US household Sector Borrowing in the Long Run:
Structural Change and Causality

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IMK
Macroeconomic Policy Institute

UNIVERSITY *of* GREENWICH

Motivation

The State of Macroeconomics

- Economics, Vol. 3, 2009
  - Reconstructing Macroeconomics

- Journal of Economic Perspectives, Vol. 24(3), 2010
  - Macroeconomics after the Crisis

- The Manchester School, Supplement 2011
  - The Future of Macroeconomics

- Oxford Review of Economic Policy, Vol. 34(1+2), 2018
  - Rebuilding Macroeconomic Theory

The State of Macroeconomics

- IMF Rethinking Macro Policy Conference
  - Part I: 2011
  - Part II: 2013

- William White, former BIS chief economist
  - Finance & Development 2009
  - "we really need to turn to Hyman Minsky"

- Vítor Constâncio, Vice-President of the ECB
  - Annual Research Conference September 2017
  - Challenges Ahead: Macro-financial linkages
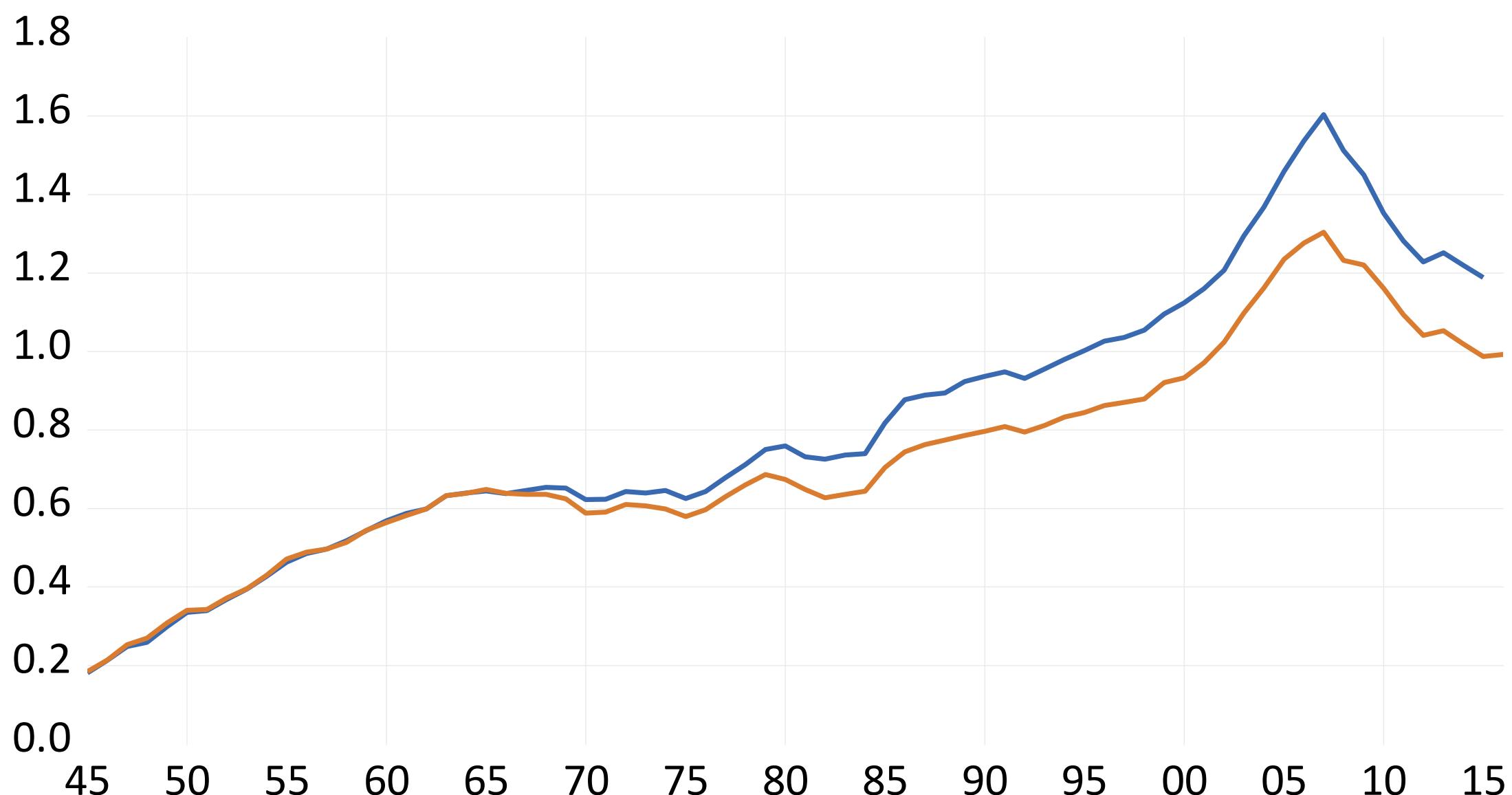
household debt to disposable income (cash)

household debt to disposable income (NIPA)

Research Question

- Which factors drove household debt accumulation over 1950-2006?

- Can we establish stable empirical relationships over the sample period despite structural changes occurring?

Four Explanations of Household Debt Accumulation

- Income Explanation
  - Higher income: more expenditures + service more liabilities
  - Do liabilities increase proportionately/disproportionately with income?
  - (Bordo & Meissner 2012; Kaminsky & Reinhart 1999; Mendoza & Terrones 2012)
- Income Distribution Explanation
  - Maintain living standard
  - Other-regarding social norms
  - (Behringer & Treeck 2013; Bertrand & Morse 2013; Carr & Jayadev 2015; Coibion et al. 2014; Cynamon & Fazzari 2015; Perugini et al. 2016; Wildauer 2016)
  - theoretical literature: consumption expenditures

- Housing Explanation
  - wealth effects (consumption)
  - changing mental accounts (Thaler)
  - speculation and herd behaviour (Shiller)
  - (Arestis & González 2014; Bezemer & Zhang 2014; Dynan & Kohn 2007; Haurin & Rosenthal 2006; Hurst & Stafford 2004; Iacoviello 2005; Kiyotaki & Moore 1997; Mian & Sufi 2011; Ryoo 2015, Stockhammer & Wildauer 2017)

- Low Interest Rate Explanation
  - central banks kept interest rates too low
  - (Bordo & Meissner 2012; Borio 2014; Borio & White 2004; Claeys & Darvas 2015; Taylor 2009)

Model and Method

Model and Method I

- household debt in the long run (5.5 decades: 1950-2006)

$\rightarrow$ cointegration analysis

- "finding empirically robust relationships"
  - parameter constancy as basis for causal interpretation
    (super-exogeneity: Hendry 1995, Engle et al. 1983)
  - primary tools: step indicator saturation (Castle et al. 2015) and recursive estimation
- "testing the model's data consistency instead of data mining"
  - model (sample) selection based on statistical tests (AR, cointegration, normal residuals, SIC)

Model and Method III

Reparameterization of $ARDL(p, m_1, \ldots, m_k)$ into Error Correction (EC) form:

$$\Delta Y_t = -\left(1 - \sum_{i=1}^{p} \lambda_i\right)\left[Y_{t-1} - \frac{\mu}{1 - \sum_{i=1}^{p} \lambda_i} - \frac{\sum_{i=1}^{k} \sum_{j=0}^{m_k} \delta_{i,j}}{1 - \sum_{i=1}^{p} \lambda_i} X_{i,t}\right] - \sum_{i=1}^{p-1} \lambda_i^* \Delta Y_{t-1} - \sum_{i=1}^{k} \sum_{j=0}^{m_k-1} \delta_{i,j}^* \Delta X_{t-j} + \upsilon_t$$

Y_t ... logarithm of household debt (bn. USD, consumption deflator)

X_t ... vector of 5 explanatory variables (from economic theory)

redefining terms:

$$\Delta Y_t = \phi\left[Y_{t-1} - c - \sum_{i=1}^{k} \theta_i X_{i,t}\right] - \sum_{i=1}^{p-1} \lambda_i^* \Delta Y_{t-1} - \sum_{i=1}^{k} \sum_{j=0}^{m-1} \delta_{i,j}^* \Delta X_{t-j} + \upsilon_t$$

ϕ ... adjustment speed

c ... long run constant

θ_i ... vector of k long run coefficients

Step Indicator Saturation (SIS)

- any econometric model is an approximation at best

- modelling all types of structural change impossible

- SIS allows to control for some of it: mean shifts

- How does it work?

  - define $T-1$ step indicators: $S_T : \begin{cases} = 0 \ for \ t \leq T \\ = 1 \ for \ t > T \end{cases}$

  - split set of indicators into 4 groups consisting of $\frac{T-1}{3}$ indicators per group

  - run regression three times including each set of indicators once

  - retain indicator if $p - value < \frac{1}{T-1}$

- (impose consistent set across recursive estimations)

Step Indicator Saturation (SIS)

- "True" model / data generating process:

  - $\log(D) = \alpha + \beta * D_{1970} + \gamma * \log(YD)$

  - where: $\alpha = 10, \beta = -0.8, \gamma = 1.2$

- Estimate naive model:

  - $\log(D) = \alpha_0 + \gamma_0 * \log(YD) + \varepsilon$

  - where: $\widehat{\alpha_0} = 7.9, \widehat{\gamma_0} = 1.45$

- Omitting the break biases the remaining parameters!

Legend:
— Data Generating Process
— Fitted Values without step indicator
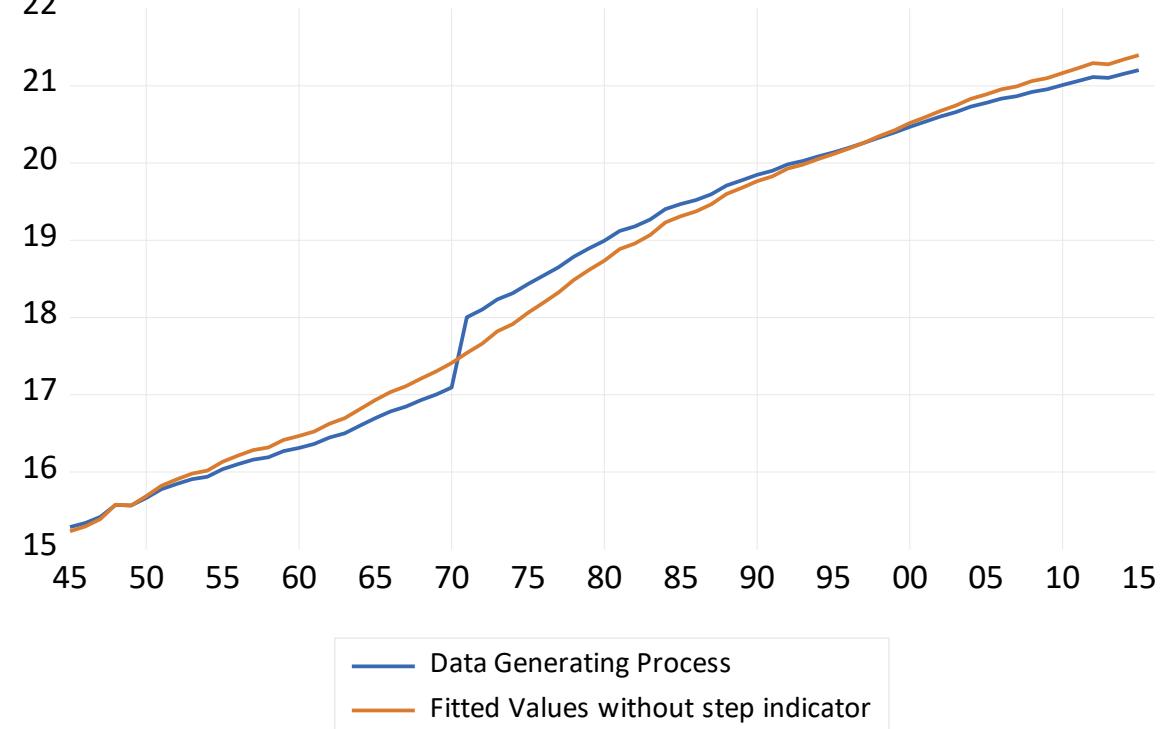
Recursive Estimation

- Varying Sample Start (VSS) Regressions
  - (backward recursive estimation)
  - fixed sample end: 2006
  - vary sample starts from 1951 to 1980
  - → selection of sample period (model selection)

- Varying Sample End (VSE) Regressions
  - (forward recursive estimation)
  - fixed sample start: 1964 (robustness: 1951, 1980)
  - vary sample end from 2006 to 1987
  - → diagnostic test of chosen model (sample)

Results:
Varying Sample Starts (VSS)

Varying Sample Start Regressions (VSS); Sample ends in 2006

Disposable Income

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
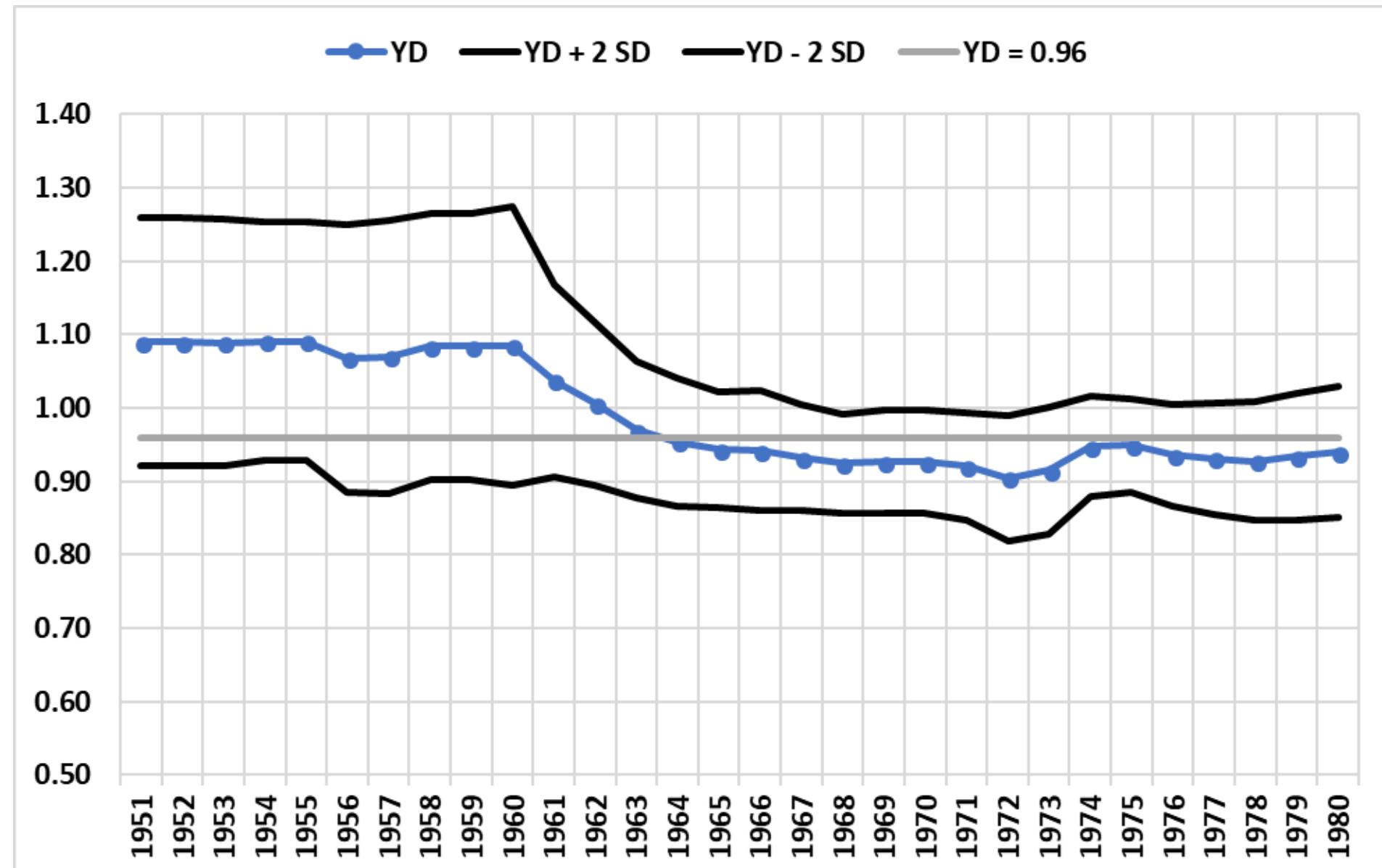
Varying Sample Start Regressions (VSS); Sample ends in 2006

House Price Index

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

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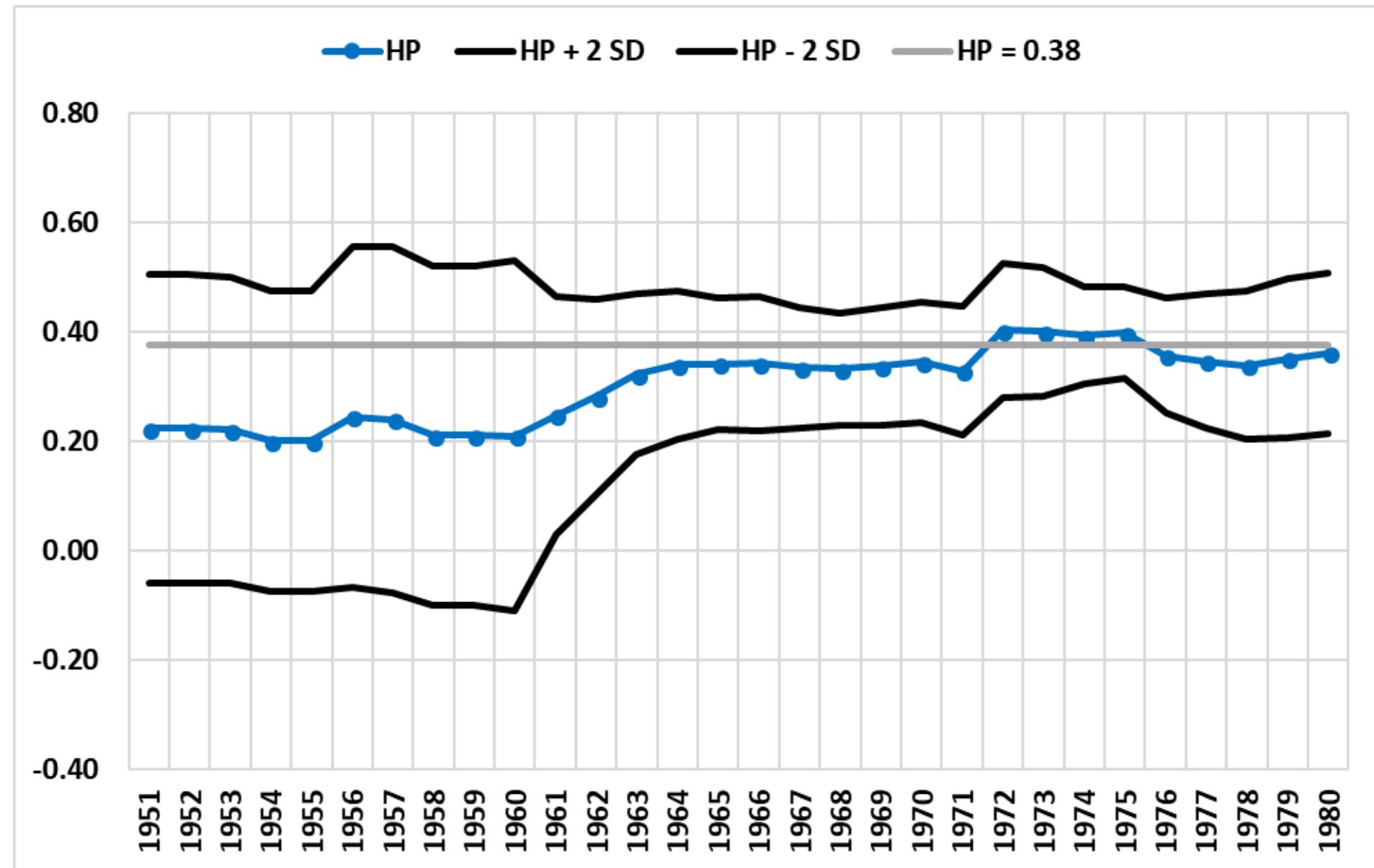
Varying Sample Start Regressions (VSS); Sample ends in 2006

Top 1% Income Share

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
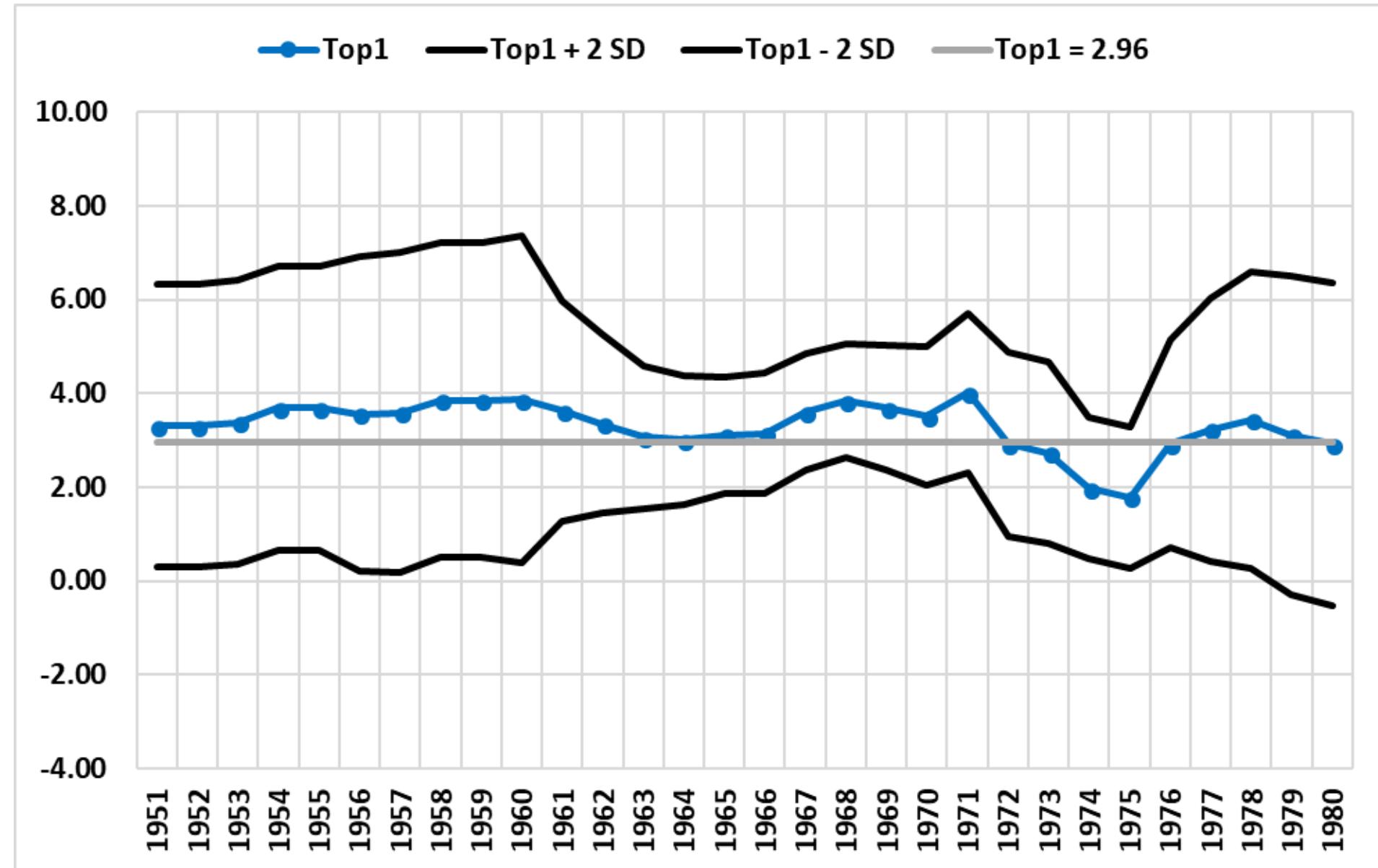
Varying Sample Start Regressions (VSS); Sample ends in 2006

30 year mortgage rate

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
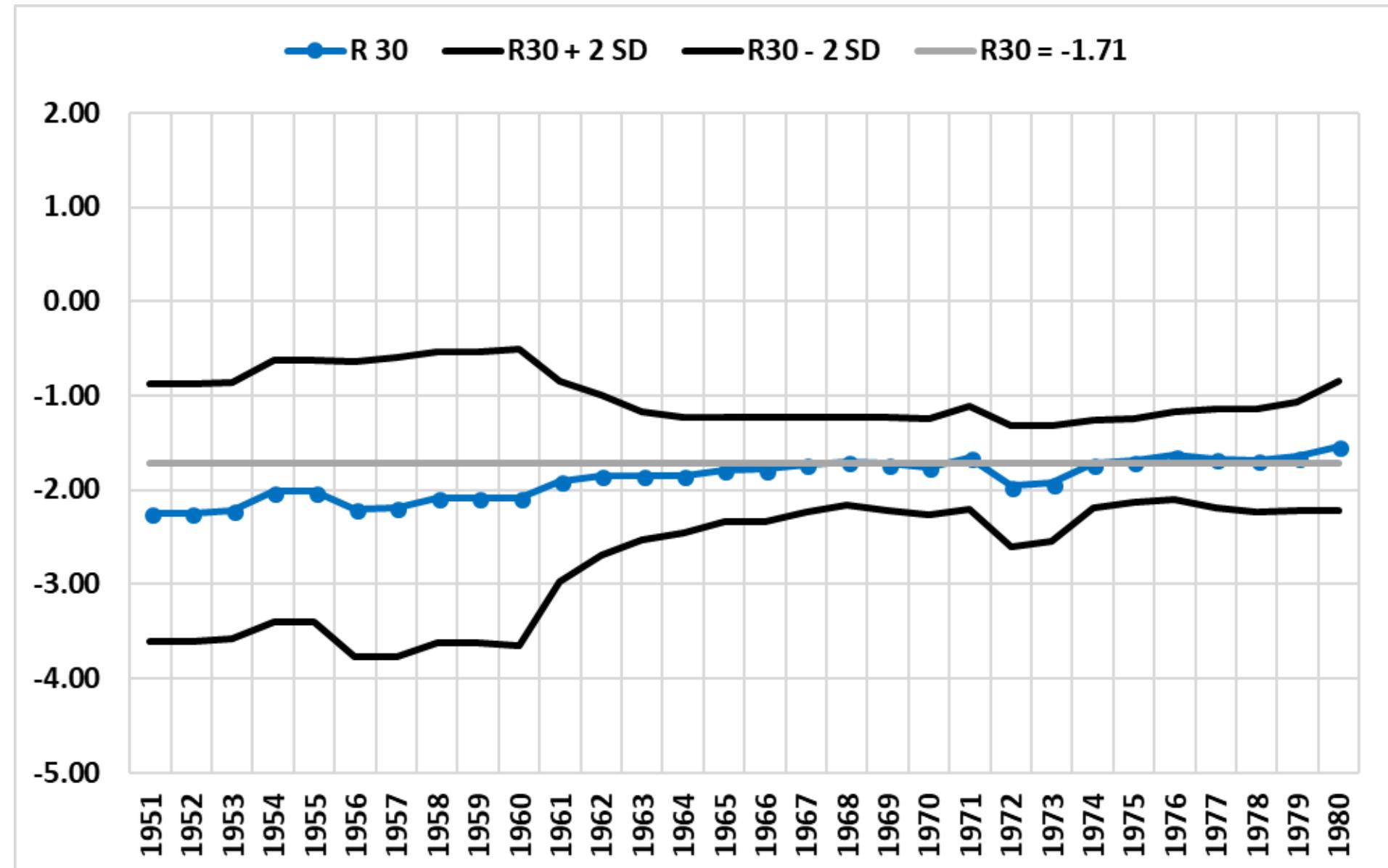
Varying Sample Start Regressions (VSS); Sample ends in 2006

1986 step indicator

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
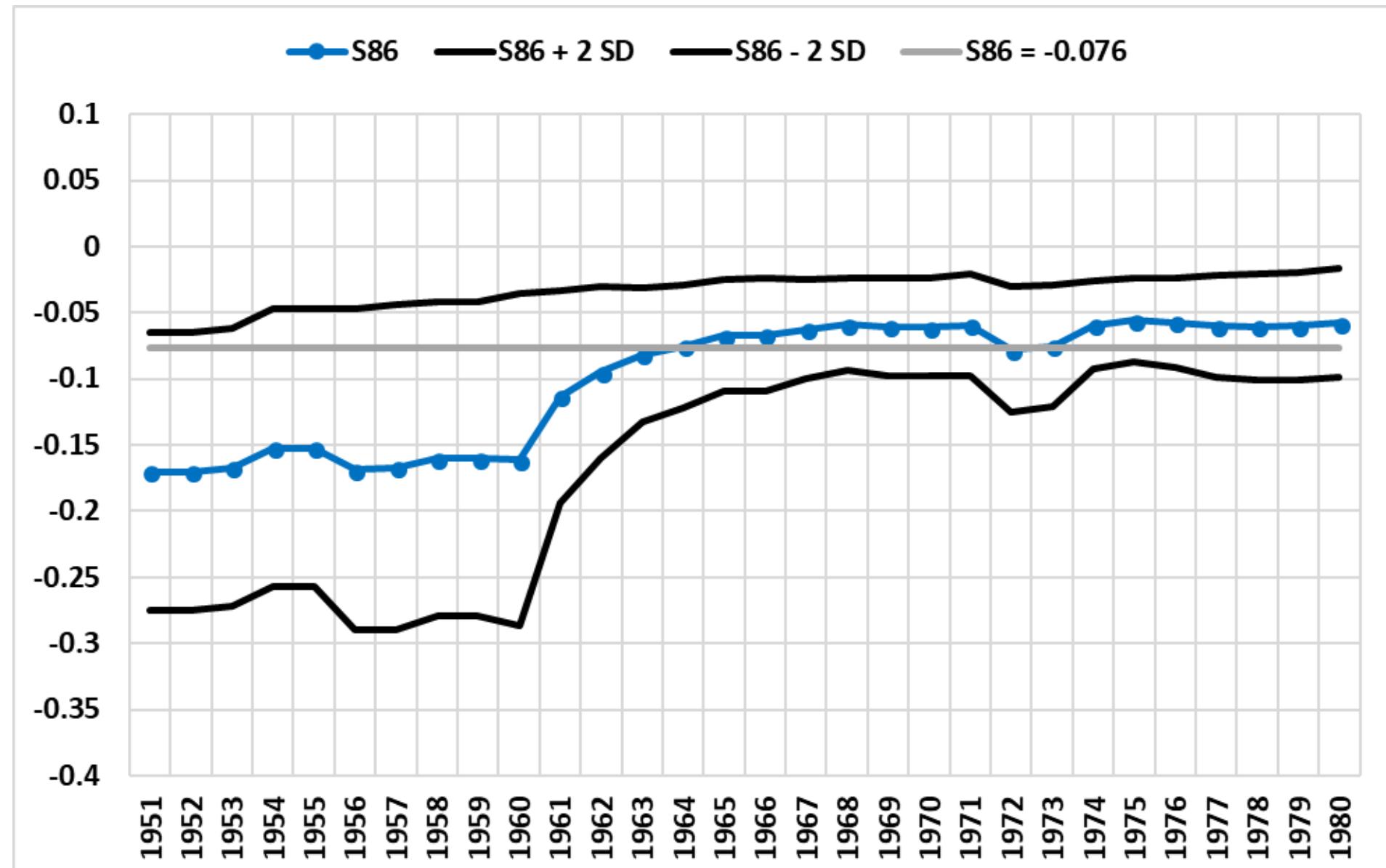
Findings I

- Structural change: pre vs post 1960

- Parameter stability post 1960
  - (close to) unity income elasticity
  - 0.35 house price elasticity
  - 3 top 1% income share semi elasticity
  - -1.7 mortgage rate semi elasticity
  - -6% 1986 step indicator shift

- 1986 step indicator
  - Tax Reform Act 1986: non-mortgage interest rate deductability
  - S&L crisis

- Preferred spec: **start in 1964**

Results:
Varying Sample Ends (VSE)

Varying Sample End Regressions (VSE); Sample starts in 1964

Disposable Income

Long run cointegrating coefficient in blue

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Average of (Min,Max) in grey
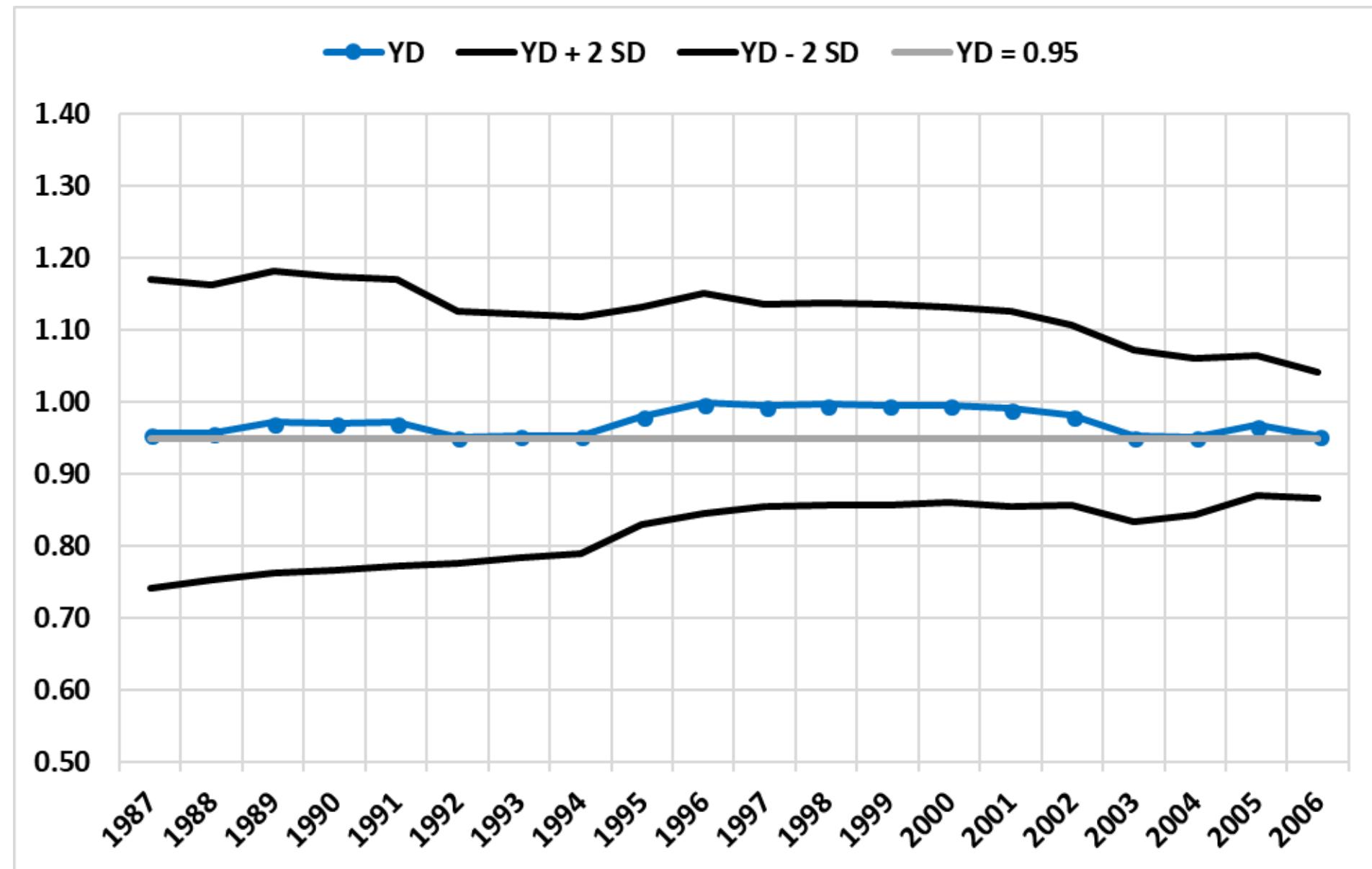
Varying Sample End Regressions (VSE); Sample starts in 1964

House Price Index

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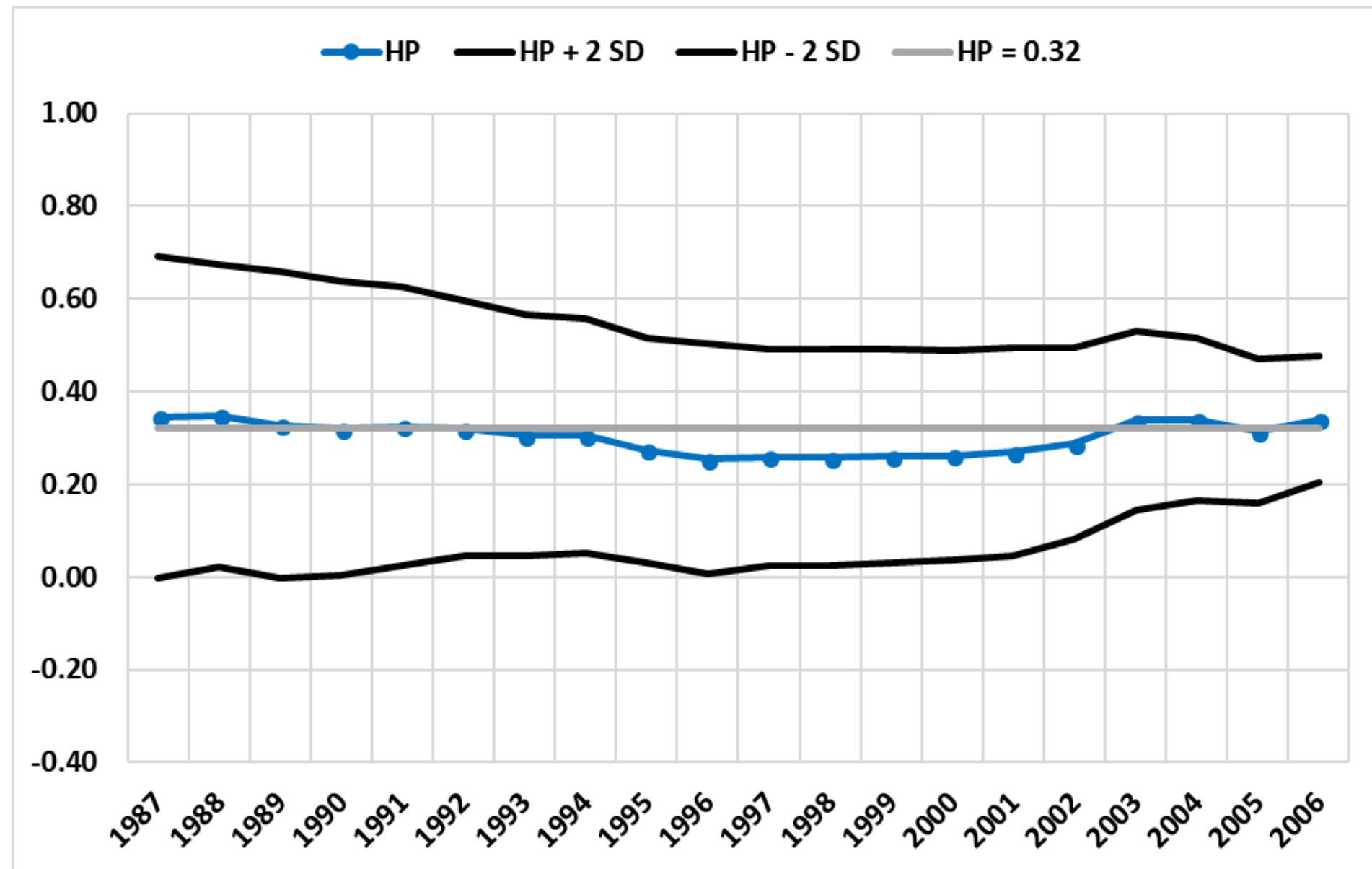
Varying Sample End Regressions (VSE); Sample starts in 1964

Top 1% Income Share

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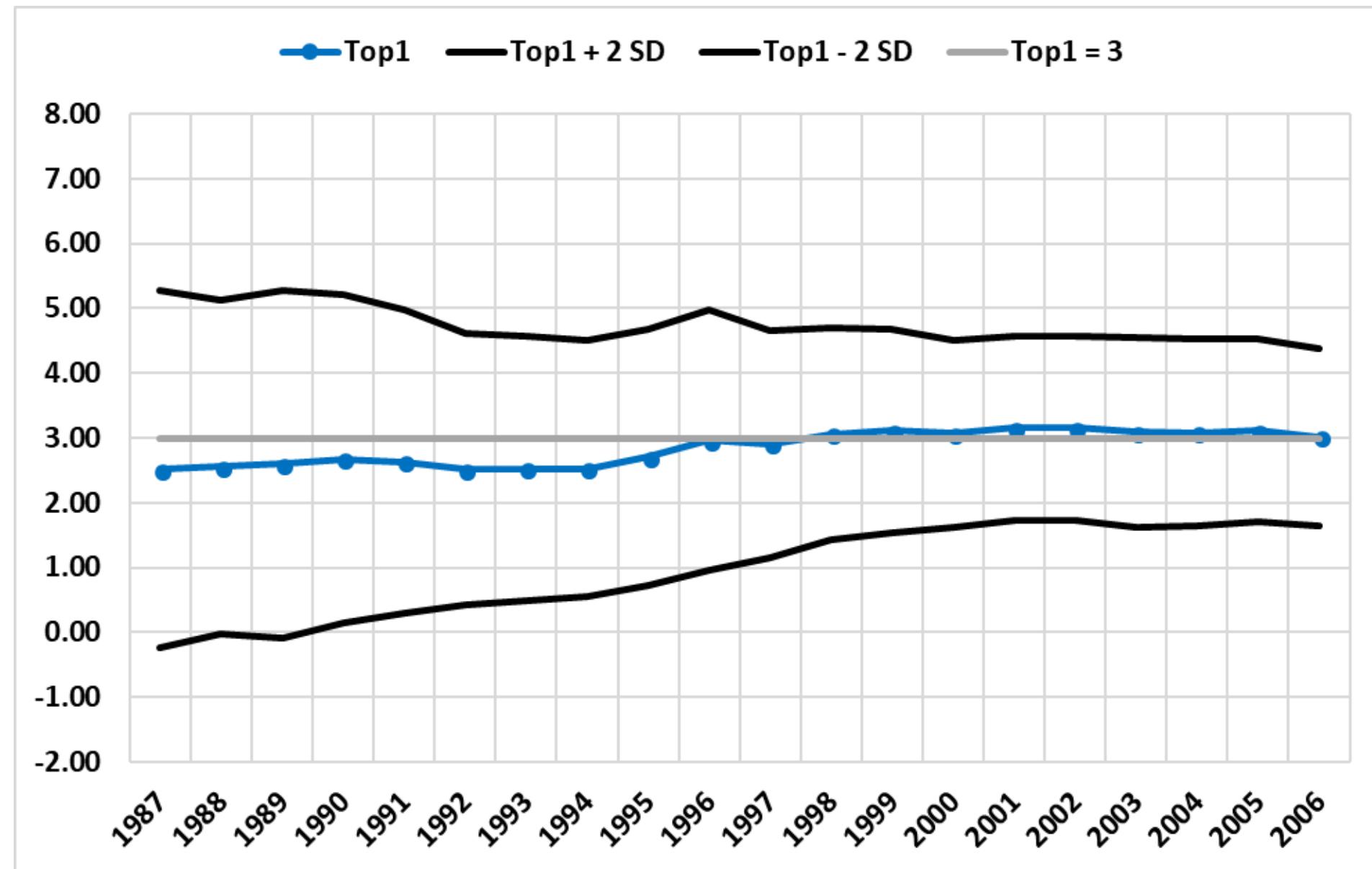
Varying Sample End Regressions (VSE); Sample starts in 1964

30 year mortgage rate

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
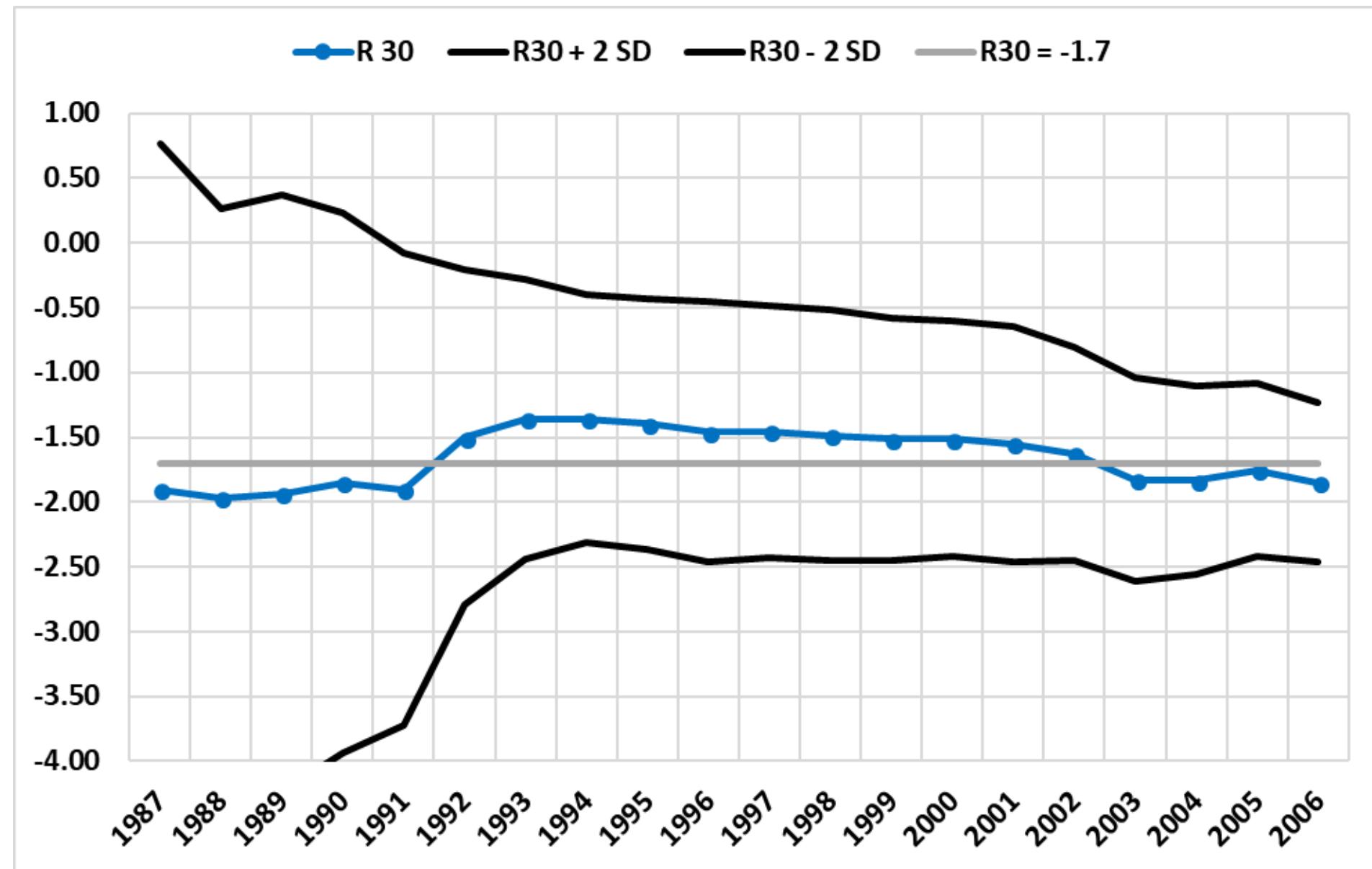
Results:
Effect Size Computation

Sample Start: 1964

line	period	actual change D/Y	explained change D/Y	YD	HP	Top1	R30
(1)	1964-2006	140%	139%	-12%	130%	21%	-2%
(2)	1997-2006	48%	43%	-2%	30%	10%	2%
(3)	1987-1996	15%	16%	-2%	8%	6%	5%
(4)	1977-1986	29%	23%	-3%	26%	4%	-2%

Results based on specification 7 in Table 1. For details see Appendix A.

$$\log\left(\frac{\widehat{D}_{2006}}{\widehat{D}_{1997}}\right) = \hat{\theta}_1 \log\left(\frac{Y^D_{2006}}{Y^D_{1997}}\right) + \hat{\theta}_2 \log\left(\frac{HP_{2006}}{HP_{1997}}\right) + \hat{\theta}_3(TOP1_{2006} - TOP1_{1997}) + \hat{\theta}_4(R_{2006} - R_{1997}) \quad \text{(A1)}$$

$$\frac{\frac{\widehat{D}_{2006}}{Y^D_{2006}}}{\frac{\widehat{D}_{1997}}{Y^D_{1997}}} = \left(\frac{Y^D_{2006}}{Y^D_{1997}}\right)^{(\hat{\theta}_1 - 1)} \quad \text{(A4)}$$

$$\frac{\frac{\widehat{D}_{2006}}{Y^D_{2006}}}{\frac{\widehat{D}_{1997}}{Y^D_{1997}}} = \left(\frac{PP_{2006}}{PP_{1997}}\right)^{\hat{\theta}_2} \quad \text{(A5)}$$

Sample Start: 1980

line	period	actual change D/Y	explained change D/Y	YD	HP	Top1	R30
(1)	1964-2006	140%	141%	-16%	142%	20%	-1%
(2)	1997-2006	48%	44%	-3%	32%	10%	2%
(3)	1987-1996	15%	15%	-3%	8%	5%	4%
(4)	1977-1986	29%	24%	-4%	28%	4%	-2%

Results based on specification 15 in Table 1. For details see Appendix A.

Sample Start: 1964

line	period	actual change D/Y	explained change D/Y	YD	HP	Top1	R30
(1)	1964-2006	140%	139%	-12%	130%	21%	-2%
(2)	1997-2006	48%	43%	-2%	30%	10%	2%
(3)	1987-1996	15%	16%	-2%	8%	6%	5%
(4)	1977-1986	29%	23%	-3%	26%	4%	-2%

Results based on specification 7 in Table 1. For details see Appendix A.

Conclusion

Conclusions

- two regimes pre 1960 vs. post 1960

  → step indicators and recursive estimation is important

- house prices main driver of US household debt

  → modelling of household debt as consumption driven misleading

- unit income elasticity

- income distribution: significant but secondary

Survey of Consumer Finances

real estate secured debt

home purchase and improvement
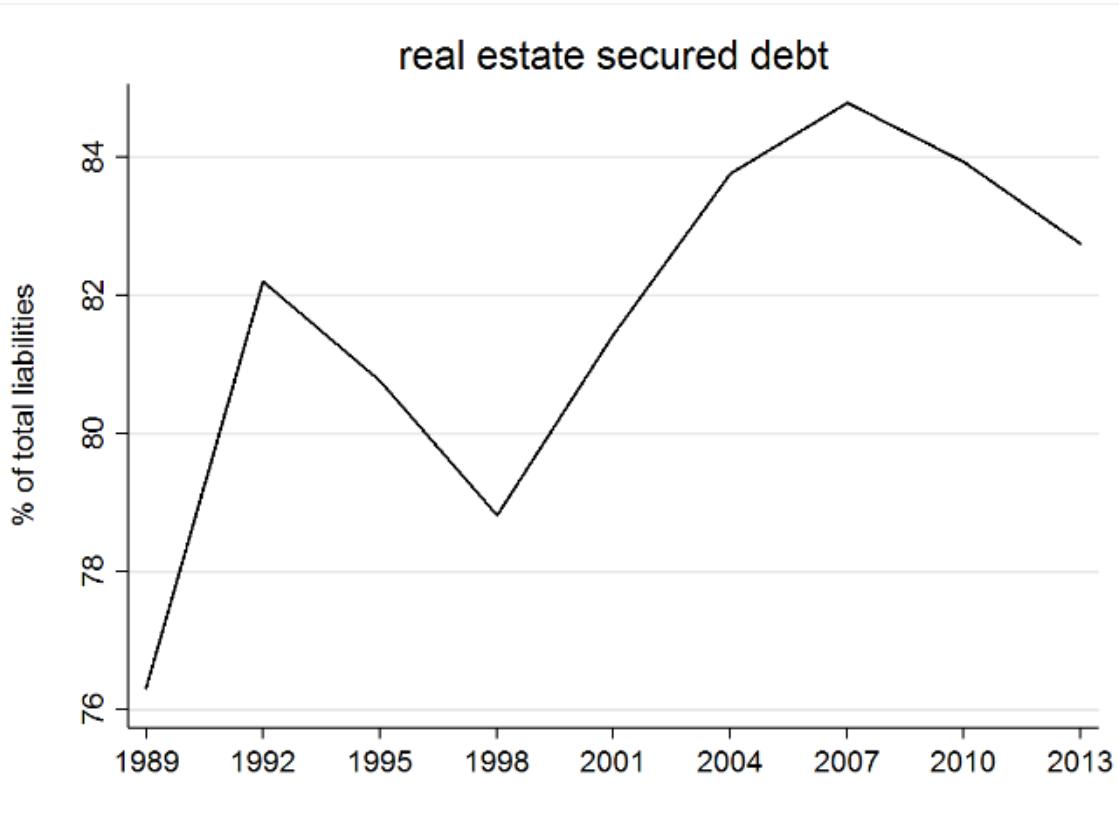
real estate collateralized debt

1998 to 2007:
    79%   to   85%
    $6,886 bn. to $12,656 bn.
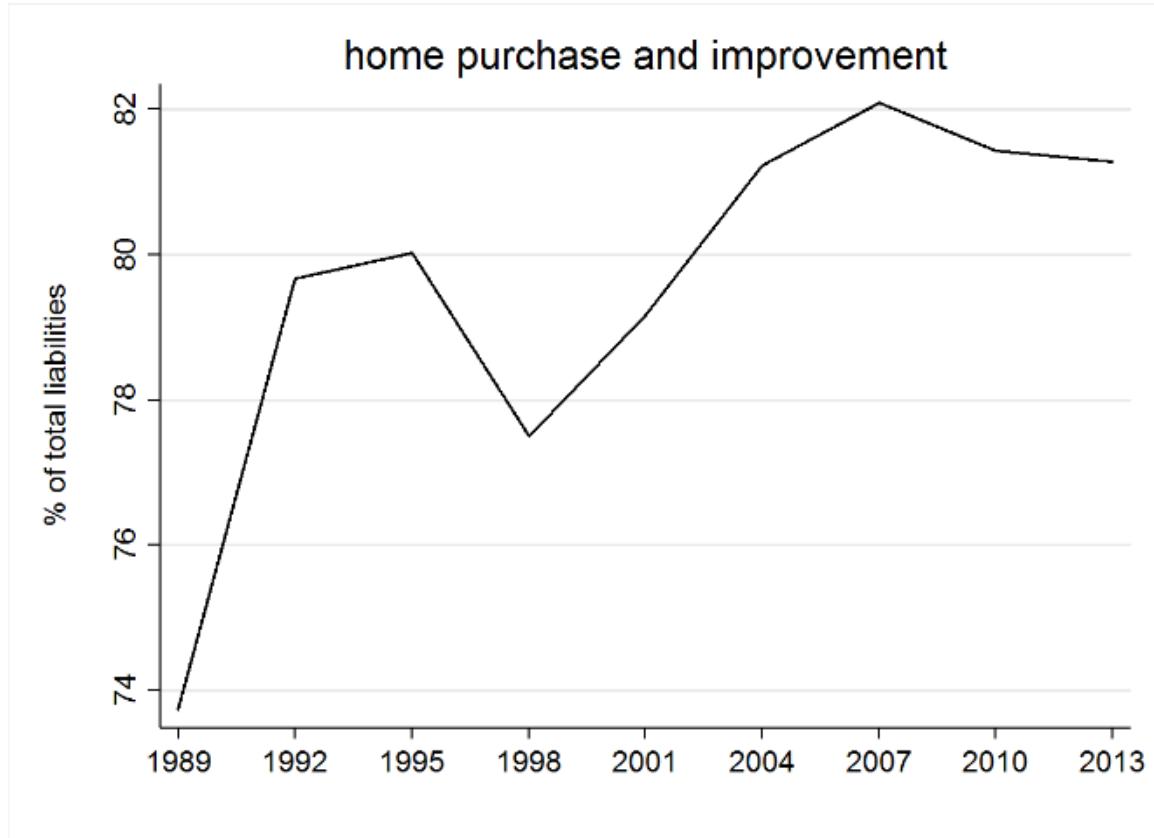
debt used to buy + improve property (≠consumption)

1998 to 2007:
    78%   to   82%
difference between the two
    $90 bn. to $341 bn.

Appendix: 4 Variable Model

Table 1: Moving Sample Starts

| specification	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ARDL	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(1,1)	(1,1)	(1,1)	(1,1)	(1,1)
sample start	1952	1954	1956	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980
adjustment	0.29***	0.31***	0.27***	0.28***	0.27***	0.45***	0.61***	0.68***	0.74***	0.74***	0.64***	0.75***	0.75***	0.71***	0.72***
	0.05	0.06	0.06	0.06	0.07	0.09	0.11	0.13	0.12	0.13	0.14	0.13	0.16	0.18	0.19
LOG(Y^D(-1))	1.09***	1.09***	1.06***	1.08***	1.08***	1.00***	0.95***	0.94***	0.92***	0.92***	0.90***	0.94(Y***)	0.93***	0.92***	0.94***
	0.08	0.08	0.09	0.09	0.10	0.06	0.04	0.04	0.03	0.04	0.04	0.03	0.03	0.04	0.04
LOG(HP)	0.22	0.20	0.24	0.21	0.20	0.28***	0.33***	0.34***	0.33***	0.34***	0.40***	0.39**	0.35***	0.33***	0.36***
	0.14	0.14	0.16	0.15	0.16	0.09	0.07	0.06	0.05	0.05	0.06	0.04	0.05	0.07	0.07
TOP1	3.30**	3.69**	3.55**	3.85**	3.86**	3.35***	3.01***	3.14***	3.84***	3.51***	2.92***	1.97**	2.91**	3.43**	2.91
	1.51	1.51	1.67	1.67	1.74	0.95	0.69	0.64	0.60	0.73	0.98	0.75	1.11	1.57	1.72
R30(-1)	-2.24***	-2.01***	-2.20***	-2.08**	-2.08**	-1.84***	-1.84***	-1.78***	-1.69***	-1.75***	-1.95***	-1.72***	-1.63***	-1.68***	-1.53***
	0.68	0.69	0.78	0.77	0.79	0.43	0.31	0.28	0.23	0.25	0.32	0.23	0.23	0.27	0.34
C	-2.12***	-2.09***	-1.91***	-1.90***	-1.74***	-1.46***	-1.27***	-1.22***	-1.14***	-1.17***	-1.13***	-1.37***	-1.21***	-1.11***	-1.27***
	0.22	0.21	0.24	0.23	0.27	0.16	0.13	0.12	0.10	0.11	0.16	0.14	0.18	0.27	0.34
normality	0.65	0.58	0.53	0.57	0.56	0.90	0.94	0.90	0.67	0.63	0.20	0.95	0.67	0.66	0.69
AR1	0.62	0.60	0.53	0.24	0.23	0.16	0.32	0.53	0.07	0.15	0.80	0.75	0.96	0.93	0.99
AR2	0.12	0.11	0.14	0.03	0.09	0.05	0.21	0.36	0.09	0.29	0.92	0.28	0.43	0.32	0.44
AR3	0.14	0.16	0.20	0.02	0.04	0.03	0.26	0.30	0.11	0.08	0.12	0.09	0.14	0.13	0.13
SIC	-4.78	-4.79	-4.82	-4.85	-4.90	-5.03	-5.14	-5.15	-5.25	-5.24	-5.25	-5.08	-5.36	-5.40	-5.29
SE of regression	0.015	0.015	0.015	0.015	0.015	0.014	0.013	0.013	0.012	0.012	0.012	0.013	0.011	0.011	0.011
N	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28
step indicators	S1954 S1958 S1986	S1954 S1958 S1986	S1958 S1986	S1958 S1986	S1986	S1986	S1986	S1986	S1986	S1986	S1986	S1986	S1986	S1986	S1986

Dependent variable: LOG(D). Specifications 1 to 10 are estimated as ARDLs with 2 lags of the dependent variable and 1 lag of each regressor. Specifications 11 to 15 are estimated as ARDLs with 1 lag of the dependent variable and 1 lag of each regressor. All specifications estimated by OLS. Normality represents the p-value of the Jarque-Bera test on the residuals, AR1-AR3 are the p-values of the Breusch-Godfrey LM test. SIC is the Schwarz Information Criterion.

Varying Sample End Regressions (VSE); Sample starts in 1951

Disposable Income

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
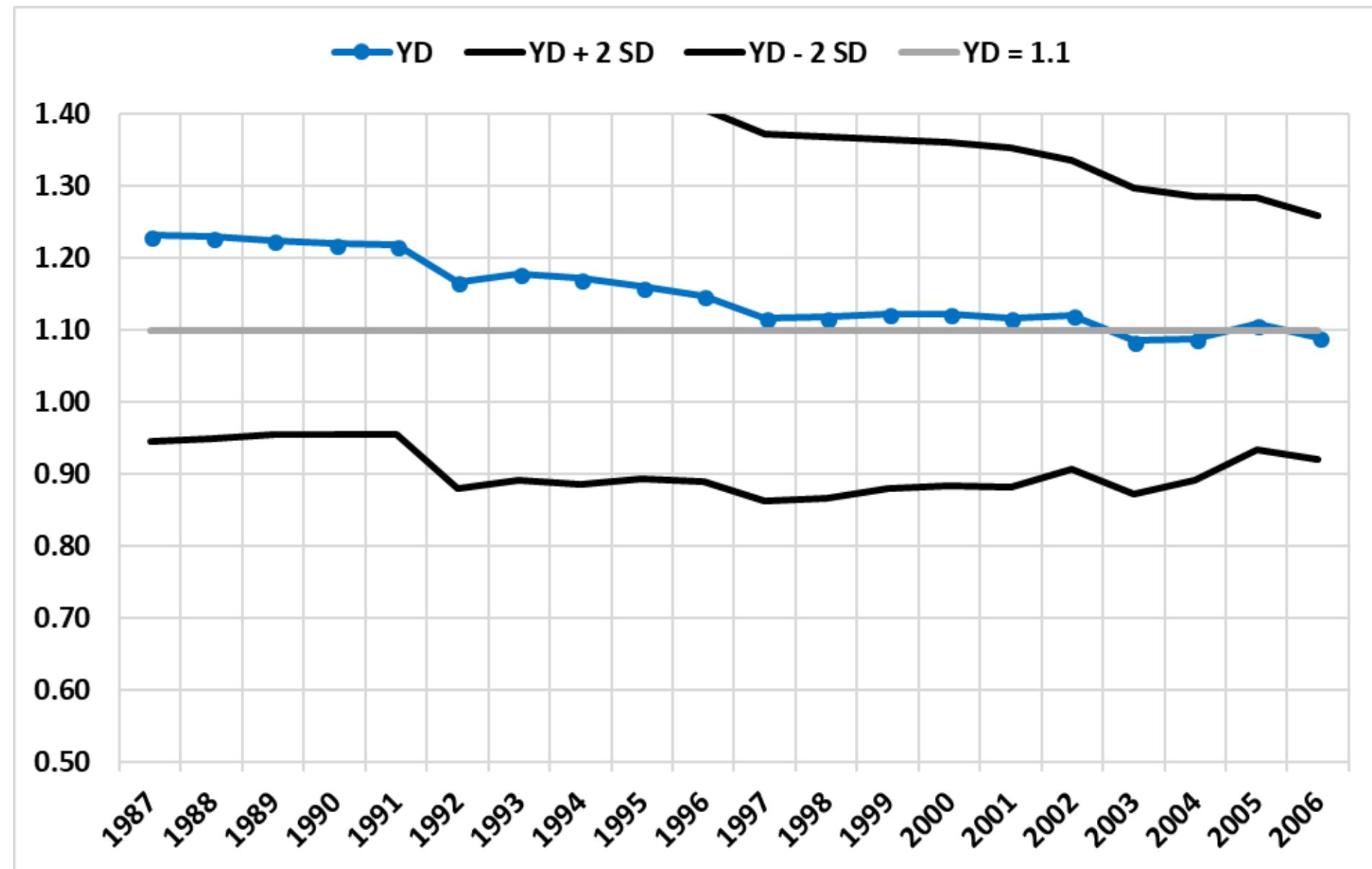
Varying Sample End Regressions (VSE); Sample starts in 1951

House Price Index

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
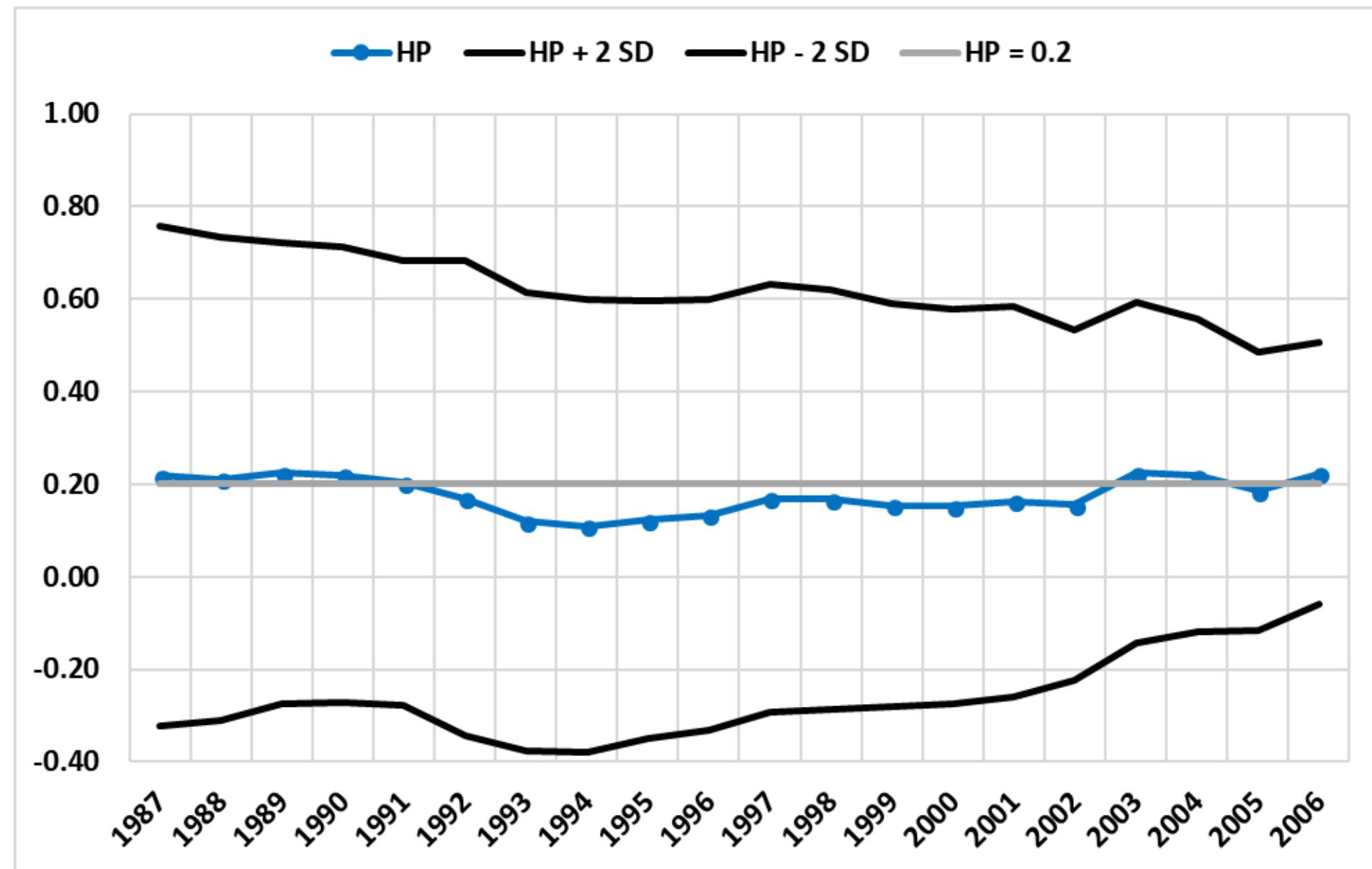
Varying Sample End Regressions (VSE); Sample starts in 1951

Top 1% Income Share

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
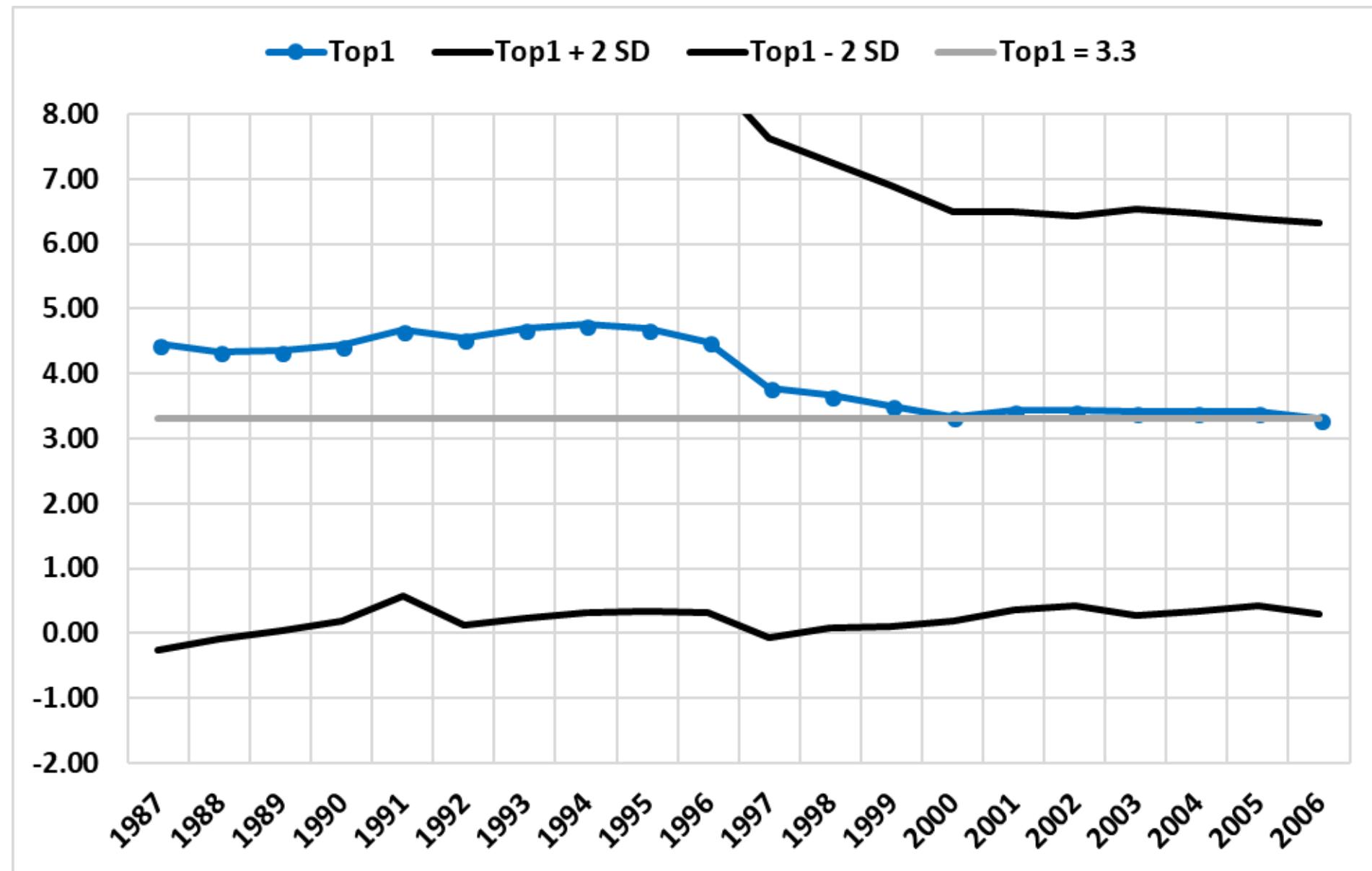
Varying Sample End Regressions (VSE); Sample starts in 1951

30 year mortgage rate

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
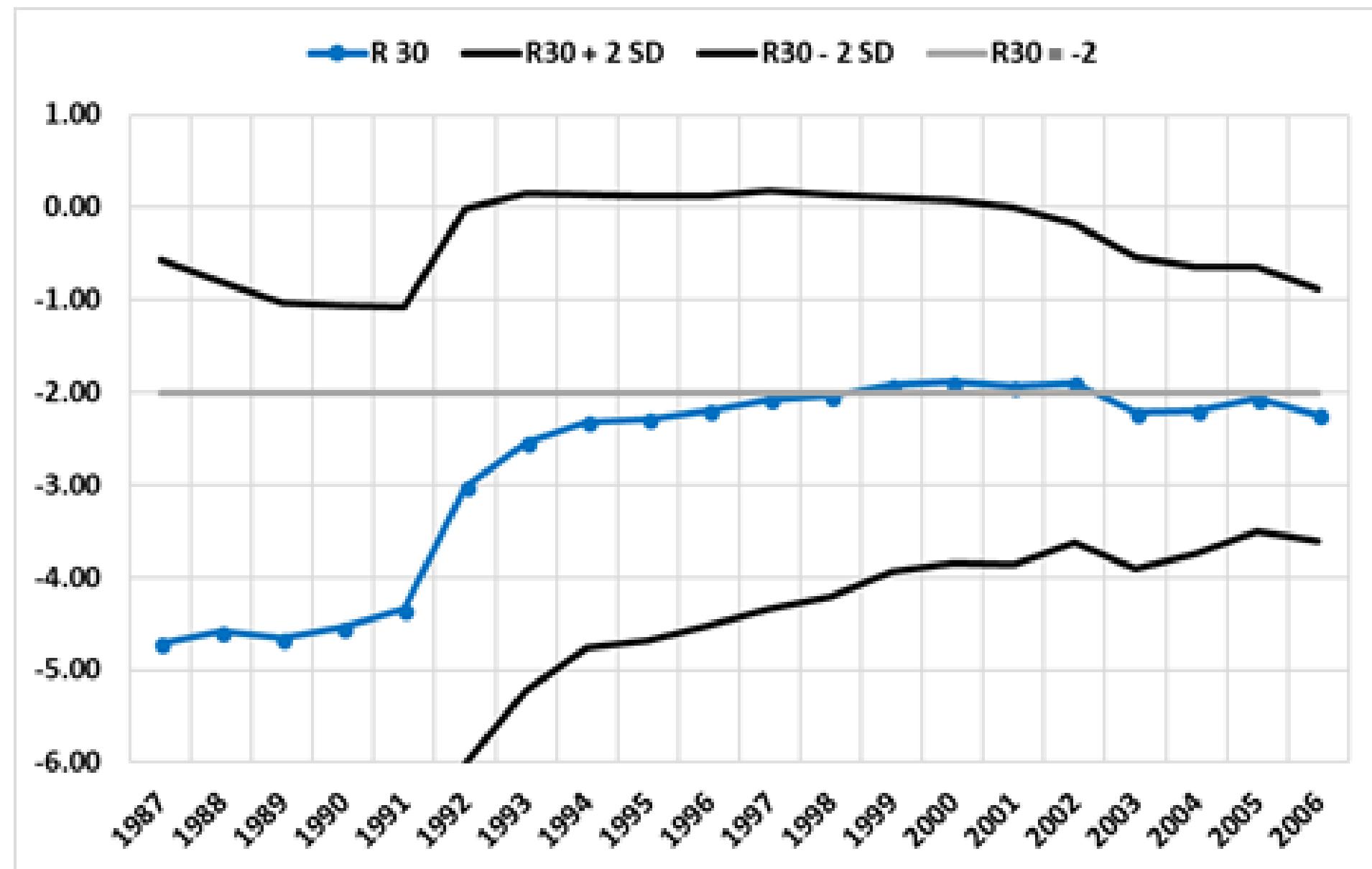
Varying Sample End Regressions (VSE); Sample starts in 1980

Disposable Income

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
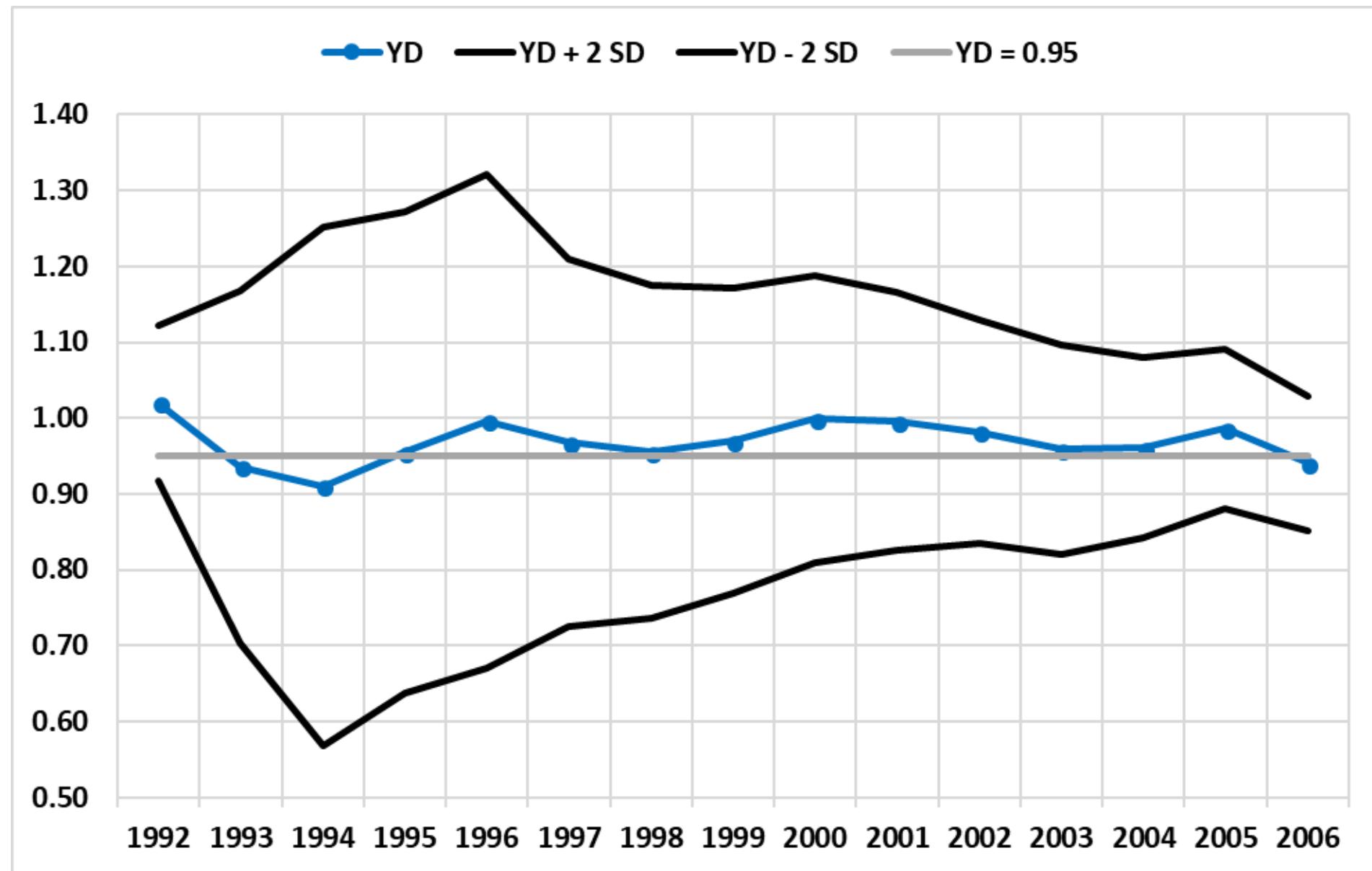
Varying Sample End Regressions (VSE); Sample starts in 1980

House Price Index

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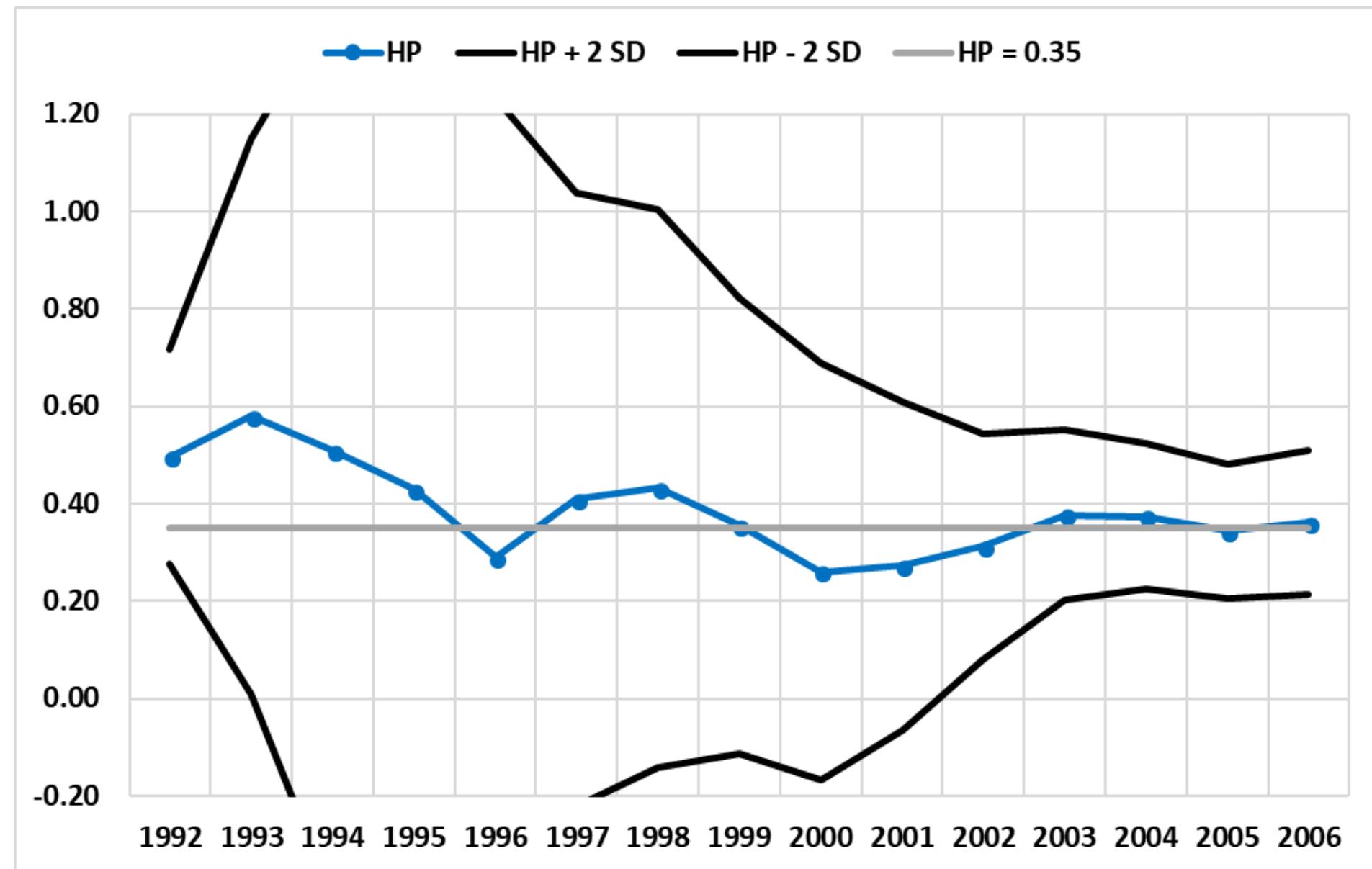
Varying Sample End Regressions (VSE); Sample starts in 1980

Top 1% Income Share

Long run cointegrating coefficient in blue

Two standard error confidence bands in black

Average of (Min,Max) in grey
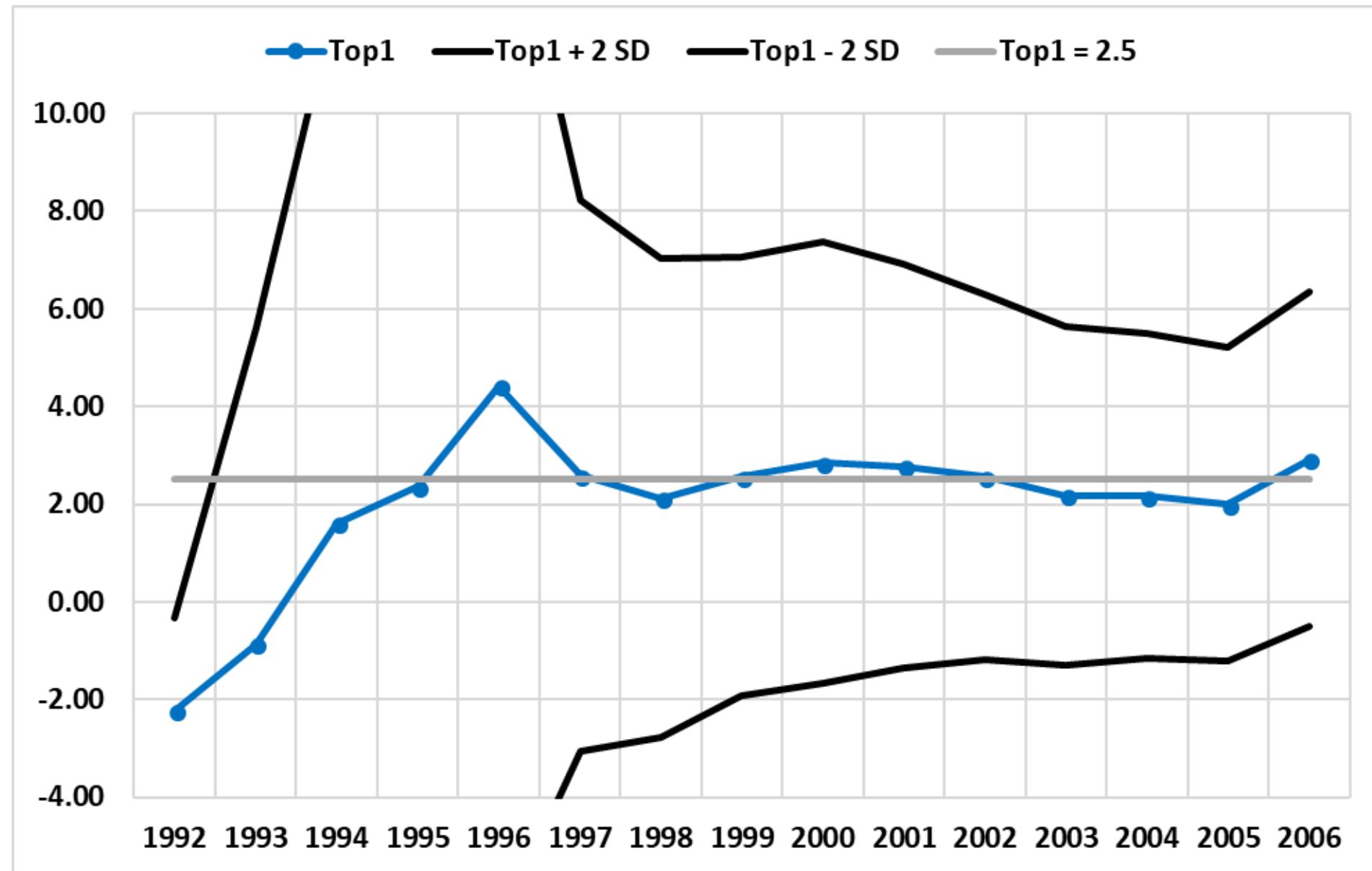
Varying Sample End Regressions (VSE); Sample starts in 1980

30 year mortgage rate

Long run cointegrating coefficient in blue

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Average of (Min,Max) in grey
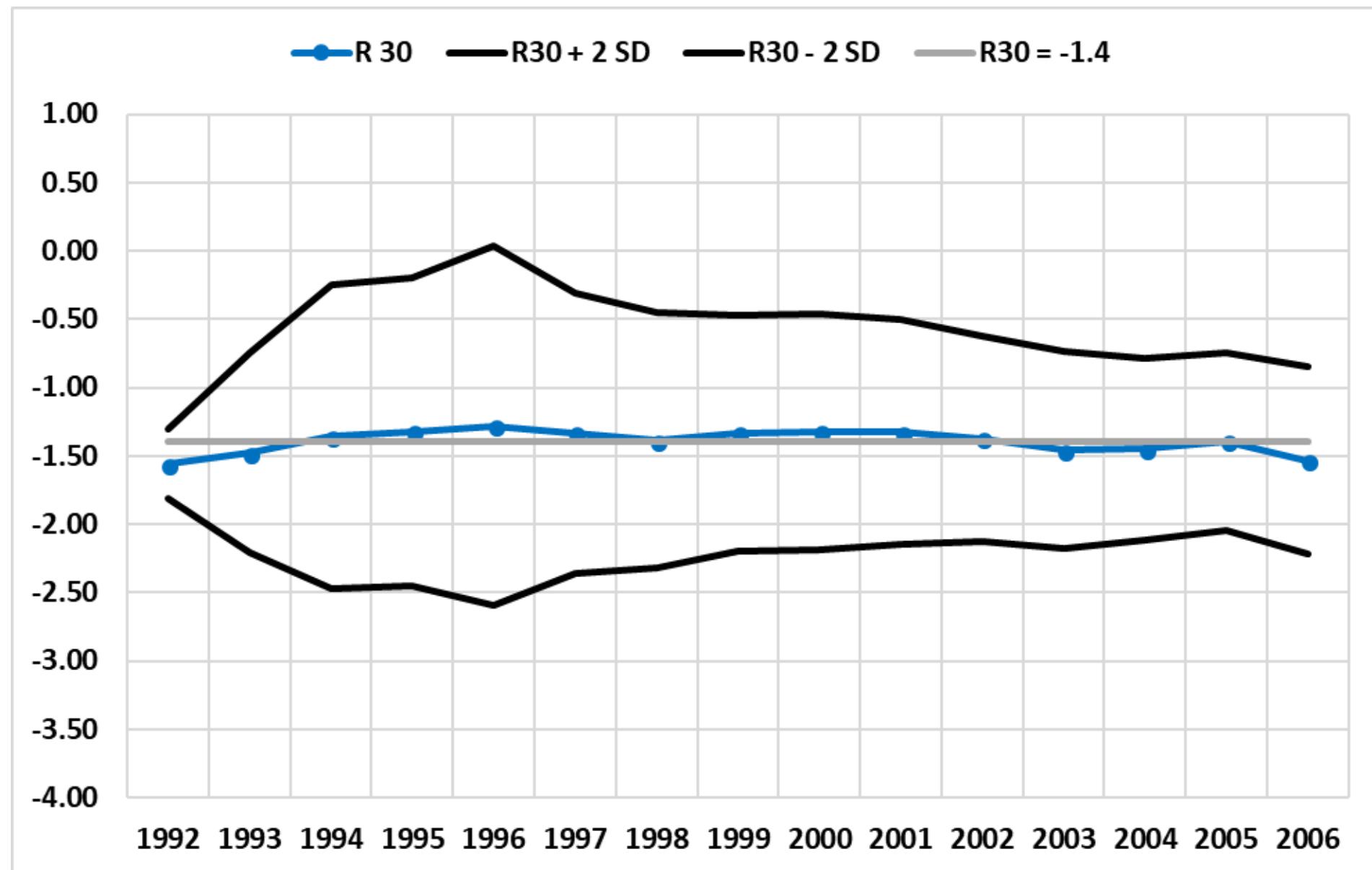
Appendix: CPI Augmented Model

Table 5: Moving Sample Starts; CPI-augmented specifications

specification	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ARDL	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(2,1)	(1,1)	(1,1)	(1,1)	(1,1)	(1,1)
sample start	1952	1954	1956	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980
adjustment	0.41***	0.40***	0.35***	0.37***	0.39***	0.61***	0.70***	0.74***	0.75***	0.76***	0.65***	0.76***	0.78***	0.72***	0.69***
	0.06	0.07	0.08	0.08	0.09	0.10	0.10	0.11	0.11	0.11	0.15	0.15	0.17	0.18	0.17
LOG(YD_N)	1.34***	1.35***	1.32***	1.34***	1.34***	1.21***	1.12***	1.11***	0.94***	1.06***	0.97***	1.04***	1.04***	1.14***	1.51***
	0.09	0.10	0.12	0.11	0.11	0.07	0.07	0.09	0.11	0.12	0.22	0.18	0.18	0.21	0.31
LOG(HP_N)	0.34***	0.36***	0.39***	0.34***	0.34***	0.36***	0.39***	0.38***	0.40***	0.42***	0.48***	0.42***	0.38**	0.36***	0.31***
	0.10	0.11	0.13	0.12	0.12	0.06	0.06	0.05	0.05	0.05	0.07	0.06	0.07	0.08	0.08
TOP1	1.59	1.29	0.97	1.46	1.50	1.89**	1.82**	1.89**	2.54***	1.52*	1.28	1.09	1.96	2.44	3.21*
	1.27	1.50	1.72	1.63	1.61	0.83	0.70	0.68	0.66	0.83	1.40	1.09	1.30	1.48	1.63
R30_N	-1.22**	-1.23*	-1.47*	-1.26*	-1.25*	-1.22***	-1.41***	-1.40***	-1.83***	-1.63***	-1.98***	-1.61***	-1.47***	-1.46**	-1.72***
	0.60	0.63	0.76	0.71	0.70	0.36	0.33	0.35	0.37	0.36	0.60	0.49	0.48	0.52	0.55
C	-2.10***	-2.09***	-1.90***	-1.92***	-1.79***	-1.56***	-1.40***	-1.38***	-1.07***	-1.32***	-1.16**	-1.47***	-1.38***	-1.26***	-0.72
	0.15	0.16	0.19	0.18	0.19	0.12	0.13	0.16	0.19	0.22	0.45	0.38	0.37	0.42	0.57
S1986	-0.09**	-0.09**	-0.10**	-0.09**	-0.09**	-0.05**	-0.05***	-0.04***	-0.05***	-0.05***	-0.07***	-0.05***	-0.05***	-0.05**	-0.06**
	0.04	0.04	0.05	0.04	0.04	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02
LOG(CPI)	-0.52***	-0.54***	-0.51***	-0.52***	-0.52***	-0.38***	-0.29***	-0.28**	-0.06	-0.22	-0.14	-0.15	-0.15	-0.34	-1.02*
	0.14	0.15	0.18	0.17	0.17	0.09	0.09	0.11	0.13	0.15	0.27	0.22	0.22	0.27	0.50
normality	0.39	0.43	0.43	0.36	0.33	0.80	0.97	0.90	0.75	0.74	0.58	0.66	0.80	0.91	0.67
AR1	0.89	0.89	0.64	0.51	0.45	0.09	0.10	0.20	0.01	0.06	0.14	0.85	0.59	0.57	0.46
AR2	0.35	0.38	0.18	0.51	0.34	0.07	0.11	0.23	0.02	0.16	0.26	0.65	0.35	0.52	0.31
AR3	0.54	0.53	0.16	0.47	0.29	0.13	0.21	0.31	0.05	0.28	0.04	0.21	0.09	0.11	0.02
SIC	-4.95	-4.90	-4.95	-4.93	-4.94	-5.31	-5.37	-5.31	-5.45	-5.50	-5.10	-5.26	-5.29	-5.30	-5.38
SE of regression	0.013	0.014	0.014	0.014	0.014	0.011	0.011	0.011	0.010	0.010	0.012	0.011	0.011	0.011	0.010
N	55	53	51	49	47	45	43	41	39	37	35	33	31	29	27
step indicators	S1954	S1954	S1958	S1958	S1986	S1986	S1986	S1986	S1986	S1986	S1986	S1986	S1986	S1986	S1986
	S1958	S1958	S1986	S1986											
	S1986	S1986													

Sample Start: 1964 + CPI augmented

line	period	actual change D/Y	explained change D/Y	YD	HP	Top1	R30	CPI	YD*CPI
(1)	1964-2006	140%	139%	44%	161%	12%	-1%	-42%	-17%
(2)	1987-1996	15%	13%	7%	9%	3%	3%	-9%	-3%
(3)	1977-1986	29%	20%	10%	30%	2%	-2%	-16%	-8%
(4)	1997-2006	48%	45%	6%	35%	6%	2%	-6%	-1%

Results based on specification 7 in Table 5. For details see Appendix A.

Sample Start: 1964 + no CPI

line	period	actual change D/Y	explained change D/Y	YD	HP	Top1	R30
(1)	1964-2006	140%	139%	-12%	130%	21%	-2%
(2)	1997-2006	48%	43%	-2%	30%	10%	2%
(3)	1987-1996	15%	16%	-2%	8%	6%	5%
(4)	1977-1986	29%	23%	-3%	26%	4%	-2%

Results based on specification 7 in Table 1. For details see Appendix A.