Measuring House Price Bubbles

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Motivation

- Excessive volatility in housing markets—formation and dissolution of price bubbles—is harmful
- Efforts to avoid the formation of bubbles would be sound policy (Crowe et al., *JFS*, 2013)
- Hence, reliable methods for measuring bubbles in real time could be helpful
- Of the various methods used to identify bubbles, most have been employed ex post, and none is generally accepted
- The commonly used methods are simplifications of the theoretically correct model with some restrictive assumptions
Aims of this study

• First to identify bubbles in six metropolitan areas ex post, using an empirical application of the theoretically correct model

• Investigate whether (some of) the simplified models are largely in line with the more complex asset pricing model ex post

• Examine if (some of) the simplified models can signal the identified bubble “in real time”, i.e. ex ante (out-of-sample)

• Make a recommendation regarding the use of the simplified models
What is a bubble?

• Two definitions:
  – Prices exhibit a sustained and substantial departure from fundamentals; e.g., prices reflect expected price growth rather than future rents (Stiglitz, JEP, 1990)
  – Rapid price growth followed by rapid decline (Lind, IJHMA, 2009)

• Most of the methods used in the literature are variations on the first idea

• Second idea has also influenced some empirical research
Ways to measure bubbles

• Ratios:
  – Price-to-rent
  – Price-to-income
  – Imputed-to-actual rents (or other ratios involving imputed rents, which are user costs multiplied by prices) (Himmelberg, Mayer and Sinai, *JEP*, 2005)
Ways to measure bubbles

• Regression models:
  – Based on one or more fundamentals, more or less based on theory, and using various estimation techniques (Case and Shiller, *BPEA*, 2003; Oikarinen, *JBF*, 2009)
  – Based on present value concepts and using VAR models to relate future rents (or, in some cases, incomes) to current prices (Black, Fraser and Hoesli, *JBFA*, 2006)
Ways to measure bubbles

• Growth rates:
  – Exponential rates of growth are indicators of bubbles (Zhou and Sornette, *PA*, 2006)
Research strategy

• Focus on 6 metropolitan areas in 3 countries:
  – Helsinki, Finland; Geneva and Zurich, Switzerland; and Chicago, Miami, and San Francisco, USA
  – Some of these are thought to have experienced bubbles and some not
  – Over 30 years of quarterly data; Constant-quality housing price indices
Research strategy

• The first step is to apply the “optimal” asset pricing or present value approach that relates prices to rents (Campbell and Shiller, *RFS*, 1988; Black, Fraser, and Hoesli, *JBFA*, 2006) to identify bubbles ex post:
  – The dynamic Gordon growth model: time-varying risk premium and rental growth expectations
  – Bubble signal if observed price-rent is X% over the equilibrium price-rent implied by the model
Research strategy

• The “optimal”/“correct” asset pricing model is computationally complex
• Thus, we compare 6 simpler alternative methods with the present value method
• The methods are:
  – price-rent ratio
  – price-income ratio
  – imputed-actual rent ratio
  – parsimonious supply and demand model
  – multivariate supply and demand model
  – exponential growth rate (EGR) model
Research strategy

• Imputed rent is the price of a typical house times the user cost

• The user cost calculation varies somewhat across countries

• Finland: $E(u_{mt}) = (1 - \tau_{mt})i_{mt} + \delta_m - E(g_{mt})$

• U.S.: $E(u_{mt}) = (1 - \tau_{mt})(i_{mt} + \lambda_m) + \delta_m - E(g_{mt})$

• Switzerland: $E(u_{mt}) = (1 - \tau_{mt})(i_{mt} + \lambda_m + \gamma_m) + \delta_m + \tau_{mt} \eta_m - (1 - \tau_{mt}^g)E(g_{mt})$
Research strategy

• The multivariate regression models include real income, population, unemployment, real interest rates, real construction costs, real spreads between 10-year and 3-month government securities and consumer sentiment as fundamentals

• The parsimonious regression models only consider real aggregate income
Research strategy

• We assess how effective each of the 6 methods is in identifying bubbles ex post

• We also conduct an ex ante or “real time” analysis:
  – We use the same 6 alternative methods, but applied recursively
  – Aim here is to determine whether any of the methods measures a bubble consistently with our ex post benchmark (the PV method)
  – We focus on the last ten years of data in each city
Research strategy

• Baseline bubble criterion:
  – For the ratio measures, a bubble occurs whenever the long-term average is exceeded by at least 20%
  – Similarly, for the present value and supply and demand approaches, a bubble occurs whenever the actual price level exceeds the equilibrium level by at least 20%
  – For the EGR analysis, ln(price) exceeds the log-linear trend by at least 20%
  – Robustness checks apply different criteria

• We will focus here on % of correct signals as a measure of ‘wellness’ of a method (working on other methods)
The benchmark model results

• In each case, a bubble signal has been followed by a substantial drop even in the nominal price level

• No such price drops without bubble signals => the model works as desired and expected

• An exception to the general rule is the late 1970s bubble signal in Helsinki which is due to low rental growth expectations (real rental prices dropped notably)
Nominal prices: European cities
Nominal prices: U.S. cities
Ex post measures: Helsinki
Ex post measures: Miami

![Graph showing ex post measures for Miami from 1980 to 2010. The graph includes various measures such as Bubble period, Bubble criterion, Price-rent ratio, Price-income ratio, Imputed-actual rent ratio, Parsimonious regression, Multivariate regression, EGR method, and Present value method. The graph highlights the bubble period from 2004 to 2008.]
## Ex post measures

Agreement of ex post measures with present value benchmark measure (%)

<table>
<thead>
<tr>
<th>City</th>
<th>Price-rent ratio</th>
<th>Price-income ratio</th>
<th>Imputed-actual rent ratio</th>
<th>Parsimonious regression</th>
<th>Multivariate regression</th>
<th>Exponential growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helsinki</td>
<td>74.9</td>
<td>61.9</td>
<td>74.5</td>
<td>63.1</td>
<td>58.3</td>
<td>63.8</td>
</tr>
<tr>
<td>Geneva</td>
<td>89.3</td>
<td>82.6</td>
<td>60.3</td>
<td>89.3</td>
<td>94.2</td>
<td>96.7</td>
</tr>
<tr>
<td>Zurich</td>
<td>88.8</td>
<td>95.2</td>
<td>76.8</td>
<td>88.8</td>
<td>96.0</td>
<td>88.0</td>
</tr>
<tr>
<td>Chicago</td>
<td>93.5</td>
<td>71.7</td>
<td>42.4</td>
<td>50.0</td>
<td>50.0</td>
<td>80.4</td>
</tr>
<tr>
<td>Miami</td>
<td>97.7</td>
<td>76.4</td>
<td>64.8</td>
<td>82.6</td>
<td>73.8</td>
<td>87.6</td>
</tr>
<tr>
<td>San Francisco</td>
<td>78.6</td>
<td>68.6</td>
<td>34.1</td>
<td>52.9</td>
<td>51.7</td>
<td>70.9</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>87.1</strong></td>
<td><strong>76.1</strong></td>
<td><strong>58.8</strong></td>
<td><strong>71.1</strong></td>
<td><strong>70.7</strong></td>
<td><strong>81.2</strong></td>
</tr>
</tbody>
</table>

Note: These figures give equal weight to sensitivity (percentage of bubble periods identified by the measure) and specificity (percentage of non-bubble periods identified by the measure). These percentages are based on the 20 percent criterion for identifying a bubble.
Ex ante measures: Helsinki
Ex ante measures: Miami
## Ex ante measures

### Average correct ex ante identification of bubble and non-bubble periods (%)

<table>
<thead>
<tr>
<th>City</th>
<th>Price-rent ratio</th>
<th>Price-income ratio</th>
<th>Imputed-actual rent ratio</th>
<th>Parsimonious regression</th>
<th>Multivariate regression</th>
<th>Exponential growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helsinki</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>77.5</td>
</tr>
<tr>
<td>Geneva</td>
<td>60.0</td>
<td>37.5</td>
<td>95.0</td>
<td>55.0</td>
<td>55.0</td>
<td>45.0</td>
</tr>
<tr>
<td>Zurich</td>
<td>100.0</td>
<td>97.5</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Chicago</td>
<td>89.0</td>
<td>80.4</td>
<td>50.0</td>
<td>50.0</td>
<td>50.0</td>
<td>60.9</td>
</tr>
<tr>
<td>Miami</td>
<td>81.1</td>
<td>86.4</td>
<td>75.0</td>
<td>68.7</td>
<td>45.5</td>
<td>68.7</td>
</tr>
<tr>
<td>San Francisco</td>
<td>73.7</td>
<td>71.0</td>
<td>50.0</td>
<td>54.8</td>
<td>50.0</td>
<td>66.1</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>84.0</strong></td>
<td><strong>78.8</strong></td>
<td><strong>78.3</strong></td>
<td><strong>71.4</strong></td>
<td><strong>66.7</strong></td>
<td><strong>69.7</strong></td>
</tr>
</tbody>
</table>

Note: These percentages are based on the 20 percent criterion for identifying a bubble.
# Ex ante measures

## Table 6. Correct ex ante identification of bubble periods (%)

<table>
<thead>
<tr>
<th></th>
<th>Number of bubble quarters</th>
<th>Price-rent ratio</th>
<th>Price-income ratio</th>
<th>Imputed-actual rent ratio</th>
<th>Parsimonious regression</th>
<th>Multivariate regression</th>
<th>Exponential growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helsinki</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Geneva</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Zurich</td>
<td>0</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Chicago</td>
<td>20</td>
<td>100.0</td>
<td>70.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Miami</td>
<td>22</td>
<td>95.5</td>
<td>72.7</td>
<td>50.0</td>
<td>81.8</td>
<td>40.9</td>
<td>81.8</td>
</tr>
<tr>
<td>San Francisco</td>
<td>31</td>
<td>80.6</td>
<td>41.9</td>
<td>0.0</td>
<td>9.7</td>
<td>0.0</td>
<td>32.3</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>92.0</strong></td>
<td><strong>61.6</strong></td>
<td><strong>16.7</strong></td>
<td><strong>30.5</strong></td>
<td><strong>13.6</strong></td>
<td><strong>46.4</strong></td>
<td></td>
</tr>
</tbody>
</table>

Note: These figures are the percentage of the most recent 40 quarters that each ex ante method identifies a bubble when the ex post benchmark identifies a bubble (i.e., sensitivity or one minus the probability of a Type I error). The number of bubble quarters is the number identified by the ex post benchmark. These percentages are based on the 20 percent criterion for identifying a bubble.
Ex ante measures

Table 7. Correct ex ante identification of non-bubble periods (%)

<table>
<thead>
<tr>
<th></th>
<th>Number of non-bubble quarters</th>
<th>Price-rent ratio</th>
<th>Price-income ratio</th>
<th>Imputed-actual rent ratio</th>
<th>Parsimonious regression</th>
<th>Multivariate regression</th>
<th>Exponential growth rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helsinki</td>
<td>40</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>77.5</td>
</tr>
<tr>
<td>Geneva</td>
<td>40</td>
<td>60.0</td>
<td>37.5</td>
<td>95.0</td>
<td>55.0</td>
<td>55.0</td>
<td>45.0</td>
</tr>
<tr>
<td>Zurich</td>
<td>40</td>
<td>100.0</td>
<td>97.5</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Chicago</td>
<td>20</td>
<td>75.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Miami</td>
<td>18</td>
<td>66.7</td>
<td>100.0</td>
<td>100.0</td>
<td>55.6</td>
<td>50.0</td>
<td>55.6</td>
</tr>
<tr>
<td>San Francisco</td>
<td>9</td>
<td>66.7</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td></td>
<td><strong>78.1</strong></td>
<td><strong>89.2</strong></td>
<td><strong>99.2</strong></td>
<td><strong>85.1</strong></td>
<td><strong>84.2</strong></td>
<td><strong>79.7</strong></td>
</tr>
</tbody>
</table>

Note: These figures are the percentage of the most recent 40 quarters that each ex ante measure does not identify a bubble when the ex post benchmark does not identify a bubble (i.e., specificity or one minus the probability of a Type II error). The number of non-bubble quarters is the number identified by the ex post benchmark. These percentages are based on the 20 percent criterion for identifying a bubble.
Conclusions

• The price-rent ratio works best and well (as an alternative to the present value method) at identifying bubbles both ex post (87% of correct signals) and ex ante (84% of correct signals), regardless of the ‘bubble threshold’

• It tends to trigger the bubble signal a bit before the actual bubble

• This method is appealing because it is simple to implement

• Most methods are highly positively correlated (similar signals)
Conclusions

• Multiple variable regression constantly works worse than a parsimonious regression (with aggregate income): The inclusion of (especially mean-reverting) variables makes the model fit actual price levels “too well”

• Results should be useful in guiding policy measures designed to mitigate house price volatility

• Data quality! (“garbage in garbage out”)


Further work

• Sensitivity of results to deleting some years at the beginning or end of period (changing the ‘equilibrium’)

• Some of our data are at the annual frequency and interpolation methods are used: Sensitivity analysis using annual data