Unsmoothing Real Estate Returns: A Regime-switching Approach

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Reported Real Estate Return

- Appraisal-based return as opposed to market-traded
- *Smoothing* – Temporal aggregation and lagging effects
  - Serial correlation
  - Dampened volatility
- Real estate perceived as "safe" investment
- Implication in asset allocation / performance measurement

Unsmoothing Appraisal-based Return

- Conventional unsmoothing methodology: Geltner (1991, 1993), Fisher et al. (1994), Cho et al. (2003), Booth & Marcato (2004), Marcato & Key (2007)
- Fairly successful in that it raises volatility of (unsmoothed) real estate return
- Yet, real estate shown to have significantly better risk hedging characteristics than other asset classes (see e.g. Hudson-Wilson et al. 2003, Worzala & Sirmans 2003, Bond et al. 2007)
- Unsmoothed return still too smooth
- We found that this was only half the truth!

Our Regime-switching Approach

- Conventional method:
  - True return process
  - Smoothing equation
- Not completely satisfactory as it ignores non-linearity in performance data
- Our approach based on Threshold Autoregressive (TAR) model (Tong 1978, 1990)
  - Switching return: high volatility in "bad regime", low in "good regime"
  - Switching smoothing: behavioral changes
- Results = direct and important practical implication

Outline

The Base Model

- Measurement equation (Blundell & Ward 1987)

$$r_t^* = \alpha r_{t-1}^* + (1-\alpha) r_t$$

  where r_t^* = observed (smoothed) return, r_t the "true" return, and the smoothing coefficient $\alpha \in (0,1)$
- Given α, can calculate the unsmoothed return by

$$r_t = \frac{1}{1-\alpha}\left(r_t^* - \alpha r_{t-1}^*\right)$$

- Can also show that the "unsmoothed" variance is strictly increasing in α

The Base Model

Continued

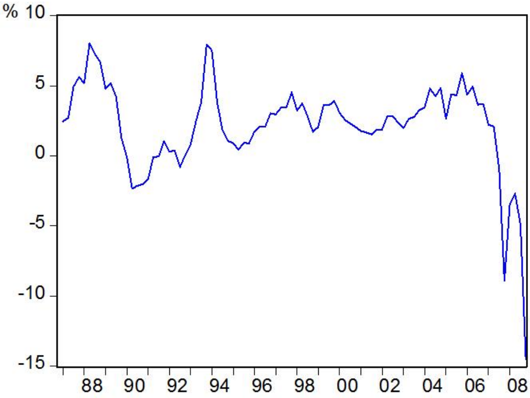
- So far true return process irrelevant in a sense that r_t may be obtained once α is known
- When α unknown, further information on r_t required
- Practical approach: *iid* return, hence $\hat{\alpha} = \hat{\rho}_1$
- Return process (State equation)

$$r_t = \gamma + \phi r_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim iid(0, \sigma_\varepsilon^2)$$

- Most studies assume $|\phi| < 1$
- Actual data probably not stationary

Non-linearity in Real Estate Return

Figure: Quarterly log-returns on IPD Index (Q4 1986 - Q4 2008)



Source: Investment Property Databank (IPD)

Regime-switching Approach

- Smoothing equation

$$r_t^* = \alpha_t r_{t-1}^* + (1-\alpha_t)\, r_t$$

- State equation

$$r_t = \gamma_t + \phi_t r_{t-1} + \varepsilon_t, \qquad \varepsilon_t \sim iid(0, \sigma_\varepsilon^2)$$

- Regime-switching parameters

$$\alpha_t = \begin{cases} \alpha_1 \;, & z_{1t-1} > c_1 \;, \\ \alpha_2 \;, & z_{1t-1} \leq c_1 \;. \end{cases} \qquad (\gamma_t, \phi_t) = \begin{cases} (\gamma_1, \phi_1) \;, & z_{2t-1} > c_2 \;, \\ (\gamma_2, \phi_2) \;, & z_{2t-1} \leq c_2 \;. \end{cases}$$

where z_{it} = an exogenous observable regime indicator

Economic Identification

- Switching in the smoothing equation
  - Probably due to behavioural shifts of the appraisal agency
  - Different arrival rates of new information in "good" and "bad" regimes
  - Our model more generalised than that of Chaplin (1997)
- Switching return
  - Tied to changes in the macroeconomic environment
  - Time-varying volatility
- Open to a large number of plausible regime indicators
- Not necessarily the same regime indicator for smoothing and return

Potential Regime Indicators

Drivers of UK Real Estate Return

- Three-month LIBOR rate (end of period)
- GDP growth (nominal)
- SA employment
- Inflation – RPI excluding mortgage interest
- Log-return on FT All Share Total Return index
- Initial Yield index (rent to capital value)
- USD-GBP spot rate

Degree of Restrictions

- Conventional AR (AR-AR): $\alpha_t = \alpha$, $\gamma_t = \gamma$, $\phi_t = \phi$
- Switching return (AR-TAR): $\alpha_t = \alpha$
- Switching behaviour (TAR-AR): $\gamma_t = \gamma$, $\phi_t = \phi$
- Co-switching (TAR-TAR)

Estimation of AR-AR

- LS which iterates between the two equations (Cochrance-Orcutt-type)
- Implied AR(2) in reported return

$$r_t^* = (1-\alpha)\gamma + (\alpha+\phi)\, r_{t-1}^* - \alpha\phi r_{t-2}^* + v_t$$

  with $v_t = (1-\alpha)\varepsilon_t$
- Given (γ,ϕ), can estimate α by LS
- Then use $\hat{\alpha}$ to obtain r_t
- Use this unsmoothed return to estimate (γ,ϕ)
- Continue until coefficients converge, i.e. differ than previous value by less than 0.01
- Consistent (though not efficient)

Estimation of TAR-TAR

- Straightforward extension of the previous technique
- Implied TAR(2)

$$(1-\phi_t L)(1-\alpha_t L)\, r_t^* = (1-\alpha_t)(\gamma_t + \varepsilon_t)$$

- Make use of an indicator function $I_{it} = \mathbf{1}(z_{it} > c_i)$ such that

$$\alpha_t = \alpha_1 I_{1t-1} + \alpha_2 (1 - I_{1t-1})$$

$$(\gamma_t, \phi_t) = (\gamma_1, \phi_1) I_{2t-1} + (\gamma_2, \phi_2)(1 - I_{2t-1})$$

- Provides perfect discrimination between regimes

Estimation of TAR-TAR

Continued

- Initialisation: $(\gamma_1^0, \gamma_2^0, \phi_1^0, \phi_2^0, c_2^0)$
- Built-in grid search to estimate the threshold level (not required when no switching involved)
- **Comment**: In practice actually easier to search over all possible values of z_{it} which are of $O(T)$
- c_i chosen such that the standard error of regression is minimised
- Consistency discussed in Franses & van Dijk (2000)
- Re-iterates till converged

Estimation Results

Table: AR-TAR (Switching Return)

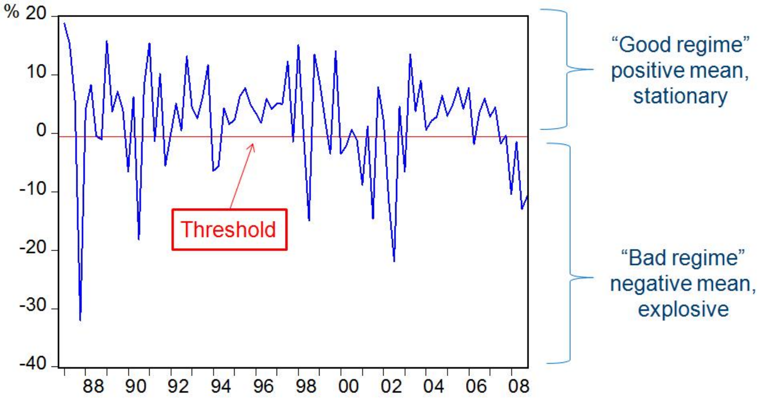
Model	α	γ_1	ϕ_1	γ_2	ϕ_2	c	π	(Min,Max)	SSE
TAR									
LIBOR	0.51**	-1.25*	1.27**	2.38**	0.18	6.25	0.56	(2.83,15.25)	233.45
	(0.07)	(0.48)	(0.10)	(0.65)	(0.11)				
INF	0.77**	0.25	-0.09	-0.22	0.95**	0.94	0.33	(-0.57,2.73)	259.44
	(0.09)	(1.67)	(0.15)	(1.08)	(0.23)				
FT	0.53**	2.22**	0.31**	-4.05**	1.77**	-1.54	0.76	(-32.0,18.84)	179.91
	(0.09)	(0.32)	(0.08)	(0.94)	(0.24)				
GDP	0.81**	1.72	0.11	5.18	4.27*	-0.41	0.94	(-1.80,2.20)	208.52
	(0.12)	(0.99)	(0.08)	(6.66)	(1.86)				
AR	0.94**	-1.35	0.12						309.53
	(0.04)	(2.82)	(0.15)						

Notes: (i) Newey-West HAC s.d. in parenthesis; (ii) * sig. at 5%, ** at 1%.

TAR on FT Returns

Implication on Real Estate Return

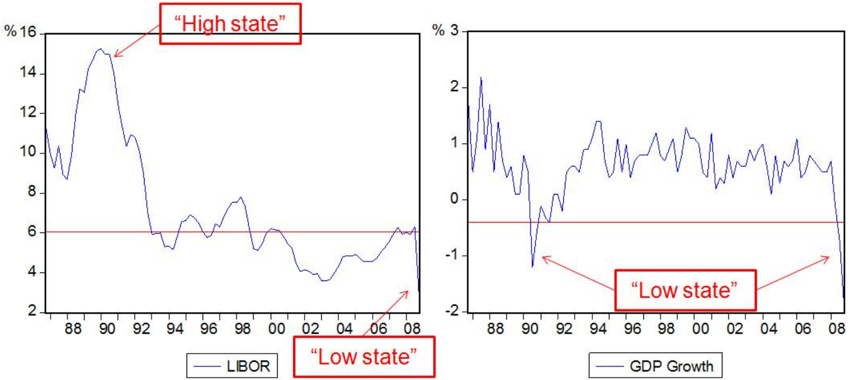
Figure: Quarterly log-returns on FT Index (Q4 1986 - Q4 2008)



Quality of Regime Indicators

The 1990s & the recent crises

Figure: End-of-quarter LIBOR and Quarterly GDP Growth

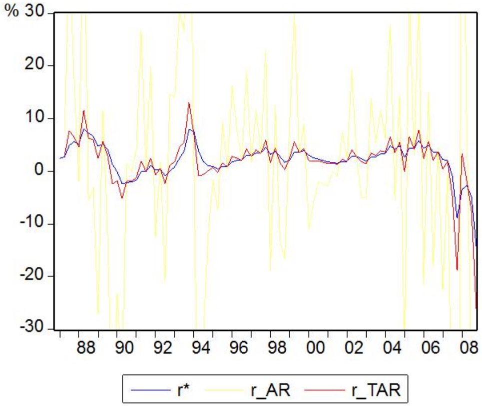


AR-TAR Results

- Arguably, much more economically sound than AR-AR
- AR-AR: Smoothing = 0.94, i.e. the unsmoothed return will be highly volatile (at all times)
- AR-TAR: "Abnormal return" sieved from "normal return" where volatility is relatively low
- Usually, explosive return in one regime (bad regime), yet steady-state variance exists
- Knight & Satchell (2011): $\phi_1^2 > 1$ and $\phi_1^2 \pi + (1-\pi)\phi_2^2 < 1$

Smoothed and Unsmoothed Returns

AR-AR vs AR-TAR



	r*	r_AR	r_TAR
Mean	2.14	-1.15	1.90
Median	2.56	1.86	2.26
Maximum	8.03	89.19	13.07
Minimum	-14.51	-177.01	-26.48
Std. Dev.	3.27	34.11	4.99
Skewness	-1.96	-2.12	-2.82
Kurtosis	10.54	13.16	16.61

Remark: Regime indicator = FT return

Switching Smoothing

Table: Estimated TAR-AR model

Model	α_1	α_2	γ	ϕ	c	π	(Min,Max)	SSE
TAR								
LIBOR	1.22**	0.75**	3.69	-0.04	12.30	0.10	(2.83,15.25)	272.24
	(0.10)	(0.20)	(2.71)	(0.20)				
INF	0.79**	1.33**	2.21	-0.09	0.87	0.43	(-0.57,2.73)	269.40
	(0.14)	(0.11)	(1.97)	(0.18)				
FT	0.21**	1.97**	1.17	0.60**	-1.54	0.76	(-32.00,18.84)	195.51
	(0.08)	(0.25)	(0.67)	(0.16)				
GDP	0.82**	1.86**	1.78	0.08	-0.59	0.95	(-1.80,2.20)	246.65
	(0.12)	(0.45)	(2.90)	(0.12)				
AR	0.94**		-1.35	0.12				309.53
	(0.04)		(2.82)	(0.15)				

Notes: (i) Newey-West HAC s.d. in parenthesis; (ii) * sig. at 5%, ** at 1%.

Switching Smoothing

Continued

- Basically,

$$\pi\hat{\alpha}_1 + (1-\pi)\hat{\alpha}_2 = \hat{\alpha}$$

- Excessive smoothing in “bad regime” i.e. high LIBOR / low FT returns / low GDP growth
- Psychological effect (?)
- But fits data slightly worse than AR-TAR (switching return)
- In some cases, lower (unconditional) volatility than smoothed return e.g. for FT return, s.d. according to TAR-AR = 2.83 less than 3.27 = s.d. of smoothed return

Co-switching Model

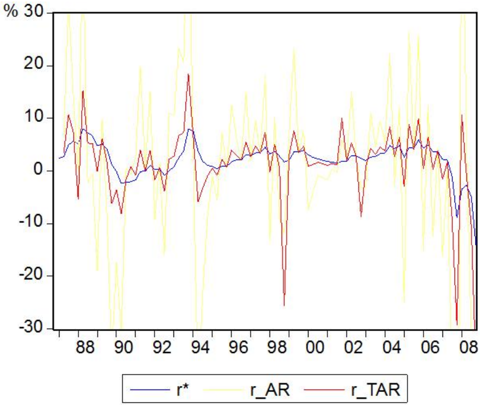
Table: Estimated TAR-TAR model

Model	α_1	α_2	γ_1	ϕ_1	γ_2	ϕ_2	c_1	c_2	SSE
TAR-TAR									
LIBOR-LIBOR	1.42**	0.73**	-0.37	0.79**	3.05**	-0.04	6.21	11.31	250.27
	(0.28)	(0.07)	(1.33)	(0.14)	(0.68)	(0.15)			
FT-FT	0.72**	0.96**	3.36**	0.01	-7.13*	1.40**	-13.33	-1.20	183.16
	(0.07)	(0.04)	(0.70)	(0.09)	(2.61)	(0.41)			
LIBOR-FT	1.40**	0.56**	1.63**	0.35**	5.28**	-0.85*	6.21	-1.79	335.93
	(0.24)	(0.09)	(0.61)	(0.12)	(1.61)	(0.42)			
FT-LIBOR	0.79**	2.22**	0.24	0.59*	3.34**	-0.18	-13.34	5.95	211.80
	(0.10)	(0.80)	(1.49)	(0.29)	(1.03)	(0.13)			
AR-AR	0.94**		-1.35	0.12					309.53
	(0.04)		(2.82)	(0.15)					

Notes: (i) Newey-West HAC s.d. in parenthesis; (ii) * sig. at 5%, ** at 1%.

Unsmoothed Returns under Co-switching

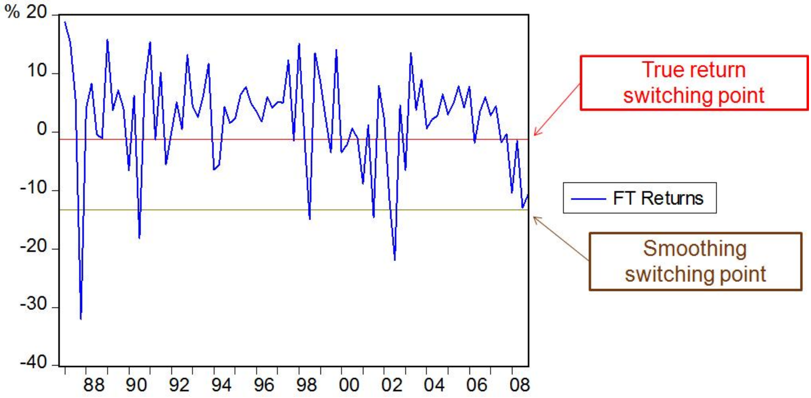
AR-AR vs TAR-TAR



	r*	r_AR	r_TAR
Mean	2.14	-1.15	1.25
Median	2.56	1.86	2.22
Maximum	8.03	89.19	18.52
Minimum	-14.51	-177.01	-39.21
Std. Dev.	3.27	34.11	7.95
Skewness	-1.96	-2.12	-2.47
Kurtosis	10.54	13.16	12.66

Remark: FT return = indicator for both smoothing and return equations

How does Co-switching work?



Comments on TAR-TAR

- Least restricted in this paper
- Explosive regime-switching behaviour either in the smoothing equation or in the return process, BUT not simultaneously
- From a theoretical viewpoint: Particular structure on the state probability when a single indicator governs both equations
- Supported by Hansen (1996, 1997) test results, especially when involved with FT returns
- Results driven by different combinations of the exogenous variables used, thereby opening up a new area of research

Implication on Asset Allocation

- The TAR-TAR unconditional variance still close to that of the conventional smoothing model
- However, **Time-varying behaviour** (conditional smoothing) masked by the latter
- More informative and also crucial to successful dynamic (active) asset allocation
- Also, sheds more light on the nature of real estate risk
- The impact in the extreme regimes, although probably short lived, profound to asset values
- After all, quality of risk measures dependent of accuracy of estimated smoothing coefficient(s)

Conclusions

- New unsmoothing technique for returns on an appraisal-based valuation index
- Clear evidence of regime effects and time-varying behavior in the commercial real estate returns
- Most promising results from the use of FT equity returns, LIBOR, and to a lesser extent, GDP growth
- TAR-TAR better than AR-AR according to SSE criteria (about 40% reduction)
- Applicable to other "illiquid" asset classes, e.g. hedge fund, venture capital, or even fine art!

Thank you!