

# The Role of Holding Periods in Repeat Sales Models

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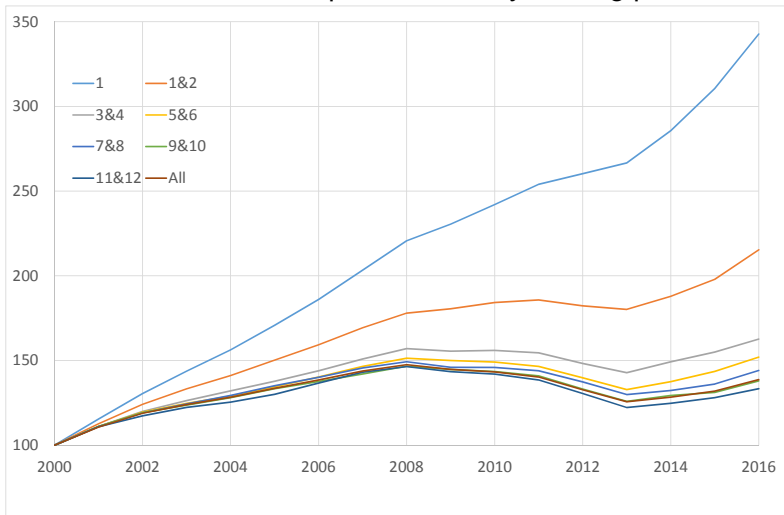
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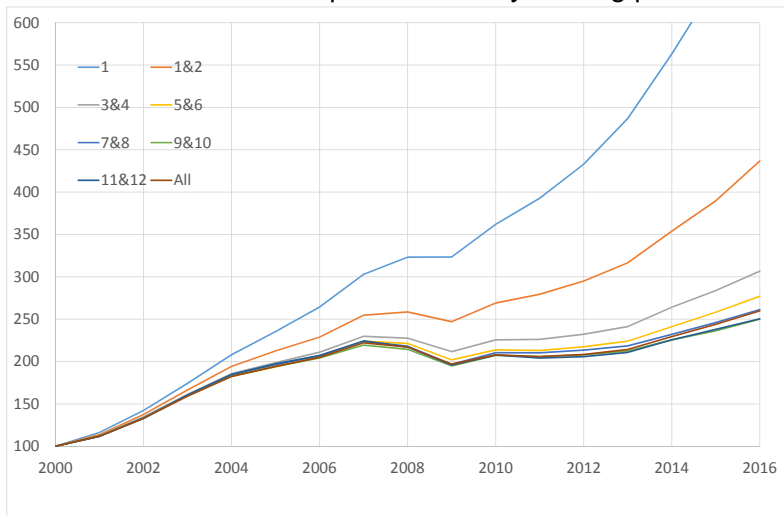
# Periodic returns depend on holding period: NL RRE

Indices estimated on sub-samples defined by holding periods



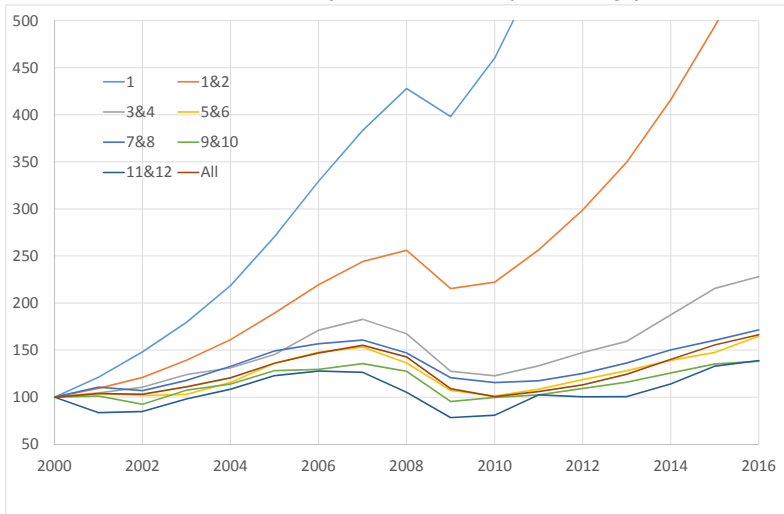
# Periodic returns depend on holding period: UK RRE

Indices estimated on sub-samples defined by holding periods



# Periodic returns depend on holding period: US CRE

Indices estimated on sub-samples defined by holding periods



# Period returns and holding period: Stats

	Housing				Commercial	
	Netherlands 1993 - 2016		England&Wales 1995 - 2016		US 1997 - 2016	
Holding Period	Avg	Std	Avg	Std	Avg	Std
1	0.099	0.045	0.124	0.048	0.159	0.071
1&2	0.072	0.050	0.095	0.056	0.117	0.084
3&4	0.055	0.053	0.074	0.062	0.061	0.102
5&6	0.051	0.054	0.068	0.064	0.046	0.098
7&8	0.049	0.055	0.064	0.067	0.033	0.080
9&10	0.047	0.057	0.063	0.067	0.031	0.098
11&12	0.046	0.058	0.063	0.069	0.046	0.145
All	0.047	0.056	0.065	0.066	0.038	0.094
Pairs	1,180,709		8,264,012		42,723	

Short (long) holding periods have large (small) periodic returns  
Irrespective of the model specification (repeat sales or hedonic)

# Periodic returns depend on holding period: Why?

## Literature

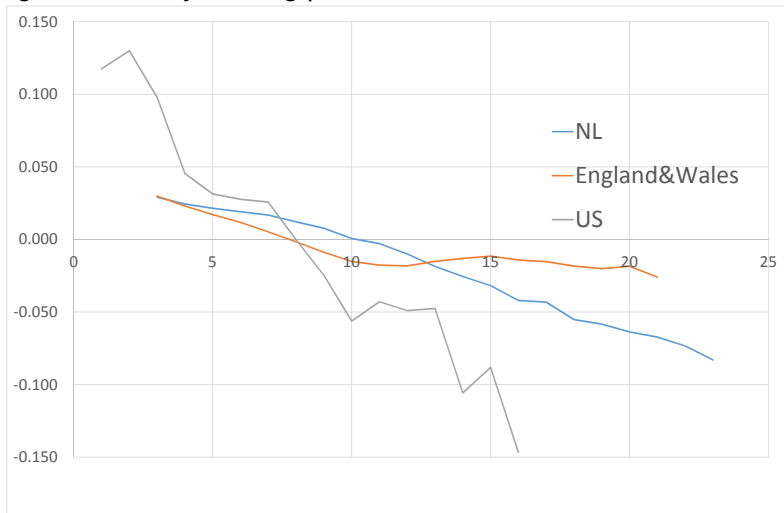
- Fix-ups right after purchase: Goetzmann and Spiegel (1995)
  - ▶ should ideally be corrected for; CAPEX is often missing
- Behavioral argument: Loss aversion / Disposition effect
  - ▶ Housing: Genesove and Mayer (2001)  
Home-owners do not sell below purchase price
  - ▶ CRE: Bokhari and Geltner (2011)  
Investors tend to sell more quickly 'winners' and to hold onto lower-performing properties longer
- Value-added strategies:
  - ▶ Housing: Steele and Goy (1997); Depken, Hollans, and Swidler (2009)  
Fix and flip (less than 1 or 2 years between buying and selling)
  - ▶ CRE: Chinloy, Hardin III, and Wu (2013)  
investors: acquire properties needing renovation, rehabilitation & re-tenanting, "value-added" properties overrepresented in RS samples

# Two claims

1. RS model is **misspecified** because it does not take into account the holding period (HP)
  - ▶ **Omitted variable bias (OVB)**
  - ▶ (Much literature on heteroskedasticity: variance is function of HP) (Case and Shiller, 1987)
2. RS index **revision** is driven by changing HP distribution over time
  - Data: Number of pairs
    - ▶ NL housing: 1 million (Land Registry Netherlands)
    - ▶ UK housing: 8 million (Land Registry England & Wales )
    - ▶ US commercial real estate (CRE): 43 thousand (Real Capital Analytics)

# Omitted variable bias in RS model: residuals

## Average residual by holding period





# Index revision: Netherlands, HP > 2 years

Year	I2016	I2015	I2014	I2013	I2012	I2011	I2010	I2009	I2008	I2007	I2006	I2005	Last - First
2005	0.288	0.289	0.290	0.291	0.292	0.294	0.295	0.297	0.299	0.302	0.301	0.302	-0.014
2006	0.324	0.326	0.328	0.329	0.331	0.332	0.334	0.336	0.338	0.338	0.338		-0.013
2007	0.361	0.364	0.366	0.368	0.370	0.372	0.374	0.377	0.377	0.377			-0.015
2008	0.387	0.391	0.394	0.397	0.399	0.402	0.404	0.404	0.405				-0.018
2009	0.367	0.372	0.377	0.381	0.384	0.386	0.387	0.388					-0.021
2010	0.357	0.363	0.369	0.373	0.376	0.377	0.378						-0.020
2011	0.338	0.345	0.350	0.355	0.355	0.356							-0.019
2012	0.282	0.288	0.292	0.294	0.295								-0.013
2013	0.227	0.232	0.233	0.234									-0.008
2014	0.250	0.252	0.254										-0.004
2015	0.275	0.277											-0.002

- Index base year: 2000
- Number of pairs: 1 million
- Revision about -2% points, **systematic downwards**

# Index revision: Netherlands, HP 3&4 years

Year	I2016	I2015	I2014	I2013	I2012	I2011	I2010	I2009	I2008	I2007	I2006	I2005	Last - First
2005	0.321	0.320	0.321	0.321	0.320	0.320	0.321	0.320	0.319	0.323	0.323	0.319	0.001
2006	0.364	0.364	0.364	0.364	0.364	0.365	0.365	0.363	0.364	0.365	0.364		0.000
2007	0.412	0.412	0.411	0.412	0.412	0.412	0.411	0.413	0.413	0.412			-0.001
2008	0.451	0.450	0.451	0.451	0.451	0.449	0.451	0.451	0.450				0.001
2009	0.441	0.442	0.442	0.442	0.440	0.443	0.443	0.442					-0.001
2010	0.445	0.446	0.445	0.443	0.446	0.447	0.446						-0.002
2011	0.435	0.435	0.434	0.437	0.437	0.436							-0.001
2012	0.394	0.391	0.392	0.392	0.391								0.003
2013	0.356	0.363	0.363	0.362									-0.005
2014	0.400	0.401	0.400										0.000
2015	0.438	0.436											0.002

- Index base year: 2000
- Number of pairs: 200,000
- Revision about 0.5% points and **no systematic revision**

# Literature on systematic revision in RS models

- Revision in RS due to periodically adding combinations of new and old sales
- No **systematic** revision when repeat sales were 'random' selections of all sales
- Shiller (1993, Ch. 8) emphasizes increase in efficiency
- Clapp and Giaccotto (1999)
  - ▶ 'The insensitivity of the magnitude of revisions to large increases in sample sizes suggests that revisions are driven by some **systematic** factor, independent of the addition of information through more transactions'
  - ▶ Revisions are more likely to be downward than upward.
  - ▶ **Excluding flips 'solves' the revision problem**
- Apart from flips no attention for holding period

# (Cumulative) HP per year of second sale

Year	Housing NL			Housing England&Wales			Commercial US		
	Pairs	Avg.	Cum.	Pairs	Avg.	Cum.	Pairs	Avg.	Cum.
2000	112,087	4.7	4.2	357,386	3.8	3.6	187	3.4	3.3
2001	155,413	5.1	4.4	622,848	4.3	3.9	493	3.8	3.6
2002	204,883	5.4	4.7	966,720	4.6	4.1	915	4.1	3.8
2003	256,691	5.7	4.9	1,311,085	4.9	4.3	1,584	4.2	4.0
2004	312,654	6.0	5.1	1,695,072	5.2	4.5	2,876	4.3	4.2
2005	378,410	6.2	5.3	2,061,490	5.5	4.7	5,395	4.5	4.3
2006	449,497	6.6	5.5	2,577,031	5.8	4.9	8,045	4.6	4.4
2007	518,442	7.0	5.7	3,094,301	6.0	5.1	11,271	4.5	4.4
2008	584,259	7.3	5.9	3,340,193	6.5	5.2	13,275	5.2	4.5
2009	629,541	7.6	6.0	3,602,428	7.1	5.3	14,391	5.4	4.6
2010	674,653	8.0	6.1	3,918,350	7.4	5.5	16,210	5.6	4.7
2011	718,110	8.4	6.3	4,229,420	8.0	5.7	18,971	6.1	4.9
2012	760,085	9.0	6.4	4,553,527	8.5	5.9	22,511	6.5	5.2
2013	798,024	9.5	6.6	4,960,701	8.9	6.1	26,636	7.0	5.4
2014	854,026	9.9	6.8	5,473,993	9.3	6.4	31,693	7.1	5.7
2015	924,892	10.4	7.1	5,979,623	9.8	6.7	37,322	7.3	5.9
2016	1,017,064	10.7	7.4	6,480,620	10.1	7.0	42,723	7.3	6.1

# Can we fix misspecification and revisions?

## A. Adjust repeat sales model to overcome OVB

### 1. RS Holding period dummy variables (leave out 1 holding period)

$$r_{i,s,t} \equiv p_{i,t} - p_{i,s} = \mu_t^{(-k)} - \mu_s^{(-k)} + \delta_{t-s}^{(-k)} + \varepsilon_{i,s,t}$$

- ▶  $\delta$  represents HP coefficients
- ▶ Residuals do not depend on which HP is left out (identical models)
- ▶ Indices **do depend** on HP
  - ★ Index represents the left-out holding period ( $-k$ )
  - ★ Difference in index **return** between left-out HP  $k$  and  $k'$  is a constant
  - ★ Second moments of **returns** (volatility, (auto)correlation) are identical

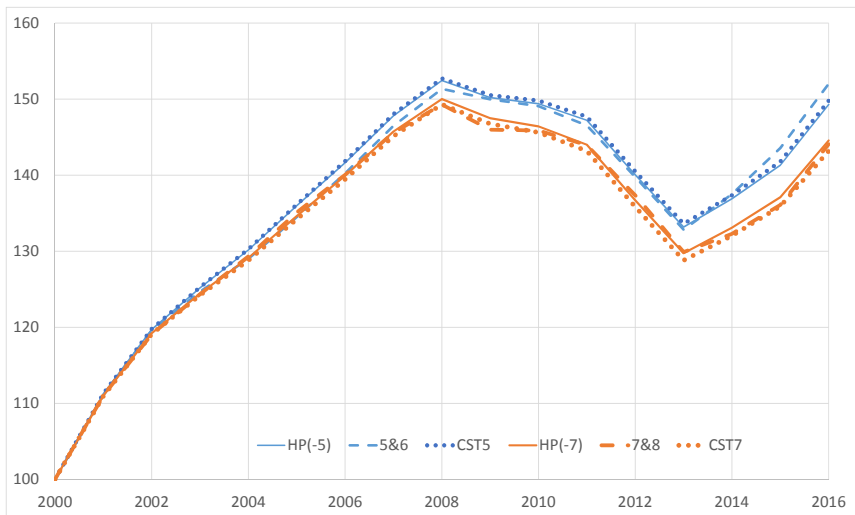
### 2. Include constant: $r_{i,s,t} = \alpha + \mu_t - \mu_s + \varepsilon_{i,s,t}$ to capture fix-ups (Goetzmann and Spiegel, 1995)

- ▶ Index return for  $k$  period holdings is  $\Delta\mu_t^{(k)} = \Delta\mu_t + \alpha/k$

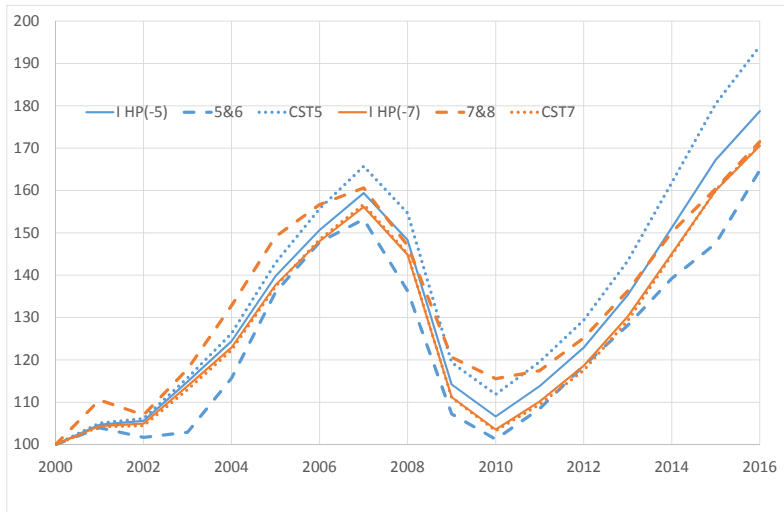
## B. Compare indices for different specifications / sub-samples of HP

## C. Analyze revision for different specifications / sub-samples of HP

# Compare indices: RRE Netherlands



# Compare indices: CRE United States



# Revision Statistics: Housing England & Wales

Model	Avg.	Avg.	Median	Min	Max	Std.Dev.	> 0.005	> 0.01	> 0.02
Standard	-0.447	0.472	0.260	-2.005	0.237	0.510	36.3%	17.0%	0.3%
HP (-3)	0.492	0.493	0.439	-0.065	1.546	0.339	43.0%	9.3%	0.0%
HP (-4)	0.372	0.374	0.303	-0.114	1.201	0.279	28.7%	3.0%	
HP (-5)	0.305	0.311	0.248	-0.199	1.039	0.248	20.7%	1.0%	
HP (-6)	0.166	0.208	0.155	-0.273	0.810	0.213	6.3%		
<b>HP (-7)</b>	<b>-0.024</b>	0.182	0.152	-0.574	0.553	0.229	<b>4.0%</b>		
HP (-8)	-0.306	0.328	0.203	-1.253	0.250	0.338	24.7%	4.7%	
HP (-9)	-0.528	0.529	0.369	-2.009	0.060	0.461	40.3%	17.0%	0.3%
HP (-10)	-0.642	0.642	0.467	-2.475	-0.032	0.532	48.0%	22.0%	2.7%
Cst	-0.314	0.377	0.247	-1.513	0.414	0.408	28.0%	8.3%	
Cst 3	0.283	0.320	0.251	-0.431	1.150	0.283	20.0%	1.7%	
Cst 4	0.134	0.215	0.162	-0.581	0.814	0.253	10.3%		
Cst 5	0.044	0.202	0.153	-0.692	0.676	0.257	7.0%		
Cst 6	-0.015	0.211	0.173	-0.766	0.614	0.270	7.0%		
Cst 7	-0.058	0.224	0.185	-0.834	0.575	0.283	10.7%		
Cst 8	-0.090	0.236	0.189	-0.919	0.546	0.294	12.0%		
Cst 9	-0.115	0.248	0.194	-0.985	0.528	0.305	14.7%		
Cst 10	-0.135	0.257	0.188	-1.038	0.515	0.313	16.0%	0.3%	

Coincides with the average holding period



# Results

- Revisions in holding period RS models (constant) are much smaller than in standard repeat sales models
  - ▶ results dependent on left-out holding period (related to average holding period in sample)
- Sensitivity analysis
  - ▶ results are robust to WLS, percentiles of first sale prices, ...
- Alternative specifications for holding period
  - ▶ Constant: restrictive model
  - ▶ Dummy variable for each holding period: many parameters in case of monthly HPs
  - ▶ Possible extension: Replace dummy variables by some flexible (stochastic) function

# Concluding remarks

- Average periodic returns depend on HPs
  - ▶ short (long) HPs have large (small) periodic returns
- Standard repeat sales model is misspecified
- Possible to create a constant HP index (either 1 HP or a weighted average)
- **Systematic** revisions are due to changing HP distribution over time and can partly be resolved by correcting for HPs
- It takes a long time for a repeat sales database to mature such that change in distribution of holding period is negligible

# Concluding remarks

## Commercial real estate

- Heterogeneous and small sample sizes
- **Random (non-systematic)** revision is a bigger problem. For solutions to **random** revisions, see van de Minne et al. (forthcoming)
- Trade-off between hedonic price and repeat sales models
  - ▶ Hedonic: all sales, OVB & misspecification
  - ▶ Repeat sales: sample selection, limited level of misspecification
- Standard hedonic price models ignore that the same property transact more than once (Francke and van de Minne, 2018)

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