Evaluation of the House Price Models Using an ECM Approach: The Case of the Netherlands

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Purpose of this research

Main purpose of this research: What is the outlook for house prices in the near future (forecasting)?

Especially in times of a housing market crisis it is important to understand the long run price level relative to price changes in the short run.

A long-run model approach is needed that relates house prices to fundamentals, but the model should be able to detect bubbles in the short run.

The model assumes that prices tend to revert to the equilibrium price level in the mid term.

Finally, the model should provide a reliable forecast of house price changes in the near future.
Research questions

- Some of the questions that we want to answer are as follows:
  - Is, or was, the Dutch housing market overvalued?
  - In which capacity can our model predict the house price developments?
  - How do housing markets react to economic growth and decline?
  - Do prices increase smoothly or unevenly during a period of adjustment to an exogenous shock?
  - Are households financially vulnerable through, for example, too high mortgage debts in comparison to disposable income?

- The research questions are investigated
  - by estimating different types of error correction models and
  - by examining the impact of different variables that can explain house price changes in the Netherlands.
What is new in the paper

- We **examine** the short-run and long-run price developments of the Dutch housing market in the period 1965-2009Q1.
- We **evaluate** (re-estimate) existing house price models for the Netherlands, which we use as a benchmark for comparison with our improved model.
- We provide a **forecast** of house prices until 2015, based on our own improved model.
Outline of the research

- Literature overview on house price models.
- Evaluation of estimations results of two models used in the Netherlands:
  - the OTB Research Institute 1978(1)-2000(2), based on half yearly data and
- Presentation of an improved error-correction model (ECM) with estimation results for an extended sample from 1965-2009Q1,
  - including ECM estimation results embedded into the unobserved components modelling approach.
- A forecast of house price changes until 2015 for three economic scenarios: recession, slow recovery and quick recovery.
- Conclusions
House price models are divided into two broad groups (De Vries and Boelhouwer, 2005):

- **demand models**
  - the housing supply is fixed, and house price changes are only a function of demand variables such as housing expenses, disposable income, borrowing capacity of a consumer, etc.

- **supply-and-demand models**
  - both demand and supply factors are important, for example supply factors such as the housing stock and new construction.
Demand models

- A simple **affordability** model
  - The focus is on the relationship between house prices and a number of demand factors, for example, price/income ratio or mortgage-payments/income ratio. Calibration of the affordability model gives a prognosis of the house price growth in the short-run.

- A **dynamic error-correction** model
  - The variables taken into account are: interest rate, household income, lagged house prices, and the error-correction term - the deviation from the long-run relationship. The error-correction term secures that the house prices are at their equilibrium level in the middle to long-run, which can be explained by economic fundamentals.
Supply-and-Demand models

In this approach, the reaction of supply factors, like the new building developments, on demand factors can be examined (and vice versa).

- An application is the **stock-flow** model which gives predictions of new construction as well as house prices through time (*see DiPasquale and Wheaton, 1994*).

- The **error-correction mechanism** is also applied within these supply-and-demand models, explaining house price growth in the middle to long-run (*see Verbruggen et al., 2005*).

The variables taken into account are those which have direct effect on both house demand and supply:

- long-run interest rate,
- disposable household income,
- lagged house prices,
- housing stock,
- number of households,
- wealth and
- the error-correction term (deviation from the long-run relationship).
What happened on the housing market ("65-"09Q1)?

- **Real house price** and **real modal income**
- **House price-to-income ratio**
- **Nominal mortgage interest rate** and **Inflation**
- **After tax interest-to-income ratio**
Affordability measure: over- and undervaluation

**Over and undervalued market price 1975-2008**

Deviation of 'Debt payments to Income' ratio to its historic average, in percentages

- Overvalued:
  - 35%
  - 27%
  - 22%
  - 13%

- Undervalued:
  - -37%
Are Median House Prices Affordable?

Based on: median house price, 100% financing of price, after tax, 5-year mortgage rate, median earnings of employees

Dutch brokerage organisation NVM 2009Q1:

- Affordable for two-earners and former owners
- Unaffordable for one-earners (only apartments are affordable)
- A more balanced judgment is possible when looking at different house types in different regions
Basic specification of Error Correction Models

$h_t$: log real house price
Combining both levels and differences

Long-run: $h_t^* = \beta_1 x_{1t} + \cdots + \beta_k x_{kt}$,
Short-run: $\Delta h_t = \alpha \Delta h_{t-1} + \delta (h_{t-1} - h_{t-1}^*) + \gamma \Delta h_t^* + \varepsilon_t$,

- **Long-run (levels)**
  - Exogenous variables $x$: income, interest, wealth, construction costs, housing stock, ...

- **Short-run (differences)**
  - $\Delta h_{t-1}$: bubble builder: the speculative influences on the market or the market’s inefficiency, $\alpha$: degree of serial correlation
  - $(h_t - h_t^*)$ bubble burster: error correction term, the deviation from the long term equilibrium, $\delta$: degree of mean reversion
    - $\star (h_t - h_t^*) > 0$: overvaluation
    - $\star (h_t - h_t^*) < 0$: undervaluation
  - $\gamma$: contemporaneous adjustments of prices to current shocks
Characteristics co-integrated Error Correction Models

- $h_t$ is non-stationary, I(1): integrated of order 1 (no time invariant first and second moment)
- If $h_t - h_t^* = h_t - x_t \beta$ for some $\beta$ is
  - stationary, then a co-integrating relation: $x_t \beta$ represents the long-run equilibrium relationship
  - non-stationary, then spurious regression results: the ECM is not valid, the usual statistics (standard errors, $R^2$, etc.) do not have their common interpretation

Extensions of ECM
- More lags of $\Delta h_t$ and $\Delta h_t^*$ can be included
- Asymmetric ECM: different coefficients for positive and negative values of error correction term

Estimation of ECM
- Dynamic Linear Regression Model (PcGive, Hendry)
- Test the null hypothesis of no co-integration by residual based augmented Dickey-Fuller test
CPB Model specification

- The Netherlands Bureau for Economic Policy Analysis (CPB) Verbruggen et al. (2005); Kranendonk and Verbruggen (2008)

- Variables used:
  - House price index (Kadaster)
  - Disposable labour income (aggregate)
  - Long-term interest rate (10-year government securities)
  - Wealth indicator
  - Housing stock (end of the year)
  - Consumer price index

- Yearly data: 1980 – 2007
### CPB Long and Short Run Re-Estimation Results

#### Long-run $h_t$

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>$t$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>$-6.5986$</td>
<td>$1.2730$</td>
<td>$-5.18$</td>
</tr>
<tr>
<td>$y_t$</td>
<td>$1.5336$</td>
<td>$0.2653$</td>
<td>$5.78$</td>
</tr>
<tr>
<td>$l_t^r$</td>
<td>$-5.944$</td>
<td>$1.6900$</td>
<td>$-3.52$</td>
</tr>
<tr>
<td>$w_t$</td>
<td>$1.6320$</td>
<td>$0.4201$</td>
<td>$3.89$</td>
</tr>
<tr>
<td>$s_t$</td>
<td>$-2.8298$</td>
<td>$0.6032$</td>
<td>$-4.69$</td>
</tr>
</tbody>
</table>

Sigma = 0.0703  
RSS = 0.1136  
$R^2 = 0.9705$  
DW = 1.11

#### Short-run $\Delta h_t$

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>$t$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta y_t^a$</td>
<td>$1.4386$</td>
<td>$0.2225$</td>
<td>$6.46$</td>
</tr>
<tr>
<td>$\Delta l_t^a$</td>
<td>$-6.3515$</td>
<td>$1.3530$</td>
<td>$-4.70$</td>
</tr>
<tr>
<td>$\Delta \nabla P_t$</td>
<td>$1.1015$</td>
<td>$0.8375$</td>
<td>$1.32$</td>
</tr>
<tr>
<td>$\Delta s_t$</td>
<td>$-2.0639$</td>
<td>$0.5536$</td>
<td>$-3.70$</td>
</tr>
<tr>
<td>$d_{2000}$</td>
<td>$0.1398$</td>
<td>$0.0358$</td>
<td>$3.90$</td>
</tr>
<tr>
<td>$ecm_{t-1}$</td>
<td>$-0.2177$</td>
<td>$0.1852$</td>
<td>$-1.18$</td>
</tr>
<tr>
<td>$ecm^+_{t-1}$</td>
<td>$0.3238$</td>
<td>$0.2905$</td>
<td>$1.11$</td>
</tr>
</tbody>
</table>

Sigma = 0.0339  
DW = 1.42
CPB Long and Short Run Re-Estimation Results

- **Long-run**
  - No evidence for co-integration (augmented DF-test)
  - Overvaluation:
    - 2004: +14%
    - 2007: 0%

- **Short-run**
  - Ad hoc dummy variable for $t = 2000$
  - No lagged real house price changes
  - No evidence for asymmetric error correction mechanism
OTB Model Specification

- Variables used:
  - (Real) Mortgage interest ($I$)
  - (Real) Household income ($Y$)
  - Seasonal effect ($d$)
- Model in percentage changes ($\nabla$) (not in log differences)
- “Error correction term”: $(IIR_t - \gamma_0)$ where $IIR_t$ is the after tax ($F$) Interest-to-Income ratio, defined by

$$IIR_t = \frac{H_t I_t (1 - F)}{Y_t}$$

- $\gamma_0$ is the long-run Interest-to-Income ratio
- Model (Boelhouwer et al, 2001, De Vries and Boelhouwer, 2009)

$$\nabla H_t = \gamma_1 \nabla H_{t-1} + \gamma_2 (IIR_{t-2} - \gamma_0) + \gamma_3 d_t + \gamma_4 \nabla Y_t + \gamma_5 \nabla I_{t}^r + \varepsilon_t$$
OTB Re-Estimation Results 1978-2000 (Half-Yearly)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>5.2626</td>
<td>1.6240</td>
<td>3.24</td>
</tr>
<tr>
<td>$\nabla H_{t-1}$</td>
<td>0.5574</td>
<td>0.0863</td>
<td>6.46</td>
</tr>
<tr>
<td>$IIR_{t-2}$</td>
<td>-0.1926</td>
<td>0.0583</td>
<td>-3.30</td>
</tr>
<tr>
<td>$d_t$</td>
<td>1.3522</td>
<td>0.3001</td>
<td>4.51</td>
</tr>
<tr>
<td>$\nabla Y_t$</td>
<td>0.5657</td>
<td>0.2520</td>
<td>2.24</td>
</tr>
</tbody>
</table>

$\gamma_0 = \frac{5.2626}{0.1926} = 27.33$

Sigma = 1.9902
$R^2 = 0.8230$
RSS = 158.4371
DW = 1.71

- $IIR_t$ is not stationary (however bounded between 0 and 100)
- OTB model is a restricted version of a general ECM

$$\Delta h_t = \gamma_1 \Delta h_{t-1} + \gamma_2 (h - (1y - 1i) - \gamma_0^*)_{t-2} + \gamma_3 d_t + \gamma_4 \Delta y_t + \gamma_5 \Delta I_t + \varepsilon_t$$

using $IIR_t \approx h_t + i_t + \ln(1 - F) - y_t - 1$ and $\Delta x_t \approx \nabla x_t$
Our improved Unobserved Component ECM

- Extended sample: 1967 - 2009Q1
- Used variables
  - Real log house price: I(1)
  - Log real modal labour income per employee: I(0)
  - Mortgage interest rate minus inflation (not in logs): I(1)
  - Linear trend (long-run relation)
- However, ECM term is non-stationary: no co-integration
- We replace the linear trend with a non-stationary trend

\[
\Delta h_t = \alpha \Delta h_{t-1} + \delta(h_{t-1} - \mu_t - x_{t-1} \beta) + \gamma \Delta x_t + \varepsilon_t,
\]

where \(\mu_t\) denotes the trend component (Harvey, 1989)

- In case of a random walk, the trend component is given by:

\[
\mu_{t+1} = \mu_t + \eta_t
\]
Estimation results

\[ \Delta h_t = 0.4726 \Delta h_{t-1} - 0.3776 ECM_{t-1} + 0.01534 \Delta IM_{t-1} - 0.5372 \Delta y_{t-1} \]

where

[ECM]_t = h_t - 1.6766 y_t + 0.0681 IM_t - \mu_{t+1}.

Standard error random walk: 0.030
(different from 0: alternative test for co-integration)

Long-term relationship: increase in period 1967 - 2009Q1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Income</td>
<td>0.744</td>
</tr>
<tr>
<td>Real Interest</td>
<td>-0.022</td>
</tr>
<tr>
<td>Random Walk</td>
<td>0.227</td>
</tr>
<tr>
<td>Sum</td>
<td>0.949</td>
</tr>
<tr>
<td>Real House Price Increase</td>
<td>1.035</td>
</tr>
</tbody>
</table>
Forecasts - Price Index (nominal values)

- Linear trend
- Random walk with drift
- Random walk

Francke, Vujić, and Vos (Ortec & UvA)
Conclusions to models

- Compared to other Dutch research institutes this research presents estimation results for a much longer sample (1967-2009).
  - It is important to stress that our approach nicely estimates a full cycle of house price movements from 1970 to 1980, the period not analysed by the other research institutes.

- Other differences with the CPB specification are that we also include lagged changes in log real house prices.

- With respect to the OTB approach, our model differs in that we present results based on an unrestricted model.
Conclusions to valuation

- All models estimate the overvaluation of the Dutch house prices differently.
  - Based on a simple affordability approach analysis it can be concluded that house prices in 2007-2008 were around 18% overvalued compared to the long-run interest payments-to-income ratio.
  - Due to a price fall of around 8% and the lower mortgage interest rate in the first half year of 2009 average affordability is in line with its historic average (median price level is not overvalued).
  - From the CPB long-run relation it can be concluded that in 2007 the overvaluation was approximately 0, whereas it was +14% in 2004.
  - Our ECM model with linear trend estimates that the Dutch house prices were severely undervalued in 1975 (-35.6%), followed by a period of extreme overvaluation in 1978 (42.9%). During the 2000s, house prices in the Netherlands were also overvalued (2006: 11.9%; 2007: 11.5%; 2008: 2.4%).

Note that part of the linear trend can capture overvaluation as well.
Conclusions to our improved model

- The linear trend and random walk (with drift) component indicates that a substantial part of house prices has not been explained by fundamental economic factors.
  - If we interpret the random walk (with drift) term together with the error-correction term as a way measuring overvaluation in the housing market, they indicate that Dutch house prices were substantially overvalued in the last decade.
  - In contrast, if overvaluation is measured by the error-correction term only, house prices were moderately above the long-run equilibrium value.
  - One can argue that a part of the random walk component captures some omitted variables in the long-term relationship. In that case only a fraction of the random walk (with drift) component can be interpreted as overvaluation.

- Our preferred model is ECM with random walk (lowest standard error). This model is the most “pessimistic” one, considering the forecasting scenarios and the overvaluation estimate.
Conclusions to forecasting

The current financial crisis in the Netherlands did not start with problems in the residential property market, but on the contrary, the global financial and economic crisis has affected the housing market.

Forecasting house prices with this model shows a recovery of prices to the level of 2008 no sooner than 2015 in all scenarios, except for the recession scenario.
Further research should encompass several extensions of the current model.

- The real interest rate could also be based on expected inflation, in order to account for real user costs.
- Among the set of explanatory variables we would also like to include housing stock and construction costs (the supply side of the market).
- We would like to improve the household income data taking into account the transition from a one-earner into a two-earner economy since 1985.
- We want to present estimation results on a more disaggregate level, such as regions or the largest cities in the Netherlands.
CPB Long Run Series

Francke, Vujić, and Vos (Ortec & UvA)
CPB Short Run Series

Francke, Vujić, and Vos (Ortec & UvA)
CPB Long and Short Run Relationships

- The long-term equation

\[ h_t = \alpha_0 + \alpha_1 y_t + \alpha_2 l_t^r + \alpha_3 w_t + \alpha_4 s_t + \varepsilon_t, \text{ for } t = 1980, \ldots, 2007. \]

- The short-term equation

\[ \Delta h_t = \beta_1 \Delta y_t^a + \beta_2 \Delta l_t^a + \beta_3 \Delta \nabla P_t + \beta_4 \Delta s_t + \beta_5 d_{2000} \]
\[ + \beta_6 ecm_{t-1} + \beta_7 ecm_{t-1}^+ + \varepsilon_t \]

where

\[ \Delta h_t = h_t - h_{t-1} \]
\[ \Delta y_t^a = 0.65 \Delta y_t + 0.35 \Delta y_{t-1} \]
\[ \Delta l_t^a = 0.5 \Delta l_t + 0.5 \Delta l_{t-1} \]
\[ \Delta \nabla P_t = \nabla P_t - \nabla P_{t-1} \]
\[ \Delta s_t = s_t - s_{t-1} \]
Appendix

OTB Series (Percentage Changes)

- % change in real house price
- After tax interest-to-income ratio
- % change in real income
- First difference real interest rate

Francke, Vujić, and Vos (Ortec & UvA)
ECM with a Linear Trend

- General-to-specific modelling approach

\[ h_t = \alpha_1 h_{t-1} + \alpha_2 h_{t-2} + \sum_{i=1}^{k} \beta_{i0} x_{it} + \sum_{i=1}^{k} \beta_{i1} x_{i,t-1} + \sum_{i=1}^{k} \beta_{i2} x_{i,t-2} + \varepsilon_t. \]

- The long-run equilibrium (substitute \( h_t = h^* \) and \( x_{it} = x^*_i \))

\[ h^* = \frac{1}{1 - \alpha_1 - \alpha_2} \sum_{i=1}^{k} x^*_i (\beta_{i0} + \beta_{i1} + \beta_{i2}). \]
## ECM with a Linear Trend Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$h_{t-1}$</td>
<td>1.2952</td>
<td>0.1189</td>
<td>10.90</td>
</tr>
<tr>
<td>$h_{t-2}$</td>
<td>-0.6100</td>
<td>0.1037</td>
<td>-5.88</td>
</tr>
<tr>
<td>$y_{t-2}$</td>
<td>0.3002</td>
<td>0.1110</td>
<td>2.70</td>
</tr>
<tr>
<td>$IM_{t-1}$</td>
<td>-0.0122</td>
<td>0.0054</td>
<td>-2.24</td>
</tr>
<tr>
<td>$IM_{t-2}$</td>
<td>-0.0149</td>
<td>0.0062</td>
<td>-2.40</td>
</tr>
<tr>
<td>Trend</td>
<td>0.0060</td>
<td>0.0015</td>
<td>4.08</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.0428</td>
<td>0.0417</td>
<td>-1.03</td>
</tr>
</tbody>
</table>

Sigma = 0.0439  
$R^2 = 0.9872$  
Log-likelihood = 77.2615  
No. of observations = 43  
$\bar{h}_t = -0.0126$

RSS = 0.0692  
$F(6, 36) = 463.9(0.0000)$  
DW = 1.88  
No. of parameters = 7  
$\sigma^2_{h_t} = 0.1261$
## Static Long-Run Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_t$</td>
<td>0.9534</td>
<td>0.3156</td>
<td>3.02</td>
</tr>
<tr>
<td>$IM_t$</td>
<td>−0.0859</td>
<td>0.0131</td>
<td>−6.57</td>
</tr>
<tr>
<td>Trend</td>
<td>0.0190</td>
<td>0.0032</td>
<td>6.04</td>
</tr>
<tr>
<td>Constant</td>
<td>−0.1360</td>
<td>0.1274</td>
<td>−1.07</td>
</tr>
</tbody>
</table>

Long-run sigma = 0.1393

$$ECM = h_t - 0.9534y_t + 0.0859 IM_t - 0.0190 Trend + 0.1360$$

Expressed in terms of the ECM model specification, we get:

$$\Delta h_t = 0.6142\Delta h_{t-1} - 0.3149 ECM_{t-1} - 0.3002\Delta y_{t-1} + 0.0149\Delta IM_{t-1}$$
Interpretation of the Estimation Results

- The marginal long-run real income elasticity is close to one.
- Linear trend included to capture absence of other important variables, like demographics and house supply.
- In comparison to the CPB and OTB models, our sample is much longer (1967 to 2009Q1):
  - We also model house price movements from 1970 to 1980.
- However, the ECM term is *not* stationary!!
- We replace the linear trend with a (non-stationary) random walk.
Appendix

ECM with a Linear Trend, 1965-2009Q1

- Log real house price
- Fitted

- Residuals: log real house price

- Error-correction term

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ERS, June 27, 2009
## ECM with a Random Walk Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta h_{t-1}$</td>
<td>0.4726</td>
<td>0.1391</td>
<td>3.3986</td>
</tr>
<tr>
<td>$\Delta IM_{t-1}$</td>
<td>0.0153</td>
<td>0.0065</td>
<td>2.3448</td>
</tr>
<tr>
<td>$\Delta y_{t-1}$</td>
<td>−0.5372</td>
<td>0.3739</td>
<td>−1.4367</td>
</tr>
<tr>
<td>$h_{t-1}$</td>
<td>−0.377</td>
<td>0.0943</td>
<td>−4.0035</td>
</tr>
<tr>
<td>$IM_{t-1}$</td>
<td>−0.0257</td>
<td>0.0089</td>
<td>−2.8870</td>
</tr>
<tr>
<td>$y_{t-1}$</td>
<td>0.6330</td>
<td>0.2952</td>
<td>2.1445</td>
</tr>
</tbody>
</table>

ECM = $h_t - 1.6766y_t + 0.0681 IM_t - \mu_{t+1}$

### Disturbances

<table>
<thead>
<tr>
<th></th>
<th>Variance</th>
<th>Std. Error</th>
</tr>
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<tbody>
<tr>
<td>Level</td>
<td>0.0009</td>
<td>0.0300</td>
</tr>
<tr>
<td>Irregular</td>
<td>0.0011</td>
<td>0.0330</td>
</tr>
</tbody>
</table>

### State vector

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>0.2020</td>
<td>0.0024</td>
</tr>
</tbody>
</table>

Std. error = 0.0473

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Log-likelihood</td>
<td>107.2840</td>
</tr>
<tr>
<td>p.e.v.</td>
<td>0.0022</td>
</tr>
<tr>
<td>DW</td>
<td>1.7405</td>
</tr>
</tbody>
</table>

$R^2 = 0.6418$
ECM with a Random Walk, 1965-2009Q1

Francke, Vujić, and Vos (Ortec & UvA)
ECM with a Random Walk, 1965-2009Q1

Appendix
Comparison of Error-Correction Models

- ECM linear trend
- ECM RW
- ECM RW Drift

Francke, Vujić, and Vos (Ortec & UvA)

ERES, June 27, 2009
Overvaluation of House Prices in NL

<table>
<thead>
<tr>
<th>Year</th>
<th>$ECM$</th>
<th>$ECM + \mu_{t+1}$</th>
<th>$ECM$</th>
<th>$ECM + \mu_{t+1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>0.0895</td>
<td>0.3249</td>
<td>0.1400</td>
<td>0.3335</td>
</tr>
<tr>
<td>2001</td>
<td>−0.1256</td>
<td>0.1015</td>
<td>−0.1118</td>
<td>0.0862</td>
</tr>
<tr>
<td>2002</td>
<td>−0.0200</td>
<td>0.2088</td>
<td>−0.0304</td>
<td>0.1727</td>
</tr>
<tr>
<td>2003</td>
<td>−0.0373</td>
<td>0.1801</td>
<td>−0.0189</td>
<td>0.1885</td>
</tr>
<tr>
<td>2004</td>
<td>−0.0048</td>
<td>0.2283</td>
<td>0.0467</td>
<td>0.2595</td>
</tr>
<tr>
<td>2005</td>
<td>−0.0430</td>
<td>0.2018</td>
<td>−0.0133</td>
<td>0.2045</td>
</tr>
<tr>
<td>2006</td>
<td>0.0761</td>
<td>0.3299</td>
<td>0.1092</td>
<td>0.3316</td>
</tr>
<tr>
<td>2007</td>
<td>0.1355</td>
<td>0.3852</td>
<td>0.1136</td>
<td>0.3399</td>
</tr>
<tr>
<td>2008</td>
<td>0.1479</td>
<td>0.3811</td>
<td>0.0294</td>
<td>0.2592</td>
</tr>
<tr>
<td>2009Q1</td>
<td>0.0733</td>
<td>0.2752</td>
<td>−0.0255</td>
<td>0.2079</td>
</tr>
</tbody>
</table>

Overvaluation:
- ECM plus random walk: 18% to 38%
- ECM only: −13% to 15%
Forecasts (2010-2015)

- Three scenarios
- Forecast period: 2010 - 2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Recession</th>
<th>Slow Recovery</th>
<th>Quick Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dP</td>
<td>IM</td>
<td>Y</td>
</tr>
<tr>
<td>2010</td>
<td>0.00</td>
<td>4.50</td>
<td>32,000</td>
</tr>
<tr>
<td>2011</td>
<td>0.50</td>
<td>4.60</td>
<td>32,500</td>
</tr>
<tr>
<td>2012</td>
<td>1.00</td>
<td>4.80</td>
<td>32,900</td>
</tr>
<tr>
<td>2013</td>
<td>1.20</td>
<td>4.80</td>
<td>33,700</td>
</tr>
<tr>
<td>2014</td>
<td>1.50</td>
<td>4.90</td>
<td>34,500</td>
</tr>
<tr>
<td>2015</td>
<td>1.70</td>
<td>4.90</td>
<td>35,500</td>
</tr>
</tbody>
</table>

Francke, Vujić, and Vos (Ortec & UvA)
## Forecasts (2010-2015)

| Year | Recession | | | Slow Recovery | | | Quick Recovery | | |
|------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|      | Linear    | RWD       | RW        | Linear    | RWD       | RW        | Linear    | RWD       | RW        |
| 2008 | 100       | 100       | 100       | 100       | 100       | 100       | 100       | 100       | 100       |
| 2009 | 90.0      | 97.5      | 95.0      | 90.0      | 97.5      | 95.0      | 90.0      | 97.5      | 95.0      |
| 2010 | 86.1      | 85.1      | 84.7      | 87.0      | 86.0      | 85.7      | 87.4      | 86.5      | 86.2      |
| 2011 | 86.6      | 84.6      | 81.7      | 89.2      | 87.2      | 84.1      | 90.4      | 88.4      | 85.2      |
| 2012 | 90.0      | 86.9      | 81.2      | 95.7      | 92.6      | 86.1      | 98.3      | 95.2      | 88.3      |
| 2013 | 96.2      | 92.3      | 83.7      | 105.1     | 101.2     | 90.6      | 109.3     | 105.3     | 93.6      |
| 2014 | 104.4     | 99.8      | 88.0      | 115.8     | 111.2     | 95.8      | 121.3     | 116.6     | 99.7      |
| 2015 | 113.6     | 108.6     | 93.4      | 125.9     | 121.2     | 100.9     | 132.1     | 126.9     | 105.2     |

RW = Random walk; RWD = Random walk with drift