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Re-Benchmarking the Leading Indicator of Remodeling Activity

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Abstract

Since 2007, the Joint Center for Housing Studies has projected short-term trends in home remodeling activity with its quarterly Leading Indicator of Remodeling Activity, or LIRA. In recent years, the quality and reliability of the LIRA's benchmark data series declined markedly, prompting a re-benchmarking of the LIRA to a measure of home improvement and repair spending based on estimates from the Department of Housing and Urban Development's biennial American Housing Survey.

The main difference between the former and re-benchmarked LIRA is that the former LIRA projected trends in home improvement spending only, whereas the re-benchmarked LIRA now tracks a broader remodeling market that includes both improvements and maintenance and repair activity. For this reason, the re-benchmarked LIRA is somewhat less cyclical, but still anticipates turning points in the market well.

Joint Center for Housing Studies
Harvard University

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Introduction

Since 2007, the Remodeling Futures Program of the Joint Center for Housing Studies has produced a quarterly leading indicator for the national home improvement industry, called the Leading Indicator of Remodeling Activity, or LIRA.[1] This research note provides an explanation of a change to the LIRA's benchmark data series from the estimate of private residential improvement spending in the U.S. Census Bureau's Construction Spending Value Put in Place, or C-30, to a Joint Center estimate based on owner improvement and repair spending from the Department of Housing and Urban Development's American Housing Survey (AHS).[2] The main motivations for re-benchmarking the LIRA are threefold:

(1) In recent years, the C-30 estimates of home improvement spending to owner-occupied units have become increasing volatile and unreliable, subject to unusually large revisions.[3]

(2) The C-30 has historically underestimated the size of the national home improvement market in dollar volume when compared to the AHS. Not only are improvement spending levels about 50% larger in the AHS, the AHS also provides estimates of maintenance and repair spending allowing for a more comprehensive market size definition.

(3) The housing and home improvement markets have gone through possibly the most severe cycles in their recorded histories since the LIRA was first released, necessitating a review of the original LIRA model and inputs for accuracy.

The Joint Center does not take re-benchmarking its LIRA lightly. However, the advantages of a re-benchmarked LIRA representing a broader segment of the remodeling market and with revised inputs that better predict post-Great Recession market trends were thought to far outweigh any disadvantages of a re-benchmarking.

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[1] For documentation on the development of the original LIRA model see Bendimerad 2007.

[2] This re-benchmarking occurs eight years after an initial re-benchmarking soon after the introduction of the LIRA that was necessitated by the abrupt discontinuation of its original benchmark series, the Census Bureau's Survey of Residential Alterations and Repairs Statistics, or C-50 series. See Will 2008.

[3] Most recently, the Census Bureau restated 10 years of C-30 data due to a long-standing processing error in the tabulation of data on private residential improvement spending: http://www.census.gov/construction/c30/news.html.

Purpose and Design of the LIRA

According to Joint Center estimates, the residential remodeling industry is closing in on $350 billion annually in improvement and repair expenditures, yet the industry continues to struggle for timely and consistent data on current market size and trends. The main purpose of the LIRA is to provide the industry with a current estimate of national home improvement and repair activity to owner-occupied properties, and, more importantly, to provide a near-term projection of changes in activity that could signal major turning points in the remodeling cycle. The LIRA is constructed as a weighted average of the annual rates of change in several key economic indicators that typically influence remodeling activity. The LIRA relies on a benchmark measure of remodeling spending both as a point of historical reference for levels of spending, but more fundamentally as a means for estimating the LIRA model and weighting methodology.

The mechanics of the LIRA are thus: on a quarterly basis, the LIRA projects the annual, or four-quarter moving, rate of change in national expenditure for home improvements and repairs with a time horizon of four quarters. This is done by averaging the rates of change in several economic indicators that strongly correlate with lagged remodeling spending. The input components of the LIRA have differently timed relationships with remodeling spending so that some are more highly correlated with spending with several quarters of lead time, while others have a more coincident relationship with improvement spending. The input variables are weighted in the LIRA model according to the strength of their correlation with historical spending and the amount of deviation from their mean so that inputs with higher correlations and lower variance or volatility will receive greater weight in calculating the LIRA output.

Again, as a leading indicator, the LIRA is designed to indicate oncoming upturns and downturns in market activity, but forecasting is, of course, an imprecise science and for this reason the LIRA is not expected to accurately predict exact rates of growth or decline so much as the general trend of growth or decline in the near-term. The major difference between the former and re-benchmarked LIRA is that the former LIRA projected trends in homeowner improvements only, while the re-benchmarked LIRA projects combined owner improvement *and* maintenance and repair activity. Because home improvement spending tends to be much

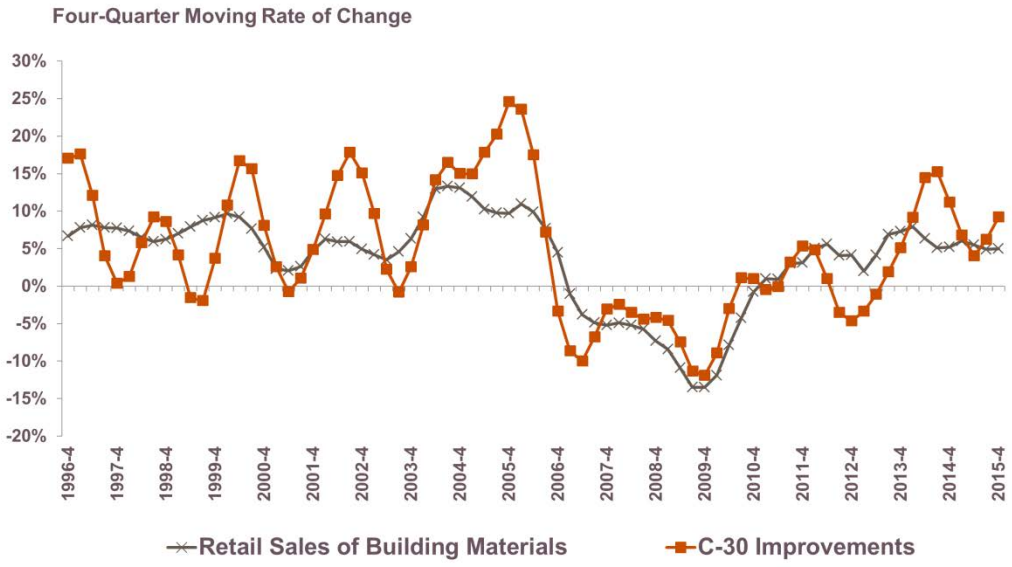
more cyclical than maintenance and repair spending over time, two separate LIRA models are estimated, each using unique input variables, lead times and weights.

Motivations for Re-Benchmarking

The Remodeling Futures Program has relied on the improvements spending data from the C-30 as a benchmark for the LIRA out of sheer necessity for a more frequent estimate than the biennial data available from the American Housing Survey, for example. The monthly publication and lengthy history of the C-30 (and its predecessor, the C-50) were critical for designing a short-term leading indicator and the known limitations of the data were considered to be of secondary importance by the Remodeling Futures Program. One limitation is that the C-30 estimates of home improvement spending to owner-occupied units have always been unusually volatile, likely due to small sample sizes and imprecision of the survey design for collecting large and infrequent expenditures like a remodeling project.[4] Figure 1 compares the C-30 improvements data to retail sales of building materials at hardware stores and home improvement centers. Although the C-30 data tends to trend in the same directions as retail sales, the magnitude of the change is typically much more pronounced, suggesting the C-30 is picking up considerable noise in its estimates and not entirely reflective of actual market activity.

[4] The improvements data in the C-30 is derived from the Bureau of Labor Statistics' Consumer Expenditure Survey (CE), which is designed to collect comprehensive information on the everyday buying habits of American consumers, not home improvements and repairs specifically. The CE sample size is approximately 7,000 households per quarter including about 4,000 homeowners compared to about 30,000 homeowners surveyed as part of the American Housing Survey.

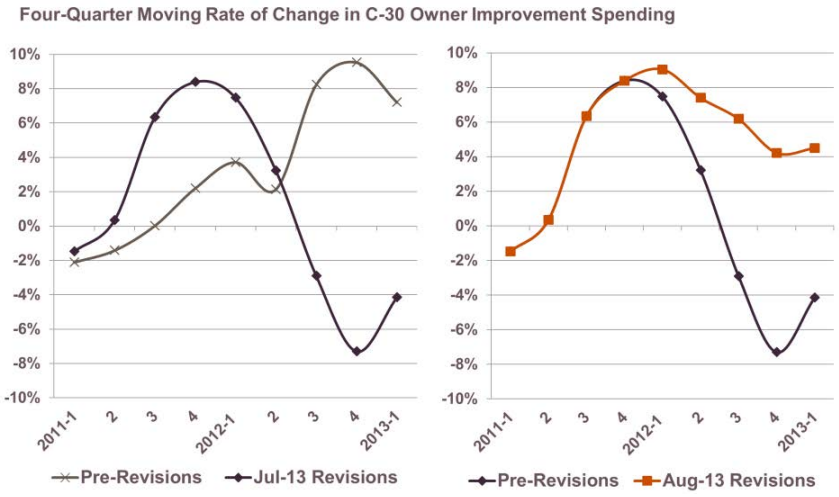
Figure 1: Census Estimates of Home Improvement Spending Are Volatile

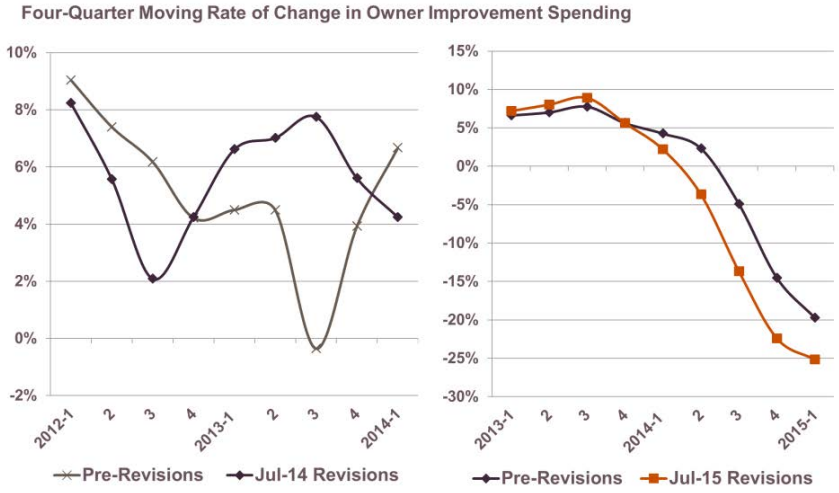


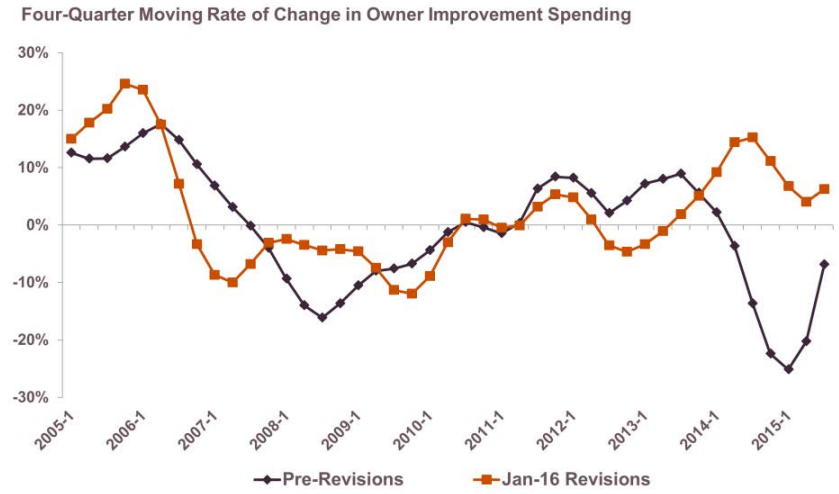
Sources: JCHS tabulations of US Department of Commerce, Monthly Retail Trade Report and US Census Bureau, Value of Private Construction Spending Put in Place (C-30).

Also, due to the nature of data collection, the monthly residential improvement estimates in the C-30 are based on partially reported data and forecasted data. Even the routine monthly revisions are based on yet incomplete reporting by survey respondents. For all of these reasons, the C-30 estimates have been subject to substantial revisions on both a monthly and annual basis. But in recent years the C-30 improvements data have become increasingly erratic and unreliable—as shown in Figure 2—and often subject to extraordinarily large and oftentimes perplexing revisions that go counter to other major indicators for the remodeling industry (Will 2013). The extreme nature of the data revisions over the past several years led to difficult decisions by the Joint Center to delay releasing a regularly scheduled LIRA in 2013 and to completely halt reporting of historical C-30 estimates as part of the LIRA releases by mid-2014. Although the Census' most recent major revision in January of this year corrected what was found to be a longstanding data processing error in the improvements estimation, the underlying volatility of the C-30 due to sample size, survey design and necessity of forecasting remains.

Figure 2: Revisions to C-30 Have Become Increasingly Extreme



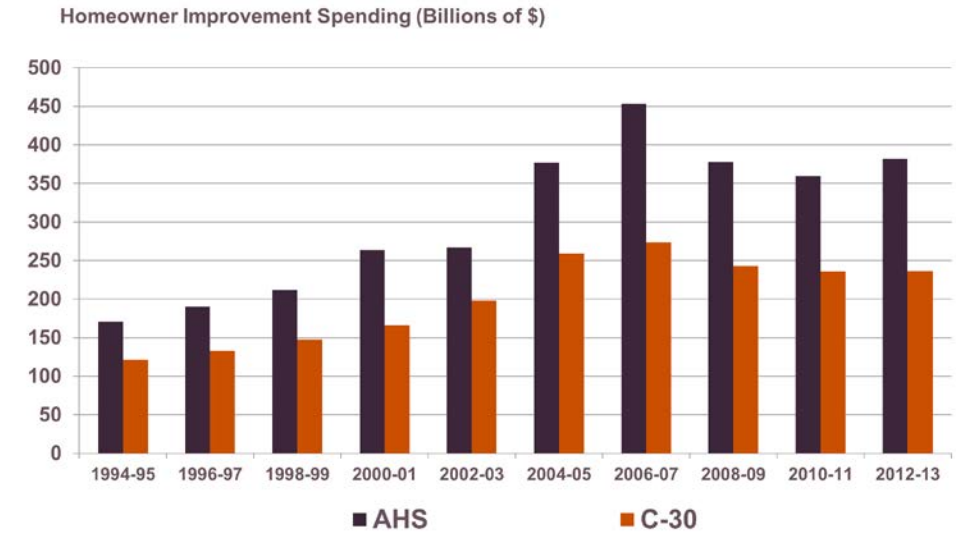




Source: JCHS tabulations of US Census Bureau, Value of Private Construction Spending Put in Place (C-30).

Another longstanding concern with the improvements data from the C-30 is the significant underestimation of national home improvement spending levels when compared to other sources, such as the American Housing Survey. A 2003 whitepaper from the Manufacturing and Construction Division of the Census Bureau investigated the differences in home remodeling data reported by the American Housing Survey and the C-30 source survey and found that improvement spending levels were about 50% larger in the AHS (Rappaport & Cole 2013). Joint Center tabulations of historical AHS and C-30 data from 1995-2013 confirm this finding (Figure 3).

Figure 3: AHS Estimates of Improvement Spending Are About 50% Larger than C-30



Sources: JCHS tabulations of HUD, American Housing Surveys and US Census Bureau, Construction Spending Value Put in Place (C-30).

The whitepaper identified several actual and possible sources of this immense difference in spending levels related to project classification, insurance payments, recent movers, respondent recall, survey procedures, sample design, and estimation procedures. Although the C-30 consistently underestimates total market spending, the trend in the improvement data seemed consistent with growth patterns in the AHS, again, until recently. The reporting of sizably different national remodeling market size estimates by the Remodeling Futures Program as part of the LIRA and in other major reports and working papers has

undoubtedly been confusing for the industry. In addition to drastic underreporting of improvement spending levels, the C-30 does not produce any estimates of home maintenance and repair activity unlike the American Housing Survey. Re-benchmarking to an AHS-based spending estimate would thus allow for a more comprehensive market size definition than is capable using the C-30.

A final motivation for re-benchmarking the LIRA at this time is that the housing and home improvement markets have gone through possibly the most severe cycles in their recorded histories since the LIRA was first released, and a comprehensive review of the LIRA model and its inputs for accuracy in projecting short-term trends is necessary. Although the LIRA inputs have been checked annually for changing correlations with the C-30 that might result in minor weight adjustments, it seems more fundamental changes have occurred in some market relationships post-housing crash and Great Recession. Already in mid-2014, the Remodeling Futures Program removed a financing input from the LIRA model due to a breakdown in the traditional relationship between low financing costs and remodeling activity during the downturn and recovery (Will 2014). Re-benchmarking the LIRA provides a good opportunity to test for other changing relationships and replace any inputs that have lost significant correlation with industry spending.

Creating Quarterly Series of Home Improvement and Repair Spending Based on Biennial Estimates from the American Housing Survey

This section outlines the methods utilized in creating a non-seasonally adjusted quarterly data series of nominal home improvement and repair spending based on the spending totals available in the biennial American Housing Survey (AHS). Although the AHS has been continuously conducted since the 1970s, a major overhaul of the home improvements module occurred with the 1995 survey, thus limiting the creation of a benchmark series to 1995. At the time of this analysis, the 2013 AHS is the most recent survey available. The benchmark series will be updated accordingly when the 2015 AHS is released later this year. Until that time, LIRA model estimations will serve as historical estimates. Homeowner spending for home improvements are recorded in the AHS for the prior two-year period, while

maintenance and repair spending is recorded for the prior year. The differentiation between spending categorized as home improvement (which might include remodeling, renovation, additions, major alterations or replacements of home components) is that improvement projects *add* value to a home, whereas maintenance and repair projects simply *preserve* the current value of the home.

In creating a quarterly home improvement data series, the first consideration is how to distribute a two-year nominal spending total into annual levels. Typically, the Joint Center has reported annual averages for national improvement spending from the AHS, assuming that half of homeowners undertake projects in one year and half in the other year of the two-year reporting period. This is, of course, a simplistic assumption and undoubtedly inaccurate especially for two-year periods that include the peak or trough of a spending cycle. Assuming zero annual market growth every two years is also problematic for correlating with industry indicators that are collected monthly or quarterly and thus exhibit much more granular variation across time periods.

It was decided that annual spending levels could be estimated by allocating the two-year levels in the AHS according to the distribution of spending in a related indicator, one which has historically correlated very highly with home improvement spending. An obvious candidate is the Department of Commerce's retail sales at building materials and supplies dealers, whose four-quarter moving rate of change has a correlation coefficient of 0.73 with the rate of change in the C-30 between 1994 and 2013.[5] This strong positive correlation coefficient suggests retail sales of building materials tend to move in the same direction as home remodeling spending and should serve as a good proxy for allocating annual spending levels from the two-year AHS figures. The results of such an allocation are reported in Table 1.

[5] Other indicators were tested for high coincident correlation with the C-30, but retail sales had the highest correlation coefficient in addition to the closest theoretical relationship that retail sales of building materials are a fairly direct measure of remodeling spending.

Table 1: Estimating Annual Home Improvement Market Size Estimates

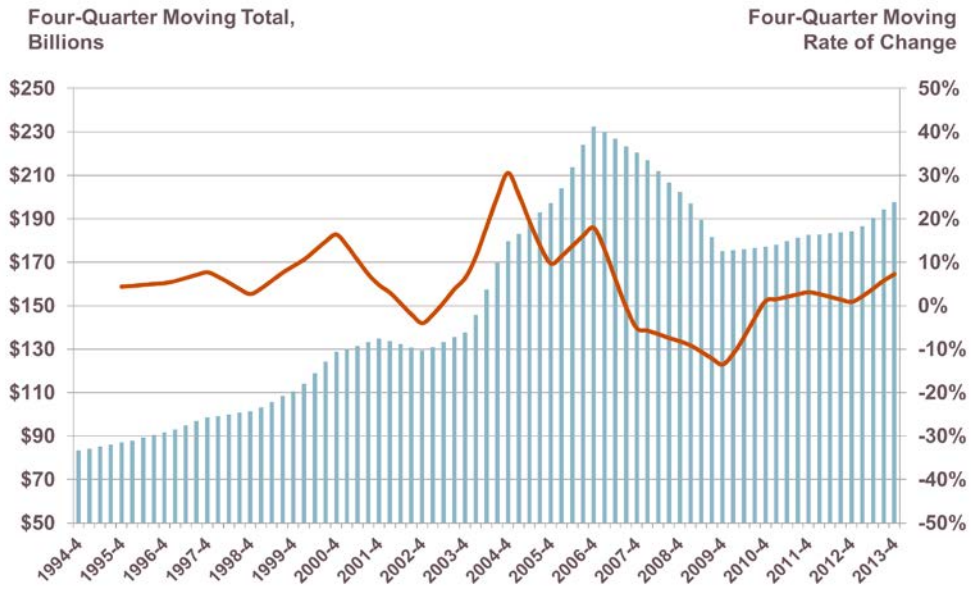
	AHS Improvements (Bil. $)		Retail Sales of Building Materials (Bil. $)	Distribution of 2-Year Retail Sales	Application of Retail Sales Distribution to 2-Year AHS Improvements (Bil. $)
		1994	135.1	48.9%	83.4
1994-95	170.5	1995	141.0	51.1%	87.1
		1996	150.5	48.1%	91.6
1996-97	190.3	1997	162.1	51.9%	98.7
		1998	172.2	47.8%	101.3
1998-99	211.9	1999	187.9	52.2%	110.6
		2000	197.6	48.8%	128.7
2000-01	263.5	2001	207.0	51.2%	134.8
		2002	217.2	48.5%	129.4
2002-03	267.1	2003	231.0	51.5%	137.6
		2004	261.2	47.7%	179.7
2004-05	376.9	2005	286.6	52.3%	197.2
		2006	299.4	51.3%	232.5
2006-07	453.0	2007	283.8	48.7%	220.4
		2008	263.2	53.6%	202.4
2008-09	377.5	2009	227.7	46.4%	175.1
		2010	226.0	49.2%	177.0
2010-11	359.5	2011	233.0	50.8%	182.5
		2012	242.6	48.2%	184.1
2012-13	381.7	2013	260.3	51.8%	197.6

Sources: JCHS tabulations of HUD, American Housing Surveys and Department of Commerce, Retail Sales at Building Materials and Supplies Dealers.

The final step in creating a quarterly home improvement data series based on biennial AHS estimates is to allocate the manufactured annual data using the quarterly seasonal factors in the C-30 series, which are produced using the X-13 ARIMA-SEATS quarterly seasonal adjustment program (Appendix Table A-1). The seasonal factors represent how much each quarterly spending level is above or below the annual trend, or average quarterly spending, for the calendar year. For ease of calculation, the distribution of the average quarterly seasonal factors for 1994-2013 was chosen to be applied to the manufactured annual home improvement spending data instead of individual seasonal factors for each quarter (Appendix Table A-2). Figure 4 presents the historical four-quarter moving total and rate of change in the manufactured AHS-based data series on home improvement spending, which will serve as the

benchmark for the improvements LIRA model. According to this created data series, national improvement spending was $83 billion in 1994 in nominal dollars, annual spending peaked during the previous cycle in 2006 at $233 billion, and by 2013 improvements had recovered to $198 billion. The annual rate of change in improvement spending over the past two decades ranged from a high of +30.6% in 2004 during the housing and remodeling boom to a low of -13.5% in 2009 during the worst of the market downturn.

Figure 4: Quarterly Home Improvement Spending Constructed Using AHS, Retail Sales and C-30

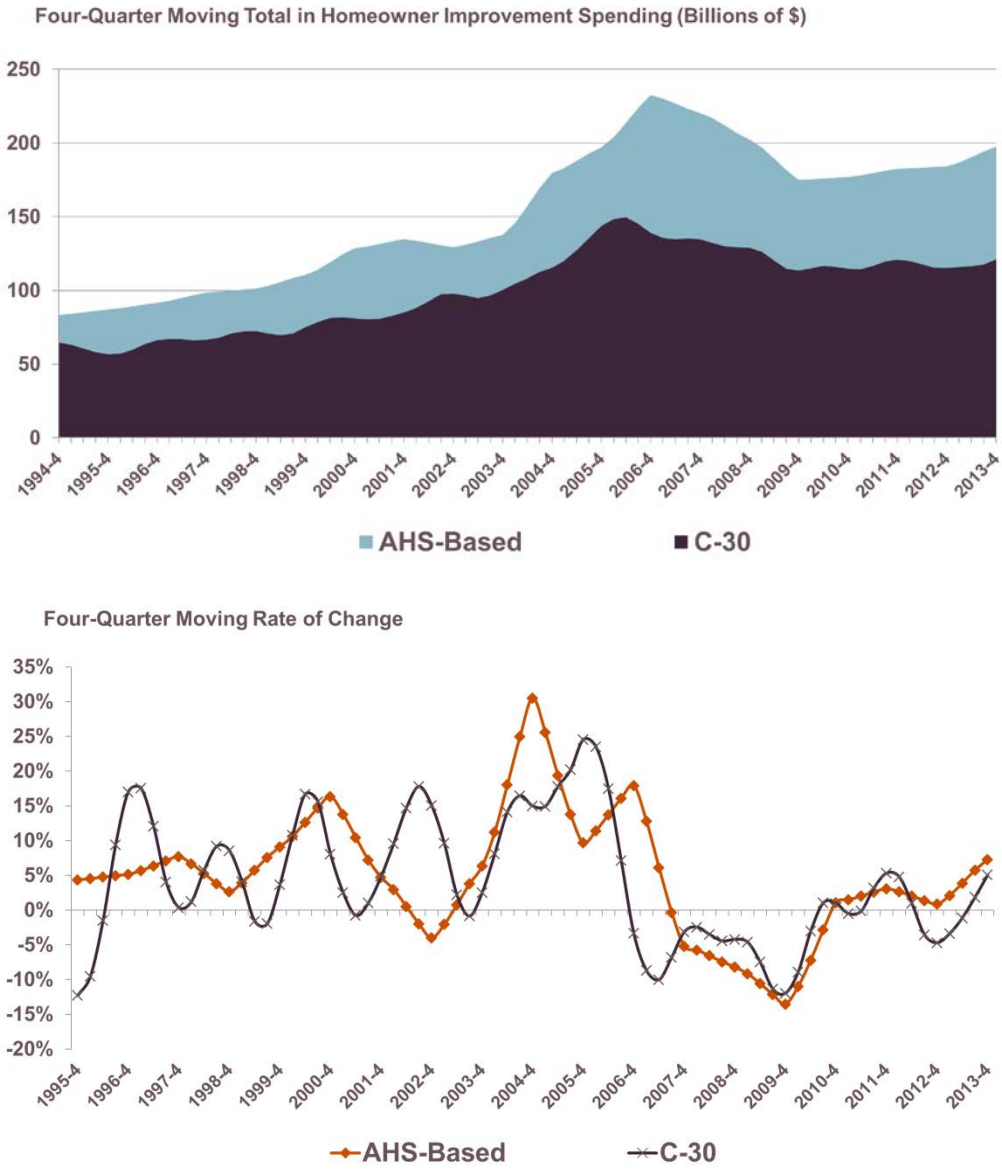


Sources: JCHS calculations using HUD, American Housing Surveys; Department of Commerce, Retail Sales of Building Materials; and US Census Bureau, Construction Spending Value Put in Place (C-30).

Figure 5 compares the manufactured AHS-based data series to the C-30 in both level and rate of change. The AHS-based benchmark is considerably larger than the C-30 and the difference in level has widened in the years since the housing bust from an average of under $40 billion between 1994 and 2005 to an average of over $70 billion between 2005 and 2013. Annual spending levels peaked just slightly later in the AHS-based benchmark in the fourth quarter of 2006 compared to the second quarter in the C-30, and both series bottomed-out in the fourth quarter of 2009. Overall, the two data series exhibit similar cyclical trends, especially since the last peak in the market, though the AHS-based benchmark is historically much less

volatile than the C-30, exhibiting more stable growth or decline from quarter to quarter. Spending through 2013 also recovered faster in the AHS-based data than the C-30.

Figure 5: Comparison of Manufactured Improvements Benchmark and C-30



Sources: JCHS calculations using HUD, American Housing Surveys; Department of Commerce, Retail Sales of Building Materials; and US Census Bureau, Construction Spending Value Put in Place (C-30).

A similar procedure was used to create a quarterly maintenance and repair expenditure series based on the annual data available in the American Housing Survey. As in creating the

improvements series, trends in retail sales of building materials were used in estimating maintenance spending for years in which AHS data is not available. However, since maintenance data is only collected annually every other year, the objective was to annually distribute two-year *growth rates* in maintenance and repair spending. This was accomplished by applying the two-year distribution of absolute growth in the level of retail sales to the two-year growth rate in the AHS repair spending levels (Table 2).

Table 2: Estimating Annual Home Maintenance and Repair Market Size

	AHS Maintenance and Repair (Bil. $)	2-Year Growth in Maintenance and Repair	Retail Sales of Building Materials (Bil. $)	Absolute Annual Change in Retail Sales (Bil. $)	Distribution of 2-Year Absolute Growth in Retail Sales	Application of Retail Sales Distribution to 2-Year AHS Growth	Application of Annualized AHS Growth to Maintenance and Repair (Bil. $)
1995	23.0		141.0				23.0
1996	NA		150.5	9.4	44.8%	6.4%	24.4
1997	26.2	14.2%	162.1	11.6	55.2%	7.8%	26.2
1998	NA		172.2	10.1	39.2%	6.5%	27.9
1999	30.6	16.5%	187.9	15.7	60.8%	10.0%	30.6
2000	NA		197.6	9.7	50.9%	6.3%	32.5
2001	34.3	12.4%	207.0	9.4	49.1%	6.1%	34.3
2002	NA		217.2	10.2	42.4%	3.3%	35.5
2003	37.0	7.8%	231.0	13.8	57.6%	4.5%	37.0
2004	NA		261.2	30.2	54.3%	8.6%	40.2
2005	42.8	15.8%	286.6	25.4	45.7%	7.2%	42.8
2006	NA		299.4	12.8	45.1%	3.1%	44.2
2007	45.8	6.9%	283.8	15.5	54.9%	3.8%	45.8
2008	NA		263.2	20.7	36.8%	1.2%	46.4
2009	47.3	3.3%	227.7	35.5	63.2%	2.1%	47.3
2010	NA		226.0	1.7	19.6%	0.9%	47.8
2011	49.5	4.6%	233.0	7.0	80.4%	3.7%	49.5
2012	NA		242.6	9.7	35.3%	1.8%	50.4
2013	52.1	5.2%	260.3	17.7	64.7%	3.3%	52.1

Note: NA - not available.

Sources: JCHS tabulations of HUD, American Housing Surveys and Department of Commerce, Retail Sales at Building Materials and Supplies Dealers.

The manufactured annual maintenance and repair spending series was then allocated into quarterly estimates using the same seasonal factors procedure as in allocating the annual improvements data. The seasonal factors used for allocating maintenance and repair spending, however, were produced using the Census Bureau's historical maintenance and repair data

from the discontinued Survey of Residential Alterations and Repairs Statistics, or C-50 series (Appendix Table A-3). Again for ease of calculation and because the C-50 was discontinued in 2007, the distribution of the average quarterly seasonal factors for 1995-2007 was chosen to be applied to the manufactured annual home maintenance spending data instead of individual seasonal factors for each quarter (Appendix Table A-4).

Figure 6 presents the historical four-quarter moving total and rate of change in the manufactured AHS-based data series on home maintenance and repair spending, which will serve as the benchmark for the maintenance LIRA model. According to this created data series, national maintenance and repair spending has grown remarkably steady over the past two decades from $23 billion in 1995, in nominal dollars, to $52 billion by 2013. Unlike the improvements data, maintenance spending is much less cyclical. The annual growth in home maintenance spending ranged from a high of +9.4% in 1999 to a low of +0.9% in 2010, not turning negative even once during the 1995-2013 period.

Figure 6: Quarterly Home Maintenance Spending Constructed Using AHS, Retail Sales and C-50

Sources: JCHS calculations using HUD, American Housing Surveys; Department of Commerce, Retail Sales of Building Materials; and US Census Bureau, Survey of Residential Alterations and Repairs (C-50).

Re-Benchmarked LIRA Models and Inputs

As noted in the previous section, home improvement activity differs from maintenance and repair activity in meaningful ways, namely improvement spending adds to a home's value, while maintenance spending merely upholds the current value. For this reason, maintenance spending tends to be for more frequent, smaller projects for most households, and therefore very stable across time. Improvement spending, on the other hand, tends to be for larger and more infrequent projects for most homeowners, and results in a much more cyclical trend over time. Surely, some home improvement projects cannot be put off for too long, such as replacing a worn out furnace or hot water heater, but many other projects could be postponed for much longer time frames, such as kitchen or bathroom upgrades. With such different trends, it is expected that improvement and repair spending will be influenced by somewhat different economic indicators. This is the main reason two leading indicator models were developed to project improvement and repair activity separately before combining the outputs of the two models for a unified outlook of the broader improvement and repair market.

The LIRA models for home improvements and maintenance, respectively, are both computed as weighted averages of the moving four-quarter rates of change of their input components. A four-quarter, or annual, rate of change is the ratio that results when the total activity in any given four-quarter period is divided by the total activity that occurred in the prior four quarter period. This calculation results in a rate of change that measures annual (year-over-year) changes in activity levels on a quarterly basis. The final inputs of the LIRA models were determined by the strength of their correlations with the measures of homeowner improvements and maintenance and repair expenditures created by the Remodeling Futures Program based on data available in the American Housing Survey, as described in the previous section. Inputs with strong and highly significant correlation coefficients received greater weight, while inputs with high variability (as measured by the standard deviation) received lesser weight. To be exact, inputs with strong correlation to the benchmark series, but low variation received the greatest weight, while those with weaker correlation and higher variation received the least weight in calculating the LIRA rates of change for improvements and maintenance spending.

Description of Improvements Model:

The same procedures were followed in creating a LIRA model benchmarked to the AHS-based estimates of homeowner improvement spending as were used when the C-30 was the reference series. A variety of economic indicators that are thought to influence, or drive, remodeling spending were identified and tested for correlation with the AHS-based data at various lead times in number of quarters. As expected, many of the indicators previously included in the LIRA model also exhibited strong correlation with the AHS-based data. However, a couple inputs that formerly correlated well with the C-30 had much weaker associations to the new benchmark series. These indicators were thus dropped from the LIRA model, including the Institute of Supply Management's Purchasing Managers' Index and NAHB's Remodeling Market Index.[6]

About 45 economic variables were considered as potential inputs to the LIRA improvements model, covering a variety of economic activity including remodeling market conditions, housing industry conditions, house price appreciation and equity measures, broader financial market conditions, consumer and professional confidence, and macroeconomic and cyclical activity. Many input candidates were dismissed due to low correlation coefficients (<0.50) and more were dismissed even with relatively high correlation due to extreme volatility, limited data history for testing (in particular, history that did not cover a complete business cycle or roughly less than 10 years), or extremely high cross-correlations with other potential inputs. A description of the final input variables used to compute the re-benchmarked improvements LIRA is found in Table 3. New additions to the model include CoreLogic's House Price Index, the Conference Board's Leading Economic Index, NAR's Existing Home Sales, and BuildFax' Residential Remodeling Permits.

[6] NAR's Pending Home Sales Index was also replaced, but with a very similar measure, existing home sales, which exhibited a stronger correlation with the same four-quarter lead.

Table 3: Description of Final Improvements LIRA Model Inputs

Indicator	Mnemonic	Source	Definition
Remodeling Market Conditions			
Residential Remodeling Permits	Permits	BuildFax	Number of properties permitted for remodeling or repair.
Housing Industry Conditions			
Retail Sales of Building Materials	Retail	Census	Value of retail sales of new building materials and supplies.
Single-Family Housing Starts	Starts	Census	New privately-owned single-family housing starts.
Single-Family Existing Home Sales	Sales	National Association of Realtors®	Single-family existing home sales based on sample of MLS.
Financial Conditions			
House Price Index	HPI	CoreLogic	Repeat-sales index of single-family homes.
Macroeconomic & Cyclical Conditions			
Leading Economic Index®	LEI	The Conference Board	Composite economic index averaging trends in manufacturing hours and new orders, unemployment claims, vendor performance, housing permits, stock prices, money supply, interest rate spread, and consumer expectations.

The correlation results and associated lead times for the final inputs, including significance levels, are found in Table 4. A simple correlation between the four-quarter rates of change in each indicator and the rates of change in homeowner improvements was calculated at varying lead times over two decades from 1994 to 2013. For each input, the lead time that produced the highest correlation with the AHS-based improvements data is outlined in the table.

Table 4: Correlation Coefficients with AHS-Based Home Improvements Spending, 1994Q1 to 2013Q4

	Lead in Number of Quarters:	L(0)	L(1)	L(2)	L(3)	L(4)	L(5)	L(6)
1	Retail Sales of Bldg. Mats.	**0.8088**	**0.8422**	**0.8171**	**0.7407**	**0.6462**	**0.5602**	**0.4864**
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	House Price Index	**0.8157**	**0.8184**	**0.7898**	**0.7319**	**0.6523**	**0.5591**	**0.4594**
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
3	Leading Economic Index	**0.7042**	**0.7325**	**0.7021**	**0.6276**	**0.5327**	**0.4386**	**0.3480**
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0029
4	Remodeling Permits	**0.5923**	**0.6894**	**0.7571**	**0.7872**	**0.7885**	**0.7719**	**0.7322**
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5	Housing Starts	**0.4682**	**0.5832**	**0.6747**	**0.7292**	**0.7436**	**0.7247**	**0.6773**
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	Existing Home Sales	**0.3516**	**0.4701**	**0.5797**	**0.6647**	**0.7207**	**0.7478**	**0.7378**
		0.0023	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Notes: The correlations for remodeling permits were calculated for a shorter time period, 2000-2013, due to input data limitations. The significance level of each correlation coefficient is reported in the line below the coefficient as a p-value indicating the level of confidence that the correlation is not equal to zero, or the probability that the correlation coefficient would have arisen if the indicator and home improvement spending were unrelated.

The next step in creating a LIRA model involves the calculation of the input weights. Again, inputs with higher correlations to the AHS-based benchmark series and lower standard deviations will have greater weight in calculating the final improvements LIRA estimates. The weight calculations are described in Table 5. The input given the greatest weight is retail sales of building materials at 19.5% due mainly to its high correlation with the benchmark series at

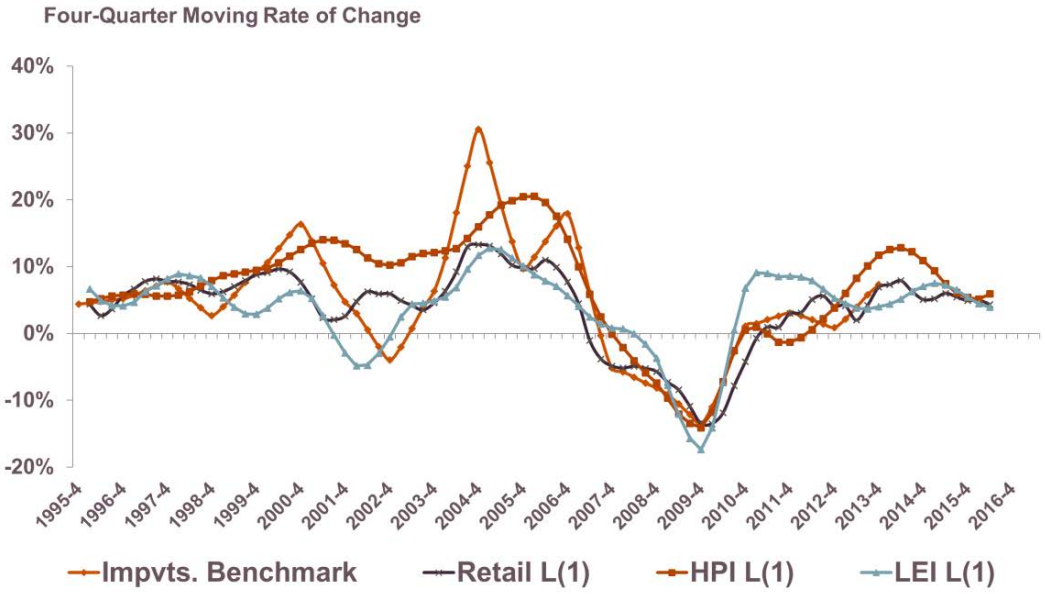
0.84, which is expected since the two-year trend in retail sales was used to estimate the annual improvement spending levels in the benchmark series. The input given the lowest weight is single-family housing starts at 12.0% mainly due to its relatively high standard deviation. See Appendix Table A-5 for the historical four-quarter moving rates of change for each input variable included in the improvements LIRA model.

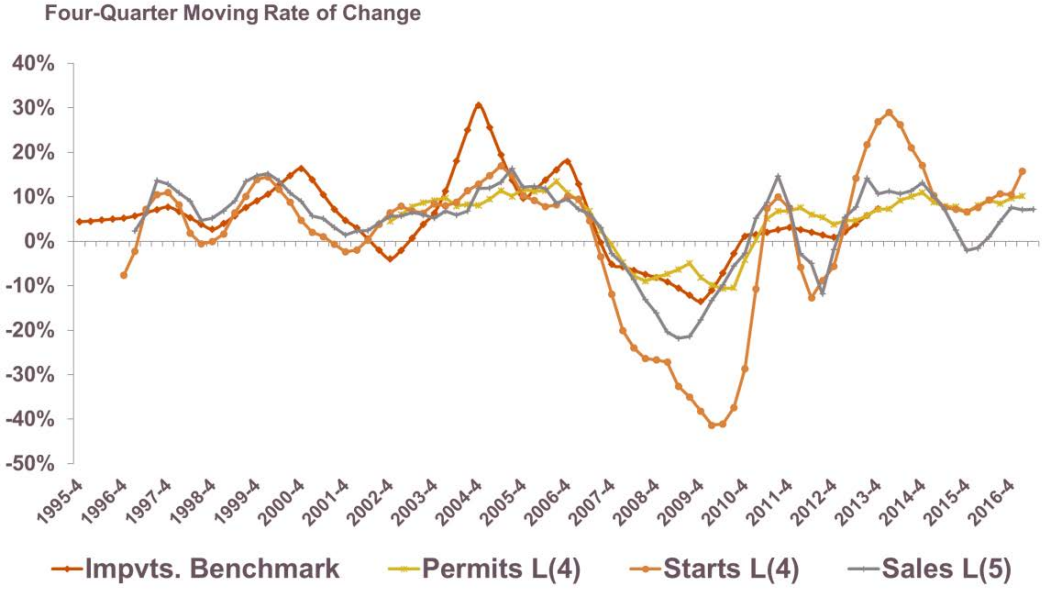
Table 5: Calculation of Improvement LIRA Weights

	Retail	HPI	LEI	Permits	Starts	Sales
Lead over AHS-based Improvements Spending (number of quarters)	L(1)	L(1)	L(1)	L(4)	L(4)	L(5)
Standard Deviation (SD)	0.064	0.084	0.062	0.070	0.167	0.095
1/SD	15.612	11.887	16.123	14.259	5.984	10.563
Share of Sum of 1/SD	21.0%	16.0%	21.7%	19.2%	8.0%	14.2%
Correlation with AHS-based Improvements Spending	0.842	0.818	0.733	0.789	0.744	0.748
Share of Sum of Correlations	18.0%	17.5%	15.7%	16.9%	15.9%	16.0%
Improvement LIRA Weights	**19.5%**	**16.7%**	**18.7%**	**18.0%**	**12.0%**	**15.1%**

Figure 7 compares the final improvements model inputs to the reference spending series at the quarterly leads that produce the strongest correlation. Again, the weighted average of these inputs produces the LIRA estimates and projections as seen in Figure 8 compared to the AHS-based benchmark data series. The improvements LIRA tracks the reference series very closely, but is significantly less volatile, especially during the previous industry boom. The LIRA and its benchmark have a correlation coefficient of 0.85 (p-value of 0.00) and a simple regression of the LIRA output on the benchmark spending series results in an R-squared value of 0.6955, which suggests that 70% of the variation, or movement, in the improvements spending benchmark can be explained by the LIRA model.

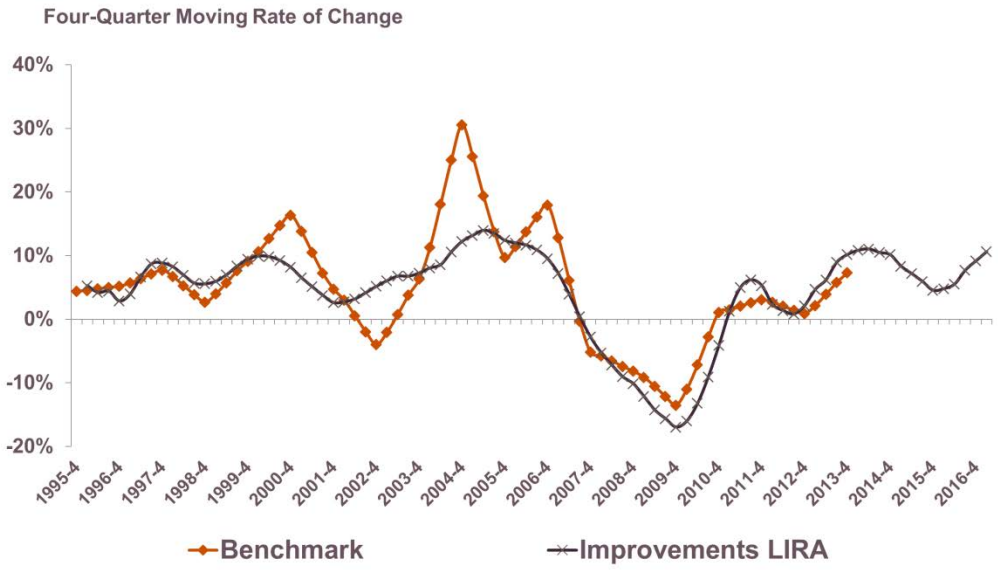
Figure 7: Improvements LIRA Inputs Compared to Benchmark





Sources: JCHS tabulations of HUD, American Housing Surveys; Department of Commerce, Retail Sales of Building Materials; CoreLogic, House Price Index; The Conference Board, Leading Economic Index®; BuildFax Residential Remodeling Permits, Census Bureau, New Residential Construction Statistics; and NAR®, Existing Home Sales.

Figure 8: LIRA Tracks AHS-Based Improvements Data Closely, Much Less Volatile During Boom



Sources: JCHS calculations using HUD, American Housing Surveys; Department of Commerce, Retail Sales of Building Materials; and US Census Bureau, Construction Spending Value Put in Place (C-30); Leading Indicator of Remodeling Activity.

Description of Maintenance & Repair Model:

The maintenance and repair LIRA model was constructed in a similar way as the improvements model. A simple correlation between the four-quarter rates of change in each tested indicator and the rates of change in homeowner maintenance and repair spending was calculated at varying lead times over two decades from 1995 to 2013. Several indicators included in the improvements model also exhibited strong correlation with the AHS-based home maintenance data. A description of the input variables chosen to compute the maintenance LIRA is found in Table 6, and the correlation coefficients and associated lead times for the inputs, including significance levels, are found in Table 7. Again, the lead time for each input that produced the highest correlation with the AHS-based repair data is outlined in the table.

Table 6: Description of Final Maintenance LIRA Model Inputs

Indicator	Mnemonic	Source	Definition
Housing Industry Conditions			
Retail Sales of Building Materials	Retail	Census	Value of retail sales of new building materials and supplies.
Single-Family Existing Home Sales	Sales	National Association of Realtors®	Single-family existing home sales based on sample of MLS.
Financial Conditions			
Median Sales Price	Prices	National Association of Realtors®	Existing single-family homes.
Macroeconomic Conditions			
Gross Domestic Product	GDP	Bureau of Economic Analysis	Value of gross domestic product.
Leading Economic Index®	LEI	The Conference Board	Composite economic index averaging trends in manufacturing hours and new orders, unemployment claims, vendor performance, housing permits, stock prices, money supply, interest rate spread, and consumer expectations.

Table 7: Correlation Coefficients with AHS-Based Home Maintenance Spending, 1995Q1 to 2013Q4

	Lead in Number of Quarters:	L(0)	L(1)	L(2)	L(3)	L(4)	L(5)	L(6)
1	GDP	**0.7451**	**0.7354**	**0.7154**	**0.6780**	**0.6208**	**0.5451**	**0.4553**
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
2	Retail Sales of Bldg. Mats.	**0.7417**	**0.7516**	**0.7440**	**0.7195**	**0.6865**	**0.6468**	**0.5986**
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	Home Sales Price	**0.5555**	**0.5773**	**0.6041**	**0.6291**	**0.6436**	**0.6377**	**0.6069**
		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4	Leading Economic Index	**0.4606**	**0.4799**	**0.4957**	**0.5076**	**0.5095**	**0.4907**	**0.4446**
		0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
5	Existing Home Sales	**0.4148**	**0.4672**	**0.5250**	**0.5848**	**0.6370**	**0.6700**	**0.6699**
		0.0004	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000

Notes: The significance level of each correlation coefficient is reported in the line below the coefficient as a p-value indicating the level of confidence that the correlation is not equal to zero, or the probability that the correlation coefficient would have arisen if the indicator and home maintenance spending were unrelated. GDP correlated slightly better with a one quarter lag to maintenance and repair spending with a coefficient of 0.7457, but preference was given to the coincident timing in this case.

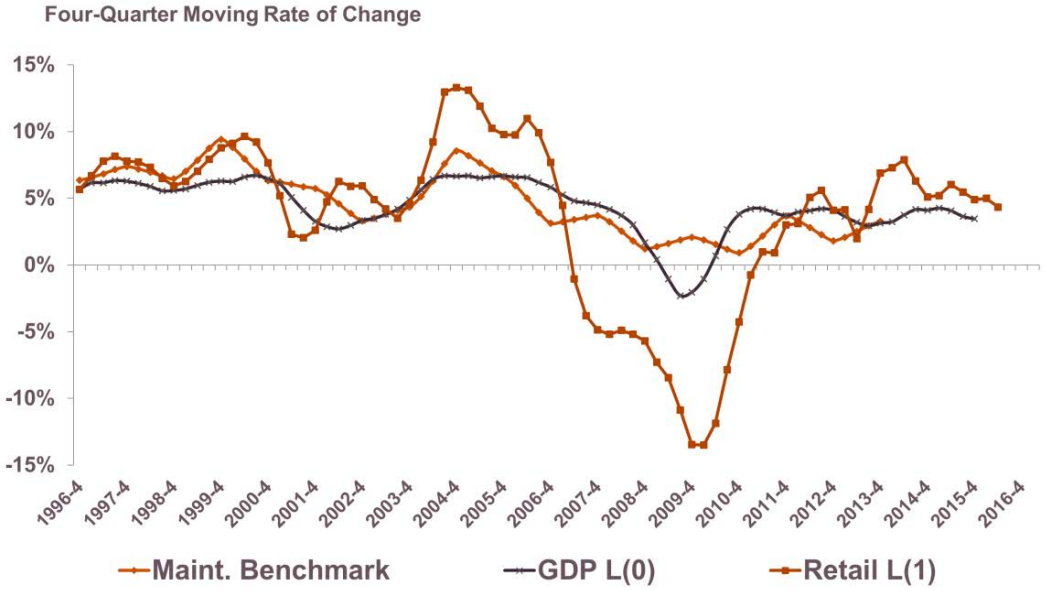
The weight calculations for the maintenance model inputs are described in Table 8. The input given the greatest weight is GDP at 33.7% due equally to its incredibly low standard deviation and relatively high correlation. See Appendix Table A-6 for the historical four-quarter moving rates of change for each input variable included in the maintenance and repair LIRA model.

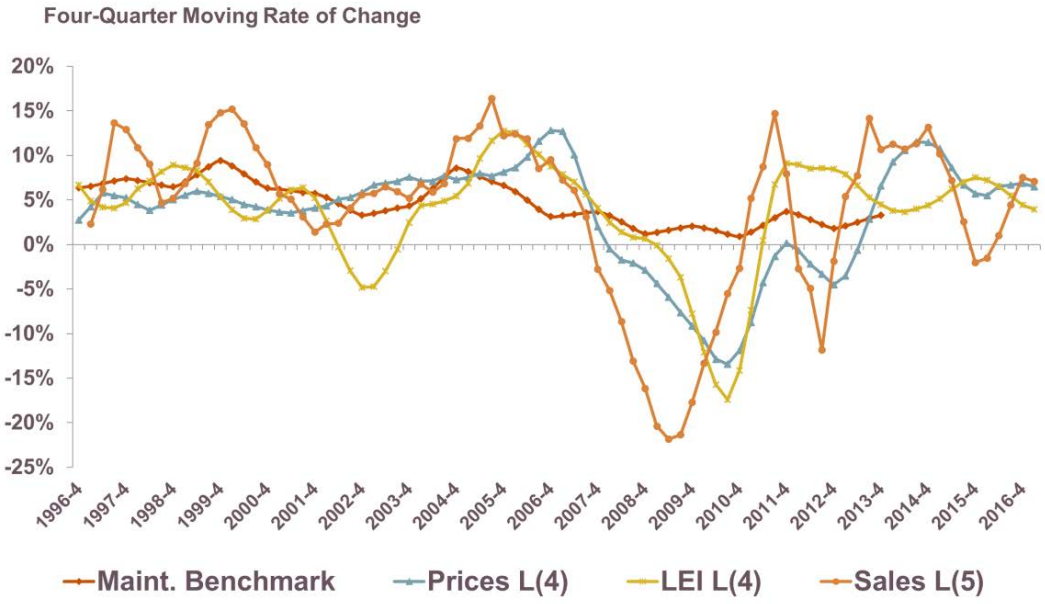
Table 8: Calculation of Maintenance LIRA Weights

	GDP	Retail	Prices	LEI	Sales
Lead over AHS-based Maintenance Spending (number of quarters)	L(0)	L(1)	L(4)	L(4)	L(4)
Standard Deviation (SD)	0.021	0.066	0.064	0.064	0.096
1/SD	46.619	15.188	15.591	15.708	10.410
Share of Sum of 1/SD	45.0%	14.7%	15.1%	15.2%	10.1%
Correlation with AHS-based Maintenance Spending	0.745	0.752	0.644	0.510	0.670
Share of Sum of Correlations	22.4%	22.6%	19.4%	15.3%	20.2%
Maintenance LIRA Weights	**33.7%**	**18.7%**	**17.2%**	**15.3%**	**15.1%**

Figure 9 compares the final inputs chosen for the maintenance and repair LIRA model to its AHS-based benchmark spending series. Although most of the maintenance model inputs are considerably more cyclical than the benchmark data, the weight placed on the most stable input, GDP, will moderate much of this volatility by design. Figure 10 compares the weighted average output of the maintenance and repair LIRA model to its reference series. The maintenance LIRA also tracks its benchmark fairly well, but was much more volatile during the last market boom and bust. This is not surprising considering how extreme the most recent boom and bust was for many of the model inputs, which suffered the worst downturns in their recorded histories after the housing crash and during the Great Recession. The maintenance and repair LIRA and its reference series have a correlation coefficient of 0.76 (p-value of 0.00) and a simple regression of the LIRA output on the benchmark results in an R-squared value of 0.5737, which suggests that about 60% of the movement in the home maintenance and repair spending benchmark can be explained by this LIRA model.

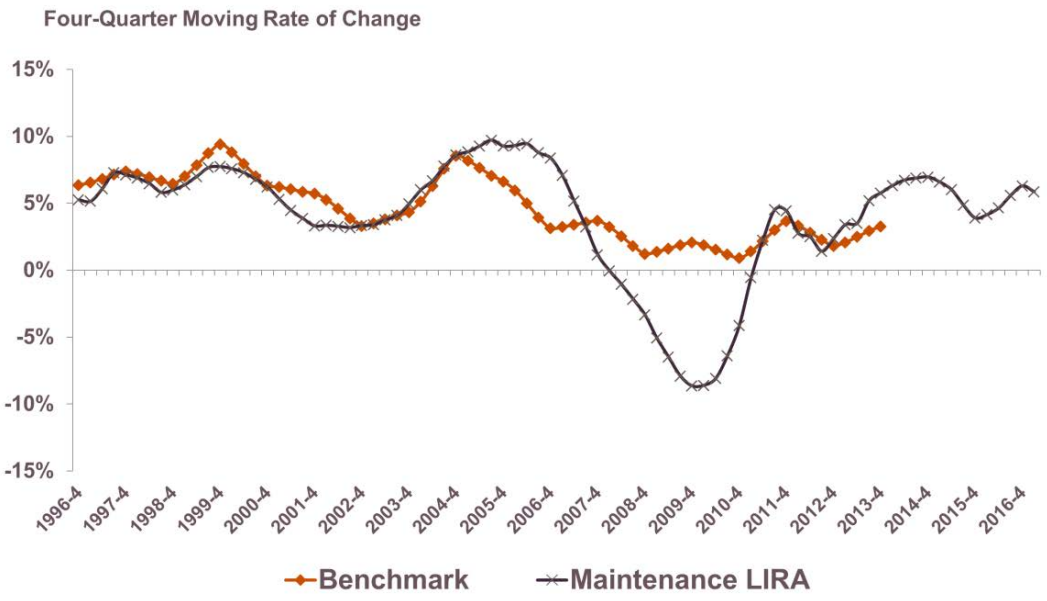
Figure 9: Maintenance LIRA Inputs Compared to Benchmark





Sources: JCHS tabulations of HUD, American Housing Surveys; Bureau of Economic Analysis, Gross Domestic Product; Department of Commerce, Retail Sales of Building Materials; The Conference Board, Leading Economic Index®; and NAR®, Median Sales Price and Existing Home Sales.

Figure 10: Maintenance LIRA Exaggerates Impact of Previous Market Boom and Bust

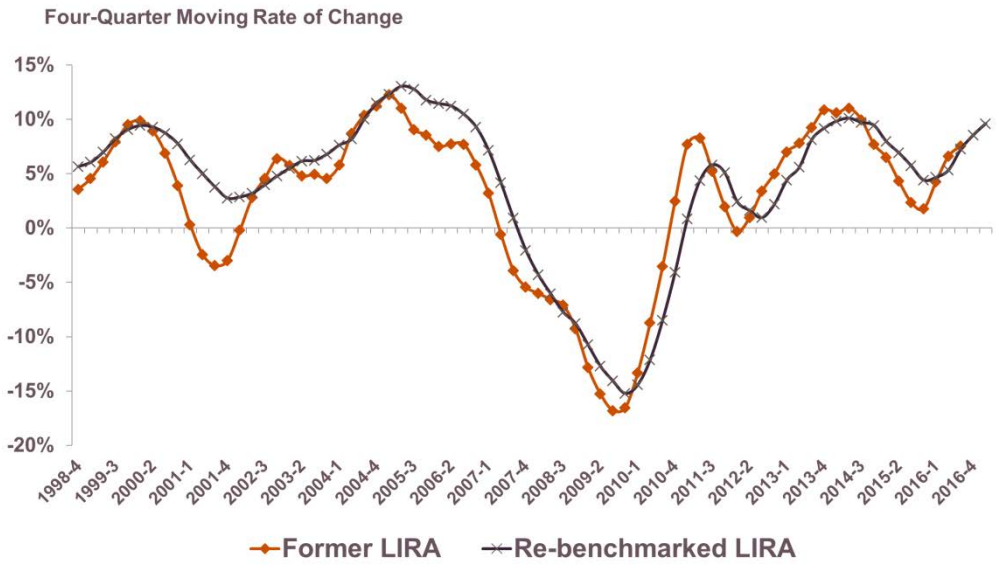


Sources: JCHS calculations using HUD, American Housing Surveys; Department of Commerce, Retail Sales of Building Materials; and US Census Bureau, Survey of Residential Alterations and Repairs (C-50); Leading Indicator of Remodeling Activity.

Comparison of Former and Re-Benchmarked LIRAs

As expected, combining the output from the re-benchmarked improvements and maintenance and repair LIRA models results in an overall smoother trajectory compared to the LIRA model benchmarked to improvements data alone from the C-30 (Figure 11).

Figure 11: Broadening Market Definition to Include Home Maintenance Smoothes Re-Benchmarked LIRA



Notes: The former LIRA modeled homeowner improvement activity only, while the re-benchmarked LIRA models improvement and repair activity.
Source: Joint Center for Housing Studies.

The re-benchmarked LIRA improves upon the former LIRA in several ways including the ability to now project trends in the broader national home improvement and repair market. The re-benchmarked LIRA also projects trends with a time horizon of four quarters, whereas the former LIRA was able to project out only three quarters. As presented in Figure 10, the newly re-benchmarked LIRA anticipates strong growth for remodeling spending to the owner-occupied housing stock moving into next year. After experiencing slowing growth through 2015, the LIRA predicts national remodeling spending will increase 8.6% this year with further acceleration of annual growth into the start of 2017. Home improvement and repair spending levels are expected to reach nearly $325 billion by then.

Figure 12: Re-Benchmarked LIRA Projecting Strong Growth for Remodeling Market into 2017

Notes: The former LIRA modeled homeowner improvement activity only, while the re-benchmarked LIRA models home improvement and repair activity. Historical estimates are produced using the LIRA model until American Housing Survey data become available.
Source: Joint Center for Housing Studies.

Conclusion

The Leading Indicator of Remodeling Activity (LIRA) was first developed by the Joint Center for Housing Studies to project near-term trends in home remodeling activity using the Census Bureau's C-30 and C-50 estimates as reference series. For many reasons, but mainly the increasingly extreme revisions to the Census data in recent years, the Joint Center pursued a re-benchmarking of the LIRA to a reference series based on improvement and repair spending reported in the American Housing Survey (AHS). The former LIRA projected trends in home improvement spending only, whereas the re-benchmarked LIRA now tracks a broader remodeling market that includes both improvements and maintenance and repair activity. For this reason, the re-benchmarked LIRA is overall somewhat less cyclical, but still appears to anticipate turning points in the industry well. Ultimately, the re-benchmarked LIRA with stronger inputs should produce projections that are more closely aligned with actual changes in home improvement and repair activity.

References

Bendimerad, Amal. 2007. *Developing a Leading Indicator for the Remodeling Industry.* Joint Center for Housing Studies of Harvard University Research Note N07-1.

Rappaport, Barry A. and Tamara A. Cole. 2003. *Research into the Differences in Home Remodeling Data: American Housing Survey and Consumer Expenditure Survey/C50 Report.* U.S. Census Bureau, Manufacturing and Construction Division. Available: http://www.census.gov/const/www/ahs_c50remodelingresearchpaper.pdf.

Will, Abbe. 2008. *Addendum to Research Note N07-1: Re-Benchmarking the Leading Indicator of Remodeling Activity.* Joint Center for Housing Studies of Harvard University Research Note N08-1.

Will, Abbe. 2013. "Census Bureau Remodeling Data Revisions Out of Sync with Other Market Indicators." Web log post. *Housing Perspectives.* Joint Center for Housing Studies of Harvard University. 17 July. Available: http://housingperspectives.blogspot.com/2013/07/census-bureau-remodeling-data-revisions.html.

Will, Abbe. 2014. "Favorable Financing Costs Not Impacting Remodeling Activity During Recovery." Web log post. *Housing Perspectives.* Joint Center for Housing Studies of Harvard University. 17 April. Available: http://housingperspectives.blogspot.com/2014/04/favorable-financing-costs-not-impacting.html.

Appendix

Table A-1: Final Seasonal Factors of Improvement Spending Levels in C-30 Produced by X-13 ARIMA-SEATS

From:	1994.1 to 2015.4
Observations:	88
Seasonal filter:	3 x 3 moving average

Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	AVERAGE
1994	78.03	113.01	116.68	92.36	100.02
1995	77.86	113.18	116.49	92.63	100.04
1996	77.52	113.53	116.00	93.34	100.10
1997	76.91	113.97	115.12	94.54	100.13
1998	76.27	114.29	114.00	96.16	100.18
1999	75.55	114.34	113.14	97.51	100.14
2000	75.18	113.81	113.33	98.10	100.11
2001	74.90	112.69	114.81	97.73	100.03
2002	75.14	110.92	117.00	96.90	99.99
2003	75.77	109.07	118.61	96.21	99.92
2004	77.00	107.62	119.15	95.65	99.85
2005	78.33	106.98	118.87	95.31	99.87
2006	79.15	106.94	118.66	95.13	99.97
2007	79.17	106.98	118.68	95.56	100.10
2008	78.64	106.86	118.62	96.40	100.13
2009	78.13	106.70	118.19	97.29	100.08
2010	77.93	106.85	117.39	97.81	100.00
2011	78.03	107.35	116.39	97.85	99.91
2012	78.50	108.23	115.12	97.43	99.82
2013	79.26	109.42	113.80	96.55	99.75

2014	80.18	110.73	112.77	95.41	99.77
2015	80.91	111.73	112.30	94.50	99.86
1994-2015 AVERAGE	77.65	110.24	116.14	95.93	
1994-2013 AVERAGE	**77.36**	**110.14**	**116.50**	**96.02**	
Distribution of Sum of 1994-2013 AVERAGE	**19.3%**	**27.5%**	**29.1%**	**24.0%**	
Table Total-	8799.07	**Mean-**	99.99	**Std. Dev.-**	15.0
		Min -	74.9	**Max -**	119.15

Notes: Seasonal factors were calculated using historical C-30 improvement spending levels revised in January 2016. Although the desired output was the average quarterly factors from 1994-2013, the most recent data available through 2015 was included with the understanding that it would result in more accurate estimations historically.

Source: JCHS run of X-13 ARIMA-SEATS program on Census Bureau, Construction Spending Value Put in Place (C-30) data reporting output from table D10.

Table A-2: Manufactured Quarterly Home Improvement Market Size Estimates

			Home Improvements		
	Home Improvements (Bil. $)		Application of Seasonal Factor Distribution (Bil. $)	Four-Quarter Moving Total (Bil. $)	Four-Quarter Moving Rate of Change (%)
		19941	16.1		
		19942	23.0		
		19943	24.3		
1994	83.4	19944	20.0	83.4	
		19951	16.8	84.1	
		19952	24.0	85.2	
		19953	25.4	86.2	
1995	87.1	19954	20.9	87.1	0.04389
		19961	17.7	88.0	0.04548
		19962	25.2	89.2	0.04770
		19963	26.7	90.5	0.04999
1996	91.6	19964	22.0	91.6	0.05183
		19971	19.1	93.0	0.05694
		19972	27.2	94.9	0.06404
		19973	28.7	97.0	0.07134
1997	98.7	19974	23.7	98.7	0.07720
		19981	19.6	99.2	0.06688
		19982	27.9	99.9	0.05270
		19983	29.5	100.7	0.03833
1998	101.3	19984	24.3	101.3	0.02693
		19991	21.4	103.1	0.03964
		19992	30.5	105.7	0.05751
		19993	32.2	108.4	0.07613
1999	110.6	19994	26.5	110.6	0.09126
		20001	24.9	114.1	0.10625
		20002	35.4	119.1	0.12672
		20003	37.5	124.3	0.14733
2000	128.7	20004	30.9	128.7	0.16356
		20011	26.1	129.9	0.13823
		20012	37.1	131.5	0.10473
		20013	39.3	133.3	0.07221
2001	134.8	20014	32.4	134.8	0.04741
		20021	25.0	133.7	0.02991
		20022	35.6	132.3	0.00552
		20023	37.7	130.7	-0.01960
2002	129.4	20024	31.1	129.4	-0.03980
		20031	26.6	131.0	-0.02048
		20032	37.9	133.3	0.00756
		20033	40.1	135.7	0.03791
2003	137.6	20034	33.0	137.6	0.06348

		20041	34.8	145.8	0.11266
		20042	49.5	157.4	0.18066
		20043	52.3	169.6	0.25012
2004	179.7	20044	43.1	179.7	0.30555
		20051	38.1	183.1	0.25589
		20052	54.3	187.9	0.19406
		20053	57.4	193.0	0.13784
2005	197.2	20054	47.3	197.2	0.09726
		20061	45.0	204.0	0.11433
		20062	64.0	213.7	0.13758
		20063	67.7	224.0	0.16092
2006	232.5	20064	55.8	232.5	0.17924
		20071	42.6	230.2	0.12829
		20072	60.7	226.9	0.06139
		20073	64.2	223.3	-0.00306
2007	220.4	20074	52.9	220.4	-0.05189
		20081	39.1	217.0	-0.05742
		20082	55.7	212.0	-0.06550
		20083	59.0	206.7	-0.07430
2008	202.4	20084	48.6	202.4	-0.08176
		20091	33.9	197.1	-0.09136
		20092	48.2	189.6	-0.10557
		20093	51.0	181.7	-0.12135
2009	175.1	20094	42.0	175.1	-0.13497
		20101	34.2	175.5	-0.10989
		20102	48.7	176.0	-0.07177
		20103	51.6	176.6	-0.02802
2010	177.0	20104	42.5	177.0	0.01103
		20111	35.3	178.1	0.01492
		20112	50.3	179.6	0.02043
		20113	53.2	181.2	0.02622
2011	182.5	20114	43.8	182.5	0.03097
		20121	35.6	182.8	0.02659
		20122	50.7	183.3	0.02046
		20123	53.6	183.8	0.01408
2012	184.1	20124	44.2	184.1	0.00891
		20131	38.2	186.7	0.02138
		20132	54.4	190.4	0.03906
		20133	57.5	194.3	0.05767
2013	197.6	20134	47.4	197.6	0.07293

Sources: JCHS tabulations of HUD, American Housing Surveys; Department of Commerce, Retail Sales at Building Materials and Supplies Dealers; and Census Bureau, Construction Spending Value Put in Place (C-30).

Table A-3: Final Seasonal Factors of Maintenance and Repair Spending Levels in C-50 Produced by X-13 ARIMA-SEATS

From:	1965.1 to 2007.4				
Observations:	172				
Seasonal filter:	3 x 5 moving average				
Year	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**	**AVERAGE**
1995	67.75	113.30	122.15	97.10	100.08
1996	67.00	113.47	123.18	95.93	99.90
1997	67.55	113.12	123.93	94.87	99.87
1998	68.52	112.28	124.71	93.90	99.85
1999	69.78	111.57	124.08	94.35	99.95
2000	71.00	110.50	122.91	95.63	100.01
2001	71.95	109.60	121.38	97.18	100.03
2002	72.93	108.23	120.63	98.29	100.02
2003	73.54	107.63	119.96	98.30	99.86
2004	75.15	106.82	119.08	98.34	99.85
2005	76.45	106.67	118.36	97.61	99.77
2006	78.02	106.47	117.56	97.62	99.92
2007	78.45	106.87	117.03	97.33	99.92
1965-2007 AVERAGE	71.00	112.45	123.64	92.90	
1995-2007 AVERAGE	**72.16**	**109.73**	**121.15**	**96.65**	
Distribution of Sum of 1995-2007 AVERAGE	**18.1%**	**27.5%**	**30.3%**	**24.2%**	
Table Total-	17199.06	**Mean-**	99.99	**Std. Dev.-**	20.6
		Min -	65.33	**Max -**	132.79

Notes: Seasonal factors were calculated using historical C-50 maintenance and repair spending levels from 1965-2007, although the desired output was the average quarterly factors from 1995-2007, because the more complete data should result in more accurate estimations.

Source: JCHS run of X-13 ARIMA-SEATS program on Census Bureau, Survey of Residential Alterations and Repairs (C-50) data reporting output from table D10.

Table A-4: Manufactured Quarterly Home Maintenance Market Size Estimates

			Home Maintenance and Repair		
	Home Maintenance and Repair (Bil. $)		Application of Seasonal Factor Distribution (Bil. $)	Four-Quarter Moving Total (Bil. $)	Four-Quarter Moving Rate of Change (%)
		19951	4.1		
		19952	6.3		
		19953	7.0		
1995	23.0	19954	5.6	23.0	
		19961	4.4	23.2	
		19962	6.7	23.6	
		19963	7.4	24.1	
1996	24.4	19964	5.9	24.4	0.06362
		19971	4.7	24.8	0.06554
		19972	7.2	25.2	0.06837
		19973	7.9	25.8	0.07139
1997	26.2	19974	6.3	26.2	0.07371
		19981	5.0	26.5	0.07198
		19982	7.7	27.0	0.06942
		19983	8.5	27.5	0.06671
1998	27.9	19984	6.8	27.9	0.06463
		19991	5.5	28.4	0.07024
		19992	8.4	29.1	0.07853
		19993	9.3	29.9	0.08735
1999	30.6	19994	7.4	30.6	0.09415
		20001	5.9	30.9	0.08815
		20002	8.9	31.4	0.07939
		20003	9.8	32.0	0.07021
2000	32.5	20004	7.9	32.5	0.06323
		20011	6.2	32.8	0.06210
		20012	9.4	33.3	0.06043
		20013	10.4	33.9	0.05864
2001	34.3	20014	8.3	34.3	0.05726
		20021	6.4	34.5	0.05269
		20022	9.7	34.9	0.04591
		20023	10.8	35.2	0.03867
2002	35.5	20024	8.6	35.5	0.03306
		20031	6.7	35.8	0.03498
		20032	10.2	36.2	0.03785
		20033	11.2	36.6	0.04097
2003	37.0	20034	9.0	37.0	0.04341
		20041	7.3	37.6	0.05129
		20042	11.0	38.5	0.06305
		20043	12.2	39.4	0.07571

2004	40.2	20044	9.7	40.2	0.08559
		20051	7.7	40.7	0.08186
		20052	11.8	41.4	0.07639
		20053	13.0	42.2	0.07065
2005	42.8	20054	10.4	42.8	0.06626
		20061	8.0	43.1	0.05961
		20062	12.1	43.5	0.04980
		20063	13.4	43.9	0.03936
2006	44.2	20064	10.7	44.2	0.03132
		20071	8.3	44.5	0.03235
		20072	12.6	44.9	0.03391
		20073	13.9	45.4	0.03559
2007	45.8	20074	11.1	45.8	0.03692
		20081	8.4	45.9	0.03233
		20082	12.7	46.1	0.02547
		20083	14.1	46.2	0.01805
2008	46.4	20084	11.2	46.4	0.01225
		20091	8.5	46.6	0.01381
		20092	13.0	46.8	0.01616
		20093	14.4	47.1	0.01875
2009	47.3	20094	11.4	47.3	0.02080
		20101	8.6	47.4	0.01864
		20102	13.1	47.5	0.01538
		20103	14.5	47.7	0.01182
2010	47.8	20104	11.6	47.8	0.00902
		20111	8.9	48.1	0.01406
		20112	13.6	48.6	0.02170
		20113	15.0	49.1	0.03009
2011	49.5	20114	12.0	49.5	0.03675
		20121	9.1	49.7	0.03331
		20122	13.8	49.9	0.02816
		20123	15.3	50.2	0.02260
2012	50.4	20124	12.2	50.4	0.01824
		20131	9.4	50.7	0.02091
		20132	14.3	51.2	0.02494
		20133	15.8	51.7	0.02935
2013	52.1	20134	12.6	52.1	0.03282

Sources: JCHS tabulations of HUD, American Housing Surveys; Department of Commerce, Retail Sales at Building Materials and Supplies Dealers; and Census Bureau, Survey of Residential Alterations and Repairs (C-50).

Table A-5: Four-Quarter Moving Rates of Change in Input Variables to Improvements LIRA

	Retail	HPI	LEI	Permits	Starts	Sales
1995-4	0.0439	0.0476	0.0666	NA	-0.0762	0.0231
1996-1	0.0267	0.0521	0.0488	NA	-0.0226	0.0619
1996-2	0.0366	0.0556	0.0420	NA	0.0723	0.1363
1996-3	0.0565	0.0574	0.0410	NA	0.1047	0.1290
1996-4	0.0668	0.0595	0.0467	NA	0.1099	0.1086
1997-1	0.0779	0.0586	0.0628	NA	0.0821	0.0904
1997-2	0.0815	0.0556	0.0712	NA	0.0178	0.0470
1997-3	0.0779	0.0556	0.0820	NA	-0.0059	0.0518
1997-4	0.0772	0.0570	0.0893	NA	-0.0009	0.0685
1998-1	0.0733	0.0624	0.0862	NA	0.0164	0.0912
1998-2	0.0648	0.0714	0.0832	NA	0.0642	0.1346
1998-3	0.0592	0.0791	0.0704	NA	0.1013	0.1478
1998-4	0.0625	0.0863	0.0535	NA	0.1391	0.1521
1999-1	0.0702	0.0892	0.0390	NA	0.1445	0.1356
1999-2	0.0792	0.0915	0.0293	NA	0.1169	0.1085
1999-3	0.0877	0.0947	0.0287	NA	0.0877	0.0896
1999-4	0.0913	0.0973	0.0378	NA	0.0468	0.0570
2000-1	0.0965	0.1056	0.0517	NA	0.0200	0.0510
2000-2	0.0921	0.1156	0.0614	NA	0.0106	0.0309
2000-3	0.0766	0.1253	0.0637	NA	-0.0070	0.0141
2000-4	0.0518	0.1348	0.0524	NA	-0.0234	0.0230
2001-1	0.0231	0.1403	0.0267	NA	-0.0195	0.0242
2001-2	0.0205	0.1397	-0.0026	NA	0.0020	0.0410
2001-3	0.0260	0.1345	-0.0294	NA	0.0382	0.0557
2001-4	0.0474	0.1258	-0.0482	0.0447	0.0639	0.0572
2002-1	0.0626	0.1130	-0.0473	0.0596	0.0788	0.0648
2002-2	0.0591	0.1044	-0.0296	0.0784	0.0681	0.0595
2002-3	0.0593	0.1024	-0.0054	0.0871	0.0635	0.0521
2002-4	0.0491	0.1054	0.0247	0.0919	0.0840	0.0679
2003-1	0.0419	0.1151	0.0441	0.0973	0.0802	0.0590
2003-2	0.0350	0.1197	0.0454	0.0794	0.0879	0.0682
2003-3	0.0458	0.1211	0.0489	0.0827	0.1134	0.1188
2003-4	0.0635	0.1235	0.0544	0.0811	0.1288	0.1193
2004-1	0.0921	0.1270	0.0688	0.0949	0.1477	0.1329
2004-2	0.1296	0.1423	0.0965	0.1139	0.1694	0.1637
2004-3	0.1330	0.1597	0.1168	0.1013	0.1488	0.1221
2004-4	0.1309	0.1773	0.1276	0.1169	0.1029	0.1240
2005-1	0.1191	0.1920	0.1258	0.1123	0.0922	0.1184
2005-2	0.1025	0.1983	0.1127	0.1136	0.0777	0.0854
2005-3	0.0978	0.2044	0.1011	0.1347	0.0821	0.0951
2005-4	0.0973	0.2053	0.0880	0.1083	0.1012	0.0721
2006-1	0.1097	0.1962	0.0786	0.0916	0.0952	0.0608
2006-2	0.0990	0.1754	0.0703	0.0680	0.0461	0.0308
2006-3	0.0769	0.1407	0.0566	0.0236	-0.0348	-0.0275
2006-4	0.0446	0.0997	0.0409	-0.0078	-0.1189	-0.0518

2007-1	-0.0104	0.0587	0.0247	-0.0474	-0.2008	-0.0862
2007-2	-0.0381	0.0245	0.0140	-0.0777	-0.2394	-0.1307
2007-3	-0.0487	-0.0009	0.0081	-0.0890	-0.2635	-0.1614
2007-4	-0.0519	-0.0214	0.0067	-0.0818	-0.2662	-0.2037
2008-1	-0.0490	-0.0407	-0.0007	-0.0733	-0.2720	-0.2182
2008-2	-0.0521	-0.0592	-0.0158	-0.0637	-0.3259	-0.2135
2008-3	-0.0570	-0.0739	-0.0368	-0.0496	-0.3502	-0.1772
2008-4	-0.0728	-0.0968	-0.0777	-0.0815	-0.3815	-0.1333
2009-1	-0.0844	-0.1205	-0.1208	-0.0983	-0.4134	-0.0986
2009-2	-0.1088	-0.1348	-0.1569	-0.1063	-0.4108	-0.0553
2009-3	-0.1347	-0.1410	-0.1740	-0.1041	-0.3739	-0.0265
2009-4	-0.1350	-0.1182	-0.1411	-0.0415	-0.2869	0.0520
2010-1	-0.1188	-0.0723	-0.0734	0.0030	-0.1068	0.0874
2010-2	-0.0785	-0.0260	0.0045	0.0513	0.0741	0.1469
2010-3	-0.0426	0.0048	0.0675	0.0681	0.1002	0.0791
2010-4	-0.0075	0.0097	0.0912	0.0681	0.0747	-0.0274
2011-1	0.0097	-0.0008	0.0899	0.0761	-0.0583	-0.0492
2011-2	0.0091	-0.0134	0.0852	0.0599	-0.1268	-0.1184
2011-3	0.0300	-0.0130	0.0859	0.0543	-0.0882	-0.0187
2011-4	0.0310	-0.0064	0.0846	0.0382	-0.0566	0.0541
2012-1	0.0505	0.0057	0.0790	0.0456	0.0346	0.0772
2012-2	0.0560	0.0223	0.0662	0.0474	0.1421	0.1414
2012-3	0.0410	0.0381	0.0528	0.0579	0.2169	0.1066
2012-4	0.0415	0.0601	0.0448	0.0717	0.2689	0.1124
2013-1	0.0199	0.0821	0.0381	0.0728	0.2903	0.1072
2013-2	0.0416	0.1012	0.0367	0.0914	0.2622	0.1133
2013-3	0.0689	0.1172	0.0401	0.1010	0.2105	0.1314
2013-4	0.0729	0.1255	0.0441	0.1100	0.1706	0.1019

Notes: NA - not available. The LIRA is computed as a weighted average of the nominal rates of change in its inputs. All of the LIRA inputs are real indicators (except for retail sales), which are converted to nominal with an adjustment by CPI-U.

Source: JCHS tabulations of source data as described in Table 3.

Table A-6: Four-Quarter Moving Rates of Change in Input Variables to Maintenance LIRA

	GDP	Retail	Prices	LEI	Sales
1996-4	0.0569	0.0668	0.0522	0.0467	0.1086
1997-1	0.0615	0.0779	0.0449	0.0628	0.0904
1997-2	0.0616	0.0815	0.0385	0.0712	0.0470
1997-3	0.0633	0.0779	0.0446	0.0820	0.0518
1997-4	0.0628	0.0772	0.0505	0.0893	0.0685
1998-1	0.0611	0.0733	0.0553	0.0862	0.0912
1998-2	0.0588	0.0648	0.0597	0.0832	0.1346
1998-3	0.0556	0.0592	0.0575	0.0704	0.1478
1998-4	0.0558	0.0625	0.0541	0.0535	0.1521
1999-1	0.0571	0.0702	0.0506	0.0390	0.1356
1999-2	0.0597	0.0792	0.0448	0.0293	0.1085
1999-3	0.0621	0.0877	0.0424	0.0287	0.0896
1999-4	0.0629	0.0913	0.0391	0.0378	0.0570
2000-1	0.0626	0.0965	0.0367	0.0517	0.0510
2000-2	0.0659	0.0921	0.0356	0.0614	0.0309
2000-3	0.0670	0.0766	0.0382	0.0637	0.0141
2000-4	0.0646	0.0518	0.0411	0.0524	0.0230
2001-1	0.0609	0.0231	0.0434	0.0267	0.0242
2001-2	0.0508	0.0205	0.0511	-0.0026	0.0410
2001-3	0.0410	0.0260	0.0531	-0.0294	0.0557
2001-4	0.0328	0.0474	0.0582	-0.0482	0.0572
2002-1	0.0288	0.0626	0.0670	-0.0473	0.0648
2002-2	0.0270	0.0591	0.0690	-0.0296	0.0595
2002-3	0.0296	0.0593	0.0709	-0.0054	0.0521
2002-4	0.0335	0.0491	0.0756	0.0247	0.0679
2003-1	0.0349	0.0419	0.0711	0.0441	0.0590
2003-2	0.0378	0.0350	0.0710	0.0454	0.0682
2003-3	0.0419	0.0458	0.0770	0.0489	0.1188
2003-4	0.0486	0.0635	0.0730	0.0544	0.1193
2004-1	0.0563	0.0921	0.0755	0.0688	0.1329
2004-2	0.0641	0.1296	0.0799	0.0965	0.1637
2004-3	0.0667	0.1330	0.0766	0.1168	0.1221
2004-4	0.0664	0.1309	0.0813	0.1276	0.1240
2005-1	0.0668	0.1191	0.0864	0.1258	0.1184
2005-2	0.0652	0.1025	0.0980	0.1127	0.0854
2005-3	0.0662	0.0978	0.1163	0.1011	0.0951
2005-4	0.0667	0.0973	0.1280	0.0880	0.0721
2006-1	0.0658	0.1097	0.1272	0.0786	0.0608
2006-2	0.0654	0.0990	0.1009	0.0703	0.0308
2006-3	0.0617	0.0769	0.0602	0.0566	-0.0275
2006-4	0.0582	0.0446	0.0202	0.0409	-0.0518
2007-1	0.0526	-0.0104	-0.0049	0.0247	-0.0862
2007-2	0.0480	-0.0381	-0.0174	0.0140	-0.1307
2007-3	0.0466	-0.0487	-0.0206	0.0081	-0.1614
2007-4	0.0449	-0.0519	-0.0287	0.0067	-0.2037
2008-1	0.0417	-0.0490	-0.0435	-0.0007	-0.2182

2008-2	0.0372	-0.0521	-0.0590	-0.0158	-0.2135
2008-3	0.0300	-0.0570	-0.0763	-0.0368	-0.1772
2008-4	0.0166	-0.0728	-0.0916	-0.0777	-0.1333
2009-1	0.0042	-0.0844	-0.1080	-0.1208	-0.0986
2009-2	-0.0105	-0.1088	-0.1285	-0.1569	-0.0553
2009-3	-0.0229	-0.1347	-0.1345	-0.1740	-0.0265
2009-4	-0.0204	-0.1350	-0.1189	-0.1411	0.0520
2010-1	-0.0105	-0.1188	-0.0872	-0.0734	0.0874
2010-2	0.0069	-0.0785	-0.0428	0.0045	0.1469
2010-3	0.0266	-0.0426	-0.0131	0.0675	0.0791
2010-4	0.0378	-0.0075	0.0014	0.0912	-0.0274
2011-1	0.0421	0.0097	-0.0066	0.0899	-0.0492
2011-2	0.0422	0.0091	-0.0217	0.0852	-0.1184
2011-3	0.0392	0.0300	-0.0333	0.0859	-0.0187
2011-4	0.0370	0.0310	-0.0452	0.0846	0.0541
2012-1	0.0396	0.0505	-0.0354	0.0790	0.0772
2012-2	0.0407	0.0560	-0.0063	0.0662	0.1414
2012-3	0.0421	0.0410	0.0286	0.0528	0.1066
2012-4	0.0411	0.0415	0.0658	0.0448	0.1124
2013-1	0.0363	0.0199	0.0928	0.0381	0.1072
2013-2	0.0319	0.0416	0.1059	0.0367	0.1133
2013-3	0.0294	0.0689	0.1150	0.0401	0.1314
2013-4	0.0314	0.0729	0.1146	0.0441	0.1019

Notes: The LIRA is computed as a weighted average of the nominal rates of change in its inputs. Some of the LIRA inputs are real indicators (number of home sales and macroeconomic index), which are converted to nominal with an adjustment by CPI-U.

Source: JCHS tabulations of source data as described in Table 6.