | -0.009 | -0.38 | 0.01 | -0.04 |

Note: Sample size in all cases equals 24. Source: Authors' calculations on Conventional Mortgage Home Price Index, 1Q1996-4Q2002.

## *Table 10: Impacts of Additional Data on First Revision in the CMHPI*

| Region | Average First Revision of Index Quarter Growth Rate ($r_{t,1}$) As Published: 2003Q2 to 2004Q3 | Average First Revision of Index Quarter Growth Rate ($r_{t,1}$) with Extra Month of Purchase Data: 2003Q2 to 2004Q3 | Percent Reduction in First Revision After Change in Methodology |
|---|---|---|---|
| **Census Division** | | | |
| New England | 0.49 | 0.03 | 92.85 |
| Mid Atlantic | 0.98 | 0.36 | 63.24 |
| South Atlantic | 0.65 | 0.12 | 81.14 |
| East South Central | 0.26 | 0.06 | 75.73 |
| West South Central | 0.52 | 0.06 | 89.20 |
| West North Central | 0.53 | 0.10 | 81.77 |
| East North Central | 0.41 | 0.03 | 91.53 |
| Mountain | 0.58 | 0.09 | 84.54 |
| Pacific | 1.37 | 0.18 | 87.12 |
| **United States** | 0.72 | 0.12 | 83.40 |

Source: Authors' calculations on Conventional Mortgage Home Price Index 2Q2003-3Q2004