Information Horizon, Portfolio Turnover, and Optimal Alpha Model

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Conventional Modeling Approach

Factor selection

- Information coefficients (IC), decile returns
- Risk-adjusted ICs, standard deviation of ICs
- Horizon IC, top decile turnover

Multi-factor model

- Ad hoc weighting
- Weighting by average IC
- Optimal weights by maximizing IR

Backtest

- Constrained by turnover

Motivation

- **Drawback in conventional approach**
  - Effect of turnover constraint unknown
  - Difficult to evolve model with AUM
- **We provide an integrated framework for alpha modeling**
  - Optimizing model IR under turnover constraint
  - Combination of factors of different information horizon
  - Qian, Hua, Sorensen (2007) (forthcoming 2007)
- **Related work**
  - Leigh Sneddon (Northfield Conference Proceedings,2005)
  - Richard Grinold (2006) (JOIM 2006)

Outline

- **Turnover of quantitative signals**
  - Factor autocorrelation
- **ICs**
  - Conventional IC, horizon IC, lagged IC
- **Optional alpha model**
  - Average IC, IC covariance
- **Optimal alpha model with turnover constraint**

Turnover of Quantitative Signals

$$T = \frac{1}{2}\sum_{i=1}^{N}\left|w_i^{t+1} - w_i^t\right|$$

$$T = \sqrt{\frac{\text{N}}{p}}s_{\text{model}}\sqrt{1-r_f}\,\text{E}\left(\frac{1}{s}\right) \quad r_f = \text{corr}\left(\tilde{F}^{t+1}, \tilde{F}^{t}\right)$$

- **The turnover is higher**
  - The higher the targeted tracking error
  - The larger the number of stocks (proportional to the square root of N)
  - The lower the forecast autocorrelation (cross sectional correlation between the consecutive forecasts
  - The lower the average stock specific risk

- **Caveats**
  - Qian et al, “Turnover of Quantitatively Managed Portfolios” (2004)

Turnover of Quantitative Signals

Category	**Factors**	**Avg($_f$)**
Momentum	EarnRev9	0.64
	Ret9Monx1	0.60
	LtgRev9	0.37
Value	E2PFY0	0.96
	B2P	0.93
	CFO2EV	0.84
Quality	RNOA	0.89
	XF	0.76
	NCOinc	0.80

- **Momentum factors have a lowest autocorrelation (highest turnover)**
- **Value factors have a highest autocorrelation ((lowest turnover)**
- **Quality factors are in between**

Turnover of Quantitative Signals

➢How to slow down the turnover?

- Turnover constraint
- More value, less momentum
- *Use moving average of factors*

➢Do the lagged factors forecast future return?

- Lower turnover at the cost of alpha?
- What is the right tradeoff?

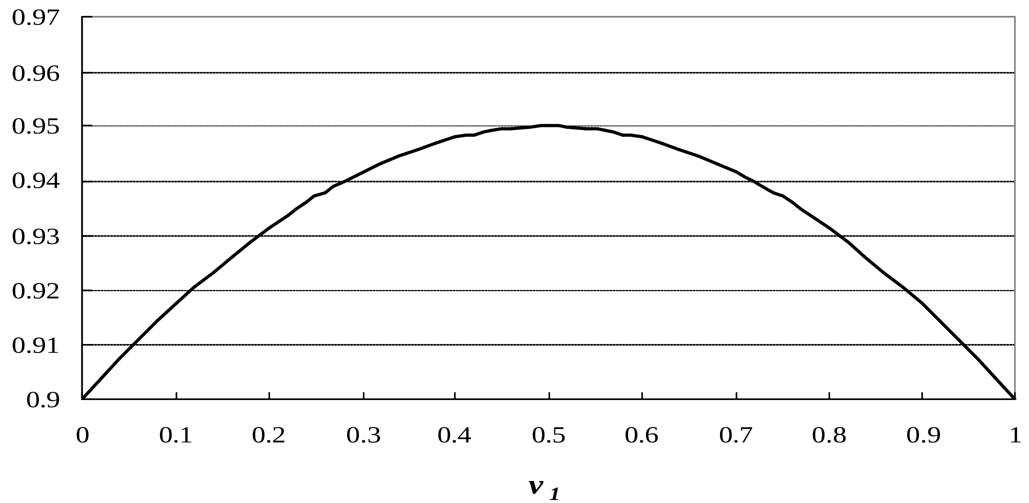
Turnover of Quantitative Signals

Moving average – MA(2)

$$\mathbf{F}_{ma}^{t} = v_0\mathbf{F}^{t} + v_1\mathbf{F}^{t-1}$$

Figure 8.2 Serial autocorrelation of forecast moving average with $L = 2$, and

$\rho_f(1) = 0.90, \rho_f(2) = 0.81$.



- *Turnover reduction – 70%* $\sqrt{1-0.95} \approx 71\% \sqrt{1-0.9}$

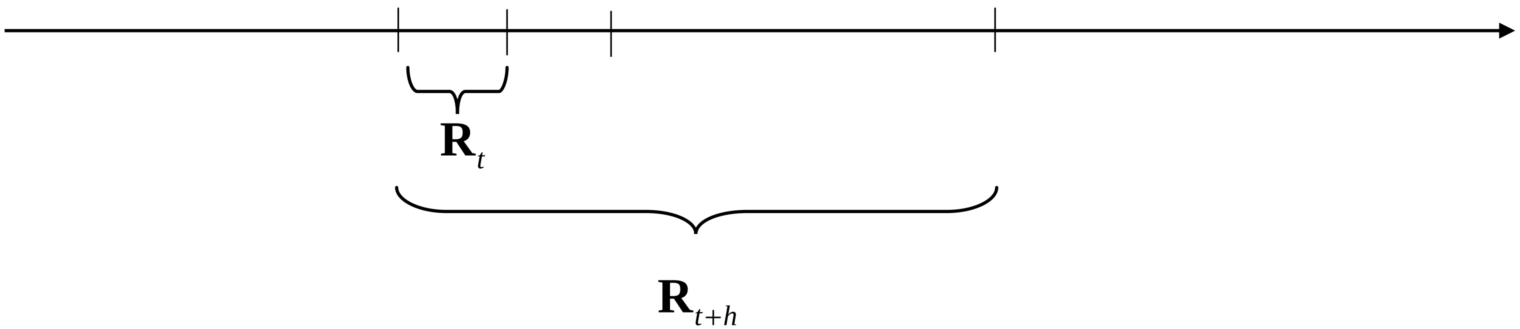
Information Coefficients

- **Conventional IC** $IC_{t,t} = \text{corr}\left(\mathbf{F}_t, \mathbf{R}_t\right)$
  - Factors known at time *t*
  - Subsequent return from t to *t*+1
- **Horizon IC** $IC_t^h = \text{corr}\left(\mathbf{F}_t, \mathbf{R}_{t,t+h}\right), \quad h = 0,1,\cdots,H$
  - Factors known at time *t*
  - Subsequent return from t to *t*+*h*
- **Lagged IC** $IC_{t-l,t} = \text{corr}\left(\mathbf{F}_{t-l}, \mathbf{R}_t\right)$
  - Factors known at time *t*-*l*
  - Subsequent return from t to *t*+1
  - Information decay

Information Coefficients

$$IC_{t,t} = \mathrm{corr}\left(\mathbf{F}_t, \mathbf{R}_t\right)$$

$$IC_{t-l,t} = \mathrm{corr}\left(\mathbf{F}_{t-l}, \mathbf{R}_t\right)$$



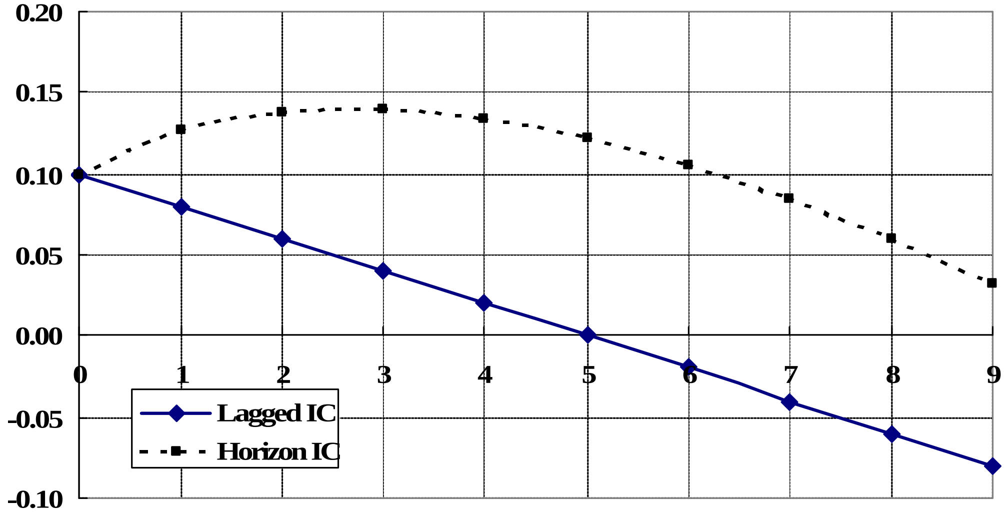
$$IC_t^h = \mathrm{corr}\left(\mathbf{F}_t, \mathbf{R}_{t,t+h}\right)$$

Information Coefficients

- **Relationship between ICs**

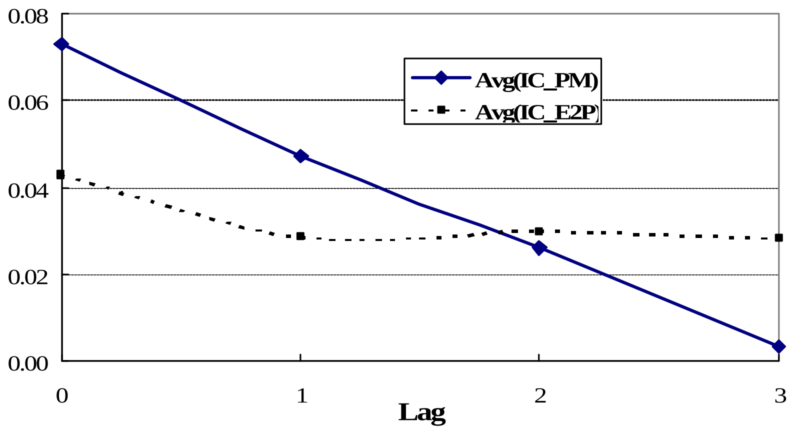
$$IC_t^h \approx \frac{IC_{t,t} + IC_{t-1,t} + \cdots + IC_{t-h,t}}{\sqrt{h+1}} = \text{avg}\left(IC\right)\sqrt{h+1}$$

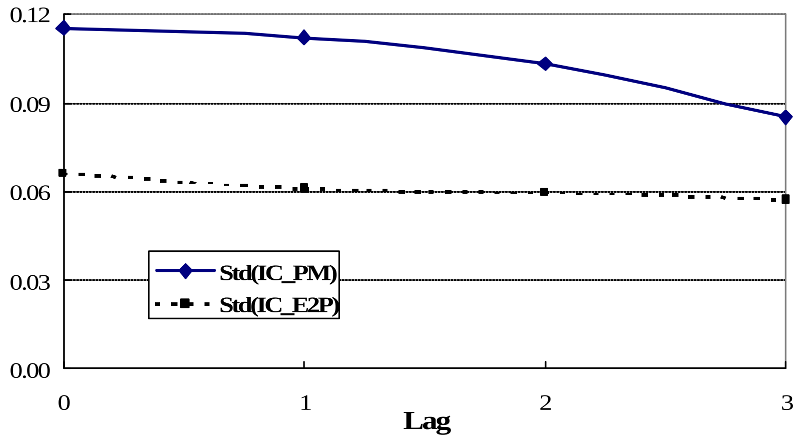
- **Similar to fundamental law of active management**

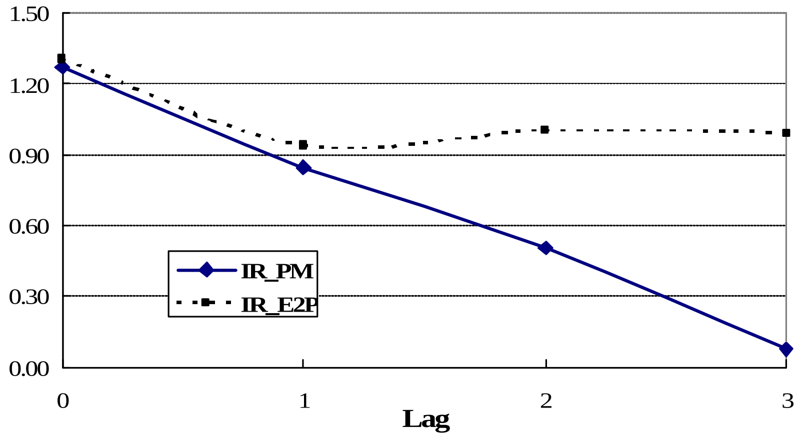


Information Coefficients

➢Two factors: E2P, PM (Ret9x1)







Optimal Alpha Model

- **The optimal factor weights v =** $(v_1, \ldots, v_M)$ **maximizes model IR**

$$\mathrm{IR} = \frac{\mathrm{avg}(IC)}{\mathrm{std}(IC)} = \frac{\mathbf{v}' \cdot \overline{\mathbf{IC}}}{\sqrt{\mathbf{v}' \cdot \mathbf{S}_{IC} \cdot \mathbf{v}}}$$

- **Input**
  - Average IC
  - Standard deviation of IC
  - IC correlations

- **Analytic solution exists**

Optimal Alpha Model – No Constraint

- **Two factors: E2P, PM**
  - IC correlation –0.4

- **Optimal weight: PM – 36%, E2P – 64%**

r_f	IR	PM_0	E2P_0	PM_1	E2P_1	PM_2	E2P_2	PM_3	E2P_3
0.85	2.30	45%	55%	0%	0%	0%	0%	0%	0%
0.86	2.33	43%	57%	0%	0%	0%	0%	0%	0%
0.87	2.36	41%	59%	0%	0%	0%	0%	0%	0%
0.88	2.38	39%	61%	0%	0%	0%	0%	0%	0%
0.89	**2.39**	36%	64%	0%	0%	0%	0%	0%	0%
0.90	2.38	34%	65%	2%	0%	0%	0%	0%	0%
0.91	2.37	31%	65%	4%	0%	0%	0%	0%	0%
0.92	2.36	28%	65%	7%	0%	0%	0%	0%	0%
0.93	2.33	24%	65%	10%	0%	0%	0%	0%	1%
0.94	2.28	21%	58%	12%	4%	0%	1%	0%	4%
0.95	2.21	18%	50%	12%	8%	0%	4%	0%	8%
0.96	2.09	15%	42%	11%	10%	2%	7%	2%	10%
0.97	1.88	11%	32%	8%	14%	5%	12%	5%	14%

Optimal Alpha Model With Constraint

- **Objective: maximize model IR utilizing current and lagged factors while controlling portfolio turnover**

$$\mathbf{F}_{c,ma}^{t} = v_{01}\mathbf{F}_1^{t} + v_{02}\mathbf{F}_2^{t} + v_{11}\mathbf{F}_1^{t-1} + v_{12}\mathbf{F}_2^{t-1} + \cdots +$$

- **Mathematical problem**

$$\text{Maximize: } \text{IR} = \frac{\mathbf{v}' \cdot \overline{\mathbf{IC}}}{\sqrt{\mathbf{v}' \cdot \mathbf{S}_{IC} \cdot \mathbf{v}}}$$

$$\text{subject to: } r_{f_{c,ma}} = r_{\text{target}}$$

Optimal Alpha Model With Constraint

➢Two factor example – IC correlations

Table 8.2 The IC correlation matrix of current and lagged values for the price momentum and earning yield factor

	PM_0	E2P_0	PM_1	E2P_1	PM_2	E2P_2	PM_3	E2P_3
PM_0	1.00	-0.42	0.86	-0.37	0.78	-0.26	0.61	-0.19
E2P_0	-0.42	1.00	-0.44	0.92	-0.31	0.84	-0.29	0.78
PM_1	0.86	-0.44	1.00	-0.45	0.88	-0.36	0.71	-0.30
E2P_1	-0.37	0.92	-0.45	1.00	-0.33	0.94	-0.30	0.86
PM_2	0.78	-0.31	0.88	-0.33	1.00	-0.28	0.83	-0.22
E2P_2	-0.26	0.84	-0.36	0.94	-0.28	1.00	-0.28	0.94
PM_3	0.61	-0.29	0.71	-0.30	0.83	-0.28	1.00	-0.30
E2P_3	-0.19	0.78	-0.30	0.86	-0.22	0.94	-0.30	1.00

Optimal Alpha Model With Constraint

➢Two factor example – factor correlations

Table 8.3 The factor correlation matrix of current and lagged values for the price momentum and earning yield factor

	PM_0	E2P_0	PM_1	E2P_1	PM_2	E2P_2	PM_3	E2P_3	PM_4	E2P_4
PM_0	1.00	-0.08	0.68	0.00	0.40	0.05	0.09	0.08	0.07	0.09
E2P_0	-0.08	1.00	-0.09	0.94	-0.06	0.84	0.01	0.73	0.03	0.61
PM_1	0.68	-0.09	1.00	-0.08	0.68	0.00	0.40	0.05	0.09	0.08
E2P_1	0.00	0.94	-0.08	1.00	-0.09	0.94	-0.06	0.84	0.01	0.73
PM_2	0.40	-0.06	0.68	-0.09	1.00	-0.08	0.68	0.00	0.40	0.05
E2P_2	0.05	0.84	0.00	0.94	-0.08	1.00	-0.09	0.94	-0.06	0.84
PM_3	0.09	0.01	0.40	-0.06	0.68	-0.09	1.00	-0.08	0.68	0.00
E2P_3	0.08	0.73	0.05	0.84	0.00	0.94	-0.08	1.00	-0.09	0.94
PM_4	0.07	0.03	0.09	0.01	0.40	-0.06	0.68	-0.09	1.00	-0.08
E2P_4	0.09	0.61	0.08	0.73	0.05	0.84	0.00	0.94	-0.08	1.00

Optimal Alpha Model – Constrained

➢Optimal weights

r_f	IR	PM_0	E2P_0	PM_1	E2P_1	PM_2	E2P_2	PM_3	E2P_3
0.85	2.30	45%	55%	0%	0%	0%	0%	0%	0%
0.86	2.33	43%	57%	0%	0%	0%	0%	0%	0%
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0.97	1.88	11%	32%	8%	14%	5%	12%	5%	14%

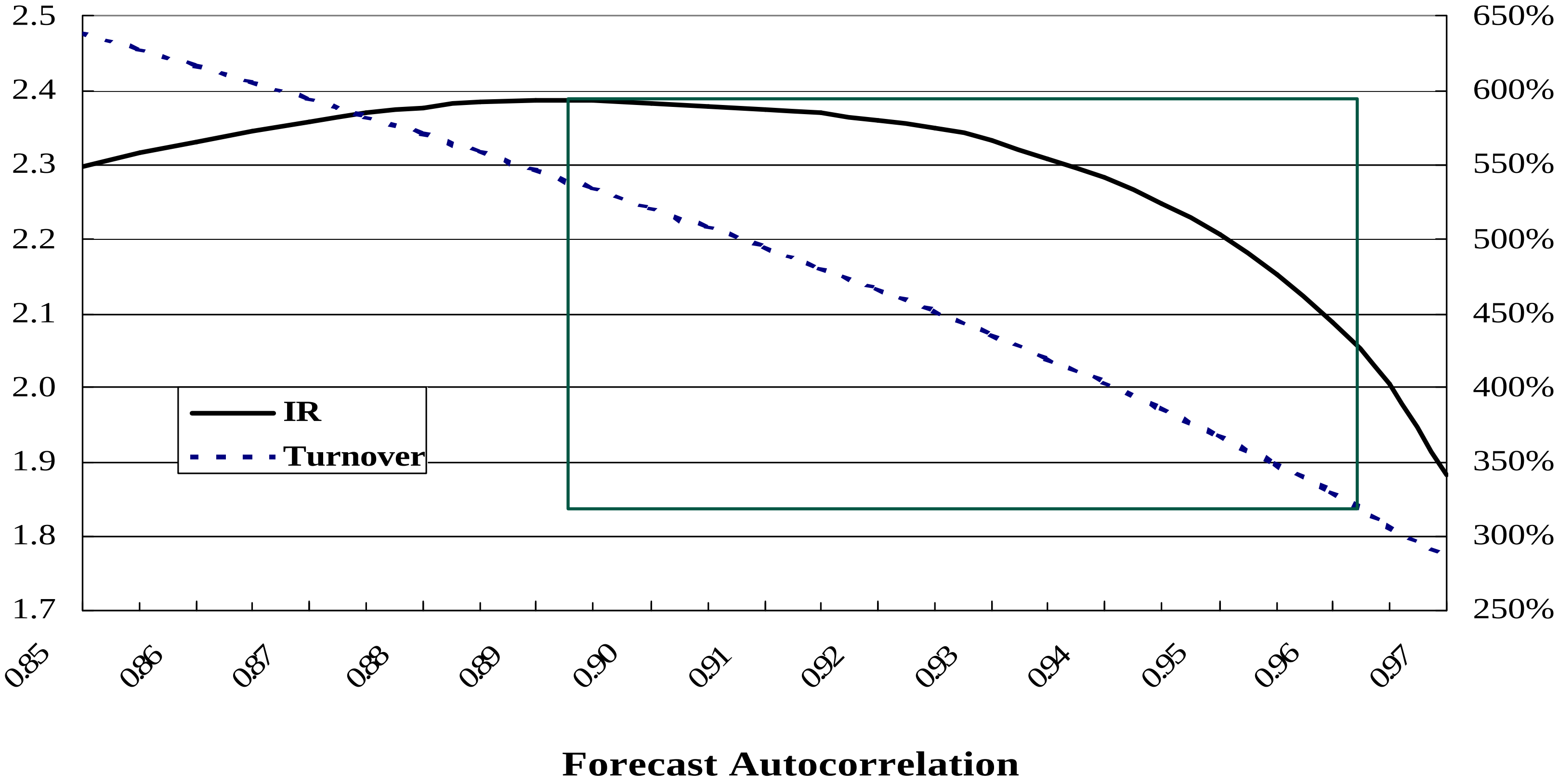
Optimal Alpha Model – Constrained

➢Optimal weights - aggregated

r_f	IR	PM	E2P	w_0	w_1	w_2	w_3
0.85	2.30	45%	55%	100%	0%	0%	0%
0.86	2.33	43%	57%	100%	0%	0%	0%
0.87	2.36	41%	59%	100%	0%	0%	0%
0.88	2.38	39%	61%	100%	0%	0%	0%
0.89	**2.39**	36%	64%	100%	0%	0%	0%
0.90	2.38	35%	65%	98%	2%	0%	0%
0.91	2.37	35%	65%	96%	4%	0%	0%
0.92	2.36	35%	65%	93%	7%	0%	0%
0.93	2.33	34%	66%	88%	10%	0%	1%
0.94	2.28	33%	67%	79%	15%	1%	4%
0.95	2.21	30%	70%	68%	20%	4%	8%
0.96	2.09	30%	70%	57%	21%	9%	13%
0.97	1.88	28%	72%	42%	23%	16%	19%

Optimal Alpha Model – Constrained

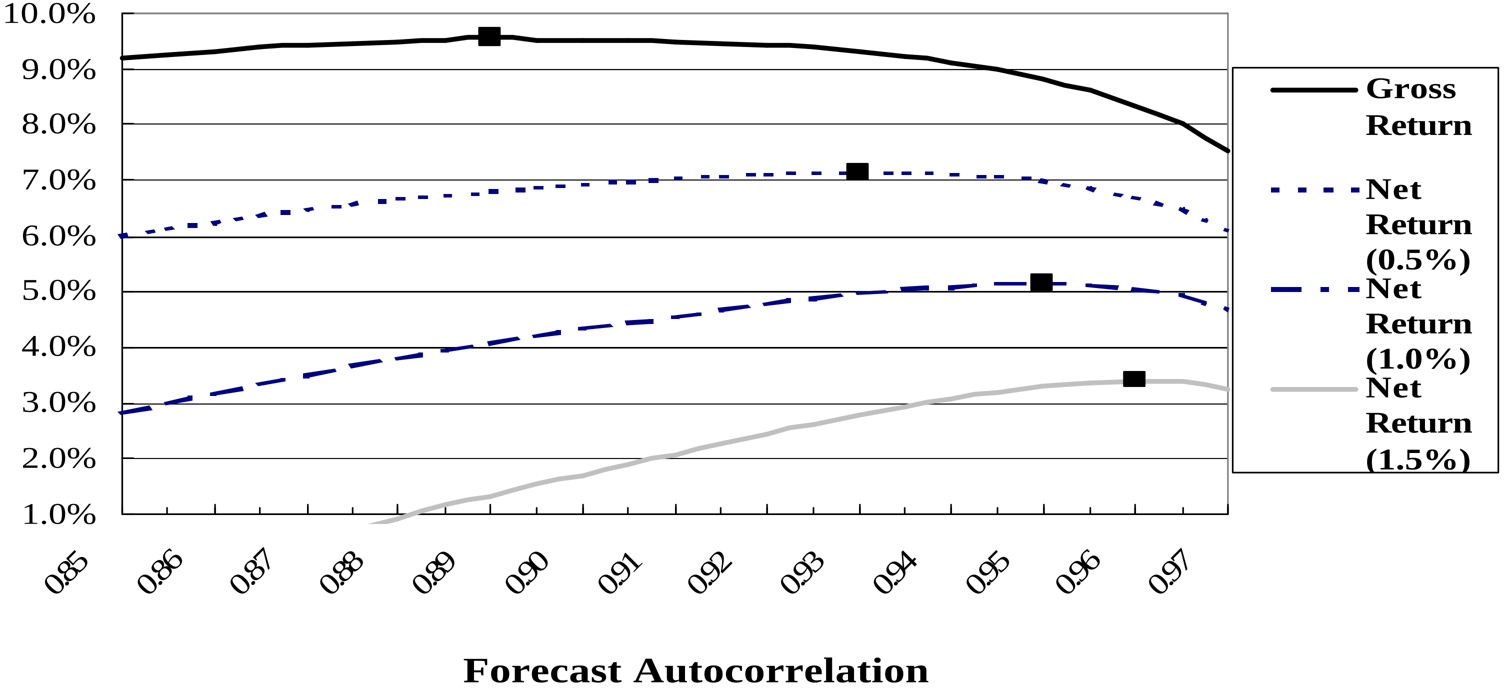
➢ **IR and turnover tradeoff**



Optimal Alpha Model – Constrained

➢Optimal net return depends on turnover and TC

Figure 8.7 The gross excess return and net excess returns under different transaction cost assumption for portfolios with $N = 3000$ **, target risk** $s_{\text{model}} = 4\%$ **, and stock specific risk** $s_0 = 30\%$ **.**



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Summary

- **Controlling portfolio turnover is crucial but it plays a secondary role in conventional approach**

- **We provide an analytic framework to address this issue**
  - Measure turnover by forecast autocorrelation
  - Reduce turnover by using moving averages of factors
  - Analyze lagged IC of lagged factors
  - Optimal model IR under turnover constraint

- **Implications**
  - Evolution of alpha model with AUM growth
  - More value/quality exposures
  - More important for large cap stocks

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