Lecture 5:
Empirics, Forecasting and Policy

Prof. Menzie Chinn
Kiel Institute for World Economics
March 7-11, 2005

Lecture Outline

- Real exchange rates
- Equilibrium exchange rates
- Evaluating models of the 1990's
- Panel estimation
- Should exchange rates be predictable?
- Some thoughts on using models in policy analysis

I

Real exchange rates

An interesting relationship

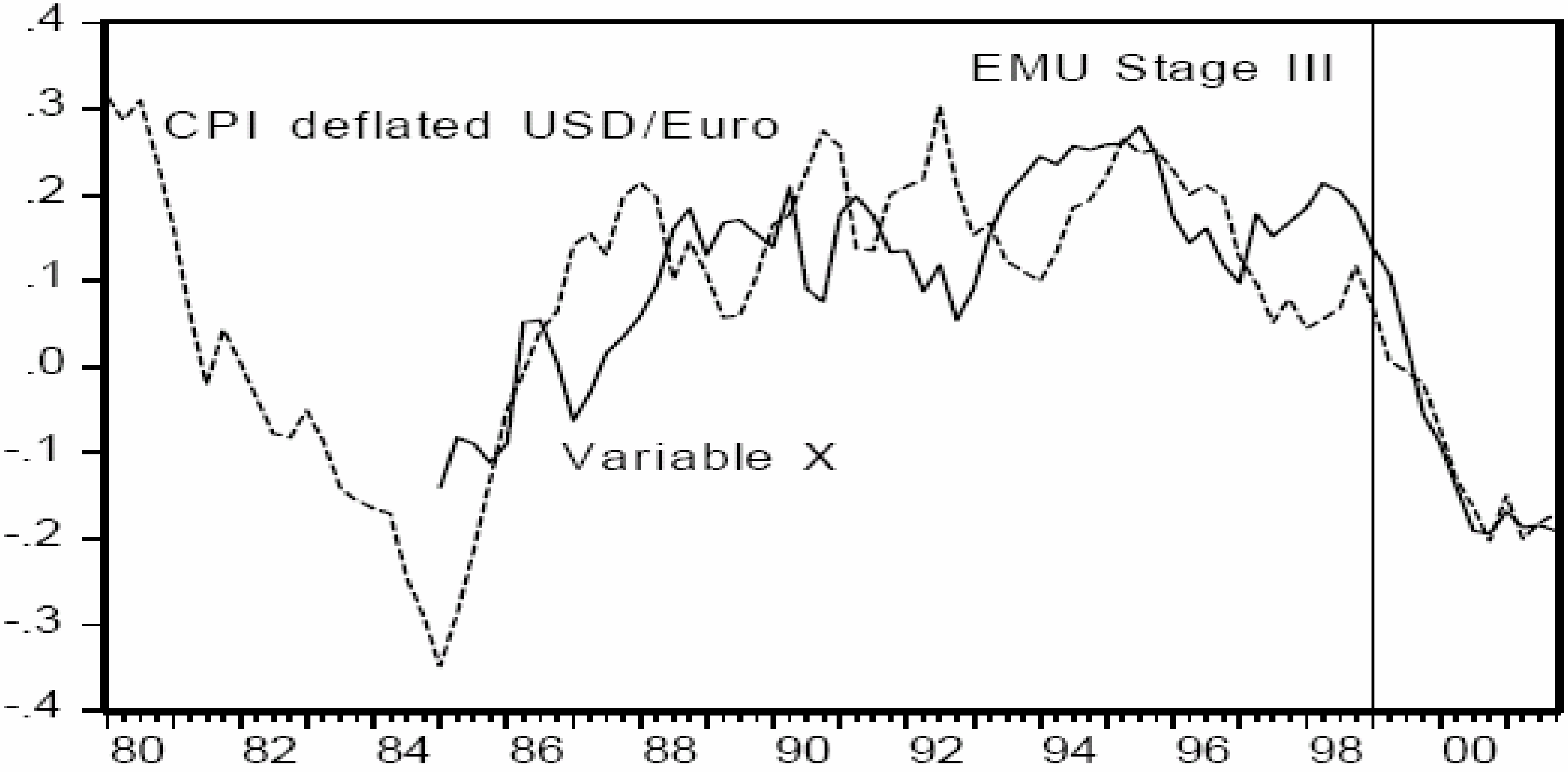


Figure 1: Real Dollar/Euro Exchange Rate and Variable X

PPP and real exchange rates

$$s = p - p^* + \mu$$

Absolute PPP in log levels

$$q \equiv s - p + p^*$$

Def'n: Log real exchange rate

Why not let this variable trend? Where's productivity?

Allowing nontradables

$$p = \alpha p^{N} - (1-\alpha) p^{T}$$

$$p^{*} = \alpha p^{N*} - (1-\alpha) p^{T*}$$

Aggregate price is avg. of nontraded and traded prices

Substitute into def'n of real exchange rate

$$q_{t} = s_t - \alpha(p_t^{N} - p_t^{N*}) - (1-\alpha)(p_t^{T} - p_t^{T*})$$

Algebra

$$q_t = [s_t - p_t^T + p_t^{T*}] - \alpha(p_t^N - p_t^{N*}) + \alpha(p_t^T - p_t^{T*})$$

$$q_t = [q_t^T] - \alpha[(p_t^N - p_t^T) - (p_t^{N*} - p_t^{T*})]$$

$$q_t = -\alpha[(p_t^N - p_t^T) - (p_t^{N*} - p_t^{T*})]$$

Where the last step involves PPP only for traded goods

What about productivity?

- Harrod-Balassa-Samuelson: the relative price of nontradables depends upon productivity differential betwn the two sectors
- Suppose a Cobb-Douglas production function governs sectoral output, and factor shares are the same in tradables, nontradables. Then

Nontradables and productivity

$$p_t^N - p_t^T = a_t^T - a_t^N$$

The higher the productivity in a sector, the lower the sectoral price

Substitute this relationship into the expression for q

$$q_t = -\alpha[(a_t^T - a_t^N) - (a_t^{T*} - a_t^{N*})]$$

Testing for OECD Countries

- Data from ISDB (now STAN)
- Annual, 1970-1994
- Productivity in services+construction vs. all else (N vs. T)
- Estimate using panel cointegration

The Data

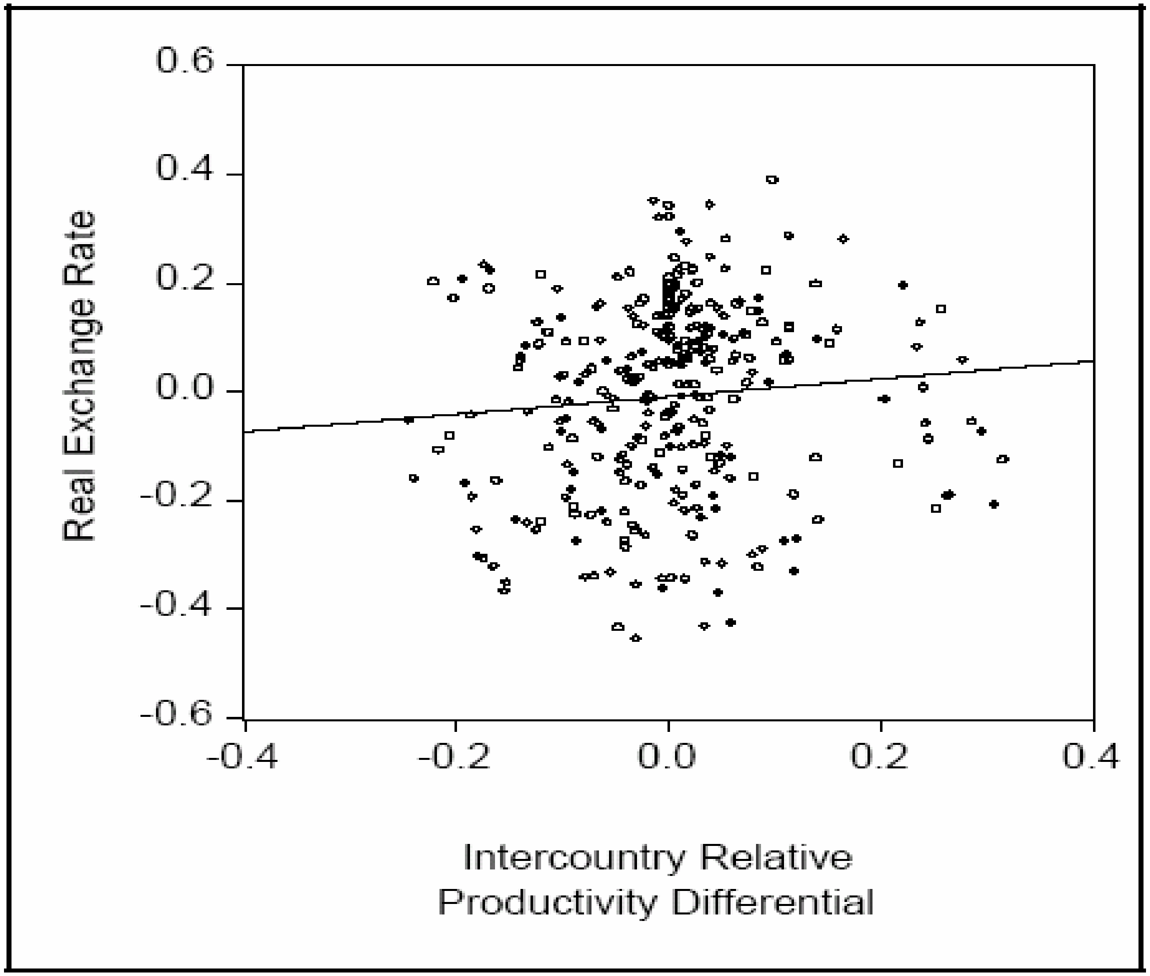


Figure 2: Real exchange rate and intercountry relative productivity

Table 4
Panel Regressions:
The Real Exchange Rate and Relative Productivity Differential

$$q_{it} = \alpha_i + \beta_1(\hat{a}_{it}^{T}) + \beta_2(\hat{a}_{it}^{N}) + \sum_{j=-4}^{+2}\xi_j \Delta z_{it+j} + u_{it}$$

$$z = (\hat{a}^{T} - \hat{a}^{N})$$

	a^T	a^N	$\overline{R2}$	N	Levin-Lin t-stat
Pred	(-1)	(+1)			
Full	-0.420** (0.213)	-0.169 (0.297)	0.99	215	-8.71***
G-7	-0.730** (0.328)	0.443** (0.320)	0.99	99	-5.59***
Full ex.JP	-0.478** (0.212)	-0.085 (0.297)	0.99	198	-11.49***
Full[a/] ex. BE IT	-0.404* (0.236)	-0.276 (0.295)	0.99	181	-6.18***

Source: Chinn (1999)

Problems

- Results are sensitive to sample (which countries included)
- Nontradable productivity is usually not statistically significant.
- Results are also sensitive to inclusion of other factors (gov’t spending, oil prices, terms of trade, per capita income)

What about in East Asia?

Table 6
Panel NLS Error Correction Model Regressions

	Full Sample	No China	No China	No China	No China
ECT	-0.091***	-0.243***	-0.153**	-0.146**	-0.149
	(0.030)	(0.047)	(0.057)	(0.057)	(0.057)
$p^N - p^T$	-0.679**	-0.411***			
	(0.300)	(0.093)			
$a^T - a^N$			-0.238	-0.231	-0.219
			(0.309)	(0.329)	(0.325)
p^{oil}					0.111
					(0.712)

Source: Chinn (2000). Sample 1971-91

East Asia again

Table 7
Panel NLS Error Correction Model Regressions on Restricted Sample

No China, Singapore, Taiwan and Thailand			
ECT	-0.166**	-0.164**	-0.167**
	(0.081)	(0.081)	(0.081)
a^T-a^N	-0.620†	-0.631†	-0.614†
	(0.394)	(0.407)	(0.400)
p^{oil}			0.129
			(0.769)

II
“Equilibrium” Exchange Rates

Behavioral eq'm exchange rates

- "Behavioral equilibrium exchange rates" (BEERs) (Clark & MacDonald) are mixtures of Balassa-Samuelson, the Sticky-Price Monetary Model, Portfolio Balance models.
- They are used by central banks, and investment banks (e.g., Morgan Stanley, Goldman Sachs)

Example: Yilmaz & Fels (2001)

Exhibit 5

The Normalised FIML Co-integration Vectors

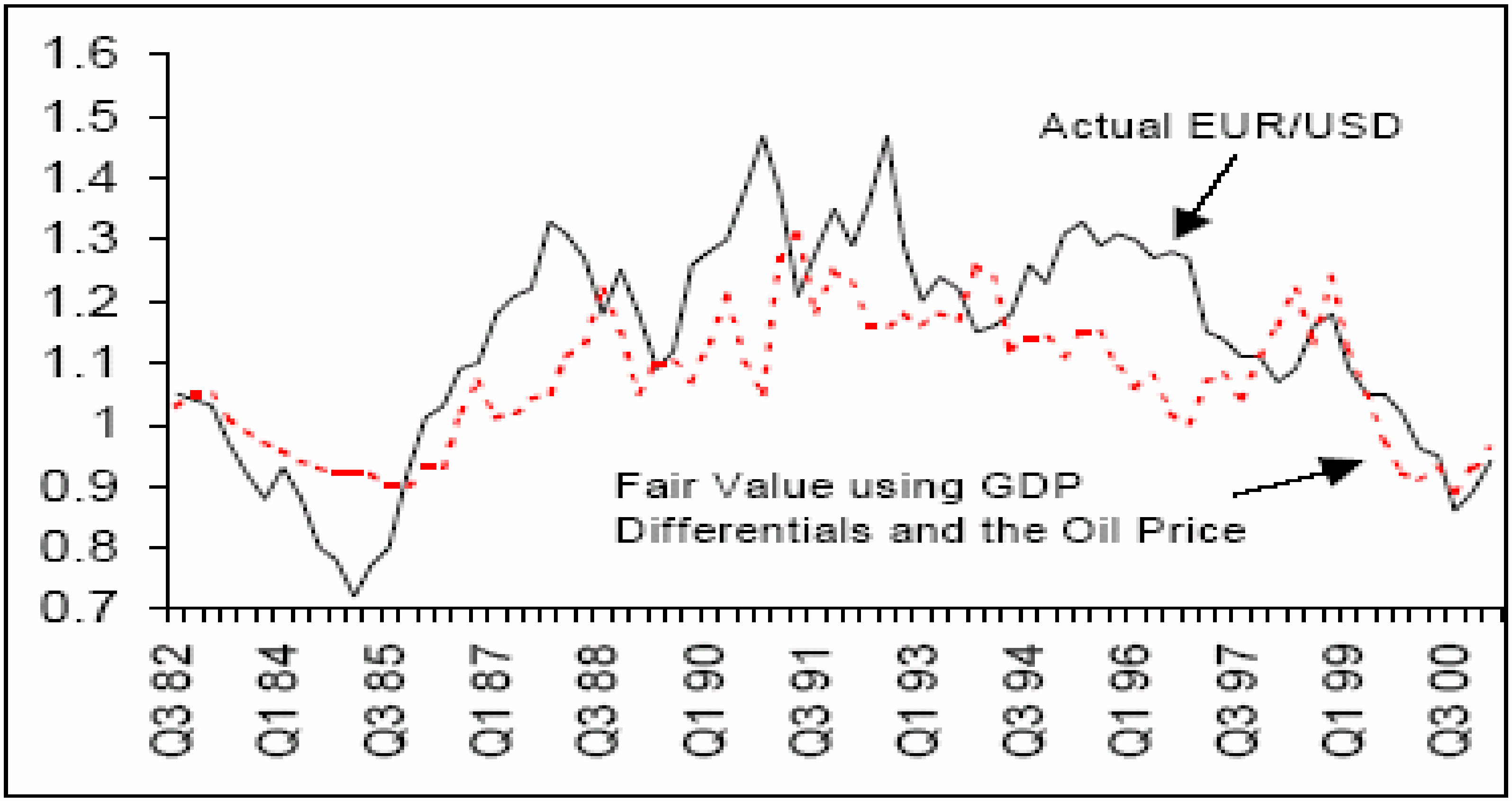
Variables	Model 1	Model 2	Model 3	Model 4
Constant	0.10	0.07	0.08	-0.34
Real Interest Rate Diff.	-6.05	Unrestricted	-7.49	-6.25
Real Oil Price	x	-0.29	-0.24	-0.26
Real GDP Diff.	x	-1.35	-1.24	x
Productivity	x	x	x	-3.25
Adjustment Speed	-0.34	-0.33	-0.23	-0.15

Source: Morgan Stanley Dean Witter Research Estimates

Implied misalignment

Exhibit 2

EUR/USD and Fair Value -- Model 2 (Our Favourite One!)



Source: Datastream, Morgan Stanley Dean Witter Research Estimates

More “equilibrium” models

- Fundamental Equilibrium Exchange Rate (FEER) models (Williamson of IIE). The exchange rate that matches the CA to what is considered the appropriate level of the CA.
- IMF “Macroeconomic balance” models (Isard & Masson). The exchange rate that matches the CA to the “norm”.

III
Evaluating Models of the 1990’s

Perspective

"There may be more forecasting of exchange rates, with less success, than almost any other economic variable."

Alan Greenspan, Testimony of the Federal Reserve Board's semiannual monetary policy report to the Congress, before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate, July 16, 2002.

Motivation

- Recent events
- Long horizon prediction
- Recent findings

Comprehensive

- Three new models compared
- Five currencies ag. dollar (& yen)
- Two specifications
- Two (three) forecasting periods
- Three forecast horizons
- Three prediction criteria

Findings

- A random walk can’t be beaten
- Structural models do better (DoC)
- “Consistency” results ambiguous
- Sticky price model holds up well
- IRP is useful predictor

The Models

$$s_t = \beta_1 m_t + \beta_2 y_t + \beta_3 i_t + \beta_4 \pi_t + u_t \quad (1)$$

Sticky price monetary model

$$s_t = \beta_1 m_t + \beta_2 y_t + \beta_3 i_t + \beta_5 z_t + u_t \quad (2)$$

Productivity model

The Models (cont'd)

$$s_t = p_t + \beta_5 \omega_t + \beta_6 r_t + \beta_7 gdebt_t + \beta_8 tot_t + \beta_9 nfa_t + u_t \quad (3)$$

Composite model

$$s_{t+k} = s_t + i_{t,k} \quad (4)$$

Interest rate parity

Data

- *m, y*, *i*, CPI, PPI from *IFS*
- Labor prod'y from BIS database
- Interest rates fm Chinn & Meredith
- NFA from Lane & Milesi-Ferretti interpolated using CA data
- Govt debt from *IFS*, interpolated

- Rolling regressions
- ECM vs. first differences
- $s_t = X_t\Gamma + u_t$
- $\Delta s_t = \Delta X_t\Gamma + u_t$
- $s_t - s_{t-k} = \delta_0 + \delta_1(s_{t-k} - X_{t-k}\Gamma) + u_t$

Forecasting

- ECT estimated *recursively* in EC specifications
- Ex ante vs. ex post
- IRP not estimated, categorized as error correction

Forecast Comparison

- MSE criterion

  MSE(model *j*)/MSE(rw)

  Diebold-Mariano (1995) test
- Direction of Change

  Value > 0.5 implies outprediction
- “Consistency” (Cheung & Chinn, ‘98)

  Same I(d), cointegration, unit elasticity

Results: MSE

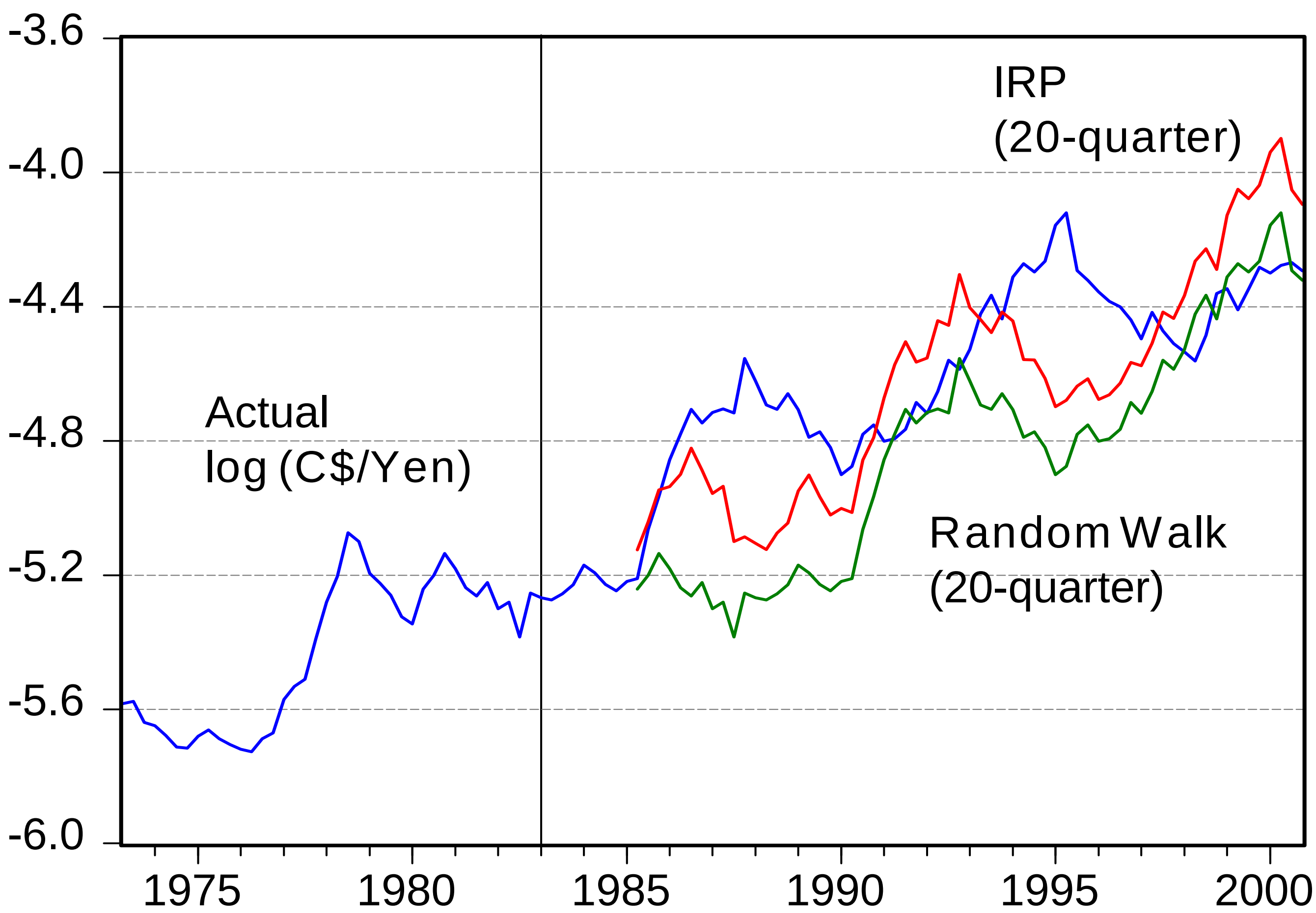
- Structural model performance is unimpressive
- Best: IRP, 20 qtr., C$/yen, 1983-2000
- Worst: first diff. composite 20 qtr. for pound/US$, 1983-2000
- Difficulty in estimating short run dynamics

Selected results: MSE

Table 2: The MSE Ratios from the Yen-Based Exchange Rates

		Sample 1: 1987 Q2 - 2000 Q4			Sample 2: 1983 Q1-2000 Q4		
Specification	Horizon	S-P	IRP	PROD	S-P	IRP	PROD
Panel B: CAN$/Yen							
ECM	1	1.1569	1.0225	1.0830	1.0244	0.9964	0.9827
		0.1101	0.6270	0.0505	0.8506	0.9252	0.8502
	4	1.3197	1.0679	1.0916	1.0386	0.9561	1.1492
		0.1194	0.7063	0.2399	0.8085	0.7305	0.1427
	20	1.2658	0.5416	1.0806	1.2267	0.4774	1.3773
		0.0873	0.0562	0.4042	0.1715	0.0353	0.2400
FD	1	1.0497		1.0193	1.0092		0.9950
		0.5369		0.8017	0.9199		0.9510
	4	1.0918		1.0984	0.7931		0.8635
		0.6933		0.7169	0.3591		0.5372
	20	0.8840		0.8338	1.0639		1.3366
		0.8657		0.8156	0.9239		0.6536

C$/Yen Forecasts

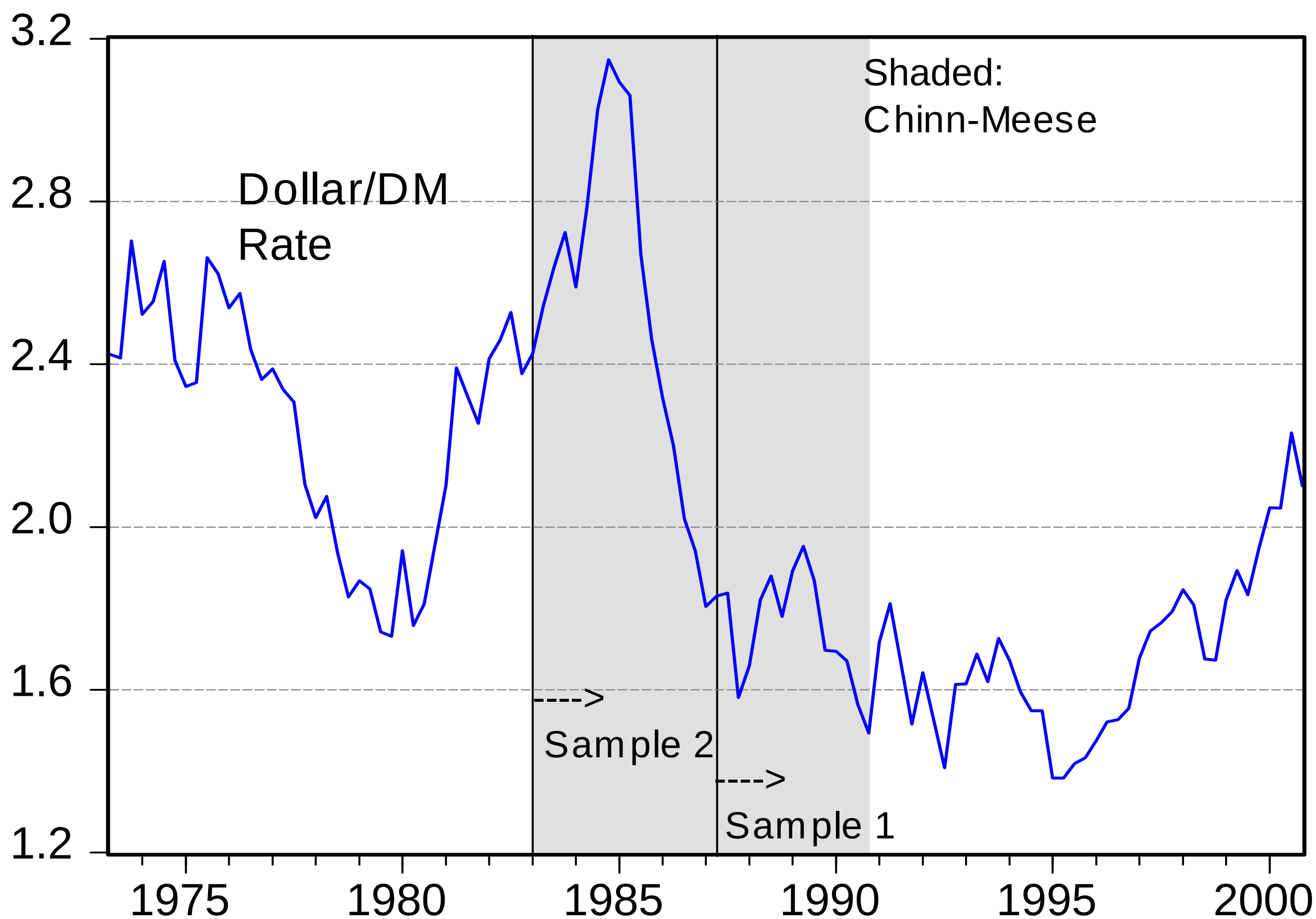


More selected results: MSE

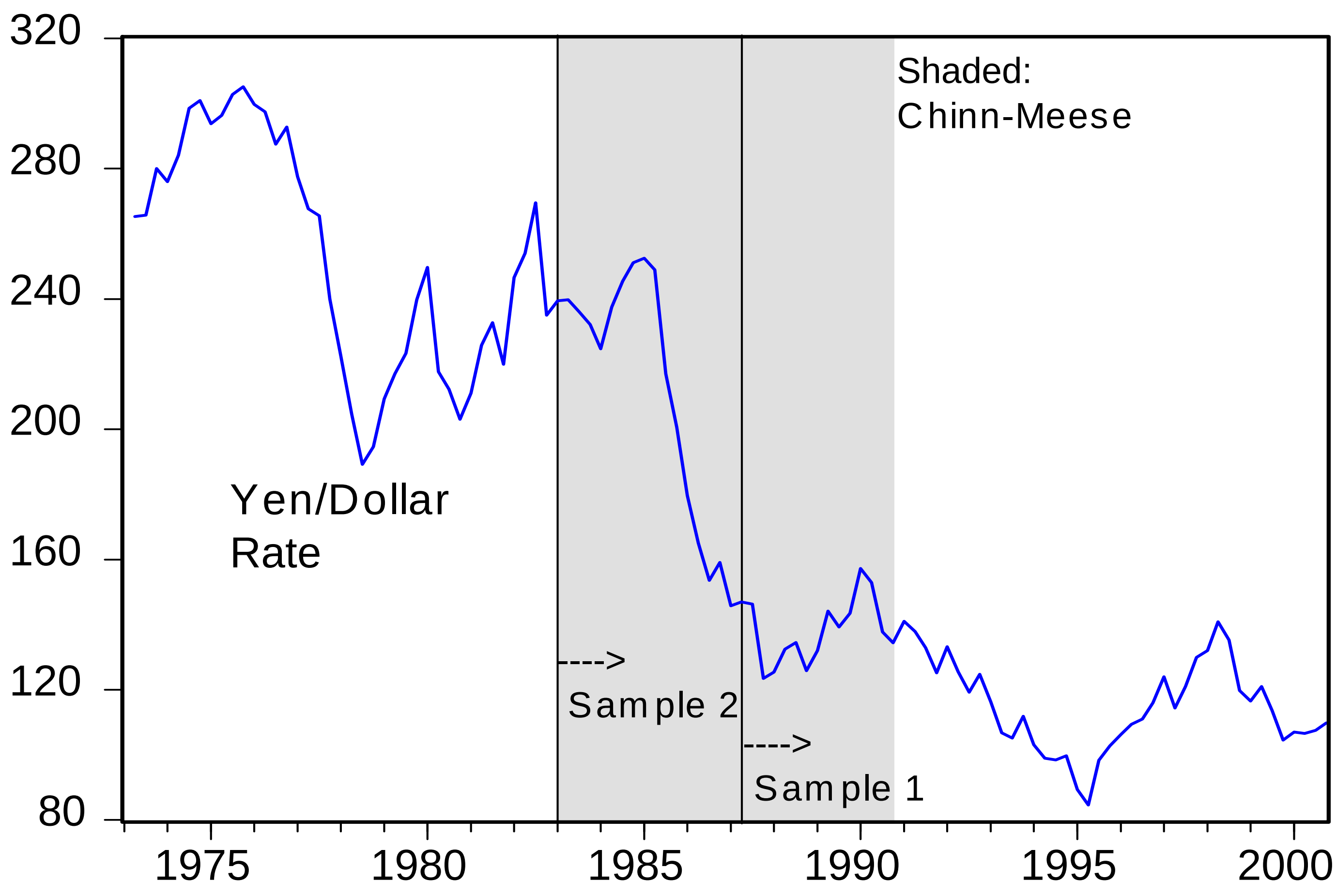
Table 1: The MSE Ratios from the Dollar-Based Exchange Rates

		Sample 1: 1987 Q2 - 2000 Q4				Sample 2: 1983 Q1-2000 Q4			
Specification	Horizon	S-P	IRP	PROD	BEER	S-P	IRP	PROD	BEER
Panel A: BP/$									
ECM	1	1.0465	1.0081	0.9954	1.0853	1.0499	1.0455	1.0418	1.0487
		0.4089	0.8832	0.8968	0.2083	0.3098	0.3183	0.3030	0.4484
	4	1.1273	1.0918	1.0169	1.0993	1.1416	1.1228	1.0850	1.1272
		0.5031	0.6204	0.8022	0.2532	0.1714	0.3095	0.2369	0.2245
	20	1.8089	1.3421	1.0953	1.3395	1.4568	0.8406	1.5450	2.1793
		0.0143	0.2402	0.4109	0.1684	0.0707	0.5178	0.0918	0.0570
FD	1	1.0411		1.0055	1.1914	1.0858		1.0792	1.0230
		0.4337		0.9399	0.2167	0.1345		0.3367	0.9010
	4	1.1195		1.1235	1.8806	1.2498		1.4551	1.4476
		0.3147		0.5237	0.0008	0.1487		0.1755	0.3510
	20	1.8908		2.5310	6.9525	3.2231		5.5574	6.0151
		0.1769		0.0205	0.0000	0.1953		0.0189	0.0013

Contrasts with Chinn & Meese



Contrasts with Chinn & Meese



Results: DoC

- DoC results more positive (17% at 10% MSL)
- Predictability greatest at long horizons
- IRP only works at long horizons

Selected results: DoC

Table 4: Direction of Change Statistics from the Yen-Based Exchange Rates

		Sample 1: 1987 Q2 - 2000 Q4			Sample 2: 1983 Q1-2000 Q4		
Specification	Horizon	S-P	IRP	PROD	S-P	IRP	PROD
Panel B: CAN$/Yen							
ECM	1	0.5455	0.5000	0.4364	0.5833	0.5343	0.5278
		0.5002	1.0000	0.3452	0.1573	0.5584	0.6374
	4	0.4808	0.5893	0.4615	0.5797	0.6438	0.5362
		0.7815	0.1815	0.5791	0.1854	0.0140	0.5472
	20	0.4167	0.7679	0.4444	0.4528	0.7969	0.5283
		0.3173	0.0001	0.5050	0.4922	0.0000	0.6803
FD	1	0.5091		0.5091	0.4722		0.5000
		0.8927		0.8927	0.6374		1.0000
	4	0.5385		0.5769	0.6377		0.6232
		0.5791		0.2673	0.0222		0.0407
	20	0.6944		0.6944	0.7359		0.7170
		0.0196		0.0196	0.0006		0.0016

Results: Consistency

- Many cases of cointegration
- Fewer cases of unit elasticity
- Only 10% (13%) meet criteria for USD (yen)
- Consistency criterion – SP does fairly well

Discussion

- Best model/spec./currency combinations do not carry over
- Error correction does best in outperformance at long horizons (ignoring significance)
- IRP is well represented in this group

IV
Panel Estimation

Limitations of CCG-P

- An exhaustive, but limited, study
- No functional nonlinearities (Sarno-Taylor ESTAR; Meese-Rose)
- No regime switching (Engel-Hamilton)
- No panel cointegration (Mark and Sul)

Mark and Sul

- Back to the monetary model (Mark, 1995)
- Using cross-currency variation to obtain “better” estimates
- Panel of OECD currencies, 1973q1-97q1
- Test for (panel) cointegration
- Use estimated cointegrating vectors to do prediction

The econometric model

$$\Delta s_{it+1} = \beta x_{it} + e_{it+1} \tag{2}$$

$$e_{it+1} = \gamma_i + \theta_{t+1} + u_{it+1}, \tag{3}$$

Table 1
Panel dynamic OLS based cointegration tests

Fundamentals	Numeraire	β_{pdols}	*t*-ratio	*P*-value[a]	*P*-value[b]
Monetary	US	0.010	**4.930**	**0.000**	**0.002**
	Switzerland	0.006	**2.219**	**0.050**	**0.067**
	Japan	0.007	**3.877**	**0.002**	**0.001**
PPP	US	−0.016	**−4.626**	**0.998**	**0.999**
	Switzerland	−0.019	**−7.417**	**0.992**	**0.989**
	Japan	−0.022	**−4.077**	**1.000**	**1.000**

[a] Parametric bootstrap *P*-value.

[b] Nonparametric bootstrap *P*-value. *P*-value is the proportion of the bootstrap distribution that lies to the *right* of the asymptotic *t*-ratio calculated from the data. A two-tailed test rejects the null hypothesis at the 5% level if the *P*-value is above 0.975 or below 0.025.

Performance of the panel regression

Table 5

Out-of-sample forecasts of US dollar returns. Bootstrapped *P*-values generated assuming cointegration

Country	U^a	P-value^d	P-value^e	U^b	P-value^d	P-value^e	U^c
A. One-quarter ahead forecasts							
Australia	1.024	0.991	0.904	**0.988**	**0.083**	0.102	1.036
Austria	**0.984**	**0.001**	**0.013**	**0.994**	0.231	0.259	**0.990**
Belgium	**0.999**	0.269	0.424	1.000	0.441	0.442	**0.998**
Canada	**0.985**	**0.020**	**0.074**	1.003	0.534	0.496	**0.982**
Denmark	1.014	0.989	0.912	**0.998**	0.361	0.365	1.016
Finland	1.001	0.708	0.527	**0.992**	0.137	0.152	1.009
France	**0.994**	**0.024**	0.155	1.000	0.440	0.426	**0.994**
Germany	**0.986**	**0.006**	**0.056**	**0.992**	0.188	0.222	**0.994**
Great Britain	**0.983**	**0.028**	**0.077**	**0.988**	0.102	0.131	**0.996**
Greece	1.016	0.995	0.909	1.012	0.883	0.891	**0.984**
Italy	**0.997**	0.174	0.269	1.004	0.598	0.537	**0.994**
Japan	1.003	0.831	0.579	**0.998**	0.343	0.332	1.005
Korea	**0.912**	**0.001**	**0.002**	**0.974**	**0.020**	**0.034**	**0.936**
Netherlands	**0.986**	**0.004**	**0.041**	**0.992**	0.193	0.226	**0.994**
Norway	**0.998**	0.202	0.380	**0.992**	0.164	0.193	1.006
Spain	**0.996**	0.115	0.341	1.024	0.736	0.691	**0.993**
Sweden	**0.975**	**0.008**	**0.034**	**0.987**	**0.079**	0.101	**0.988**
Switzerland	**0.982**	**0.002**	**0.008**	**0.988**	**0.073**	**0.092**	**0.995**
Mean	**0.991**	**0.002**	**0.010**	**0.996**	0.135	0.145	**0.995**
Median	**0.995**	**0.025**	0.163	**0.993**	0.131	0.173	**0.994**

Long horizon performance

B. Sixteen-quarter ahead forecasts							
Australia	**0.864**	0.127	0.222	**0.728**	**0.045**	**0.053**	1.186
Austria	**0.837**	**0.070**	0.131	**0.549**	**0.006**	**0.008**	1.525
Belgium	**0.405**	**0.001**	**0.001**	**0.577**	**0.009**	**0.015**	**0.703**
Canada	**0.552**	**0.005**	**0.009**	**0.601**	**0.015**	**0.023**	**0.919**
Denmark	**0.858**	**0.092**	0.174	**0.732**	**0.069**	**0.071**	1.172
Finland	**0.859**	**0.099**	0.164	**0.631**	**0.006**	**0.012**	1.360
France	**0.583**	**0.002**	**0.004**	**0.683**	**0.033**	**0.048**	**0.854**
Germany	**0.518**	**0.001**	**0.003**	**0.440**	**0.001**	**0.001**	1.178
Great Britain	**0.570**	**0.004**	**0.012**	**0.601**	**0.015**	**0.018**	**0.948**
Greece	1.046	0.657	0.594	**0.854**	0.738	0.817	**0.787**
Italy	**0.745**	**0.003**	**0.016**	**0.878**	0.195	0.207	**0.849**
Japan	**0.996**	0.476	0.433	**0.895**	0.222	0.219	1.113
Korea	**0.486**	**0.001**	**0.012**	**0.682**	**0.048**	**0.067**	**0.714**
Netherlands	**0.703**	**0.006**	**0.032**	**0.399**	**0.001**	**0.001**	1.762
Norway	**0.537**	**0.001**	**0.002**	**0.829**	0.126	0.133	**0.648**
Spain	**0.672**	**0.006**	**0.028**	1.219	0.178	0.182	**0.859**
Sweden	**0.372**	**0.001**	**0.001**	**0.541**	**0.004**	**0.004**	**0.687**
Switzerland	**0.751**	**0.019**	**0.049**	**0.575**	**0.007**	**0.007**	1.307
Mean	**0.686**	**0.001**	**0.001**	**0.690**	**0.001**	**0.001**	1.032
Median	**0.688**	**0.001**	**0.001**	**0.656**	**0.001**	**0.003**	**0.933**

Conclusions

- Cointegration holds
- A random walk is outpredicted
- Results improve at long horizons
- Results robust to alternative base currencies
- Monetary fundamentals outperform purchasing power parity fundamentals

V
Should Exchange Rates Be Predictable?

Predictability vs. forecastability

- Prediction is using ex post data
- Forecasting is prediction ex ante
- Efficient markets hypothesis says the random component of asset prices is not forecastable.
- But it does not preclude being able to predict t+j dated prices with t+j dated data.

PV once again

$$(2.1) \qquad s_t = (1-b)\sum_{j=0}^{\infty} b^j E_t(a_1' x_{t+j}) + b\sum_{j=0}^{\infty} b^j E_t(a_2' x_{t+j}), \quad 0 < b < 1$$

$$s_t = (1-b)m_t + b\rho_t + bE_t(s_{t+1}).$$

$$s_t = (1-b)\sum_{j=0}^{\infty} b^j E_t m_{t+j} + b\sum_{j=0}^{\infty} b^j E_t \rho_{t+j}$$

$$\Delta m_t = \phi \Delta m_{t-1} + \varepsilon_{mt}; \qquad \Delta\rho_t = \gamma \Delta\rho_{t-1} + \varepsilon_{\rho t}.$$

The exchange rate in PV form

(2.1) $$\Delta s_t = \frac{\phi(1-b)}{1-b\phi}\Delta m_{t-1} + \frac{1}{1-b\phi}\varepsilon_{mt} + \frac{b\gamma}{1-b\gamma}\Delta\rho_{t-1} + \frac{b}{(1-b)(1-b\gamma)}\varepsilon_{\rho t}.$$

Consider first the special case of $\rho_t = 0$. Then as $b \to 1$, $\Delta s_t \approx \frac{1}{1-\phi}\varepsilon_{mt}$. In this case, the variance of the change in the exchange rate is finite as $b \to 1$. If $\rho_t \neq 0$, then as $b \to 1$, $\Delta s_t \approx \text{constant} \times \varepsilon_{\rho t}$. In this case, as b increases, the variance of the change in the exchange rate gets large, but the variance is dominated by the i.i.d. term $\varepsilon_{\rho t}$.

What predicts what?

Bivariate Granger Causality Tests, Different Measures of Δf_t

Full Sample: 1974:1-2001:3

A. Rejections at 1%(***), 5% (**), and 10% (*) level of H_0: Δs_t fails to cause Δf_t

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Canada	France	Germany	Italy	Japan	U.K.
(1)	$\Delta(m-m^*)$		*		**	**	
(2)	$\Delta(p-p^*)$			***	***	***	
(3)	$i-i^*$		**			**	
(4)	$\Delta(i-i^*)$		**			***	
(5)	$\Delta(m-m^*)$ $-\Delta(y-y^*)$		*		*		
(6)	$\Delta(y-y^*)$						

The standard story fails

B. Rejections at 1%(***), 5% (**), and 10% (*) level of H_0: Δf_t fails to cause Δs_t

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Canada	France	Germany	Italy	Japan	U.K.
(1)	$\Delta(m-m^*)$						
(2)	$\Delta(p-p^*)$	*					
(3)	$i-i^*$					**	
(4)	$\Delta(i-i^*)$						
(5)	$\Delta(m-m^*)$ $-\Delta(y-y^*)$						
(6)	$\Delta(y-y^*)$						

Notes:

VAR approach

Rejections at 1%(***), 5% (**), and 10% (*)
Null Hypothesis A: Δs_t fails to cause Δf_t jointly
Null Hypothesis B: Δf_t jointly fail to cause Δs_t

VAR	Variables in VAR		Canada	France	Germany	Italy	Japan	U.K.
1	$\Delta(y-y^*)$, $\Delta(p-p^*)$, $i-i^*$	A		*	**	***	***	
		B						
2	$\Delta(y-y^*)$, $\Delta(p-p^*)$, $\Delta(i-i^*)$	A		**	*	***	***	
		B						
3	$\Delta(m-m^*)$, $\Delta(y-y^*)$	A		**				
		B						
4	$\Delta(m-m^*)$, $\Delta(y-y^*)$, $\Delta(p-p^*)$	A		**	*	***	*	
		B						
5	$\Delta(y-y^*)$, $\Delta(p-p^*)$	A			**	***		
		B						

VI
Some thoughts on policy analysis