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The empirical modelling of house prices and debt revisited: A policy-oriented perspective

by

Pål Boug*
Håvard Hungnes*
Takamitsu Kurita**

* Statistics Norway, Research Department, Unit for Macroeconomics
**Fukuoka University, Department of Economics

Introduction

❑ Background

- The substantial deregulation of housing markets in the 1980s enhanced the exposures from imbalances in these markets to the real economy in many countries, see e.g. Mian *et al*. (2013), Leamer (2015) and Boug *et al*. (2021).
- Several examples in which housing market imbalances have substantially affected the real economy
  - The Norwegian banking crisis in 1988-1993
  - The global financial crisis in 2008
  - The Covid-19 pandemic
- The monetary authorities' ability to contribute to a more stable development in financial magnitudes, including house prices and household debt, is potentially important in reducing fluctuations in the real economy.

Introduction (cont.)

❑ Literature

- The empirical literature on the housing market, and in particular on the fundamental drivers of house prices, is overwhelming, see Duca *et al*. (2021)
- Studies of the Norwegian housing market include
  - Bjørnland and Jacobsen (2010) and Robstad (2018) => impulse-response analysis of monetary policy based on a structural VAR
  - Anundsen and Jansen (2013) and Anundsen (2019, 2021) => determination of the fundamentals of house prices (and debt) based on a cointegrated VAR
- The literature pay little attention to the question whether the authorities can influence the housing market, say by means of the key policy rate, in order to *stabilize or control* both house prices and household debt.

Introduction (cont.)

Question asked in this paper

- We ask whether house prices and debt, two important financial magnitudes entering the decision process of Norges Bank, are *empirically controllable* to some pre-specified target levels using the interest rate as an instrument.
- The question is answered by a control analysis of non-stationary time series, as proposed by Johansen and Juselius (2001), see also Kurita (2018), within the context of a cointegrated VAR.
- The question of empirical controllability may not after all be obvious from the authorities point of view given the literature showing that changes in the fundamentals cannot account for the large fluctuations in house prices in many countries, see e.g. Bolt *et al*. (2019).

Introduction (cont.)

Main findings

- We identify two cointegrating relationships which are interpreted as a long-run house price relation and a debt relation.
- Our findings support the hypothesis of a long-run mutual dependency between house prices and debt such that both are linked to income, the housing stock and the interest rate in the long run.
- We find that around 80 per cent and 90 per cent of the adjustments towards equilibrium after a system-wide shock are made after six years in the cases of the house price relation and the debt relation, respectively.
- Our findings suggest that both house prices and debt are controllable magnitudes to some pre-specified target levels through the interest rate, which enables the central bank to reduce large fluctuations and bubble tendencies in the housing market.

Outline

- Theory
- Overview of data
- Cointegration analysis
- Control analysis
- Conclusions

Theory

❑ The life-cycle model of housing

- Anundsen and Jansen (2013) arrived at the following inverted demand function $f(\cdot)$ for real housing stock K_t:

$$P_t = f(D_t, Y_t, K_t, R_t), \text{ where}$$

$$\frac{\partial f}{\partial D_t} > 0, \quad \frac{\partial f}{\partial Y_t} > 0, \quad \frac{\partial f}{\partial K_t} < 0 \quad \text{and} \quad \frac{\partial f}{\partial R_t} \lessgtr 0$$

- Given the real housing stock supply, we may think of P_t as the price level that clears the housing market, depending on the remaining factors D_t, Y_t and R_t.

- We specify a log-linearised version of the model as

$$p_t = c_p + \theta_d d_t + \theta_y y_t - \theta_k k_t - \theta_R R_t + \upsilon_t,$$

which embodies a static long-run equilibrium for real house prices

Theory (cont.)

Extension of the life-cycle model

- Building on Anundsen and Jansen (2013), we specify a log-linearised equilibrium condition for household debt as

$$d_t = c_d + \phi_p p_t + \phi_y y_t + \phi_k k_t - \phi_R R_t + \nu_t,$$

where ϕ_p, ϕ_y, ϕ_k and ϕ_R are non-negative

- Banks may agree to provide more mortgage if households have more collateral, higher income or face lower interest expenses.

Theory (cont.)

The identification problem

- The equilibrium conditions for p_t and d_t serve as two candidates for cointegrating relationships.
- In the case of one CI-vector, the sign of the coefficient for k_t and also for R_t if positive will play critical roles in the identification of the condition for p_t *or* d_t.
- In the case of two CI-vectors, various coefficient restrictions have to be explored in such a way that the empirical relationships can be identified and interpreted in line with the conditions for p_t *and* d_t.

  => long-run mutual dependency between p_t and d_t?

- The empirical analysis considers the vector

  $X_t = (p_t, d_t, y_t, k_t, R_t)'$, which is modelled as a full VAR

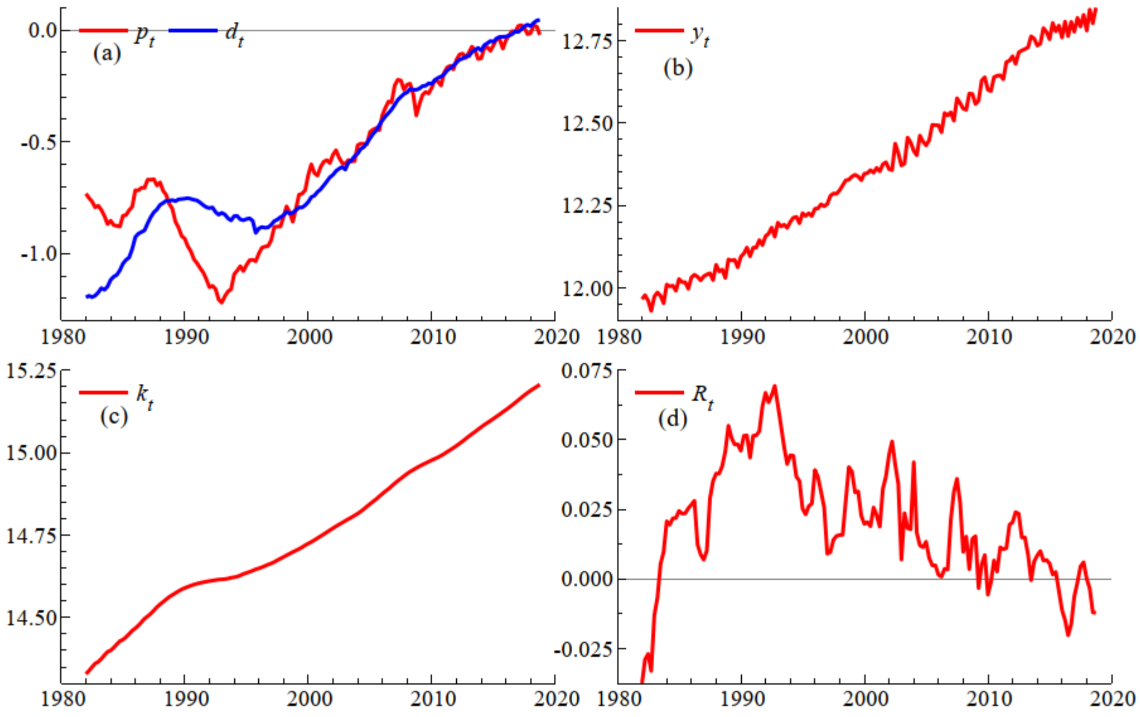
Overview of data

❑ Time series from the National Accounts

- p_t The log of real house prices measured by the overall price index for residential buildings in the second-hand market and adjusted by the consumption deflator, PC_t, in the National Accounts. Source: Statistics Norway.
- d_t The log of household real debt measured by the total amount of outstanding gross household debt and adjusted by PC_t. Source: Statistics Norway.
- y_t The log of household real disposable income measured by disposable income excluding dividend payments and adjusted by PC_t. Source: Statistics Norway.
- k_t The log of total housing stock in fixed 2018-prices calculated in the National Accounts by means of the perpetual inventory method. Source: Statistics Norway.
- R_t The real after-tax interest rate calculated by $\frac{1+4\times I_t\times(1-\Upsilon_t)}{CPI_t/CPI_{t-4}}-1$, where I_t, Υ_t and CPI_t are the average nominal interest rate (quarterly) paid by households on loans in private financial institutions, the capital tax rate and the consumer price index for all commodities, respectively. Source: Statistics Norway.

Overview of data (cont.)

- **Close interdependency between p_t and d_t**



Notes: Sample period: $1982q1 - 2018q4$. The household real debt matches mean and range to the real house prices (panel a). Source: Statistics Norway.

Cointegration analysis

Rank determination

$$\Delta X_t = \alpha \begin{pmatrix} \beta \\ \rho \end{pmatrix}' \begin{pmatrix} X_{t-1} \\ t \end{pmatrix} + \sum_{i=1}^{k-1} \Delta\Gamma_i X_{t-i} + \vartheta + \delta D_t + \varepsilon_t$$

H_0	λ_i	λ_{trace}	p-value
$r = 0$	0.275	104.69	0.002**
$r \leq 1$	0.244	68.72	0.017*
$r \leq 2$	0.164	37.44	0.160
$r \leq 3$	0.104	17.41	0.393
$r \leq 4$	0.045	5.13	0.585

Notes: Sample period: 1982q1 – 2018q4. The underlying VAR is of order 6 with $X_t = (p_t, d_t, y_t, k_t, R_t)'$ as modelled variables, a linear trend as a restricted variable and constants, seasonal dummies and nine dummy variables for outliers as unrestricted deterministic terms. r denotes the rank order of $\Pi = \alpha\beta'$ in (7), λ_i are the eigenvalues from the reduced rank regressions, λ_{trace} are the trace test statistics adjusted for degrees of freedom and p-value are the significance probabilities based on the approximations to the asymptotic distributions derived by Doornik (1998). ** and * denote rejection of the null hypothesis at the 1 and 5 per cent significance level, respectively.

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Cointegration analysis (cont.)

❑ Long-run structure (r = 2)

$$\alpha \begin{pmatrix} \beta \\ \rho \end{pmatrix}' \begin{pmatrix} X_{t-1} \\ t \end{pmatrix} = \begin{pmatrix} \alpha_{p,1} & \alpha_{p,2} \\ \alpha_{d,1} & \alpha_{d,2} \\ \alpha_{y,1} & \alpha_{y,2} \\ \alpha_{k,1} & \alpha_{k,2} \\ \alpha_{R,1} & \alpha_{R,2} \end{pmatrix} \begin{pmatrix} \beta_{p,1} & \beta_{d,1} & \beta_{y,1} & \beta_{k,1} & \beta_{R,1} & \rho_1 \\ \beta_{p,2} & \beta_{d,2} & \beta_{y,2} & \beta_{k,2} & \beta_{R,2} & \rho_2 \end{pmatrix} \begin{pmatrix} X_{t-1} \\ t \end{pmatrix}$$

$$\hat{\alpha} \begin{pmatrix} \hat{\beta} \\ \hat{\rho} \end{pmatrix}' = \begin{pmatrix} \underset{(0.040)}{-0.237} & \underset{(0.014)}{-0.082} \\ \underset{(-)}{0} & \underset{(0.006)}{-0.022} \\ \underset{(-)}{0} & \underset{(-)}{0} \\ \underset{(-)}{0} & \underset{(-)}{0} \\ \underset{(-)}{0} & \underset{(0.004)}{-0.011} \end{pmatrix} \begin{pmatrix} \underset{(-)}{1} & \underset{(0.02)}{-0.65} & \underset{(0.21)}{-1.49} & \underset{(-)}{1.49} & \underset{(-)}{0} & \underset{(-)}{0} \\ \underset{(-)}{-1} & \underset{(-)}{1} & \underset{(-)}{0} & \underset{(-)}{0} & \underset{(1.80)}{8.13} & \underset{(-)}{0} \end{pmatrix}$$

Cointegration analysis (cont.)

- Long-run mutual dependency between p_t and d_t

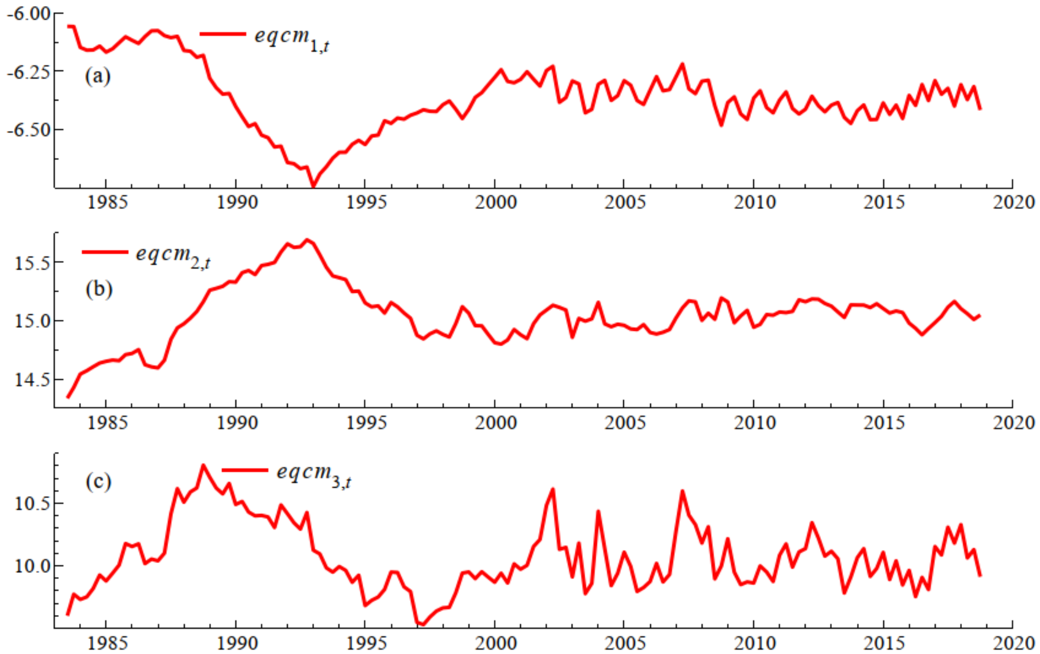
$$p_t = \underset{(0.02)}{0.65} d_t + \underset{(0.21)}{1.49} y_t - 1.49 k_t$$

$$d_t = p_t - \underset{(1.80)}{8.13} R_t$$

=> $$p_t = 4.29 y_t - 4.29 k_t - 15.37 R_t$$

Cointegration analysis (cont.)

❑ Mean-reversion properties

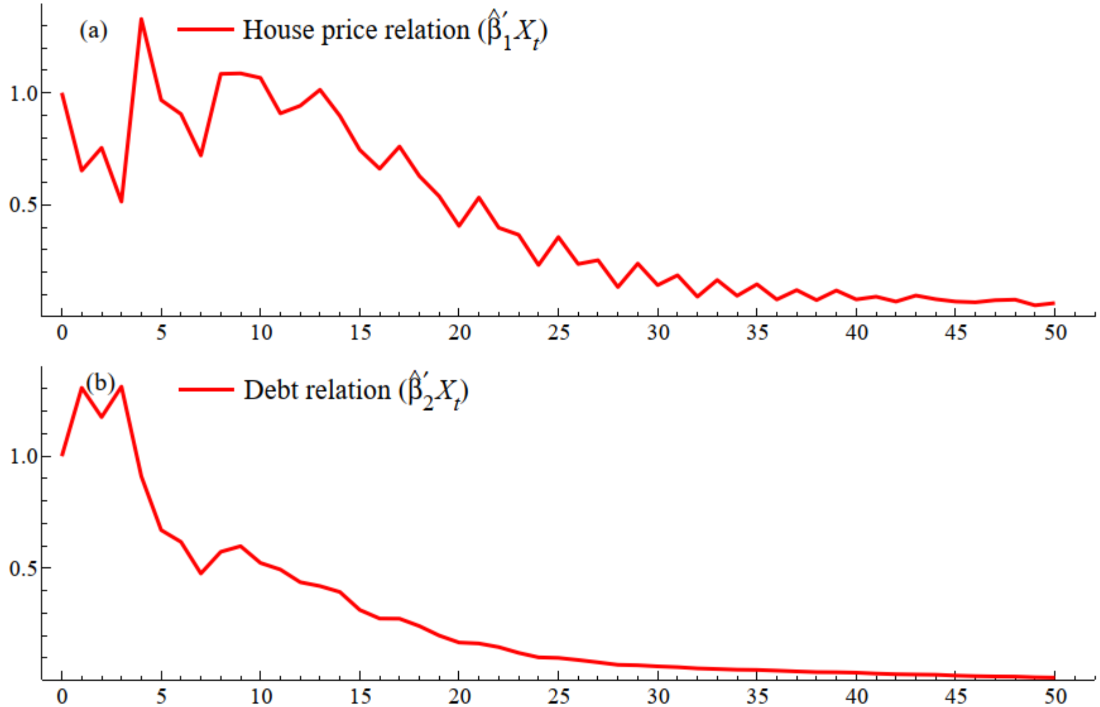


Notes: Sample period: $1982q1 - 2018q4$. The first equilibrium correction term (panel a), $eqcm_{1,t} = p_t - 0.65d_t - 1.49y_t + 1.49k_t$, the second equilibrium correction term (panel b), $eqcm_{2,t} = d_t - p_t + 8.13R_t$ and their combination (panel c), $eqcm_{3,t} = p_t - 4.29y_t + 4.29k_t + 15.37R_t$.

Cointegration analysis (cont.)

❑ Persistence profiles

$$h(\beta_j' X_t, n) = \frac{\beta_j' A_n \Omega A_n' \beta_j}{\beta_j' \Omega \beta_j}$$, Pesaran and Shin (1996)



Control analysis

The basic idea

- Johansen and Juselius (2001) defines the notions of instruments and target variables for policy analysis in the context of the cointegrated VAR.
- A target variable is said to be *controllable* if it can be made *stationary* around a desired target value by using the chosen instrument.
- We ask whether house prices and debt are *controllable* to some pre-specified target levels using the real after-tax interest rate as the instrument in the context of our cointegrated VAR.
- The selection of R as a policy instrument is justifiable (given X) on the grounds that a long-run one-to-one relationship exists between the money market rate, which is closely related to the key policy rate, and the interest rate on mortgage credit, see Hungnes (2015).

Control analysis (cont.)

Brief overview of the theory

$\Delta X_t = \alpha(\beta' X_{t-1} - \mu) + \varepsilon_t$, (CVAR with k = 1 to simplify matters)

a, b are selection matrices, v is a policy intervention, b^* is a target value, $a'X_t$ represents an instrument variable (R_t) and $b'X_t$ represent target variables $(p_t,\, d_t)$.

A policy intervention replaces $a'X_t$ with $a'X_t + v$ with the aim of turning $b'X_t$ into a stationary series with mean b^*. The controlled value of X_t in this context, X_t^{ctr}, is expressed as

$$X_t^{ctr} = X_t + a(a'a)^{-1}v$$

so that we can then infer the system dynamics will deliver a sequence of new series X_{t+h}^{new} for $h = 1, 2, \ldots$ from the initial value X_t^{ctr}. The desired target value b^* can then be specified by its long-run expected value:

$$b^* = b' \lim_{h\to\infty} \mathbf{E}\left(X_{t+h}^{new} \left| X_t^{ctr}\right.\right) = b'\left\{C\left[X_t + a(a'a)^{-1}v\right] + \alpha(\beta'\alpha)^{-1}\mu\right\}$$

Control analysis (cont.)

❑ Brief overview of the theory (cont.)

If a sequence of interventions takes place at all time points, so that the control rule is compatible with the CVAR which now generates X_t^{new}, we are able to express X_t^{ctr} as

$$X_t^{ctr} = X_t^{new} - a(b'Ca)^{-1}\left[(b'X_t^{new} - b^*) - b'\alpha(\beta'\alpha)^{-1}(\beta' X_t^{new} - \mu)\right]$$

The CVAR then derives the value of X_{t+1}^{new} given X_t^{ctr}, that is,

$$X_{t+1}^{new} = (I_p + \alpha\beta')X_t^{ctr} - \alpha\mu + \varepsilon_{t+1}$$

In the empirical analysis, it is important to verify that $det(b'Ca) \neq 0$, so as to make the control rule feasible. Hence, $det(b'Ca) \neq 0$ is referred to as the controllability condition in this study.

Control analysis (cont.)

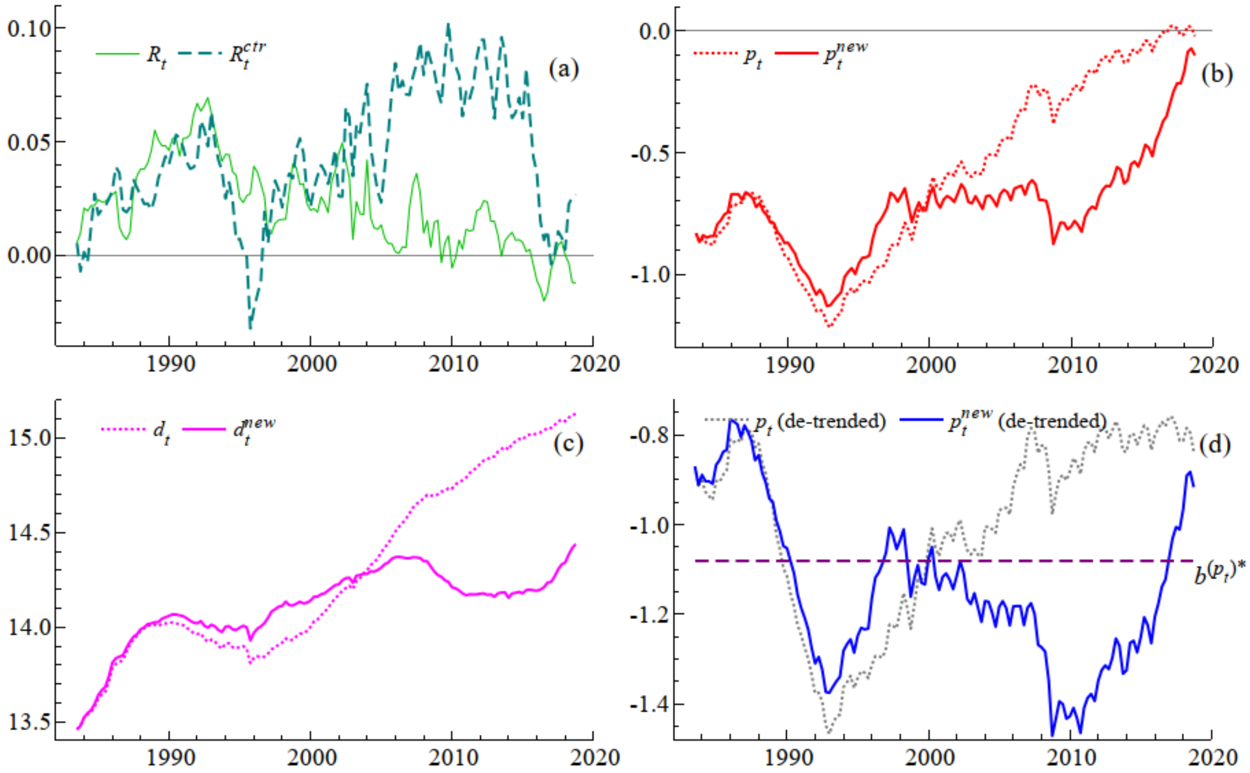
❑ Controllability of p_t and d_t

$$\hat{C} = \begin{bmatrix} \underset{(0.243)}{-0.113} & \underset{(0.339)}{0.605} & \underset{(0.327)}{0.99} & \underset{(14.37)}{-15.75} & \underset{(0.621)}{-1.72} \\ \underset{(0.263)}{-0.099} & \underset{(0.366)}{0.807} & \underset{(0.353)}{0.366} & \underset{(15.5)}{-25.71} & \underset{(0.671)}{-2.32} \\ \underset{(0.0863)}{0.015} & \underset{(0.12)}{-0.026} & \underset{(0.116)}{0.489} & \underset{(5.1)}{-1.597} & \underset{(0.22)}{0.177} \\ \underset{(0.0593)}{-0.082} & \underset{(0.0826)}{0.128} & \underset{(0.0797)}{0.121} & \underset{(3.505)}{4.161} & \underset{(0.152)}{-0.513} \\ \underset{(0.0912)}{0.128} & \underset{(0.127)}{-0.221} & \underset{(0.123)}{-0.065} & \underset{(5.389)}{-5.731} & \underset{(0.233)}{0.877} \end{bmatrix} \begin{matrix} \Rightarrow \; b^{(p_t)\prime}\hat{C}a \\ \Rightarrow \; b^{(d_t)\prime}\hat{C}a \\ \\ \\ \\ \end{matrix}$$

- The conditions for controllability is satisfied.
- We can then do policy simulations in the context of our CVAR in order to control p_t and d_t through R_t

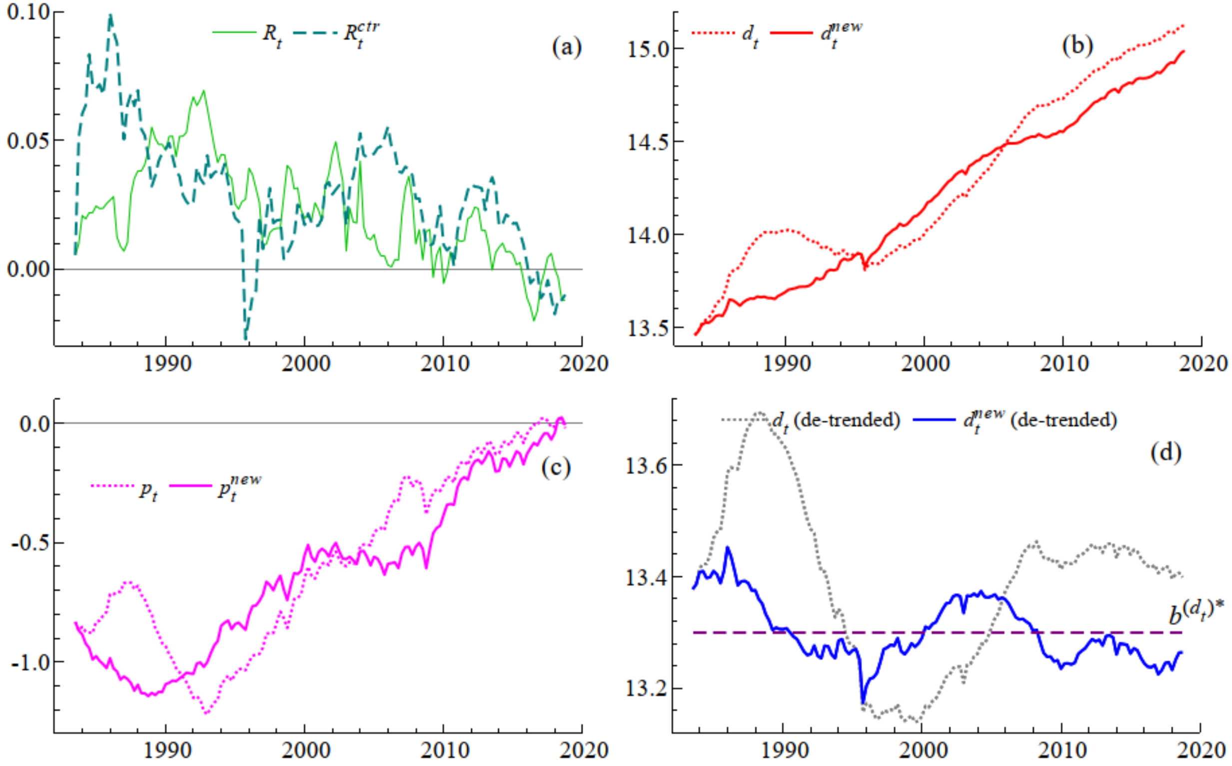
Control analysis (cont.)

- **Stabilising p_t by R_t**



Control analysis (cont.)

- Stabilising d_t by R_t



Conclusions

- We identify *two cointegrating relationships* which are interpreted as a long-run house price relation and a debt relation.
- Our findings support the hypothesis of a *long-run mutual dependency between house prices and debt* such that both are linked to income, the housing stock and the interest rate in the long run.
- We find that around *80 per cent and 90 per cent of the adjustments towards equilibrium after a system-wide shock are made after six years* in the cases of the house price relation and the debt relation, respectively.
- Our findings suggest that both *house prices and debt are controllable magnitudes* to some pre-specified target levels through the interest rate, which enables the central bank to reduce large fluctuations and bubble tendencies in the housing market.

Conclusions (cont.)

- We believe that the present study provides theoretically understandable and empirically relevant representations of house prices and debt which are two financial magnitudes entering the decision process of Norges Bank.
- We should emphasise that our modelling framework is based on the underlying premise that the housing stock representing the supply side of the housing market is fixed.
- The implications of extending the VAR analysis with observable variables for the purpose of modelling a flexible supply side are left for future research.

Thank you!

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