Why so Glum? The Meese-Rogoff Methodology Meets the Stock Market

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Motivation

- Meese-Rogoff (1983a,b): the most devastating critique of exchange rate determination models
  - Random walk prediction of no change out-forecasts structural models estimated with historical data *even given actual future fundamentals*
  - Big negative effect on international finance

Not the Classic Stock Market Finding

- Well-known: difficult to out-predict a random walk for stocks
- But researchers do *not* give models *out of sample fundamentals* (only *forecasts* of fundamentals)

Summary of What We Do

- Use same methodology as Meese-Rogoff, *different asset class*
  - Apply to broad *stock price indices* for four countries (Germany, Japan, UK, and USA)
  - Consider five different forecasting horizons (1-, 3-, 6-, 12-, and 24-months ahead)
  - Same forecasting techniques, metrics, sample period as MR
  - *Give forecasters actual future fundamentals*

Algebra of MR

- Meese Rogoff find: exchange rate models, estimated through the date on which forecast made *can't beat a random walk* (at short horizons – up to 2 years), *despite model being given future fundamentals*

A Generic Model

$$s_t = \beta(t-1,1) f_t + x_t$$ 1-period

$$s_{t+k} = \beta(t-k,k) f_{t+k} + x_{t+k}$$ k-period

Forecast Errors are {x}

Random Walk "Model"

$$s_t = s_{t-1} + u_t$$ 1-period

$$s_{t+k} = s_{t-1} + u_{t+k}$$ k-period

RW: fancy way of saying forecast no change

Key, Devastating MR finding:

$$RMSE(x) > RMSE(u) \qquad k < 24 \text{ months}$$

- Models – even given information about future fundamentals – *do worse than mindless prediction of no change*, for up to 24 months in advance (sometimes greater.)

Key Questions/Results

- Q1: What happens if MR standard applied to other markets?
  - A1: Random walk "model" matches/beats other stock models, similar to Meese-Rogoff for FX!
- Q2: What does this mean in terms of familiar parametric measures of model performance, e.g. R^2, ρ?
  - A2: Not all about fundamentals information vs. residuals. *Autocorrelation properties of residuals important too.*

Theory for Fundamentals-Based Stock Models

- Consider standard present value model of firm value
    - (Assume stocks do not give non-pecuniary returns)

$$P_t=PV(D_{t+1},D_{t+2},\ldots)=PV(N_{t+1},N_{t+2},\ldots) \qquad (1)$$

where: PV() is present value operator; P_t is price at time t; D is dividend; and N is earnings

Consider a non-stochastic (! … as in MR) discount rate $0<\rho<1$:

$$PV(X_{t+1},X_{t+2},\ldots) = E_t\Sigma_i(X_{t+i}\rho^i) \qquad (2)$$

where E() is expectation operator. Then for any θ,

$$P_t = \theta\ E_t\Sigma_i(D_{t+i}\rho^i) + (1-\theta)\ E_t\Sigma_i(N_{t+i}\rho^i) \qquad (4)$$

Assume growth of fundamentals is proportional:

$$X_{t+i+1} = [1+g(X)_t]X_{t+i} + \varepsilon_{t+i+1} \qquad (5)$$

where: $\{\varepsilon\}$ is white noise, and g_t is growth rate of X estimated through t, assumed to be constant from t onward.

- Fama and French: plausible for dividends and earnings

Take natural logarithms, arrive at:

$$p_t = \beta_0 + \beta_d d_t + \beta_{dg}[1+g(d)_t]$$

$$+ \beta_n n_t + \beta_{ng}[1+g(n)_t] + \beta_i \ln(1+i_t) + u_t \qquad (8)$$

where: i is interest rate (added in *ad hoc* fashion); $\{\beta\}$ coefficients of interest; lower cases denote logs.

- Will compare size of $\{u\}$ with size of $\{v\} = p_{t+i} - p_t$

Three "Fundamentals-Based" Models

1. "Gordon-Growth Dividends:" $\beta_n = \beta_{ng} = \beta_i = 0$

2. "Gordon-Growth Earnings:" $\beta_d = \beta_{dg} = \beta_i = 0$

3. "Composite:" unrestricted

- All embedded in (8)

Two Alternative Atheoretical Models

- Univariate: Long Autoregression, where maximal lag length a function of sample size (Hannan), $M = T/\ln(T)$
- Multivariate: VAR of logs of prices, dividends, and earnings.
  - Lag length chosen by standard criteria (FPE/HQIC/SIC)
    - Germany (2); Japan (2); UK (3); USA (4)

Summary: We Consider 5 alternative models to random walk

1. Univariate autoregression
2. VAR (prices, dividends, earnings)
3. Gordon-growth model of dividends (levels and growth)
4. Gordon-growth model of earnings
5. Composite model: dividends, earnings, interest rates

Methodological Strategy

- Stick as close to Meese-Rogoff as possible
  - Monthly data set, March 1973 – June 1981
    - Forecasting Period starts December 1976
  - Forecast at 1, 3, 6, 12 month horizons (add 24 to MR)

Forecasting Strategy

- Estimate version of through start of forecast period, forecast, add observation, repeat
  - *Use actual future values of fundamentals* (as necessary)
- That is, compare accuracy of forecast

$$p_{t+i} = b_0 + b_d d_{t+i} + b_{dg}[1+g(d)_{t+i}]$$

$$+ b_n n_{t+i} + b_{ng}[1+g(n)_{t+i}] + b_i \ln(1+i_{t+i})$$

with "forecast" p_t

Standard Measures of Forecast Accuracy

Preferred:

- $RootMeanSquareError \equiv \{ \sum_{s=0}^{N_k - 1} [F(t+s+k) - A(t+s+k)]^2 / N_k \}^{1/2}$

Checks:

- $MeanAbsoluteError \equiv \sum_{s=0}^{N_k - 1} [|F(t+s+k) - A(t+s+k)|] / N_k$

- $MeanError \equiv \sum_{s=0}^{N_k - 1} [F(t+s+k) - A(t+s+k)] / N_k$

Data Set

- Popular, broad stock price indices covering most of national market

    1.CDAX (Germany

    2.Nikkei 225 (Japan)

    3.FTSE All-Share (UK)

    4.S&P 500 (USA)

- Month-end prices
- Use Dividend Yield and Price/Earnings ratios to "back out" Dividends and Earnings
  - Measurement Error, at short horizons? (lagged updates?)
  - Hence, tend to be cautious, focus on longer-horizons
- Natural Logarithms of all variables
  - Interest Rates: $\ln(1+(i_t/100))$
- All variables nominal

Growth Rates

- Use Four Different Measures:

    1. "Three-Year, Forward Looking" $\ln(x_{t+36}-x_t)/3$: Default

    2. "One-Year, Forward Looking" $\ln(x_{t+12}-x_t)$

    3. "Three-Year, Backward Looking" $\ln(x_t-x_{t-36})/3$

    4. "One-Year, Backward Looking" $\ln(x_t-x_{t-12})$

Data Sources

- Shiller for American data
- GFD for ratios
- Datastream for Stock Price Indices
- BIS for interest rates (IMF for Japan)

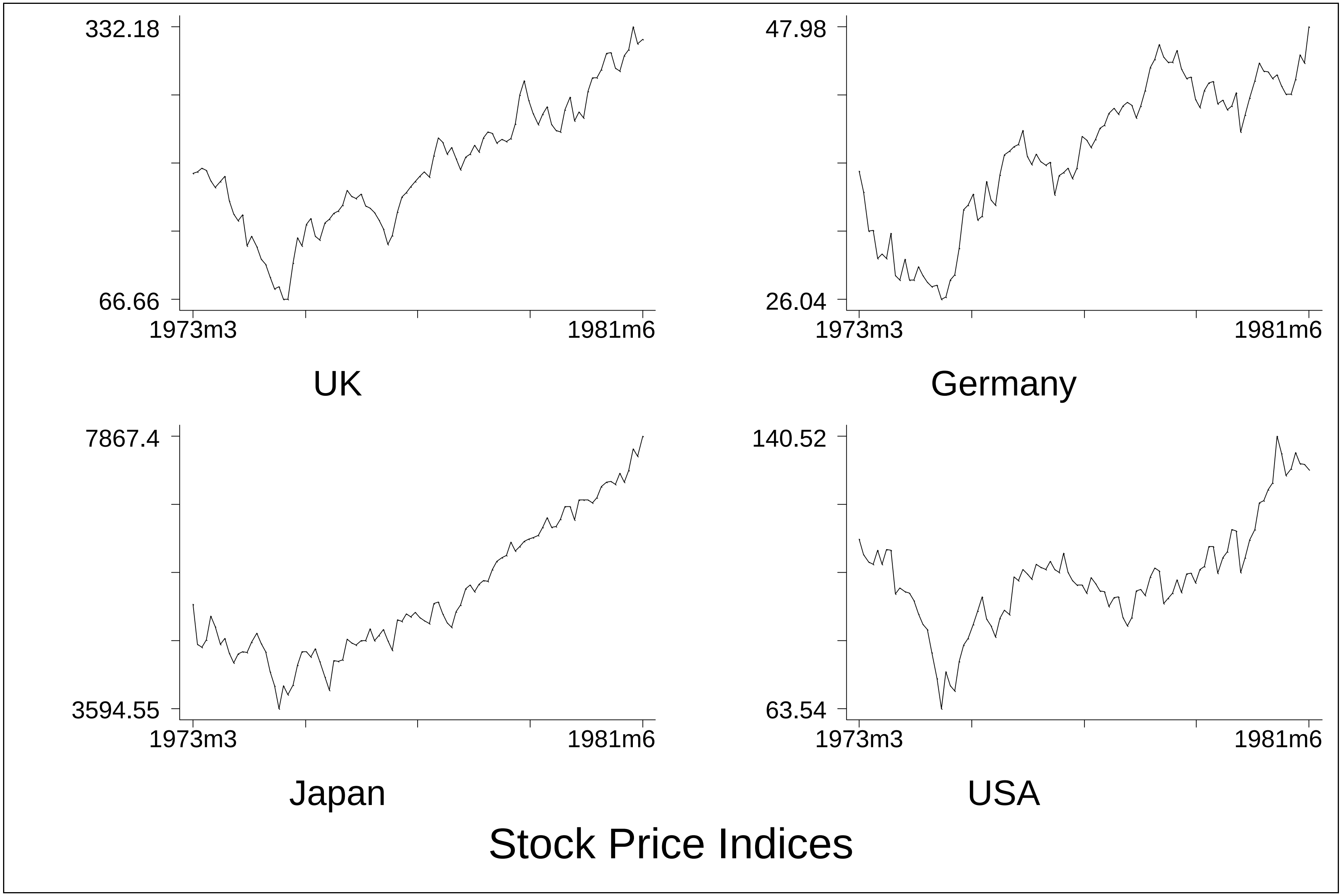

Figure 1: Raw Stock Price Indices

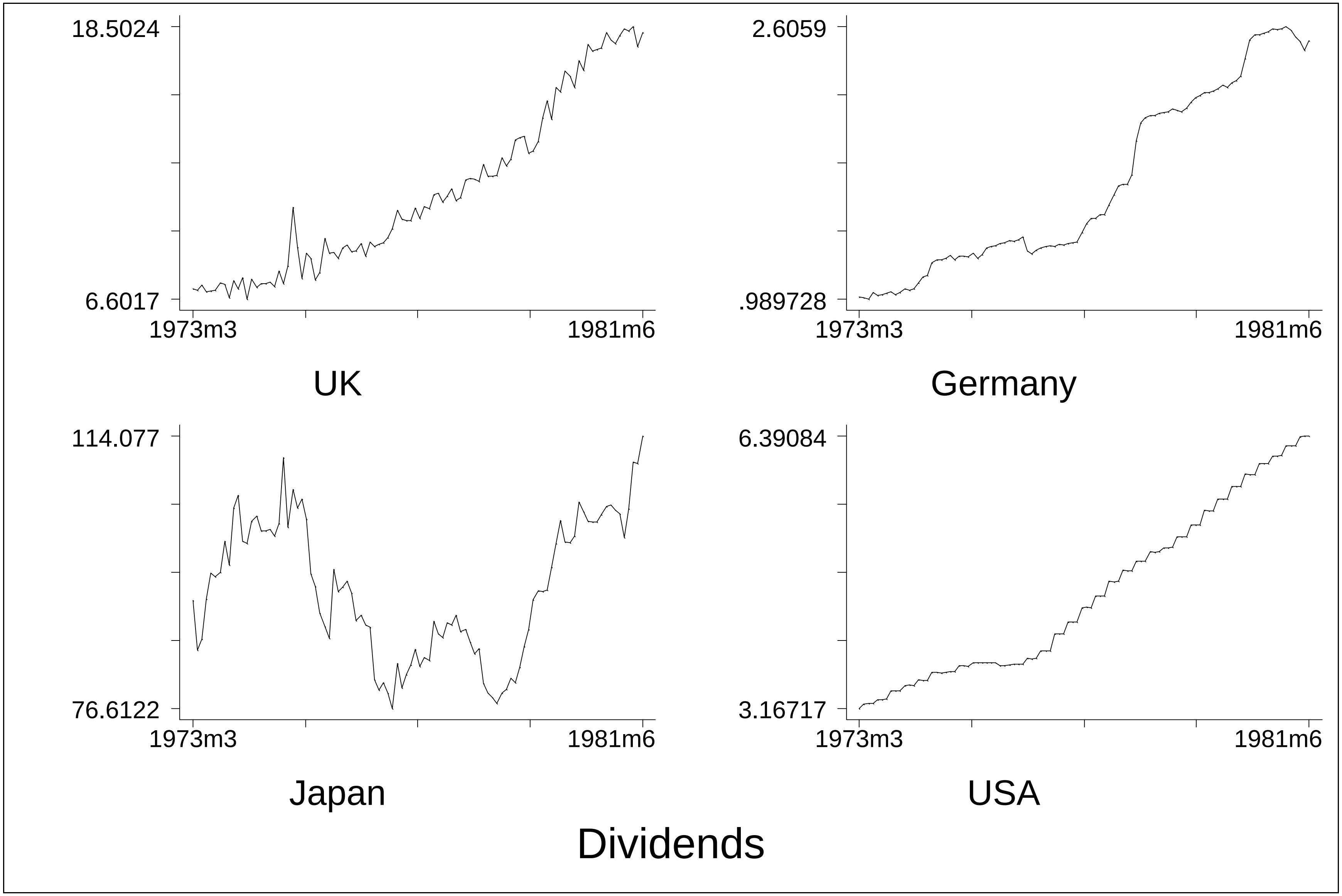

Figure 2: Dividends Extracted from Dividend/Price Ratios

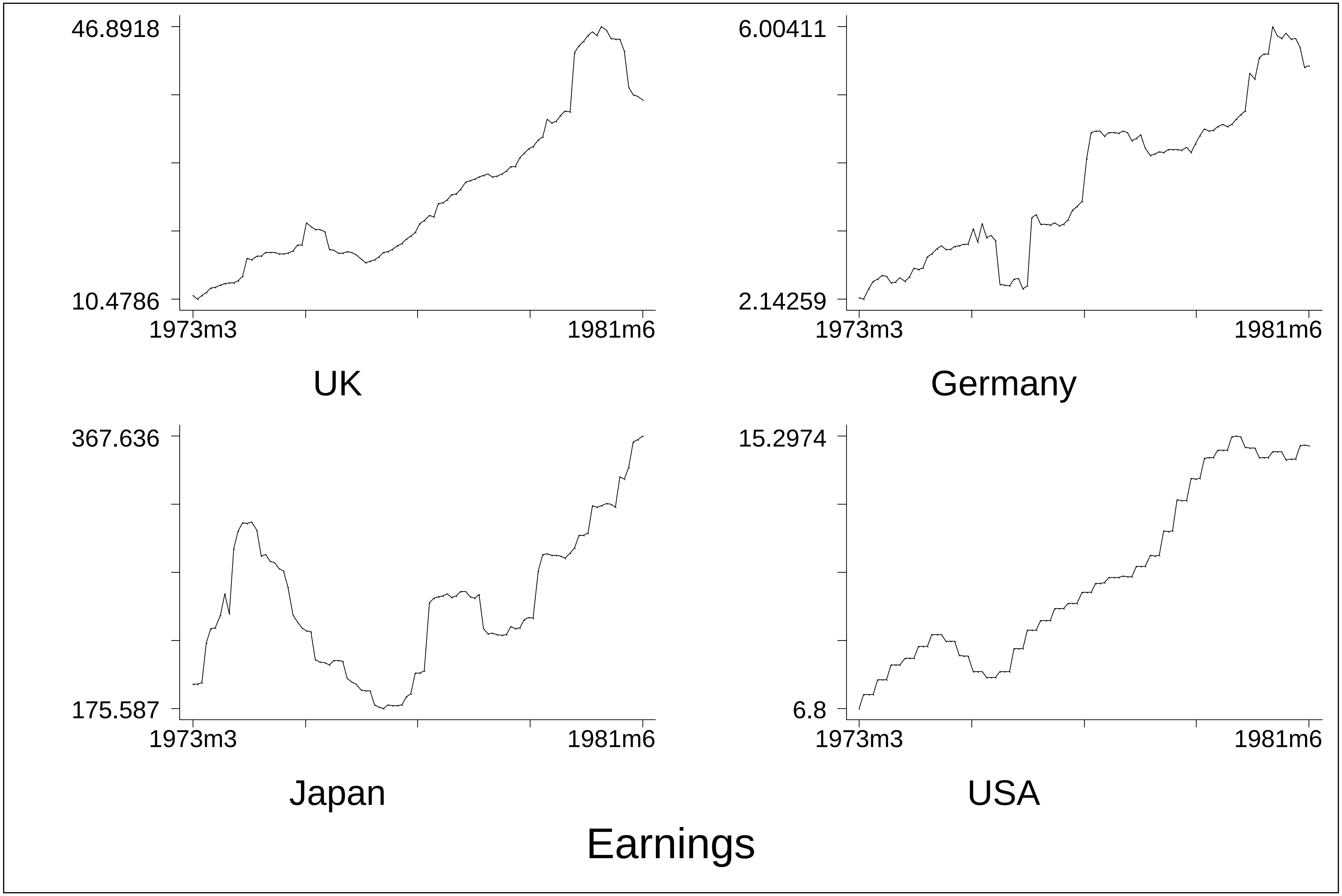

Figure 3: Earnings Extracted from Price/Earnings Ratios

Key Result: Random Walk Model Dominates Other Models

- *All* Fundamentals-Based Models out-forecast by RW model in RMSE at *all* horizons (*despite actual future fundamentals!*)
  - Differences in RMSE sometimes large
- RW also beats VAR uniformly
- Only long AR beats RW, 2/12 times
  - Substantive difference only for 12-month Japan
- Same basic message from using MAE

Table 1: Root Mean Square Forecast Errors

Stock Market	Horiz (mon)	RW	Univ	VAR	Gord Earn	Gord Div	Comp
Germany	**1**	2.68	2.86	3.09	8.05	6.59	5.30
	6	6.13	8.41	10.86	10.45	13.65	8.36
	12	8.65	9.11	19.31	12.97	24.24	12.41
Japan	**1**	2.70	2.75	3.53	16.93	11.27	9.99
	6	6.03	6.09	13.18	21.84	14.98	14.23
	12	10.93	8.19	24.44	27.85	20.03	19.03
UK	**1**	5.51	5.85	5.59	27.44	15.16	13.49
	6	12.95	22.20	12.96	41.60	20.05	19.13
	12	18.09	37.02	19.31	58.12	21.94	24.68
USA	**1**	4.14	4.06	4.64	12.53	10.43	13.26
	6	8.68	10.40	10.25	17.18	14.01	25.11
	12	12.59	15.32	14.80	24.32	18.71	40.73

Percentage terms. 3-yr fwd-looking growth rates.

Meese-Rogoff (1983a): Root Mean Square Forecast Errors

		Random Walk	Forward Rate	Univ AR	VAR	Frenkel-Bilson	Dornbusch-Frankel	Hooper-Morton
$/mark	1	3.72	3.20	3.51	5.40	3.17	3.65	3.50
	6	8.71	9.03	12.40	11.83	9.64	12.03	9.95
	12	12.98	12.60	22.53	15.06	16.12	18.87	15.69
$/yen	1	3.68	3.72	4.46	7.76	4.11	4.40	4.20
	6	11.58	11.93	22.04	18.90	13.38	13.94	11.94
	12	18.31	18.95	52.18	22.98	18.55	20.41	19.20
$/pound	1	2.56	2.67	2.79	5.56	2.82	2.90	3.03
	6	6.45	7.23	7.27	12.97	8.90	8.88	9.08
	12	9.96	11.62	13.35	21.28	14.62	13.66	14.57
EER	1	1.99	N.A.	2.72	4.10	2.40	2.50	2.74
	6	6.09	N.A.	6.82	8.91	7.07	6.49	7.11
	12	8.65	14.24	11.14	10.96	11.40	9.80	10.35

The comparison with Table 1 is striking!

Table 2: Mean Absolute Forecast Errors

Stock Market	Horiz (mon)	RW	Univ	VAR	Gord Earn	Gord Div	Comp
Germany	**1**	2.13	2.42	2.45	6.81	5.24	4.20
	6	5.24	6.55	9.14	9.96	9.60	6.54
	12	7.61	7.22	15.82	10.88	16.57	9.63
Japan	**1**	2.02	2.16	2.84	16.34	10.00	8.65
	6	5.22	4.84	11.99	21.52	13.89	12.45
	12	10.19	6.05	22.78	27.67	19.13	16.95
UK	**1**	4.51	4.61	4.22	23.42	12.26	10.81
	6	10.64	20.28	11.16	34.90	15.82	14.94
	12	15.36	36.27	16.81	48.69	18.39	19.82
USA	**1**	3.25	3.25	3.69	10.94	8.19	10.53
	6	6.96	8.24	8.78	15.57	10.99	20.51
	12	10.38	13.09	12.41	22.51	14.84	35.06

Percentage terms. 3-yr fwd-looking growth rates.

Sensitivity Checks

- Use Mean Error (as well as RMSE, MAE)
- Use backward-looking (as well as forward-looking) growth rates, one- (as well as three-) year horizons
- Look at 3- and 24- (as well as 1-, 6, and 12-) month horizons
- Examine more models:
  - Random Walk with drift
- Grid-Search Techniques

- Examine more estimation techniques:
  - GLS (AR correction)
  - IV (lame: 12-month lags for levels of fundamentals)
  - LAD (median regression)
  - Add seasonal dummies
- Examine different forecasting periods
  - Start in November 1978 (instead of November 1976)
  - End in November 1980 (instead of June 1981)

What's going on?

Study completely generic fundamentals-based model

$$p_t = \lambda f_t + \varepsilon_t \qquad (10)$$

where: p_t is time t price of asset (exchange rate or stock price); f is fundamentals pre-multiplied by parameters λ; ε is an error **orthogonal to (elements of) f.**

Note: General Setup

- (10) can arise directly from asset-demand and arbitrage conditions as in MR
- Can represent reduced-form obtained by solving for unobservables as in Engel and West (2005)
- Only restriction: **f variables are observable** (possibly with error).

Assume **error term is persistent**

$$\varepsilon_t = \rho\varepsilon_{t-1} + u_t \tag{11}$$

where $-1 \leq \rho \leq 1$ and u is iid.

So, **Variance of ε_t:**

$$\text{Var}(\varepsilon) = [1/(1-\rho^2)] \text{ Var}(u). \tag{12}$$

Key Meese-Rogoff Comparison:

- Between a) root mean squared error (RMSE) of the forecast derived from (10), and b) that of the change in asset price.
- Consider one-step ahead forecast.

MR finding: RMSE of ε exceeds RMSE of the first-difference of the asset price p:

$$Var(\varepsilon) = [1/(1-\rho^2)]\ Var(u) > E[(p_t - p_{t-1})^2] \qquad (13)$$

Interpretation

- Model's forecast error variance larger than mean of the asset prices' squared first-difference (random walk error) with step size of one month.
- (Longer step sizes in the future)

Grinding (skip without loss)

From equation (10),

$$(p_t - p_{t-1}) = \lambda(f_t - f_{t-1}) + \varepsilon_t - \varepsilon_{t-1} = \lambda(f_t - f_{t-1}) + (\rho-1)\varepsilon_{t-1} + u_t \qquad (14)$$

Since f is assumed orthogonal to ε and u, assuming away estimation error, we have:

$$E[(p_t - p_{t-1})^2] = E\lambda^2(f_t - f_{t-1})^2 + (\rho-1)^2 Var(\varepsilon) + Var(u). \qquad (15)$$

From equation (12),

$$E[(p_t - p_{t-1})^2] = E\lambda^2(f_t - f_{t-1})^2 + [(\rho-1)^2/(1-\rho^2)]Var(u) + Var(u) \quad (16)$$

(One-Step) **Full Information Meese-Rogoff (FIMR)** result:

$$\frac{E\lambda^2(f_t - f_{t-1})^2}{Var(u)} < \frac{[1-(\rho^2-2\rho+1)-(1-\rho^2)]}{(1-\rho^2)} = \frac{(2\rho-1)}{(1-\rho^2)} \qquad (17)$$

or

$$\frac{E\lambda^2(f_t - f_{t-1})^2}{Var(\varepsilon)} < 2\rho - 1 \qquad (17a)$$

Intuition

The random walk is likely to have a lower RMSE than the forecasting model (FIMR holds) when either:

a) fundamentals have low explanatory power [low $E\lambda^2(f_t - f_{t-1})^2$]; or

b) the forecasting residual (ε) or its innovation (u) has a large variance; or

c) when the residual is highly persistent (high ρ).

More Intuition

- When model performs well, Meese-Rogoff result less likely (sensible)
- Two senses in which model can work well:
    - Impact of expected change in the fundamentals large
    - Model error small

More Interesting Result

- As $\rho \to 0$, impossible to get FIMR *regardless of the relative size of fundamentals information and residual variance.*
  - For $\rho < .5$, FIMR impossible (regardless of how informative are fundamentals)

Two Conceptual Experiments ($\rho \rightarrow 1$)

- Since ρ often high, use (17) and (17a) to think about what is held constant.

Experiment 1

- In (17), let $\rho \rightarrow 1$ holding $[E\lambda^2(f_t - f_{t-1})^2]$ and Var(u) constant:

$$\frac{E\lambda^2(f_t - f_{t-1})^2}{Var(u)} < \frac{[1-(\rho^2 - 2\rho + 1) - (1-\rho^2)]}{(1-\rho^2)} = \frac{(2\rho - 1)}{(1-\rho^2)}$$

- *Full Information Meese-Rogoff result condition* ***must hold*** *in the limit* ***regardless of the information in fundamentals****.*

- FIMR criterion leads us to discard the model because of high shock persistence, *even though the fundamentals-based model contains lots of information.*

Experiment 2

- In (17a), let $\rho \rightarrow 1$ holding $E[\lambda^2(f_t - f_{t-1})^2]$ and $Var(\varepsilon)$ constant.

- In limit, FIMR condition becomes:

$$\frac{E\lambda^2(f_t - f_{t-1})^2}{Var(\varepsilon)} < 1$$

or

$$R^2 < 1 - [E\lambda^2(f_t - f_{t-1})^2] / Var(\varepsilon)]$$

("low" goodness of fit implies FIMR)

FIMR Interpretation

- Meese-Rogoff measure needs to be interpreted carefully.
- How seriously one takes FIMR depends on ρ (extraneous parameter?) *and its meaning*.
    - Errors may be persistent because the model omits some persistent fundamentals
- Models with highly persistent errors likely to have problems meeting the FIMR criterion and thus MR

Some FIMR Measures in Data

- Apply FIMR measure to simple Foreign Exchange models (updated data from MR period)
- Monetary Model of Exchange Rate:

$$s_t = \lambda_0 + \lambda_1(m_t - m_t^*) + \lambda_2(i_t - i_t^*) + \lambda_3(y_t - y_t^*) + \varepsilon_t,$$

s is log (PFX) exchange rate, m is money, i is short-term interest rate, and y is real output

Fundamentals:

$$f_t = \lambda_0 + \lambda_1(m_t - m_t^*) + \lambda_2(i_t - i_t^*) + \lambda_3(y_t - y_t^*)$$

Expected first difference fundamental is:

$$E(f_t - f_{t-1})^2 = E[\{\Delta(\lambda_1(m_t - m_t^*) + \lambda_2(i_t - i_t^*) + \lambda_3(y_t - y_t^*)\}^2]$$

OLS – Exchange Rate Model

Time: 1973m3-1981m6

	Germany	UK	Japan
$E\lambda^2(f_t - f_{t-1})^2$	0.00011	0.00044	0.00007
$Var(\varepsilon)$	0.00997	0.01327	0.0070
ρ – Simple OLS	0.97116	0.98519	0.9885
ρ- Autocorrelogram	0.9526	0.983	0.9761

Can use estimates in (17a):

$$\frac{E\lambda^2(f_t - f_{t-1})^2}{Var(\varepsilon)} < 2\rho - 1$$

Germany: $\frac{.00011}{.00997} = .01142 < .94232$

UK : $\frac{.00044}{.01328} = .03316 < .97038$

Japan : $\frac{.00007}{.00702} = .00992 < .9770$

- Recall FX model passes MR for 1 month
- FIMR is tougher!

Stock Market

- FIMR standard useful if gives low-cost indicator of models performance according to full-blown MR method
- Parallel to FX results above, next apply FIMR measure to simple stock market model

Use Linearized Gordon Growth Model

$$p_t = \beta_o + \beta_d d_t + \beta_{dg} \ln(1 + g_t^D) + \varepsilon_t,$$

where

- p the level of country's stock index, d aggregate dividends,

  $(1 + g_t^D)$ is one plus dividend growth rate

- Estimate this model for Germany, UK, Japan and the US over the MR period, 1973m3-1981m6

Now simply estimate

$$\lambda^2 E(f_t - f_{t-1})^2 = E[\{\Delta(\beta_d d_t + \beta_{dg} \ln(1+g_t^D))\}^2].$$

using stock-market data

OLS – Stock-Market Gordon Dividend Model

Time: 1973m3-1981m6

	Germany	UK	Japan	US
$\lambda^2 E(f_t - f_{t-1})^2$	0.00169	0.00924	0.00001	0.00125
$Var(\varepsilon)$	0.00803	0.04226	0.03307	0.01248
ρ – Simple OLS	0.98293	0.99692	0.99638	0.9997
ρ - Autocorrelogram	0.9793	0.9921	0.996	0.9937

Now use estimates in expression (17a):

$$\frac{E\lambda^2(f_t - f_{t-1})^2}{Var(\varepsilon)} < 2\rho - 1$$

Germany: $\frac{.00169}{.00802} = 0.2105 < .96586$

UK : $\frac{.00925}{.04226} = .2187 < .99384$

Japan : $\frac{.00001}{.03307} = .00038 < .99276$

US $\frac{.00125}{.01248} = .10051 < .9994$

Conclusion

- International finance is in no worse shape at modeling important asset prices than domestic finance on the level of stock prices.
- The Meese-Rogoff methodology may not be revealing for any asset price, especially with a lot of persistence in the composite residual.