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# Actuarial Values of Housing Markets

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# The Geneva Association

Singapore Actuarial Society

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## Acknowledgments

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# Why the Housing Market?
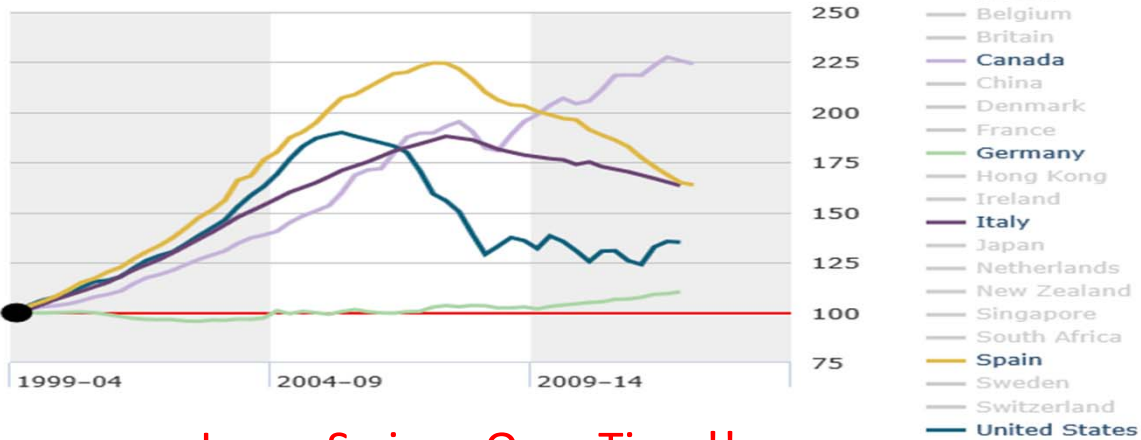
## Firstly the Size!

- ✓ US Residential Housing Value ≈ US$16 Trillion
- ✓ US GDP in 2013 ≈ US$ 16 Trillion
- ✓ 2006-2011 downturn loss in market value ≈ US$ 7 Trillion

- ➢ China GDP in 2013 ≈ US$ 8 Trillion
- ➢ China's Residential Housing Value ≈ 32 Trillion

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# Again, Why the Housing Market?

Q1 2000=100



| | |
|---|---|
| Australia | |
| Austria | |
| Belgium | |
| Britain | |
| **Canada** | |
| China | |
| Denmark | |
| France | |
| **Germany** | |
| Hong Kong | |
| Ireland | |
| **Italy** | |
| Japan | |
| Netherlands | |
| New Zealand | |
| Singapore | |
| South Africa | |
| **Spain** | |
| Sweden | |
| Switzerland | |
| **United States** | |

Large Swings Over Time!!

# A Practical Question

For mortgage lenders, traditional loan-to-value metrics can be unreliable. For example, 80% loan-to-value in June 2006 became 112% (or 184% in Las Vegas) loan-to-value in June 2010

**Case-Shiller Housing Price Index**
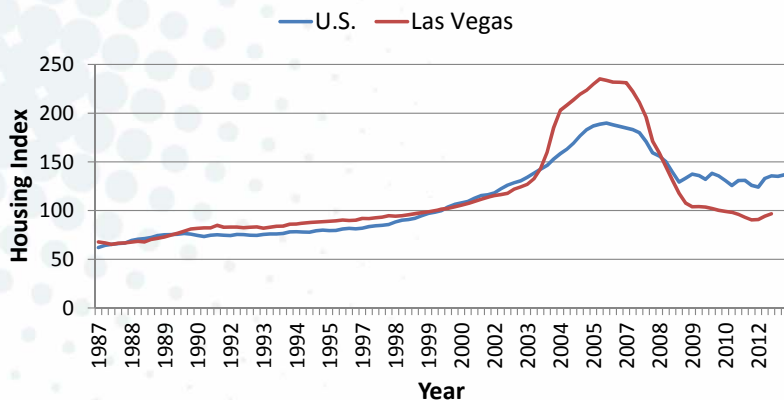


# Search for Counter Cyclical LTV

1. Mark-to-market is the culprit of the recent financial crisis
   - ✓ M2M of mortgage loans
   - ✓ M2M of MBS, CDOs, and $CDO^2$
2. Capital rules relying solely on market values cannot achieve counter-cyclical effects
3. We examine a candidate: the actuarial approach

# Actuarial Housing Value

1. We construct an actuarial housing value that incorporates a broader set of economic and demographic factors.

2. The resulting actuarial housing value is shown to be less volatile than market value, and more representative of housing's sustainable value.

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# Actuarial Housing Value Formulas (1)

$$QC(t) = \frac{HPI(t)}{HPI(t-1)} - 1$$

$$\overrightarrow{QC(t)} = \{QC(t-j), \quad where \quad j = 0,1,\dots,39\}$$

$$Cap(t) = E\left[\overrightarrow{QC(t)}\right] + \sigma\left[\overrightarrow{QC(t)}\right] - drift$$

$$Floor(t) = E\left[\overrightarrow{QC(t)}\right] - \sigma\left[\overrightarrow{QC(t)}\right] - drift$$

The Quarterly Housing Price Change is controlled within the range of [ Floor(t) , Cap(t) ]

$$AQC(t) = max\{Floor(t), min(QC(t), Cap(t))\}$$

## Actuarial Housing Value Formulas (2)

We adjust the Quarterly Change in housing price by constraining within the range of [ Floor(t) , Cap(t) ]

We use the Adjusted Quarterly Change to derive Actuarial Housing Value (AHV):

$$\widehat{QC}(t) = max\{Floor(t), min(QC(t), Cap(t))\}$$

$$AHV(t) = AHV(t-1) \cdot \widehat{QC}(t)$$

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## A Key of Calculating Actuarial Value

1. The unique strength of the Housing Actuarial Value method is derived from the inclusion of factors specific to the metro area being measured, through the use of the *drift* term.

2. The drift for any particular area is determined by several meaningful factors, such as construction cost, demographic distribution, migration, etc.

3. Some of these factors will be previewed on the following slides.

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## Data Used to Construct Actuarial Values

| Data | Data Source |
|---|---|
| Case-Shiller Index | S&P |
| Housing Market Inventory Supply | Zillow |
| Foreclosure Home % in Transaction | Zillow |
| Newly Applied Building Permit | Census Bureau & Texas A&M University |
| Housing Inventory | Zillow |
| Construction Cost | Marshall & Swift/Boeckh |
| Demographic Information | U.S. Census Bureau |
| Households with Age Information | U.S. Department of Housing and Urban Development |
| Household Income at Zip Level | Internal Revenue Service |
| U.S. Household Formation | U.S. Census Bureau |
| International Sale in Housing Market | National Association of Realtors |
| Mortgage Loan Standard | Ellie Mae Origination Insight Report |
| House Price at Zip Level | Zillow |

## Washington DC Housing Actuarial Value



Washington DC — Case-Shiller, Actuarial Value

Detroit Housing Actuarial Value



Los Angeles Housing Actuarial Value

Phoenix Housing Actuarial Value



U.S. Housing Actuarial Value
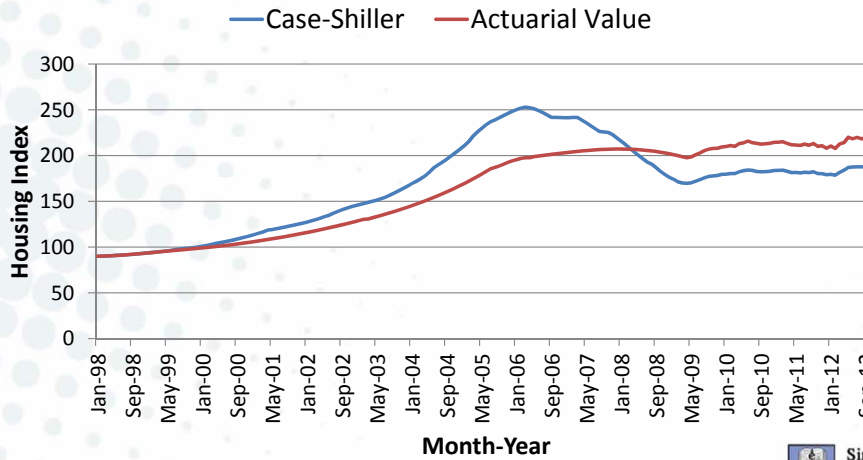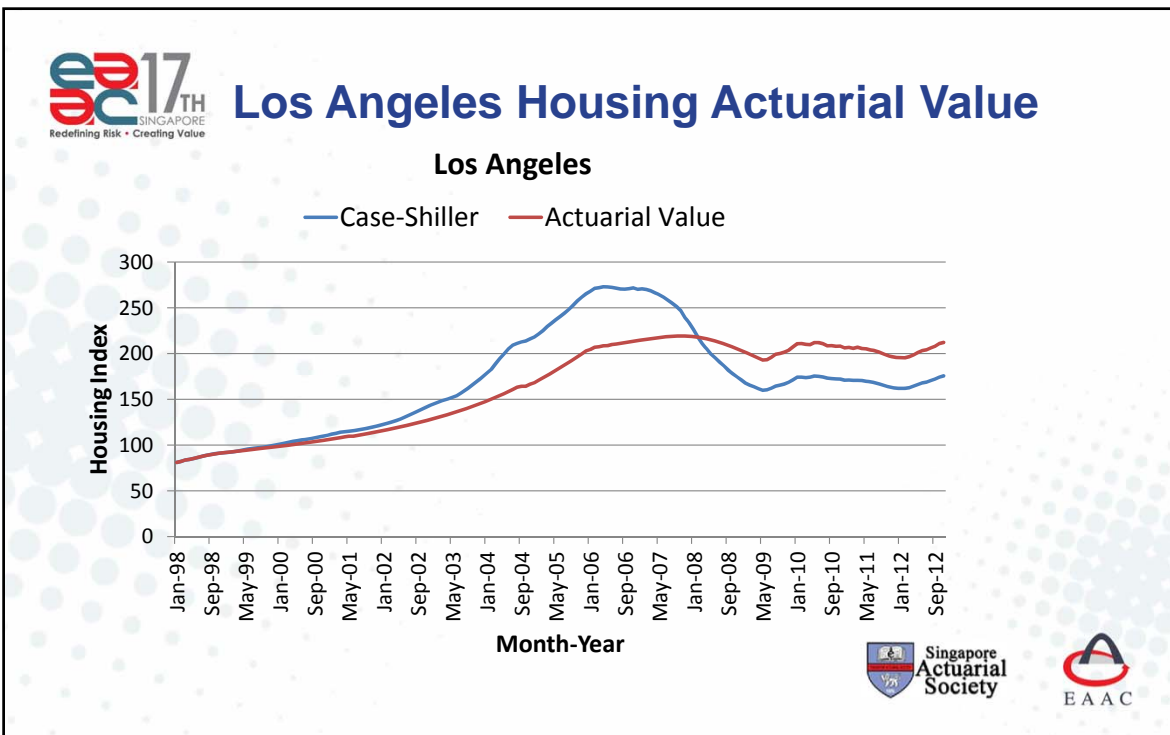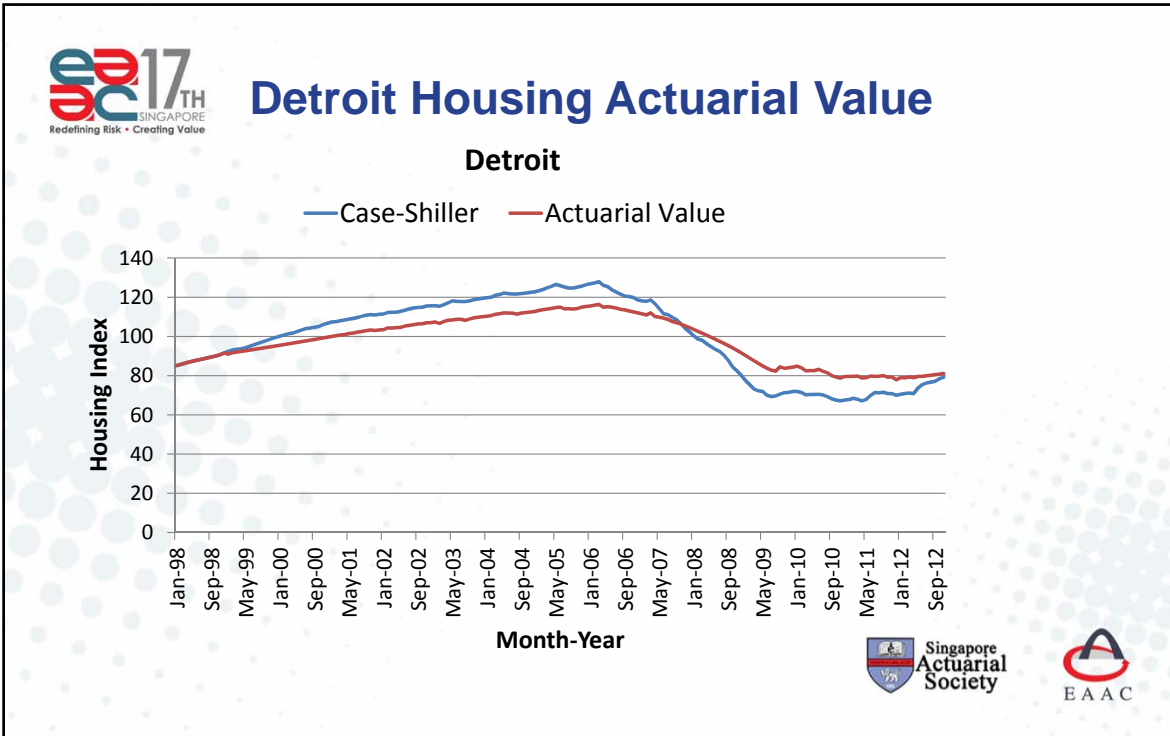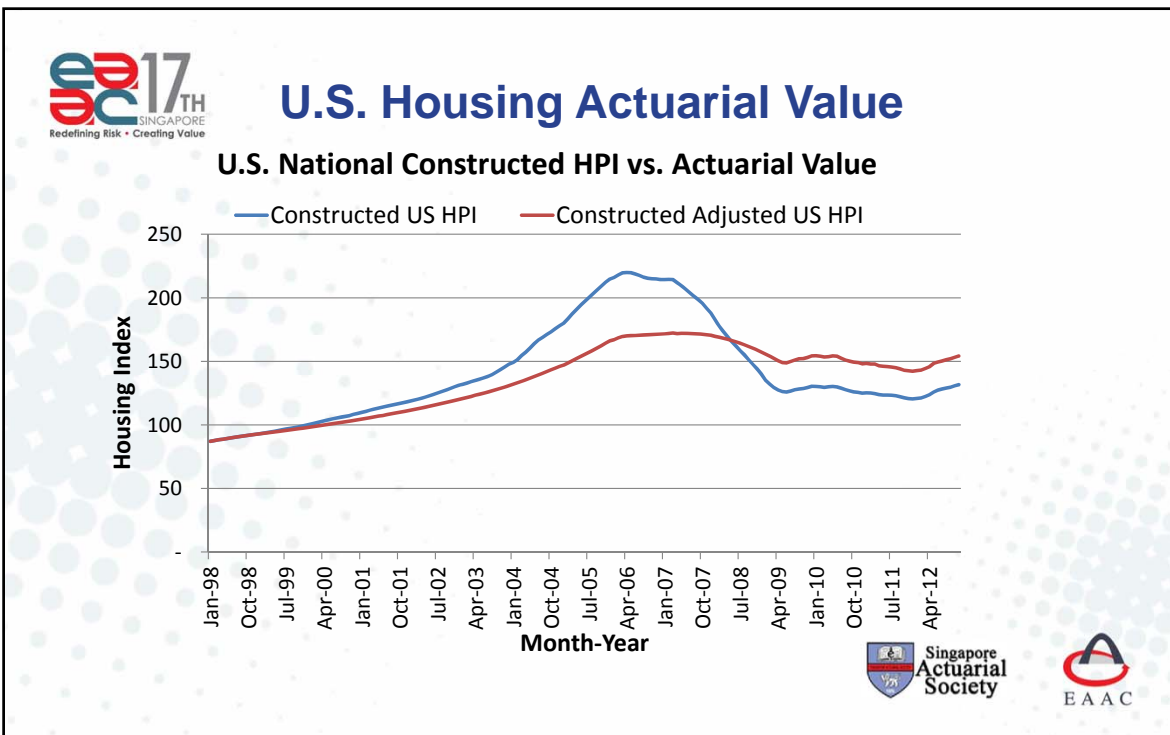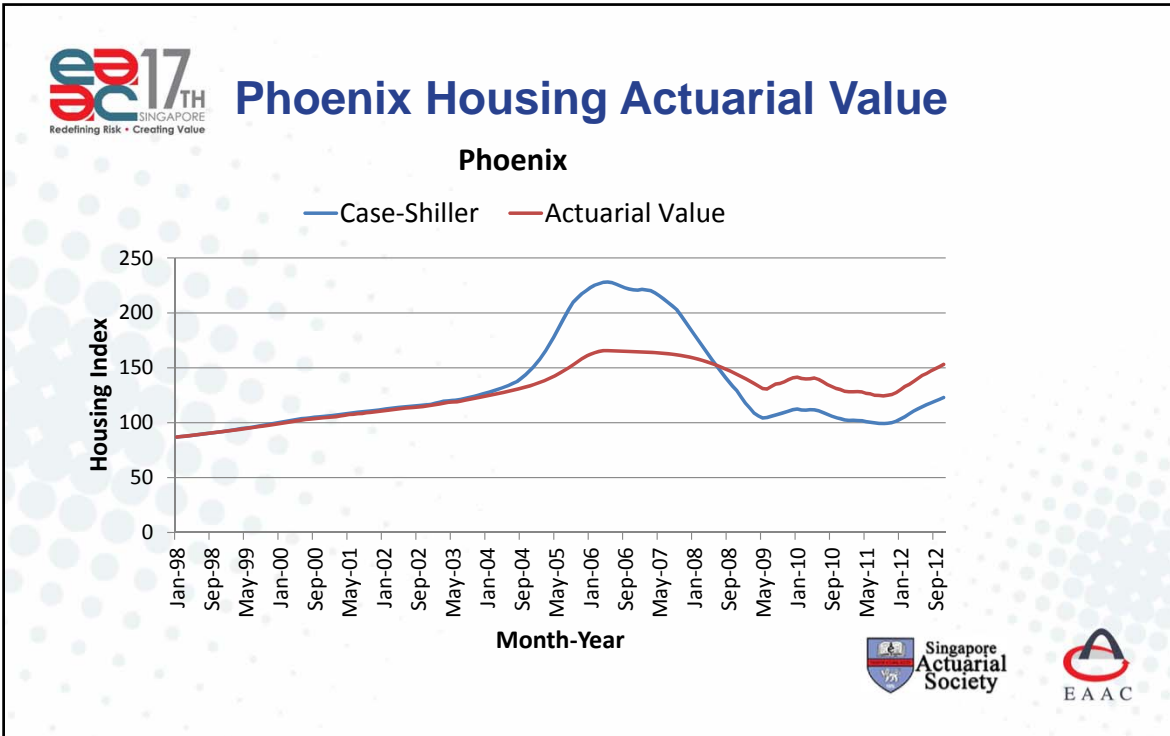
1. So how are the actuarial values calibrated?
2. We calibrate the drift term to reflect the combined effects of economic and demographic factors impacting the supply and demand of housing units in a metropolitan area

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## Supply of Housing Units

Over the last five years, about 10% of houses in the market are sold every month on average.

**U.S. Housing Market Inventory Supply***
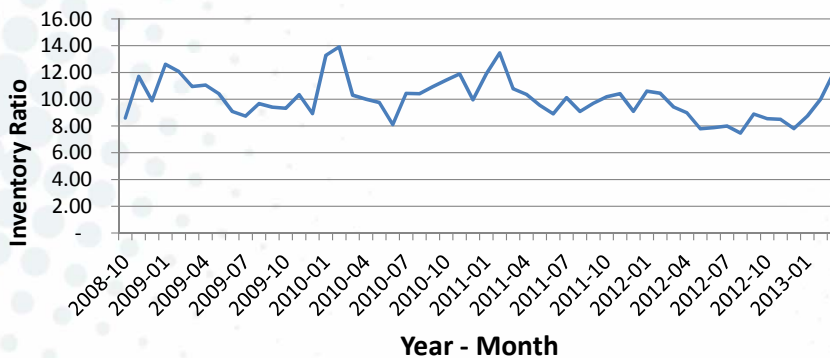


* Inventory Supply is the total number on listings at the end of a month divided by the number of homes sold in that month.

## Supply side: Willing to sell vs. Forced to Sell

We have observed two types of houses for sale.

1. Some homeowners have the flexibility to withdraw their home listing if their home is not sold within some time window (e.g., 1-2 months). We categorize this type as "*Willing to sell*"

2. Some home listings were not withdrawn from the market even after extended listing periods that failed to attract a buyer. These listings were periodically adjusted to reduce the asking price. We categorize this type as "*Forced to sell*".

## Forced to Sell Houses

"Forced-to-sell" houses can be further divided into four classes:

1. Foreclosure Houses

2. Newly Built Houses

3. Migration Outflow

4. Death

# Foreclosure Houses

Before 2006, the foreclosure homes % in all US was around 2%. This ratio jumped to 20% in 2009 and remained high after that. Since late 2007, the abnormally high level of foreclosure rate can have material impact on the housing prices, cause a departure from long-term "equilibrium" housing values.
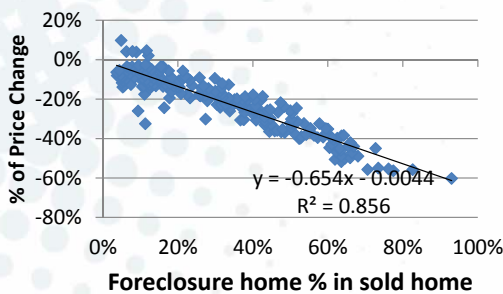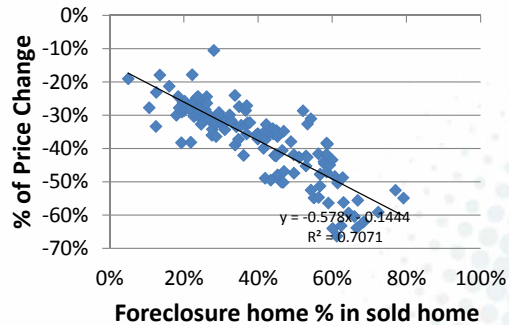
**Foreclosure House % in Transactions**



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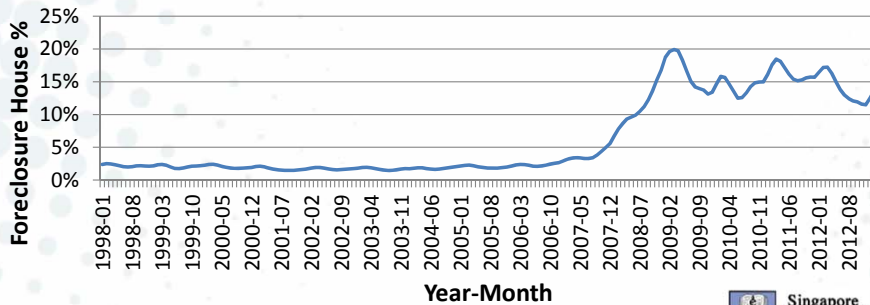
# Foreclosure Houses

Our analysis show that foreclosure home % increases explain a big part of the price drops during 2008-2010.

**Los Angeles 2008-2010 House Price Change vs. Foreclosure Home %***



$y = -0.654x - 0.0044$
$R^2 = 0.856$

**Phoenix 2008-2010 House Price Change vs. Foreclosure Home %**
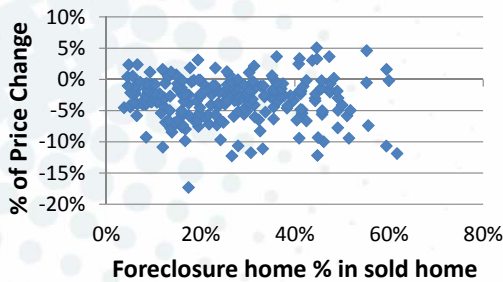


$y = -0.578x - 0.1444$
$R^2 = 0.7071$

# Foreclosure Houses

However, this strong relationship soon disappeared after 2010. Below are the graphs of this relationship in 2011. Similar results are also observed in 2012.

**Los Angeles 2010-2011 House Price Change vs. Foreclosure Home %**

**Phoenix 2010-2011 House Price Change vs. Foreclosure Home %**



# Newly Built Houses

During 2002-2006, there was a dramatic increase in building permit applications.
The cumulative effect of fewer newly built houses from 2008-2012 eventually led to a low inventory of house supply.
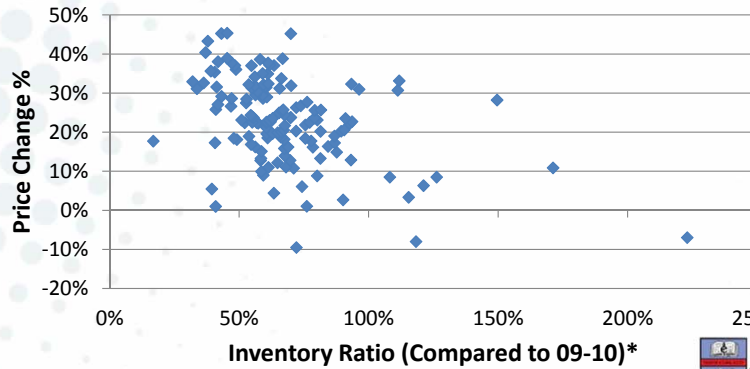
**Single Family Building Permit**
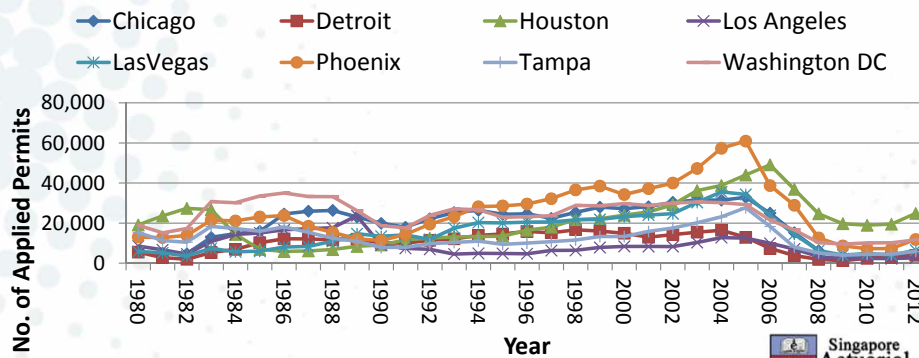
# Newly Built Houses

It can be argued that the housing market recovery since 2012 has been fueled by reduced levels of inventory. Other factors, such as mortgage rates, foreclosure rates and household income have not changed significantly from 2011 to 2012.

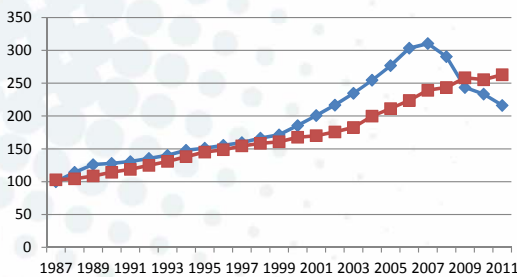**Phoenix 2012-2013 Price Change % vs. Inventory**



# Newly Built Houses

Housing prices dropped below the construction costs in 2009-2011, which led to the recently low supply of newly built houses.
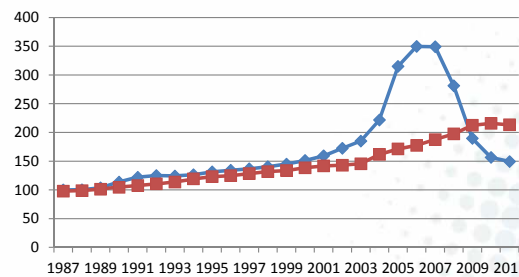
**Chicago**

**Las Vegas**



Data Source: Marshall & Swift/Boeckh - Residential Construction Cost Index. All rights reserved.

## Migration Outflow

From 2000 to 2008, among eight metropolitan areas, Detroit is the only one which experienced a net population decrease due to the high negative net migration.

| | Chicago | Detroit | Houston | Las Vegas | Los Angeles | Phoenix | Tampa | Washington DC |
|---|---|---|---|---|---|---|---|---|
| 2000 Population | 9,098,629 | 4,452,558 | 4,715,417 | 1,375,535 | 12,365,624 | 3,251,887 | 2,396,011 | 4,796,065 |
| 2000-2008 Net Migration | (119,923) | (237,573) | 468,210 | 380,112 | (420,191) | 717,353 | 328,419 | 137,771 |
| 2000-2008 Population Change | 470,995 | (27,448) | 1,012,726 | 490,211 | 507,184 | 1,030,012 | 337,750 | 562,065 |
| 2000-2008 Population Change % | 5.2% | -0.6% | 21.5% | 35.6% | 4.1% | 31.7% | 14.1% | 11.7% |

## Dynamics of Housing Units Supply

The graphs below show the different "forced to sell" components for Los Angeles and Phoenix before, during and after the housing bubble.
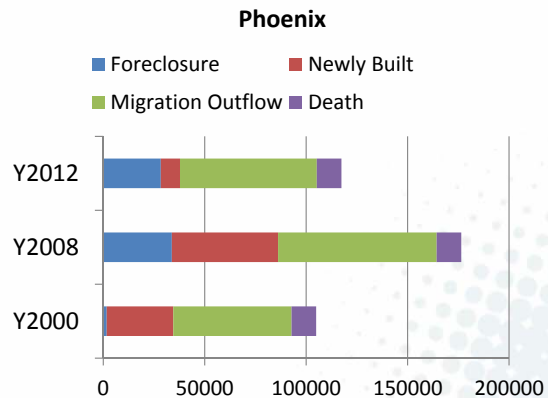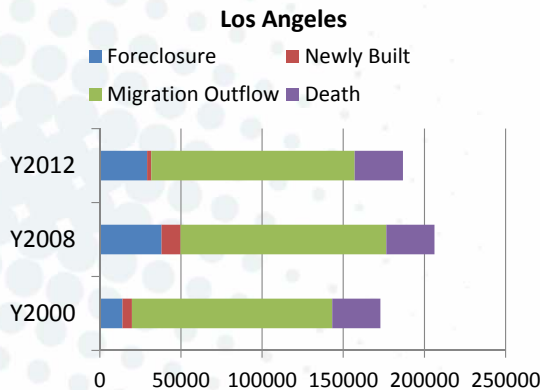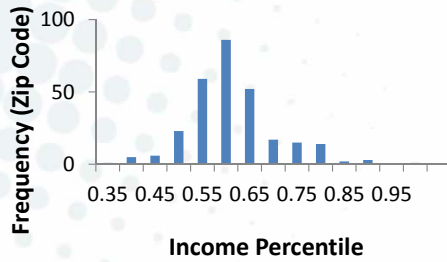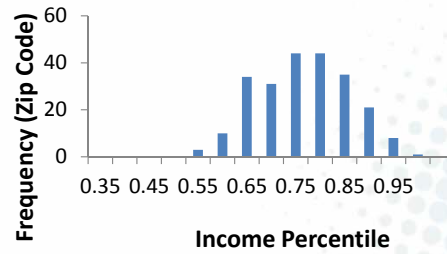
## Household Income Distribution

Traditionally, researches use the ratio of median house price to median household income as the indicator for measuring housing affordability. Our research indicates that this ratio may not be the best indicator. We have found that a higher percentile (e.g. 65%) of the income distribution is a better metric than the median (50%) to match with transacted house prices.

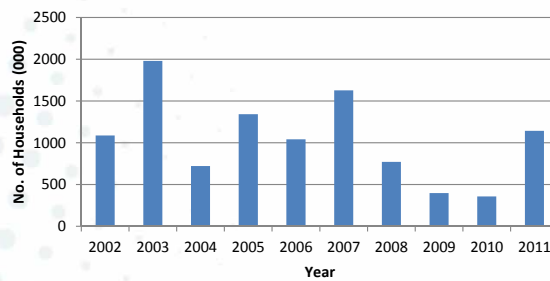**Chicago 1998 House Price Implied Income Percentile**



**Chicago 2008 House Price Implied Income Percentile**



## Age Distribution

After the financial crisis, a decrease in household formation is observed during 2008 to 2010. Below is the graph of the recent ten years of US household formation data.

**US Household Formation**



It is fair to expect this temporary delay of household formation will result in a rebound of this rate, which would increase the demand for housing. Since young adults are typically the driver of household formation, it is important to analyze age distributions within metropolitan areas, especially for the 18 to 35 age group.
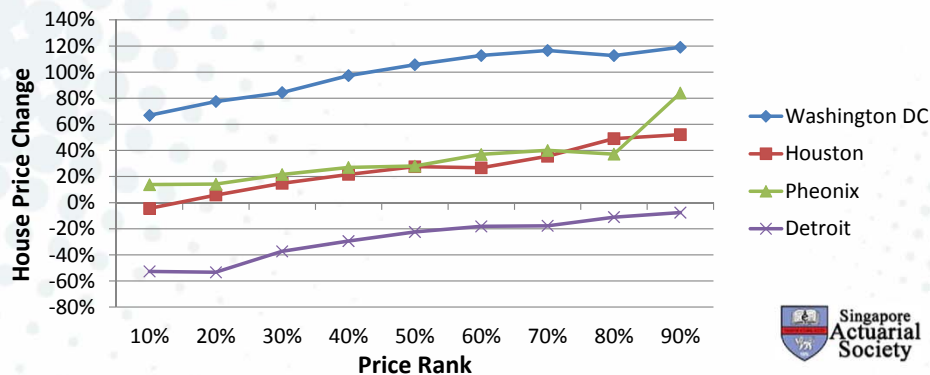
## An Area of Future Research

It is observed that different price ranks have different price changes in the past years. Below is the graph of the house price changes from 12/1999 to 12/2012 for different price ranks of several metro areas.

**House Price Change by Price Ranks**



## Conclusions

1. We have presented an actuarial method of valuing residential properties for metropolitan areas, by incorporating key factors affecting the supply and demand for houses.

2. The housing actuarial values hold the promise of being useful to lenders and regulators in implementing counter-cyclical measures.

3. Further research is needed to expand the data collection and to refine the analysis.