Why Country House Price Indexes May Differ: Does Measurement Matter?

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ABSTRACT

A key factor in understanding the global recession is an understanding of movements in residential property price indexes (RPPIs. While economic fundamentals naturally have a major bearing, RPPI variation may also be determined by differences in the methodology used to construct the indexes. Key RPPI methodological issues include the: (i) use of stocks or flows and values or quantities for weights; (ii) method of enabling constant quality measures; (iii) coverage in terms of geography, type of housing and financing; and (iv) valuation of prices. The paper outlines such issues and reports on empirical work in progress to estimate the effects of such measurement issues on RPPI changes for two countries as case studies, and for an international panel data set.

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[1] Many of the residential property price indexes used in this study have been helpfully drawn from the Bank for International Settlements' (BIS) database of property price indexes available at: http://www.bis.org/statistics/pp.htm. Use of the database requires a citation of the appropriate national source as given in Annex 2. The help of Marc Prud'Homme (Statistics Canada), Chihiro Shimizu (Reitaku University), and Niall O'Hanlon (Central Statistical Office, Ireland) is also acknowledged. The usual disclaimers apply.

[2] The views expressed herein are those of the author and should not be attributed to the IMF, its Executive Board, or its management. Any errors or omissions are the author's responsibility.

I. INTRODUCTION

The October 2009 Report to the G-20 Finance Ministers and Central Bank Governors on the *Financial Crisis and Information Gaps*[3] described data on dwellings and their associated price changes as critical ingredients for financial stability policy analysis. The six major banking crises in advanced countries since the mid–1970s were all associated with a housing bust (Reinhart and Rogoff, 2009).[4] An understanding of deviations from equilibrium prices in housing markets requires reliable and, for international comparisons, consistently-measured, residential property price indexes (RPPIs). RPPIs are particularly prone to methodological differences, which can undermine both within-country and cross-country analysis. It is a difficult but important area. There is an important empirical question as to whether, and, if so, the extent to which, measurement differences matter.

Against this background, the paper first, outlines the quite significant methodological differences that can occur with the measurement of RPPIs. Two case studies are then considered to ground the analysis—the United Kingdom (UK) and its six major RPPIs and the United States (US) and its two major RPPIs.[5]

The formal empirical analysis is based on a panel of about ten years of quarterly data for over 100 RPPIs from nearly 20 countries; all the series differ (at least within countries) with regard to their methodological features. A fixed effects (for country) model with RPPIs regressed on measurement characteristics will help identify the extent to which measurement differences matter and the salient measurement features.

Key RPPI measurement variables include the: (i) use of stocks or flows (transactions) for weights; (ii) use of values or quantities for weights; (iii) use of fixed or chained weights; (iv) the method of enabling constant quality measures (repeat sales pricing, hedonic approach, mix-adjustment through stratification, sale price appraisal ratio (SPAR); (v) geographical coverage (capital city, urban etc.), (vi) coverage by type of housing (single family house, apartment etc.); (vi) vintage covered, new or existing property; (vii) valuation method (and source data) of prices (asking, transaction, appraisal etc.).

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[3] Available at: http://www.imf.org/external/np/seminars/eng/2010/infogaps/index.htm.

[4] Claessens, Kose, and Terrones (2008, page 25) find that "..recessions associated with house price busts are on average over a quarter longer than those without busts. Moreover, output declines (and corresponding cumulative losses) are typically much larger in recessions with busts, 2.2 (3.7) percent versus 1.5 (2.3) percent in those without busts. These sizeable differences also extend to the other macroeconomic variables, including consumption, investment and the unemployment rate."

[5] For the United States as an example, annual changes in the **S**&P Case-Shiller National Home Price Index turned negative in 2006 Q4, but such changes in the FHFA "purchases only" residential property price index turned negative a full year later in 2007 Q4. Both indexes use the repeat-sales methodology, but differ in coverage, weighting and source data.

A. The Potential for Mismeasurement and International Guidelines

There are at present, no internationally-accepted guidelines on compiling HPIs. However, a recent initiative to produce a *Handbook on Residential Property Price Indice*[6] is near completion. Pilot experimental results have been developed by Eurostat (2010a) on the development of comparable RPPIs for owner-occupied housing (OOH) in the framework of the Harmonized Indexes of Consumer Prices (HICP) for countries in the euro area and at the European Union level. A common set of accepted methods and approaches is described in a technical manual published by Eurostat (2010b). The report on the experimental RPPIs notes methodological shortcomings but also draws attention to significantly and continuously improved indexes since the early stages of the project. The report stresses that the RPPI results "..must be understood as experimental and they have therefore been labeled as such." (2010a, page 5).

The application of such guidelines is not be straightforward. The heterogeneity of houses, in terms of location and characteristics, and the low turnover of sales complicate the determination of average house price changes. Further, methods of compiling RPPIs are to a large extent dictated by the source data on house price transactions, the nature of which is often the result of the variable country-specific administrative arrangements for financing and purchasing houses. For many countries more than one national index is available each using quite different methods and have different coverage. There is also a question of transparency and compliance. In many countries residential property price indexes by private organizations such as realtors and lenders serve to advertise their business. The available information on their methodology is generally not up to the standard of a statistical office and, for some users, there will always be skepticism as to conflicts of interest, whether justified or not. Private organizations are unlikely to abandon their indexes if their source data and methods do not meet the standards of the newly developed international guidelines.

Extreme care is thus required when comparing residential property price indexes of different countries for which the nature of source data and methods employed may be quite different. But what of measuring house prices changes for an individual country? Surely that should be straightforward. Economists should have a single reliable measure upon which to base their work. We consider two case studies, the UK and the US on the coexistence of national RPPIs using different data and methods.

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[6] The U.N. Inter-Secretariat Working Group on Price Statistics (IWGPS) is responsible for developing internationally-accepted guidelines on price indexes. Under its aegis, Eurostat is acting as the lead agency for developing a *Handbook on Residential Property Price Indexes* and in 2009 commissioned its writing expected to be completed in late 2011. The current draft is available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/hicp/methodology/owner_occupied_housing_hpi/rppi_handbook.

B. Case studies on National Residential Property Price Indexes

UK Residential Property Price Indexes

There are **eight** major residential property price indexes in the UK based on different types of source data.[7] The Land Registry records form the basis of both the *Land Registry* index, compiled by Calnea Analytics Limited, and the *LSL*/Acadametrics (Financial Times) index (*AcadHPI*). Prices are the registered transaction price on completion of the sale. The *Halifax* and *Nationwide* indexes are based on their own mortgage approval records and the Department of Communities and Local Government (*DCLG*) index on all transactions bought with a mortgage issued by one of about 50 lenders. *Rightmove*'s index is based on the asking prices of property included on Rightmove.co.uk. There are two survey-based indexes, one carried out by the Royal Institution of Chartered Surveyors (*RICS*) based on the opinions of a sample of their members and the *Hometrack* survey which is based on the opinions of a sample of estate agents (realtors) and surveyors. These opinion-based "net balance" indicators are excluded from the analysis below as they are not designed for the analysis of change

Do UK residential property price indexes differ?

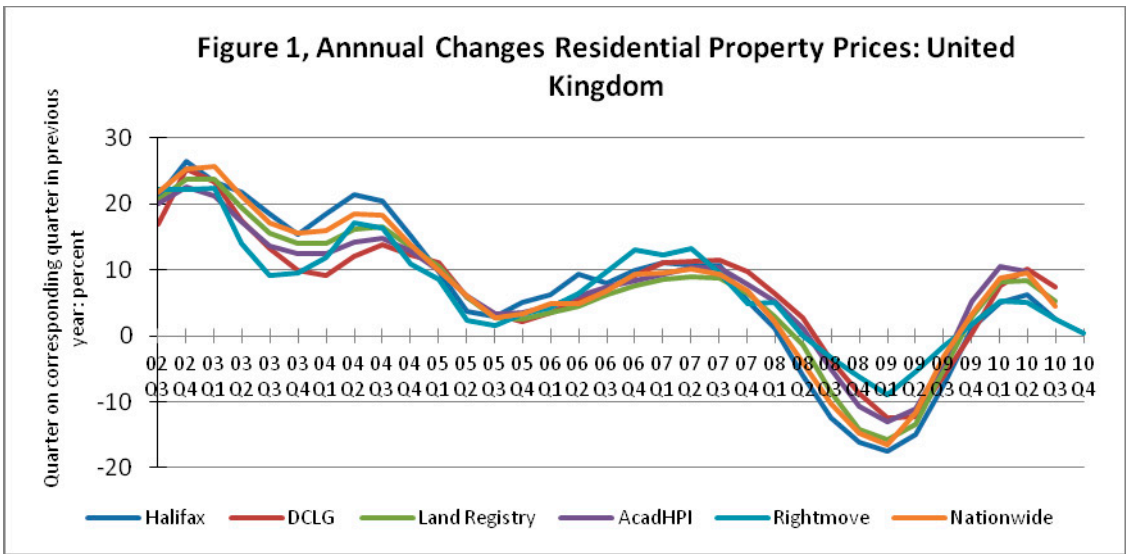
Figure 1 shows that in spite of the substantial methodological and data differences outlined below, there is a striking similarity in trend and timing of the turning points for annual changes (quarter-on-corresponding previous year's quarter) in UK national RPPIs. Differences do exist, especially in the amplitude of the 2003/4 turning points and 2008/09 trough. For 2008 Q4, the average fall for the six indexes was 11.8 percent, but the range was about 10 percentage points: falls of 16.2 for Halifax and only 6.3 percent for Rightmove.

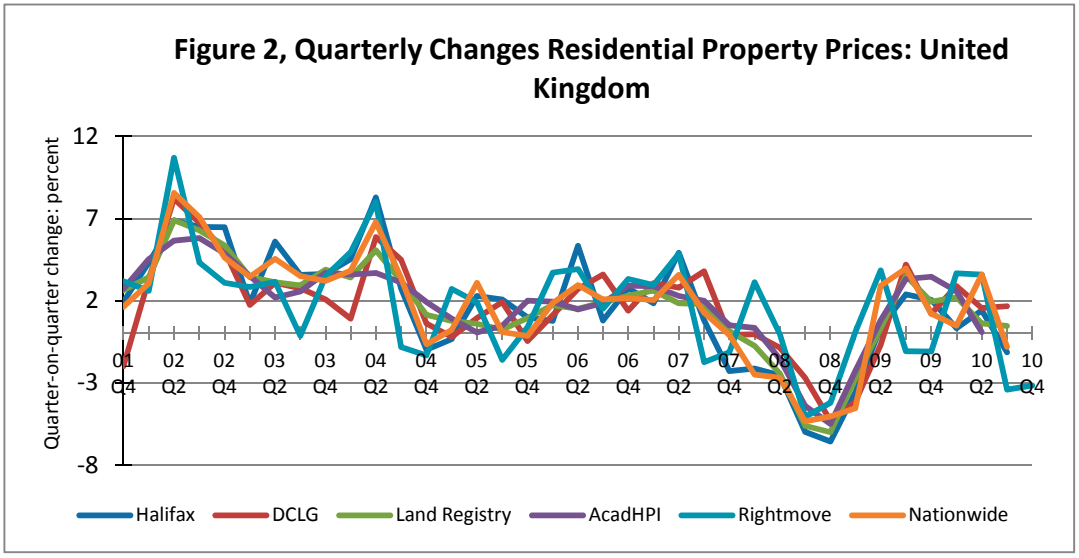
Figure 2 shows the more volatile quarter-on-quarter changes, though for 63 percent of the periods all RPPIs changed in the same direction and for 85 percent of the periods at most one RPPI showed a different direction of change. Yet the magnitudes of the difference are often substantial, especially for the Rightmove. For example, Rightmove showed a 2009 Q2/Q1 *quarterly* fall of 1.1 percent when all other indexes showed increases averaging 3.5 percent. The coincidence of the trends and turning points suggests either some commonality in measurement or, in these respects, measurement differences don't matter much.

Are there commonalities in measurement?

Land Registry and AcadHPI are both based on the same data and can be seen from Figure 2

[7] Details of these methods can be found in review papers including Fenwick and Duff (2002), Wood (2005), Dey-Chowdhury (2007), and, in some detail, UK Government Statistical Service (2010)—though see also Carless (2011) and the methodological papers from the originating organizations.





to more closely track each other. They both record the price "on completion," that is, the price returned to the Land Registry as part of the legal process of registering the completed sale. They are comprehensive in their coverage of transactions,[8] at least for England and Wales. There is a need to control for the changing mix in the quality of houses sold. More expensive houses may be sold one month leading us to think average prices have increased when this may not be the case. The repeat sales methodology employed by Land Registry constrains its coverage of the property prices to properties transacted more than once, to enable an average of the price changes of the same (matched) houses to be measured.[9] The

[8] There remains a sample selection bias if the indexes are used to represent price changes of the stock of houses (Mason and Pryce, 2011).

[9] The Land Registry data is a record of all residential property transactions made in England and Wales since January 1995. At the time of writing it contained details on over 15 million sales. Of these, just over five

(continued)

prices of like are, broadly speaking, compared with like, at the cost of using a more limited sample and incurring a selection bias. AcadHPI uses the Land Registry's entire transaction database. Its mechanism of adjusting for the differential quality mix is to weight strata categorized by property type and location.[10] The weights are transactions-based relative quantities between January 2000 and December 2003. Land Registry is implicitly weighted by the relative number of repeat transactions in the sample.

Nationwide and Halifax include prices for properties for which they are the mortgagee. The DCLG index covers all transactions bought with a mortgage issued by one of about 50 lenders (about 55 percent of mortgage transactions—more than Nationwide and Halifax) reporting to the Regulated Mortgage Survey of the Council of Mortgage Lenders. All three indexes cover transactions in the United Kingdom but, unlike the Land Registry-based indexes, exclude cash sales—about 25 percent of all purchase. While the lender-based source data have some similarities, there is much in their construction that differs.

Nationwide and Halifax are based on the asking price when a mortgage is first approved—when the property is under offer, that is later than when first advertised but prior to completion. Not all approved applications will go through to completion. DCLG is based on transaction prices "on completion." DCLG is a transaction value-weighted[11] average of individual stratum indexes with weights, based on a three year moving average, updated annually. Nationwide and Halifax are complied as stock quantity-weighted averages of the strata price changes. Weights for Nationwide are updated every two years based on four year moving averages of data, while Halifax uses constant weights from 1983.

All three indexes use hedonic regressions to minimize the effect of changes in the quality-mix on price measurement, though the specifications of the regressions differ.[12] DCLG further use the results from hedonic regressions to determine strata quality (price-

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million were identifiable matched pairs.
http://www.landreg.gov.uk/kb/Default.asp?ToDo=view&questId=344&catId=32.

[10] Due to delays in processing Land Registry (LR) data, the AcadHPI results are not termed "final" until a significant volume of LR data is available which is normally after three months have passed. AcadHPI forecast results makes use of Halifax, Nationwide, and DCLG indexes. One month after any given month, LR provides average house prices based upon about 70% of the eventual total transactions, which are used to replace the AcadHPI "forecast" result with an AcadHPI "updated" result. A further month later, LR provides prices based upon about 90% of the eventual total transactions which are used to replace the first with a second AcadHPI "updated" result. Three months after any given month, LR provides prices based upon about 95% of the total transactions for the month. Taking the current month as month T, in month T + 4 the AcadHPI results are regarded as sufficiently updated to be described as the AcadHPI "final" index (Meissner and Satchell, 2010, page 14).

[11] Fixed quantity baskets are applied to estimated prices in the months compared yielding a value-weighted index of price changes.

[12] See Dey-Chowdhury, 2007.

determining) characteristics for use as stratification factors.[13] Halifax and Nationwide define "typical" properties by fixed characteristic sets and value them over time using the estimated coefficients of hedonic regression equations.

In spite of these quite substantial differences, the indexes can be seen to track a similar broad trend and turning points in residential property prices. Interestingly, there is no more commonality between mortgage-based indexes than those based on Land Registry data.

Rightmove advertises properties for sale online throughout the United Kingdom covering the asking prices of 90 percent of estate agents (realtors) that advertise on their site. Properties that do not sell are also included. The index is compiled from the asking prices of properties, the prices at the very beginning of the buying and selling process. Weights (and mix-adjustment) are according to the stock of properties in terms of geographical distribution and property type. Rightmove is distinct in its use of asking price and has the least commonality with other indexes.[14]

Do the commonalities in measurement matter?

Three main points are apparent:

- Similar trends and turning points are tracked by all indexes in spite of their data and methodological differences, yet substantial differences remain especially at some peaks and troughs, and more so for quarter-on-quarter comparisons.

- The use of quarterly *annual* changes in Figure 1 does much to smooth the discrepancies endemic in the quarter-on-quarter indexes in Figure 2.

- Indexes using similar source data seem to move more closely together, even though the coverage of the data and methodology may vary considerably. The correspondence between the Land Registry and AcadHPi is the most striking, being based on the same data but having very different coverage, weighting, and methodologies for controlling for quality mix.

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[13] As an example, DCLG includes in their regression variables relating to location (local authority district or London borough), property type (PT), type of neighborhood (using the ACORN classification), local authority cluster membership, defined by the Office for National Statistics, number of habitable rooms, old or new (New), first-time buyer or former owner-occupier (FT), plus interaction terms for ACORN and PT, ACORN and FT, and PT and New. Each combination of the variables in the regression forms a stratum defined by the combinations of characteristics of the property: about 1,000 property types/strata.

[14] At least in terms of its correlation. The correlation coefficient between Rightmove and each of Halifax, DCLF, Land Registry, AcadHPI, and Nationwide are, respectively, 0.71, 0.55, 0.68, 0.62, and 0.73. No other correlation coefficient for comparison between these series has a lower correlation coefficient. Land Registry and AcadHPI, based on the same source data, have a correlation of 0.98 for their RPPIs.

But these points are based on a single country's experience. Consider a further example, the United States.

House price indexes for the United States

The United States has four main indexes for residential property prices, the CoreLogic National Home Price Index, the Federal Housing Finance Agency (FHFA)[15] "purchases only" house price index,[16] the S&P/Case-Shiller National Home Price Index, and the US Census Bureau Price Index of New Houses. FHFA, CoreLogic, and Case-Shiller use the repeat-sales methodology to control for quality changes in the mix of houses sold. They have the same coverage of type of properties; that is, they include transactions on one-family houses and exclude 2- to 4-family houses, condominiums and cooperatives, and weight changes in regional price indexes over 9 US census divisions.[17]

Different movements

- Figure 3 shows the Census Bureau index to be quite different from FHFA and Case-Shiller, though this is to be expected since its coverage is of new houses only.
- CoreLogic and Case-Shiller have very similar patterns.
- What is striking from Figure 3 is the different timing of the downturn in house prices: Annual changes in Case-Shiller turn negative in 2006 Q4 in Figure 3, but FHFA turns negative a full year later in 2007 Q4. Figure 4 shows quarterly changes in Case–Shiller to turn negative in 2006 Q3, while FHFA dips into a negative change in 2006 Q4 to subsequently have positive changes for the next two quarters to then turn negative in 2007 Q3.

[15] The Federal Housing Finance Agency regulates Fannie Mae, Freddie Mac and the 12 Federal Home Loan Banks.

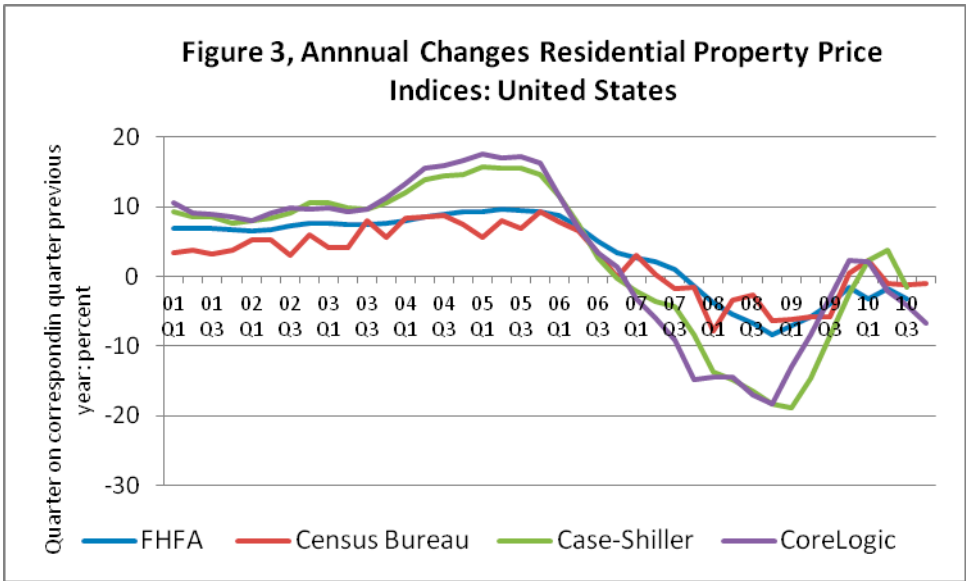
[16] The FHFA produces an "all transactions" HPI that includes refinance appraisals that are not sales that comprise nearly 90 percent (about 35 million of the 40 million repeat transactions). FHFA itself notes evidence that prices based on appraisals submitted for refinancing tend to lag market trends and have an appraisal bias. The "purchases-only" HPI excludes refinancing transactions. Leventis (2008) estimates that removing appraisals accounts for 1.54 percentage points of FHFAs 4.27 percent average difference over Case-Shiller for the four-quarter price change estimates over 2006Q3-2007Q3for the ten original MAs.

[17] The FHFA, Case-Shiller and Census Bureau indexes do not incorporate Condominiums. However, in November 2008, Standard & Poor's launched indexes designed to track condominium prices in five major metropolitan areas—Boston, Chicago, Los Angeles, New York and San Francisco. The National Association of Realtors provides median values (by quarter) for a larger number of cities for condominium prices, but these are not quality adjusted.

- The difference in the magnitude of the 2008/09 downturn is also striking. Figure 3 shows for 2008 Q4 and 2009 Q1 Case-Shiller registering annual falls of over 18 percent compared with falls of around 7–8 percent for FHFA; similar discrepancies are apparent from Figure 4.

- Even the nature of the differences cannot be relied upon. From Figure 3, up to 2006 Q2 Case-Shiller exceeded FHFA, this being reversed between 2006 Q3 to 2009 Q4, and reversed again from 2010 Q1.

- Figure 4 shows highly volatile quarter-on-quarter changes. Yet in spite of methodological differences, the peaks and troughs of Case-Shiller and FHFA roughly coincide—peaking in Q2—though their amplitudes differ.

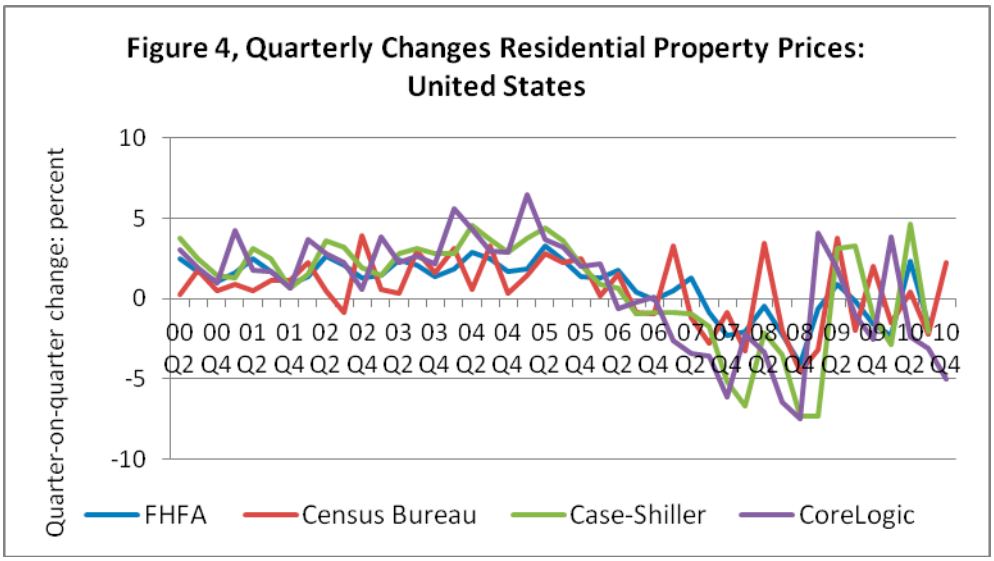


Differences in methods

Differences in the indexes are to be expected. While all indexes, aside from the Census Bureau index, use the repeat sales methodology and cover the same type of houses, the coverage, weighting, and implementation of the repeat sales methodology differ.

On coverage, the Census Bureau index only covers new dwellings while the repeat sales methodology of the other indexes excludes new dwellings. The Case-Shiller index is based on publicly available transaction sales prices from local recording offices while the FHFA index is based on data on conventional, conforming mortgage transactions obtained from Fannie Mae and Freddie Mac. The "conforming" loan limit for mortgages is a capped and

FHFA data are biased against houses purchased with relatively "high" or "low" mortgages.[18] The Case-Shiller index does not have valuation data from 13 states with non-disclosure laws, while the CoreLogic and FHFA indexes uses mortgage data in place of public records from these states.



On weighting, the FHFA index is a geometrically-weighted average of price changes of the nine census division; the weights are the relative *number* of one-family housing units. Case-Shiller is an arithmetically-weighted average of price changes; the weights are the relative dollar *value* of one-family housing units. For example, the Case-Shiller index places a 22 percent weight on the Pacific division in contrast to the 14 percent weight of the FHFA index, due to the relatively higher house prices in California. The weights used for aggregating both indexes are estimated using US Census data, updated every ten years, that is, in 1990, 2000, and 2010, though linear interpolations are used by FHFA to chain-weight the indexes retrospectively once the subsequent benchmark census results are available.

On the implementation of the repeat sales methodology, sales pairs with longer time intervals are given less weight than sales pairs with shorter intervals[19] The down-weighting for lengthy intervals used for Case-Shiller is more modest than that used by FHFA. CoreLogic does not use an interval weighting system.

Studies undertaken by FHFA economists on why the FHFA and Case-Shiller indexes differ find the most important reasons are the non-coverage by FHFA of "low and moderate-

[18] The upper end is also not fully represented both because such transactions are less likely to use conventional mortgage loans, and because the size of the associated mortgages can lie above the conforming loan limits (loan amount restrictions) in the agencies. However, the study found that the bias due to this was limited.

[19] This procedure is well justified when phrased as a correction for heteroskedastic error variances as greater noise accompanies ratios over longer periods. The correction reduces the error but does not increase bias.

priced" sales, somewhat offset by the non-coverage of "high-priced" sales, and differences in down-weighting long-intervals and filters used exclude non-arms-length sales.

The case studies, while of interest to ground more detailed analysis are, in a statistical sense, constrained by their limited degrees of freedom: that is, too many variables chasing too few observations. It is natural to consider a data set of many countries each with more than one RPPI with different coverage and/or utilizing different methods. The panel structure of the data would have measures of RPPI inflation as cross sections with different coverage and methods as explanatory variables. The time series dimension of the panel would be the quarterly changes in the RPPIs. Fixed effect controls would be by country.[20]

II. DOES MEASUREMENT MATTER? INTERNATIONAL EVIDENCE

There is evidence of differential RPPI growth rates between countries.[21] But there is also a variety of quite dispirit methods employed between countries for calculating RPPIs. In this section we employ a panel regression that attempts to distinguish measurement effects from residential property price inflation.

A. The RPPI series

The study is based on a panel of about 157 series of quarterly residential property price index (RPPIs) for 24 countries over 2004:Q2 to 2010:Q1. Details of the RPPI series are given in Annex 2. Log rates of changes in quarterly RPPIs are defined below for RPPI series i=1,…,N_c in country c=1,…,C over t=1,…,T quarters where N_c is the number of RPPIs in country c, given in Annex 2 alongside each country name.

$$dhpi_{i,c}^{t} = \ln\left(\frac{hpi_{i,c}^{t}}{hpi_{i,c}^{t-1}}\right)$$

[20] An alternative approach is retrospective country studies that use different RPPI methodologies. These include, for Ottawa, Canada: Li, Prud'homme, and Yu (2006); Sydney, Australia: Hill and Melser (2008); the USA: Leventis (2008); Tokyo, Japan: Shimizu, Nishimuraand, and Watanabe (2009). Such studies provide valuable insights into the empirical effect of methodological differences, though are usually on constrained data sets, for example to a single city, and undertaken not on real time series. This study benefits from using cross country information and examines the measurement issues concerning real time RPPIs.

[21] Hilbers *et al.* (2008) demonstrated the variability in European country RPPI growth rates by distinguishing between European countries according to their RPPI average (real) growth rate between 1985 and 2005-07. House prices in Spain, Belgium, Ireland, the United Kingdom, the Netherlands, and France more than doubled; the Nordic countries, Italy and Greece increased by about 50–100 percent; and Germany, Austria, Switzerland, and Portugal remained largely flat or fell over the two decades.

Our concern is explaining variation in inflation *rates*, not levels. For the 2004:Q2 to 2010:Q1 the Levin, Lin, and Chu *t* statistic of -16.5045 rejected the null hypothesis that each individual series had a common integrated time series versus the alternative hypothesis that all individuals series are stationary rejected (*p*-value=0.0000). The null was also rejected when tested using the Im, Pesaran and Shin *W*-statistic of -24.3148 (*p*-value=0.0000) and by the ADF Fisher Chi-square statistic of 1259.28, (*p*-value=0.0000), and the Phillips and Perron Fisher Chi-square statistic of 1,640.76 (*p*-value=0.0000).

B. Coverage and measurement of explanatory variables

Explanatory variables are classified into those based on data coverage coverage (vintage, geographical classification, type of dwelling) and those based on method. They include:[22]

Based on coverage:

- ***Vintage*** (benchmarked on ***both*** new and existing).
  New (newly constructed dwelling=1 (0 otherwise); **Xsting** (existing dwelling) =1.

- ***Geographical coverage*** (benchmarked on ***national*** coverage).
  Capital (major) city=1 (0 otherwise); **Big cities**=1 (0 otherwise); **Urban** areas (0 otherwise); **Notcapital**=1 (0 otherwise); **Rural**=1 (0 otherwise).

- ***Type of dwelling*** (benchmarked on ***both*** apartments and single family homes).
  Apartment=1 (0 otherwise); Single family home (**Sfh**)=1 (0 otherwise).

Based on method:

- ***Quality-mix adjustment*** (benchmarked on ***price per dwelling,*** no adjustment).
  H**edonic** regression-based=1 (0 otherwise); **Repeat** sales=1 (0 otherwise); **SPAR**=1 (0 otherwise); **MixAdjust**=1 (0 otherwise); **SqMeter**=1 (0 otherwise).

- ***Type of price*** (benchmarked on ***transaction price***). **Asking** price =1 (0 otherwise); Tax/mortgage **Appraisal** price=1 (0 otherwise).

[22] Information on the characteristics of the property price indexes was based on the methodological notes attached to the source data, survey papers, and, often, extensive email correspondence with the providing institutions.

- ***Weights: as a flow of sales transactions or stock*** (benchmarked on ***sales***=0)**.** **Wstock=1** (0 otherwise).

- ***Weights: quantity or value shares*** (benchmarked on ***value***=0). **Wquantity**=1 (0 otherwise); **Wsqmeter**=1(0 otherwise); **Wpop**ulation=1(0 otherwise); **Wprice** in base-period =1(0 otherwise).
- ***Weights: fixed or chained/regularly-updated or unweighted*** (benchmarked on ***fixed***=0).**Wchain=1** (0 otherwise); **Unweighted**=1 (0 otherwise).

- ***Weights: rolling/average or annual*** (benchmarked on ***annual***=0). **Wrolling=1** (0 otherwise).

- ***Aggregation at higher level: geometric or arithmetic*** (benchmarked on arithmetic). **Geometric=1**(0 otherwise).

Interaction variables were included, but with little success. Some dummy variables were included to reflect changes in methodology over time.

The categorization is of course not always straightforward. For example, for the Austrian RPPIs, the *Immobilienpreisindex,* one third of the data are transaction prices and two thirds are quotation prices: the index was characterized as being based on transaction prices.

C. The Results

The estimator is a cross-section SUR specification to allow for conditional correlation between the contemporaneous residuals for cross-sections (but restricts residuals in different periods to be uncorrelated), and to allow for cross-sectional heteroskedasticity (Beck and Katz (1995).

The results from a specification that includes fixed country effects and a parsimonious selection of variables, based on experimentation over different sub-periods, are presented in Table 1. Though not given here for brevity,[23] about half of the 23 fixed country dummy variables were statistically significant (12 cases at the 5 percent level). Their coefficients provide estimates of the extent to which country inflation rates differ, benchmarked on Poland, conditioned on the indexes' differences in measurement.

[23] Results are available from the author.

Of note is the low $\overline{R}^2$ of 0.043. Only two measurement variables are statistically significant at a 5 percent level. Further:

- $\overline{R}^2$ for a regression of the panel data on a constant is of course **zero**; increasing to
- **0.013** when just measurement variables are included; to
- **0.026** when just the 157 cross-section fixed effects are included; to
- **0.044** when the 157 fixed effects are replaced by 24 country fixed effects; to
- **0.141** when just time dummies are included; to
- **0.190400** when both country and time fixed effects are included;[24] and to
- **0.190034** when also conditioned on salient measurement variables.

Measurement does not seem to matter.

The restriction for the model in Table 1 that the coefficients were constant over time was relaxed for the parsimonious set of explanatory variables.[25] This specification also included fixed-**time** effects and fixed **cou**ntry effects. The methodological explanatory variables were categorized, as noted in IIB above, as those based on **cov**erage and **meth**od. The results for moving window regressions are given in Table 2.

First, the regressions have substantial explanatory power, $\overline{R}^2$ at about 0.45 in mid-2009. This is especially notable given only fixed country and time (on a stationary series) effects, and measurement variables are included—seasonal variables have yet to be tested. There are no structural explanatory variables to explain house price inflation by means of the supply and demand (and financing) of country's housing market, as in, for example, Muellbauer and

[24] When the fixed effects were tested against an unrestricted model for such effects, the null hypothesis was rejected. For the fixed time effect, F=28.803 (*p*-value=0.0000); cross-section, F=1.622 (*p*-value=0.0000); both cross-section and time fixed effects, F=5.238 (*p*-value=0.0000).

[25] Capital, new, apartment, sfh, xsting, appraisal, hedonic? sqmeter, unweighted, wstock, wprice, asking, and sqmeter. The selection was based on the results from a general model for the whole period rather than optimal parsimonious representations for the sub-periods of the moving window regressions whose results are given in Table 2.

Murphy (2008).[26] From the results of Table 2, column 2, measurement matters and, in particular, $\overline{R}^2$ increases over the period of recession, when it really matters.

Second, is an interest as to whether the results are driven by the time and/or country (cou) fixed effects, and not by the measurement variables. Table 2 shows the explanatory power of the model is not just substantively driven by the fixed time and cou effects. On excluding the country- and time-fixed effects, Table 2, column 6, $\overline{R}^2$, while diminished, accounted during the recession for between a fifth and a quarter of the variation in residential property price inflation rates.

Third, is the question, given that measurement matters, what matters most, coverage variables or methodological variables? Table 2, columns 7 and 8 find that dropping either set leaves the other with substantial explanatory power, though "method" is for the large part slightly more important than "coverage." The high $\overline{R}^2$ after dropping either set of variables is an indication of multicollinearity between the two sets of variables. Some methods are conducive to some data sets which in turn have specific coverage.[27] Given the intercorrelations between the variable sets, there is a case for ensuring like RPPIs are compared with like in terms of coverage, on the assumption that some differences in methods are likely to be picked up by coverage variables.

Table 3 provides results for an illustrative regression which allows all measurement variables to change over time, for brevity, over the period 2009Q1 to 2009:Q2. $\overline{R}^2 = 0.503$ with 16 of the 26 (13 in two periods) variables statistically significant at the 5 percent level—a major improvement on the constrained model of Table 1. The impact of the variables is quite volatile over time; a variable being significant in one quarter is no guarantee of it being so in the next.

Figures 1–4 illustrate the nature, magnitude and volatility of individual regression coefficients over time for four illustrative explanatory variables: the use of stock (as against transaction) weights, hedonic regressions (as against price per dwelling), unweighted or equal weights (as against value shares), and appraisal (as against transaction) price data. A lighter-fill marker in the Figures indicates that the coefficient's value is statistically significant at a 5 percent level. There are trends to the coefficients for stock weights (rising)

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[26] The papers finds the main drivers of house prices to include income, the housing stock, demography, credit availability, interest rates, and lagged appreciation.

[27] For example in the United States, the repeat purchase method is used to hold constant the quality mix of transactions for existing houses, but for new houses sold only once, the hedonic method is used, since new houses (coverage) will generally have only one transaction (method). More generally, Land Registry data based on transaction prices often has a large coverage, but limited characteristic variables, arguing against the use of hedonic regressions, while the opposite applies to realtor data based on asking prices.

and for appraisals (falling)—see Figures 1 and 4 respectively. Measured inflation using appraisal data showed higher rates using transactions for the initial period, but the pattern became quite volatile near and during the recession. The use of stock weights, as opposed to transactions, had a negative impact on measured inflation in the pre-recession period with more volatility in subsequent periods. The impact of both hedonic quality-mix adjustment methods and unweighted measures—Figures 2 and 3—while generally negative and statistically significant, was quite volatile and marked over the whole period.

Figure 5 provides a measure of residential property price inflation for the 24 countries, derived from the fixed-time effects in the regression. The implicit weighting for each country in this global measure is the number of series in each country.[28] It is a measure of global residential property price inflation that uses over 150 such indexes and is conditioned in the regression on differences in measurement. Given measurement matters, it shows global residential property price inflation having abstracted from it differences in measurement.

The measurement-adjusted global inflation and the unadjusted-global inflation measures in Figure 5 to a large extent track the same trend and turning points. This was also found in section II for different measures for the UK and US. However, the turning points for the measurement-adjusted measure is later (2008:Q3 against 2008:Q2) and the fall deeper than the unadjusted measure, and substantially so (2008:Q4 -0.036 against -0.020). Yet overall, the two series track each other much closer during the recession than prior to it.

III. CONCLUSIONS

The paper outlined the wide variation in the form RPPIs can take both with respect to coverage and method. The case studies showed that different RPPIs for a country broadly follow similar trends and turning points. Yet they also identified substantial differences in measured national residential property price inflation between different indexes within a country. Economists interested in residential property price inflation have the problem of having to choose between several measures and economists faced with a singular index in their country have to make a judgment whether the method and coverage of the RPPI is appropriate.

The results from the panel regression in section II provide a more extensive and formal analysis of this measurement problem. They clearly demonstrate that measurement matters;

[28] The weighting is illustrative of the method and has no justification. But explicit weights can be imposed, even on an annual basis. One approach to including weights (relative household consumption expenditures) is by use of a weighted least squares estimator using a framework outlined in Diewert (2005). A problem with this approach is that weights have been already been introduced to correct for heteroskedasticity. An alternative approach would be to measure methodology-adjusted dwellings inflation for each country using coefficients from the global model to standardize each country's method, and then apply explicit weights to each series.

substantively so and particularly when it really matters, during a recession. The effects of individual measurement variables vary over time with some collinearity between those explanatory variables concerned with differences in method and those concerned with differences in coverage. An economist may be advised on the basis of this study that matching residential property price indexes with similar coverage (geographical, vintage, type), a more obvious task, will to a large extent, control for the effects of differences in method.

Different patterns over time are distinguished for the effects (coefficients) on residential property price inflation of different measurement variables. The analysis culminates in a measure of global inflation for the 24 countries that abstracts measurement effects from measured changes in residential property price inflation.

Table 1, Regression of residential property prices on measurement variables

Variable	**Coefficient**	**Std. Error**	***t*-Statistic**	**Prob.**
C	0.020	0.006	3.351	0.001
APPRAISAL	0.004	0.005	0.826	0.409
SQMETER	0.005	0.004	1.286	0.199
HEDONIC	-0.005	0.003	-1.762	0.078
APARTMENT	0.000	0.002	-0.080	0.936
CAPITAL	0.000	0.001	-0.040	0.968
ASKING	0.000	0.003	0.079	0.937
XSTING	-0.001	0.002	-0.329	0.742
NEW	0.000	0.003	0.038	0.970
SFH	0.000	0.002	0.227	0.821
WSTOCK	-0.002	0.002	-0.906	0.365
UNWEIGHTED	-0.008	0.002	-3.375	0.001
WROLLING	-0.007	0.002	-3.084	0.002
WPRICE	0.000	0.001	-0.165	0.869
R-squared	0.053	Mean dependent var		0.011
Adjusted R-squared	0.043	S.D. dependent var		0.041
S.E. of regression	0.040	Akaike info criterion		-3.606
Sum squared resid	5.552	Schwarz criterion		-3.542
Log likelihood	6462.596	Hannan-Quinn criter.		-3.583
F-statistic	5.483	Durbin-Watson stat		1.689
Prob(F-statistic)	0.000			

Sample: 2004Q2 to 2010Q1; 155 cross-sections; 3564 obs.
Fixed time effects and fixed country effects not shown for brevity.

Table 2, Fit of measurement variables in moving window regression

	RbarSq*100 CovMeth CouTime	RbarSq*100 Excl Time	Time jointly sig F-Stat	Time jointly sig p-value	RbarSq*100 Excl Cou and Time	RbarSq*100 Excl Cov	RbarSq*100 Excl Meth
04 Q4	23.74	22.13	1.795	0.128	10.51	19.46	20.85
05 Q1	22.18	20.21	1.973	0.097	8.08	21.50	19.64
05 Q2	25.66	24.48	2.559	0.038	9.33	25.68	20.89
05 Q3	28.56	27.58	2.192	0.069	9.52	27.46	23.50
05 Q4	32.70	32.38	1.120	0.346	11.13	30.81	25.78
06 Q1	36.82	35.85	2.684	0.031	9.11	35.39	29.18
06 Q2	41.97	41.27	2.934	0.020	8.06	41.12	34.80
06 Q3	34.81	34.41	2.221	0.065	6.83	34.37	30.96
06 Q4	28.39	28.05	1.804	0.126	5.53	28.32	26.30
07 Q1	26.18	26.14	0.810	0.519	6.50	26.07	23.83
07 Q2	18.41	18.17	1.266	0.282	9.22	17.45	16.53
07 Q3	18.29	17.74	1.571	0.180	9.87	16.52	16.92
07 Q4	19.91	19.29	0.423	0.792	10.27	17.86	18.33
08 Q1	27.24	26.40	1.935	0.103	13.69	25.00	25.05
08 Q2	30.39	28.66	5.326	0.000	15.83	28.18	27.87
08 Q3	33.29	33.35	4.726	0.001	21.21	32.20	30.21
08 Q4	37.00	36.07	3.669	0.006	21.7	35.13	29.95
09 Q1	41.83	39.68	7.323	0.000	21.51	39.72	34.95
09 Q2	45.15	42.76	8.329	0.000	24.41	43.86	37.06
09 Q3	45.43	44.26	3.860	0.004	24.54	43.81	38.31
09 Q4	39.43	38.69	0.664	0.052	16.89	37.99	33.54
10 Q1	41.12	40.09	1.125	0.290	9.78	37.80	32.95

Figures are for 5-quarters' moving (by one quarter) window regressions appropriately centered. Figures for 2009:Q4 and for 2010:Q1 are based on regressions over 2009Q2-2010:Q1 and 2009Q4-2010:Q1 respectively.

Table 3, Illustrative regression results for 2009:Q1 to 2009Q2

Variable	**Coefficient**	**Std. Error**	***t*-Statistic**	**Prob.**
C	0.005	0.014	0.372	0.71
APPRAISAL--2009Q1	-0.025	0.005	-4.547	0.00
APPRAISAL--2009Q2	0.036	0.006	6.065	0.00
SQMETER-2009Q1	-0.023	0.009	-2.472	0.01
SQMETER--2009Q2	-0.012	0.009	-1.449	0.15
HEDONIC--2009Q1	-0.004	0.002	-1.570	0.12
HEDONIC--2009Q2	0.012	0.002	5.889	0.00
APARTMENT--2009Q1	-0.004	0.002	-1.980	0.05
APARTMENT--2009Q2	-0.013	0.002	-5.653	0.00
CAPITAL--2009Q1	-0.014	0.003	-4.325	0.00
CAPITAL--2009Q2	0.001	0.002	0.573	0.57
ASKING--2009Q1	0.030	0.002	19.099	0.00
ASKING--2009Q2	0.021	0.001	14.030	0.00
XSTING--2009Q1	-0.001	0.004	-0.389	0.70
XSTING--2009Q2	0.000	0.003	0.139	0.89
NEW--2009Q1	0.000	0.005	-0.061	0.95
NEW--2009Q2	-0.023	0.005	-4.995	0.00
SFH--2009Q1	-0.010	0.002	-6.667	0.00
SFH--2009Q2	-0.003	0.002	-2.118	0.04
WSTOCK--2009Q1	-0.011	0.008	-1.447	0.15
WSTOCK--2009Q2	-0.003	0.007	-0.453	0.65
UNWEIGHTED--2009Q1	-0.014	0.003	-4.251	0.00
UNWEIGHTED--2009Q2	0.010	0.003	3.381	0.00
WROLLING--2009Q1	-0.013	0.003	-3.697	0.00
WROLLING--2009Q2	-0.011	0.004	-2.581	0.01
WPRICE--2009Q1	0.017	0.009	1.899	0.06
WPRICE--2009Q2	-0.008	0.008	-0.952	0.34

R-squared	0.587	Mean dependent var	-0.013
Adjusted R-squared	0.503	S.D. dependent var	0.046
S.E. of regression	0.033	Akaike info criterion	-3.843
Sum squared resid	0.262	Schwarz criterion	-3.206
Log likelihood	617.911	Hannan-Quinn criter.	-3.588
F-statistic	6.939	Durbin-Watson stat	2.601
Prob(F-statistic)	0.000		

Sample: 2009Q1 2009Q2; 148 cross-sections; 295 obs.
Fixed time effects and fixed country effects not shown for brevity.

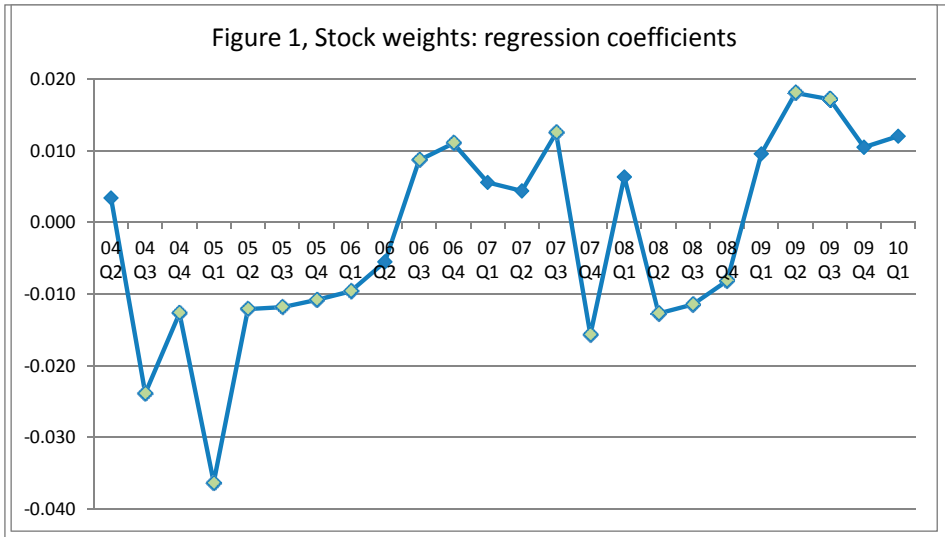
Figure 1, Stock weights: regression coefficients
0.020
0.010
0.000
-0.010
-0.020
-0.030
-0.040
04 Q2 04 Q3 04 Q4 05 Q1 05 Q2 05 Q3 05 Q4 06 Q1 06 Q2 06 Q3 06 Q4 07 Q1 07 Q2 07 Q3 07 Q4 08 Q1 08 Q2 08 Q3 08 Q4 09 Q1 09 Q2 09 Q3 09 Q4 10 Q1

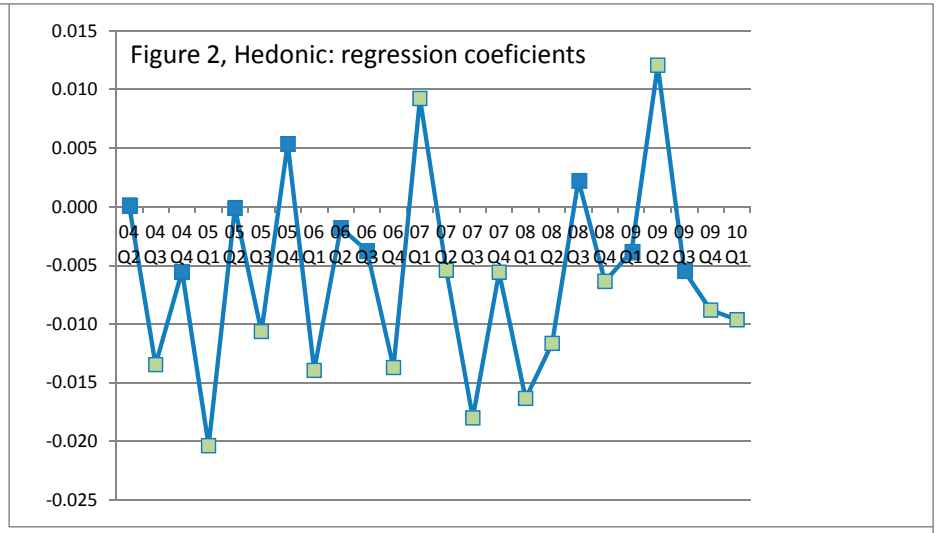
Figure 2, Hedonic: regression coeficients
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
-0.025
04 Q2 04 Q3 04 Q4 05 Q1 05 Q2 05 Q3 05 Q4 06 Q1 06 Q2 06 Q3 06 Q4 07 Q1 07 Q2 07 Q3 07 Q4 08 Q1 08 Q2 08 Q3 08 Q4 09 Q1 09 Q2 09 Q3 09 Q4 10 Q1

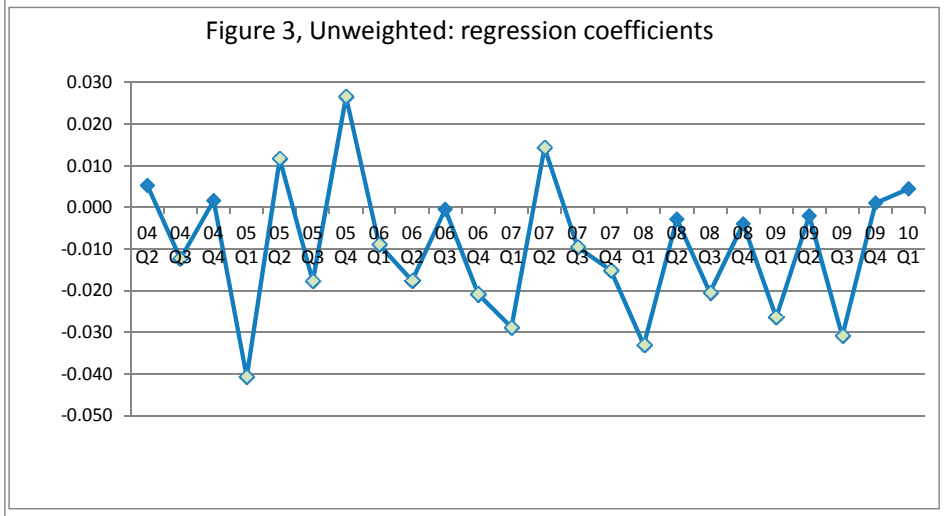
Figure 3, Unweighted: regression coefficients
0.030
0.020
0.010
0.000
-0.010
-0.020
-0.030
-0.040
-0.050
04 Q2 04 Q3 04 Q4 05 Q1 05 Q2 05 Q3 05 Q4 06 Q1 06 Q2 06 Q3 06 Q4 07 Q1 07 Q2 07 Q3 07 Q4 08 Q1 08 Q2 08 Q3 08 Q4 09 Q1 09 Q2 09 Q3 09 Q4 10 Q1

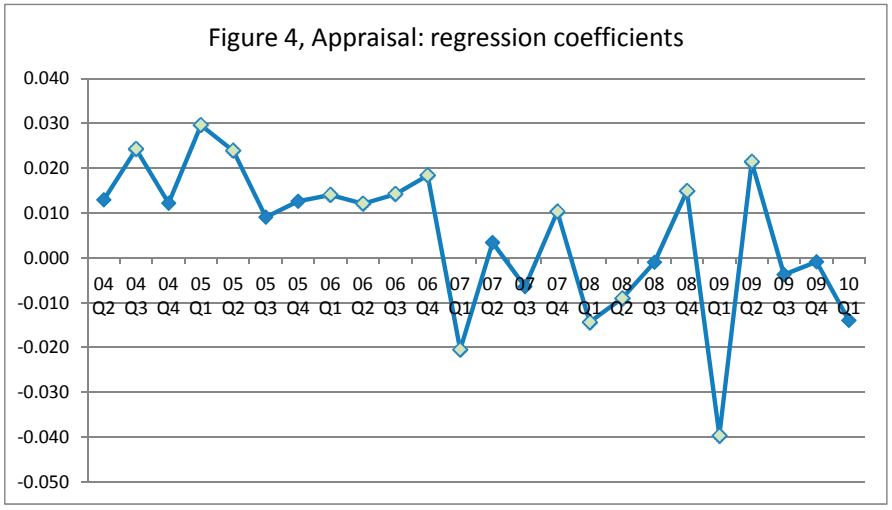
Figure 4, Appraisal: regression coefficients
0.040
0.030
0.020
0.010
0.000
-0.010
-0.020
-0.030
-0.040
-0.050
04 Q2 04 Q3 04 Q4 05 Q1 05 Q2 05 Q3 05 Q4 06 Q1 06 Q2 06 Q3 06 Q4 07 Q1 07 Q2 07 Q3 07 Q4 08 Q1 08 Q2 08 Q3 08 Q4 09 Q1 09 Q2 09 Q3 09 Q4 10 Q1

22

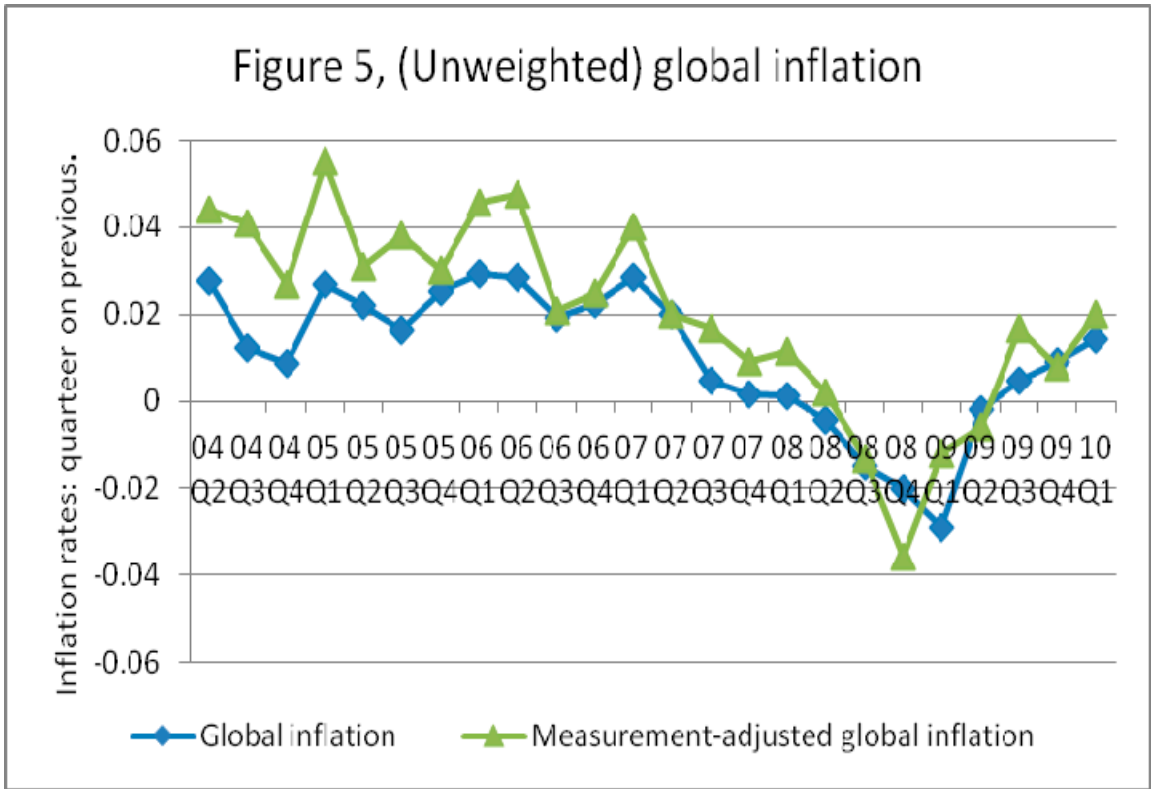
Figure 5, (Unweighted) global inflation
Inflation rates: quarteer on previous.
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
04 04 04 05 05 05 05 06 06 06 06 07 07 07 07 08 08 08 08 09 09 09 09 10
Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1
Global inflation
Measurement-adjusted global inflation

ANNEX 1: ISSUES IN RPPI METHODOLOGY

RPPI methodology can vary according to method used to control for quality mix, coverage, nature of prices, and weights—Eiglsperger (2006), Fenwick (2006) and the draft *Handbook on Residential Property Price Indexes.*[29]

A. Stocks or transactions

A key issue is whether the purpose of the RPPI is to measure changes in the price component of the value of the stock of housing or the value of houses transacted. If the former, then the weights must be based on relative stock values, as outlined in section E below, and the prices reflect price changes in the stock of housing, as opposed to those sold. RPPIs that utilize data on the prices of houses sold, or for sale, are subject to selectivity bias if the sample of houses is not a random sample of the stock. Appraisal data, usually required for property tax assessment, may be available for the much of the stock of housing and while open to errors from appraiser bias[30] or changes in appraisal rules, enable RPPIs to be estimated that are free from selectivity bias. Alternatively, RPPIs based on price data of houses sold may be estimated using dummy time variables in a hedonic regression, but a correction for selectivity bias incorporated in the two-stage censored regression estimator, as undertaken in Gatzlaff and Haurin (1998).[31]

B. Constant-quality comparisons

At their simplest RPPIs are measured as weighted changes in average (often median) prices. Yet since housing is heterogeneous there is a need to make ensure that average price change measures are not tainted by changes in the quality mix. Alternative methods include:

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[29] The current draft is available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/hicp/methodology/owner_occupied_housing_hpi/rppi_handbook.

[30] Quan and Quigley (1991) point to a problem of appraisal smoothing. Appraisers are argued to work by updating current estimates of comparable property values each time a transaction occurs. The appraiser's role is identified as signal extraction that, as a result of their larger set of information and experience, reduces the price dispersion of equivalent transaction prices by buyers and sellers. An implication is a process known as appraisal smoothing or "appraisal lag." Geltner *et al*. (2003) discuss the process of de-lagging appraisal indexes to remove the effects of smoothing, the lag bias, and provide a summary of the results of empirical studies.

[31] The two-stage estimator requires joint estimation of the probability that a house will sell and the transaction price. The first stage for the probability of a sale uses as explanatory variables, property, owner, and macroeconomic factors that affect reservation and offer prices. From the results, a selection bias correction variable is calculated. Once inserted in the second stage OLS regression of transaction prices, unbiased OLS estimates of RPPIs can be derived from the coefficients on the time dummies.

Repeat sales pricing

restrict the comparison to repeat sales. The repeat-sale method was developed by Bailey, Muth and Nourse (1963) and has since been extended by amongst others Shiller (1991, 1993). Each period, data are collected on sales and if a record of an earlier transaction for the home is identified, the two transactions are paired and treated as a repeat sale. By limiting the sample to price comparisons of pairs of like sales it mitigates the shortcomings of RPPIs based on median sales that have no control for quality change. The primary disadvantages are (i) the quality of a repeat purchase may depreciate, with wear and tear, or appreciate, with renovations;[32] (ii) there is potential sample selectivity bias[33] and error due to relatively small sample sizes—houses not sold or sold once[34] in the period are omitted and atypical houses may be sold more frequently thus biasing the sample (see Gatzlaff and Haurin (1998), Hwang and Quigley (2004) and Mason and Pryce (2011) for correction mechanisms for sample selection bias); (iii) time dummies are used in a regression of prices of repeat sales to generate average house price indexes.[35] As a result, as new transaction pairs become available with the addition of new historical data, the index is subject to a volatile revision history;

Hedonic approach

has as its basis regression of house prices on price-determining characteristics. It can be used for a data set of prices of all houses, say using appraisal data, as long as each price has an associated characteristic data set. There are two major forms: characteristics price (or hedonic imputation) indexes in which the quality characteristics in a fixed period are revalued by the coefficients from hedonic regressions in each period as the basis for constant quality indexes. There are as many possible RPPIs as there are fixed reference periods, but index number theory provides guidance on an appropriate choice. Alternatively, time

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[32] Some fairly arbitrary methods are used to mitigate such effects, for example, the CS-RPPI (i) assigns smaller weights to sales pairs with large price changes relative to the community around them—in large metro areas typically 10–15 percent of pairs are down-weighted; (ii) sales pairs with longer time intervals are given less weight than sales pairs with shorter intervals—in large metro areas the interval weights for sales pairs with ten-year intervals will be 20–45 percent smaller than those for six-month intervals; (iii) deeds that indicate that the sale is unlikely to be arms-length are excluded; and (iv) homes that sell more than once within 6 months are excluded as they are considered likely to following a major remodeling. The hedonic repeated measure developed by Shiller (1991, 1993) makes it possible to account for possible changes in house characteristics between first and second sales.

[33] If the purpose of the measure relates to changes in the stock of house prices.

[34] A hybrid measure combines information on single sales and repeat sales using characteristics to control for quality, see Englund, Quigley and Redfearn (1998). Chau, *et al*. (2005) surveys the percentage of repeat sales pairs to number of transactions (maximum 50%) in a number of studies finding high inter-country variability, for example, 23 percent for Hong Kong for comparisons over 10 years compared with 6.6 percent over 18 years for areas in California.

[35] Dreiman and Pennington-Cross (2004) address the implications for the estimator of the (asymmetric and positive) relationship between the time between transaction and the variance of the error term.

dummies are included in the hedonic regressions and their coefficients provide the basis for estimates of quality-adjusted price changes. Silver and Heravi (2007), Diewert, Heravi and Silver (2008) provides accounts of these approaches the factors determining differences in their results and Li, Prud'homme, and Yu (2006) and Hill and Melser (2008) provide empirical work on how such RPPIs based on theses approaches differ.

Mix-adjustment through stratification

Mix-adjusted RPPIs may be compiled as weighted averages of strata based on location and other price-determining characteristics (see examples in Wood (2005). Such indexes are equivalent to hedonic time dummy indexes for which the stratifying factors are dummy variables in the regression. The advantage of using a regression (hedonic) formulation is that estimates for standard errors are obtained for the (RPPI) coefficients on the time dummy variables.

Sale price appraisal ratio (SPAR) method

SPAR combines information from appraisals and transactions. It includes unmatched transactions and, unlike the repeat purchase method, does not need to be revised when a new transaction is paired. There is claimed to be a constant quality, except for age, provided that appraisals are adjusted by the value of improvements—see Bourassa, Hoesl, and Sun (2006) for details. The unmatched comparisons between say periods t and t-1, are the average prices of the "new" (sold only in period t) compared with the "old" (sold only in period t-1) and the quality adjustment used can be shown[36] to be the ratio of the average appraised values in some previous period 0 of the new against the old. The viability of the method depends critically on the quality of appraisals and their not becoming out of date.

Standard 'model' portfolio approach

This approach is based on controlling for quality changes by making periodic valuation of a standard property portfolio or standard units of different types/specifications in a given areas. The sample may be changed over time to keep constant the age of the property. The sample may be based on active transactions and/or appraisals (Chau *et al*., 2005)..

C. Coverage

Geographical

RPPIs can be national, cover just the capital city, major cities, major urban areas, rural areas, or some or all of the above being aggregated from sub-indexes of regional or more local administrative areas. The evidence is of substantial variation in inter-area growth rates in RPPIs (for example, Abraham and Hendershott (1996) and Capozza *et al.* (2002). The

[36] Algebraically, this can be easily done using geometric, recommended for an unweighted SPAR by Vries *et al*. (2008), as opposed to arithmetic means.

concern of this paper is where a reliable national RPPI is not available for a country but a say reliable capital city RPPI is used as a proxy for a national one. In such a case the "national" index has a defective geographical coverage.

Type of housing

RPPIs may be restricted to (combinations of) types of housing such as newly built houses and or apartments, single-family houses, apartments, apartment *and* terrace houses. These serve different purposes, for example, newly-built residential property price indexare appropriate for measuring the cost of shelter in a consumer price index using the net purchase (or acquisitions) concept (see Diewert (2004) and Baldwin, Nakamura and Prud'homme (2006)).

Source data and financing

Administrative data sources used to record prices may be restricted to purchases financed by a particular mortgage organization. For example the aforementioned OFHEO RPPI is based on data on conventional conforming mortgage transactions (including refinancing) obtained from Freddie Mac and Fannie Mae, about 60 percent of all loans. Notable exclusions are transactions for properties financed by government insured loans, Jumbo mortgages, sub-prime loans, private loans or no loans.

D. Prices: source data, valuation, and time-lines

The sale and purchase of a house usually touches a number of organizations to promote its sale (real estate agents), finance its purchase (mortgage lenders), administer taxes (tax authority), and register its legal title (Land Registry or notorary[37]). The price may change along the timeline of the process from asking price to final completion (of contract) price. The continuum is such that the asking price for an individual property can change, and is likely to fall, the longer the property is on the market. While generally it is the final completion price that RPPIs should measure, prices at earlier stages may be used for RPPIs for pragmatic reasons.

For example, the final completion price data base may not be timely or may exclude many price-determining characteristics necessary for mix-adjustments, while an earlier data base, say from mortgage lenders, may have sufficient price-determining characteristics and be more timely, but would exclude cash sales and the effects of any renegotiation of prices between mortgage approval and completion. The length of the timeline, potential for renegotiating price, and adequacy of source data will vary between countries and over time for individual countries . An illustration is provided below based on Wood (2005 for the U.K. timeline which may take 6 months.

[37] In France, all real estate transactions have to be registered in front of a notary who have a monopoly Gouriéroux and Laferrère (2006).

The Rightmove RPPI is based on the sellers' asking prices posted on internet site. Such prices may well be revised by the time they are used by the Halifax, Nationwide, and Hometrack RPPIs at mortgage approval stage, but the samples are restricted to loans approved by mortgage lenders Halifax and Nationwide, and for Hometrack, a survey of approx 4,000 estate agents. Yet prices can be renegotiated further even at this late stage (called "gazumping") and the ODPM index registers prices at completion based on data from a larger sample of mortgage lenders. The Land Registry while released even later, included all transactions including those purchased by cash without a mortgage. There is an apparent tradeoff between the timeliness of the indicator and its quality.

E. Weights: stocks or transactions and values or quantities

RPPIs can be designed to measure changes in transaction prices or the price component of changes in the value of the stock of housing, depending on analytical need. The implications for price measurement were outlined in Section A above, Here our concern is with weights**.**

First, there is the issue whether democratic or plutocratic weights should be used. For an index aggregated over regions, types of housing, and possibly other stratification factors, democratic weights would require the relative volumes of transactions of each stratum while plutocratic weights would require the relative monetary nominal values. Such values may be purchase values or stock values, depending on the purpose of the index. As outlined in section IIA above, an RPPI of the price component of changes in the value of the stock of houses not only requires relative stock value weights, but that the prices, if based on transactions, be adjusted for selectivity bias, something not always feasible.

Weights should be updated as regularly as possible and annual chained Lowe indexes or, more so, geometric Young indexes are preferred as most likely approximations, given timely weights will be unavailable, to chained superlative indexes (see ILO *et al.* (2004) for these index number issues). For regression formulations weighted least squares (WLS) estimators can be used since there is an equivalence between different weighting systems used for such estimators and individual weighted index number formulas (see Silver (2002) and Diewert (2005).

ANNEX 2: HOUSE PRICE SERIES

Many of the residential property price indexes used in this study have been drawn from the Bank for International Settlements' (BIS) database of property price indexes available at: http://www.bis.org/statistics/pp.htm. The codes cited below alongside "BIS" refer to this database. Use of the database requires a citation of the appropriate national source as noted at: http://www.bis.org/statistics/pp/disclaimer.htm and given below along with the websites used.

The BIS country series have been supplemented by further residential property price indexes, not always published, from the national sources indicated below.

Australia: 14 series

BIS: Q:AU:2:1:1:1:0:0 and Q:AU:4:1:1:1:0:0; House Price Indexes; original source: Australian Bureau of Statistics: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6464.02009?OpenDocument.

RP Data; RP Data-Rismark's Home Value Indexes: Capital Gain (final values), Repeat Sales, and Stratified median; data provided to author by RP Data; website: http://www.rpdata.com/. See also: www.rpnz.com.au/derivatives/pdfs/Basing_NZ.pdf

Austria: 10 series

BIS:Q:AT:2:8:0:0:1:0, Q:AT:1:1:0:0:1:0, Q:AT:1:8:0:0:1:0, Q:AT:2:8:1:0:1:0, Q:AT:1:2:1:0:1:0, Q:AT:1:8:1:0:1:0, Q:AT:1:8:2:0:1:0, Q:AT:2:1:0:0:1:0, Q:AT:2:2:1:0:1:0, Q:AT:2:8:1:0:1:0; Residential Property Price Index; original source: Oesterreichischen Nationalbank: http://www.oenb.at/isaweb/report.do?lang=EN&report=6.6.

Belgium: 8 series

BIS: Q:BE:2:2:1:2:0:0; Stadim Indexes; original source and further indexes: STADIM (Study and Advice Bureau on Immovables): http://www.stadim.be/index.php?page=stadimdexen&hl=en.

BIS: Q:BE:0:1:1:0:0:0, Q:BE:0:2:1:0:0:0, Q:BE:0:3:1:0:0:0, Q:BE:0:4:1:0:0:0, and Q:BE:0:8:1:0:0:0; Prix Ventes de Biens Immobiliersoriginal; original source: SPF Economie, DGSIE (Service public federal Economie, Direction Generale Statistique et Information Economique (FPS Economy, DGSEI (Federal Public Service, Directorate-General Statistics and Economic Information)): http://statbel.fgov.be/fr/modules/publications/statistiques/economie/ventes_de_biens_immobiliers.jsp.

Canada: 6 series

Teranet (developed in alliance with the National Bank of Canada); Teranet House Price Index; source: http://www.housepriceindex.ca/Default.aspx.

New Housing Price Index; Statistics Canada; source: http://www.statcan.gc.ca/daily-quotidien/110210/dq110210a-eng.htm

Resale-Housing Prices (Royal LePage); Bank of Canada; source: http://www.bankofcanada.ca/en/rates/indinf/real_data_en.html.

The Canadian Real Estate Association (CREA); Residential Average Price; source: CREA, available on subscription: http://creastats.crea.ca/natl/.

Czech Republic: 2 series

BIS: Q:CZ:0:2:1:1:3:0 and Q:CZ:0:8:1:1:1:0; Price Indexes of Houses and Flats; original source: Czech Statistical Office, Tables 1–6 and 2–6: http://www.czso.cz/CSU/2009EDICNIPLAN.NSF/P/7009-09.

Denmark: 4 series

BIS: Q:DK:0:2:0:1:0:0 and Q:DK:0:8:0:1:0:0; Price index for sales of property; original source: Statistics Denmark: http://www.statbank.dk/STATBANK5A/DEFAULT.ASP?W=1024.

Association of Danish Mortgage Banks; Average Sqm. Prices of Owner Occupied Dwellings: http://www.realkreditraadet.dk/Statistics/Prices_and_trades_of_owner_occupied_homes.aspx

Estonia: 2 series

BIS: Q:EE:0:8:0:1:1:0 and Q:EE:2:8:0:1:1:0; original source via Statistics Estonia: Estonian Land Board from whose website a data query facility is available: http://www.maaamet.ee/kinnisvara/htraru/Start.aspx. The facility is in Estonian, however, an English-language Guide to its use and technical information are available at: http://www.maaamet.ee/index.php?lang_id=2&page_id=453&menu_id=78.

Finland: 9 series

BIS: Q:FI:0:1:1:1:1:0, Q:FI:0:1:2:1:1:0, Q:FI:0:2:1:1:1:0, Q:FI:0:8:1:1:1:0, Q:FI:4:2:1:1:1:0, Q:FI:9:1:1:1:1:0, Q:FI:9:1:2:1:1:0, Q:FI:A:1:1:1:1:0, and Q:FI:A:1:2:1:1:0; House Price Index; original source: Statistics Finland, unpublished and available from Bank of Finland (Suomen Pankki): http://www.suomenpankki.fi/en/julkaisut/selvitykset_ja_raportit/main/Pages/default.aspx.

France: 8 series

BIS: Q:FR:2:8:1:1:0:0; Indice d'Évolution des Prix des Logements Anciens: original source: INSEE, National Institute of Statistics and Economic Research: http://www.insee.fr/fr/themes/document.asp?ref_id=ip1297 and

http://www.indexes.insee.fr/bsweb/servlet/bsweb?action=BS_RECHGUIDEE&BS_IDARBO=05000000000000.

BIS: Q:FR:0:2:2:3:0:0, Q:FR:0:8:2:3:1:0, Q:FR:3:2:2:3:0:0, and Q:FR:3:8:2:3:1:0; Enquete Commercialsation Logements Nuefs; original source: Ministère de l'Equipment Ministère de l'Écologie, de l'Énergiie, du Développement durable, et de la Mer (Meeddm).

Greece: 9 series

BIS: Q:GR:0:8:0:0:0:0, Q:GR:0:8:1:0:0:0, Q:GR:0:8:2:0:0:0, Q:GR:1:1:0:0:1:0, Q:GR:3:8:0:0:1:0, Q:GR:4:8:0:0:1:0, Q:GR:5:8:0:0:0:0, Q:GR:8:8:0:0:0:0, and Q:GR:9:8:0:0:1:0; Index of the Price of Dwellings; original source: Bank of Greece: http://www.bankofgreece.gr/PAGES/EN/STATISTICS/REALESTATE.ASPX.

Ireland: 11 series

BIS: Q:IE:0:1:0:2:0:0, Q:IE:1:1:0:2:0:0, and Q:IE:2:1:0:2:0:0; Permanent tsb House Price Index; original source: Economic and Social Research Institute (ESRI) based on data from Permanent TSB Bank; http://www.esri.ie/irish_economy/permanent_tsbesri_house_p/ and https://www.permanenttsb.ie/aboutus/housepriceindex/#d.en.1460.

BIS: Q:IE:0:1:1:3:0:0, Q:IE:0:1:2:3:0:0, and Q:IE:2:1:1:3:0; Average house prices; original source and further series: The Department of the Environment, Heritage, and Local Government; available at: http://www.environ.ie/en/Publications/StatisticsandRegularPublications/HousingStatistics/FileDownLoad,15295,en.XLS and http://www.environ.ie/en/Publications/StatisticsandRegularPublications/HousingStatistics/

Netherlands: 10 series

BIS: M:NL:0:1:1:1:0:0, M:NL:0:2:1:1:0:0, and M:NL:0:8:1:1:0:0; House Price Index and Average Purchase Prices; original source and further series: CBS (Central Bureau voor de Statistiek) published in cooperation with the Dutch Land registry Office, Kadaster: http://statline.cbs.nl/STATWEB/SELECTION/?DM=SLEN&PA=71533ENG&LA=EN&VW=T.

New Zealand: 3 series

BIS: Q:NZ:0:1:0:3:0:0, Q:NZ:0:3:0:3:0:0, and Q:NZ:4:3:0:3:0:0; Quotable Value Quarterly House Price Index; original source: Quotable Value Limited; available at: Reserve Bank of New Zealand: http://www.rbnz.govt.nz/keygraphs/1697975.html.

Norway: 4 series

BIS: Q:NO:0:1:0:1:0:0, Q:NO:0:3:0:1:0:0, Q:NO:0:4:0:1:0:0, and Q:NO:0:8:0:1:0:0; House Price Index; original source and further series (see "More Tables in StatBank"): Statistics Norway: http://www.ssb.no/english/subjects/08/02/30/bpi_en/.

Poland: 4 series

BIS: Q:PL:2:8:1:2:1:0, Q:PL:2:8:2:2:1:0, Q:PL:4:8:1:2:1:0, and Q:PL:4:8:2:2:1:0; Average Asking Prices of Flats; original source: National Bank of Poland (growth rates): http://www.nbp.pl/HOMEN.ASPX?F=/EN/SYSTEMFINANSOWY/STABILNOSC.HTML.

Russia: 2 series

BIS: Q:RU:9:1:1:1:1:0 and Q:RU:9:1:2:1:1:0; Indexes of Prices in Primary/Secondary Market of Dwellings; original source: Federal State Statistics Service: http://www.gks.ru/wps/wcm/connect/rosstat/rosstatsite.eng/figures/prices/.

Slovak Republic: 3series

BIS: Q:SK:0:1:1:2:1:0; Residential Property Price Indexes; original source and further series: National Bank of Slovakia: http://www.nbs.sk/EN/STATISTICS/SELECTED-MACROECONOMICS-INDICATORS/RESIDENTIAL-PROPERTY-PRICES.

Slovenia: 6 series

BIS: Q:SI:0:1:1:1:0:0, Q:SI:0:8:2:1:0:0, and Q:SI:2:1:1:1:0:0; Residential Housing Price Indexes; original source and further series: Statistical Office of the Republic of Slovenia: http://www.stat.si/eng/novica_prikazi.aspx?id=3714.

Spain: 2 series

BIS: Q:ES:0:1:1:1:1:0 and Q:ES:0:1:2:1:1:0; Precio M^2 Vivienda Libre; original source: Banco de Espana: http://www.bde.es/infoest/si_1_6.csv.

Sweden: 2 series

BIS: Q:SE:0:1:0:1:0:0; Real Estate Prices; original source and other indexes; Statistics Sweden: http://www.scb.se/Pages/Product____10966.aspx and

http://www.ssd.scb.se/databaser/makro/produkt.asp?produktid=BO0501&lang=2.

Switzerland: 6 series

BIS: CH:0:2:0:2:0:0 and CH:0:8:0:2:0:0; Real Estate Price Indexes; original source: Swiss National Bank: http://www.snb.ch/en/iabout/stat/statpub/statmon/stats/statmon/statmon_O4_3 (original source: Wüest & Partner AG).

Wüest & Partner AG; Transaction and Asking Price Indexes: http://www.wuestundpartner.com/online_services/immobilienindizes/transaktionspreisindex/index_e.phtml.

United Kingdom: 27 series

BIS: Q:GB:3:1:0:2:0:0; Halifax House Price Index; original source and further series: Halifax Research: http://www.lloydsbankinggroup.com/media1/research/halifax_hpi.asp (historical house price data).

BIS: Q:GB:0:1:2:1:0:0; Communities and Local Government House Price Index; original source and further series: Department of Communities and Local Government, available at: http://www.communities.gov.uk/housing/housingresearch/housingstatistics/housingstatisticsby/housingmarket/housepriceindex/. Also available from UK (Office for) National Statistics at: http://www.statistics.gov.uk/hub/people-places/housing-and-households/housing-market/index.html. (© Crown copyright 2008 Land Registry).

Acadametrics; LSL Property Services/Acadametrics House Price Index; source: http://www.acadametrics.co.uk/acadHousePrices.php.

Land Registry; House Price Index; source: http://www.landreg.gov.uk/houseprices/.

Nationwide; Nationwide House Price Index; source: http://www.nationwide.co.uk/hpi/historical.htm.

Rightmove; House Price Index; source: http://www.rightmove.co.uk/news/house-price-index.

United States: 4 series

BIS: Q:US:0:2:2:1:0:0; US Census Bureau; Constant Quality (Laspeyres) Price Index of New One-Family Houses Sold; original source: http://www.census.gov/const/www/constpriceindex.html.

Federal Housing Finance Agency (FHFA); FHFA "Purchases-Only" House price index; source: http://www.fhfa.gov/DEFAULT.ASPX?PAGE=84.

Standard & Poor's; S&P/Case-Shiller National Home Price Index; source: http://www.standardandpoors.com/indexes/sp-case-shiller-home-price-indexes/en/us/?indexId=spusa-cashpidff--p-us----.

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