Doing Justice to Fundamentals in Exchange Rate Forecasting: A Control over Estimation Risks

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Random Walk Beats Monetary Model!

- Meese and Rogoff (1983) starting the research documented that fundamentals little predict changes in exchange rates.
- Recent studies find some success for fundamentals-related models at longer-horizons.
  Univariate approach: Mark (1995), Chinn and Meese (1995);
  Panel approach: Groen (2000, 2005), Mark and Sul (2001)

Random Walk Beats Monetary Model!

- Some do not: Kilian (1999), Berkowitz and Giorgianni (2001).
- The success of the models has not proven to be robust.

Do We Have to Give Up?

⋯ "Our suggestion that the exchange rate will nearly follow a random walk ⋯ means that forecasting changes in exchange rates is difficult, but perhaps still <u>possible</u>." ⋯

quoted from Engel and West (2004).

Our View

- The conflicting findings are mostly due to differences in the econometric approach chosen.
- The divergence of results suggests a reconciliation between the approaches.

VECM

The monetary model has a VAR representation:

$$\triangle e_{it} = \beta_i^{(1)} x_{it-1} + \varepsilon_{it}^1,$$

$$\triangle x_{it} = \alpha_i x_{it-1} + \sum_{l=1}^{p_i} c_{il}^2 \triangle e_{it-1} + \sum_{l=1}^{p_i} d_{il}^2 \triangle x_{it-1} + \varepsilon_{it}^2,$$

e_{it} : log exchange rate for country i against US at time t.

$x_{it} = f_{it} - e_{it}$: deviation of log exchange rate from fundamental, f_{it}.

VECM

$$\triangle e_{it} = \beta_i^{(1)} x_{it-1} + \varepsilon_{it}^1,$$

$$\triangle x_{it} = \alpha_i x_{it-1} + \sum_{l=1}^{p_i} c_{il}^2 \triangle e_{it-1} + \sum_{l=1}^{p_i} d_{il}^2 \triangle x_{it-1} + \varepsilon_{it}^2,$$

- A cointegration exists between e_{it} and f_{it} with pre-specified vector $(1, -1)$, when $e_{it} \equiv \mathrm{I}(1)$, and $f_{it} \equiv \mathrm{I}(1)$.

Our Empirical Concerns

- Empirical validity of the monetary-related model.

  In-Sample: $\text{H}_0 : \beta_i^{(1)} = 0$.

  Out of Sample: $\text{H}_0 : \frac{\text{MSE(M.M.)}}{\text{MSE(R.W.)}}$

  $\text{H}_0 : \text{MSE(M.M.)} = \text{MSE(R.W.)}$

- Testing if e_{it} and f_{it} are cointegrated with $(1, -1)$.

  $\text{H}_0 : \beta_i^{(1)} = 0$ and $\alpha_i = 0$

Data Characteristics

Long-horizon regression:

$$e_{it} - e_{it-k} = \beta_i^{(k)} x_{it-k} + \varepsilon_{it},$$

$\mathsf{H}_0 : \beta_i^{(k)} = 0.$

- x_{it} is highly persistent.

	Canada	German	Japan	Swiss
AC of x_{it}	0.94	0.97	0.97	0.93

- $e_{it} - e_{it-k} = \sum_{j=0}^{k} \triangle e_{it-j}$ is overlapping sums of short-horizon $\triangle e_{it-j}$.

Estimation Risks

- LS estimation of $\beta_i^{(k)}$ is biased (Stambaugh, 1999).
- Overlapping sum: Small-sample distribution of LS estimator of $\beta_i^{(k)}$ is more dispersed with k. In some settings, inconsistency can be expected (Valkanov, 2003).
- It calls for an approach that can deal with the overall estimation risks, including bias and estimation errors.

Our Shrinkage Approach

We consider a Stein-like estimator for β_i

$$\tilde{\beta}_i = \omega_i \cdot \hat{\beta}_i + (1 - \omega_i) \cdot \bar{\beta},$$

where

$\hat{\beta}_i$: OLS estimator

$\bar{\beta}$: the pooled estimator

ω_i : shrinking factor.

The Idea

- $\hat{\beta}_i$ has lots of estimation errors, though asymptotically unbiased.
- $\bar{\beta}$ has larger bias but less estimation errors.
- The decision theory suggests that taking a proper weighted average between $\hat{\beta}_i$ and $\bar{\beta}$ produce less risks:

$$\text{MSE}\left[\tilde{\beta}_i\right] \leq \text{MSE}\left[\hat{\beta}_i\right]$$

The Advantage

- Like the panel-based estimator, it makes use of cross-sectional information.
- It is more flexible by allowing for seperate slope estimates $\tilde{\beta}_i$ for different countries, as the OLS estimator does.

Shrinkage Target

- The original Stein estimator for sample mean

$$\tilde{x} = (1 - \omega) \cdot \bar{x} + \omega \cdot c$$

where

$\bar{x}$: sample mean (unrestricted estimator)

c : constant (restricted estimator)

Shrinkage Target

- Here

$$\tilde{\beta}_i = (1 - \omega_i) \cdot \hat{\beta}_i + \omega \cdot \bar{\beta},$$

 where

 $\hat{\beta}_i$: the OLS estimator(unrestricted estimator)

 $\bar{\beta}$: the pooled estimator (restricted estimator)

- The constraint imposed in the estimator is

$$\beta_1 = \beta_2 = \cdots = \beta_N.$$

- Efficiency gains take place due to the constraint.

Why $\bar{\beta}$?

- Alternative shrinkage targets as constraints exist.
- The choice of $\bar{\beta}$ reflects a belief that β_i are different and near to each other.
- It is hard to tell which target works well a priori, without checking out-of-sample performance.

Shrinking Factor

- $\tilde{\beta}_i \underset{p}{\rightarrow} \beta_i$ so long as $\tilde{\omega}_i \underset{p}{\rightarrow} \omega_i$.
- Under the quadratic loss function,

$$
\begin{aligned}
\omega_i =& 1 - \frac{\sigma_{i,ls} + \gamma_{i,ls}^2 - \rho_i - \gamma_{i,ls}\gamma_{i,g}}{\sigma_{i,ls}^2 + \gamma_{i,ls}^2 + \sigma_{i,g}^2 + \gamma_{i,g}^2 - 2\rho_i - 2\gamma_{i,ls}\gamma_{i,g}}. \\
=& 1 - f\,(\text{biases of, variances of, and covariance} \\
& \qquad \text{between the 2 combined estimators})
\end{aligned}
$$

Shrinking Factor

- The weight adapts itself to the data, and controls information quality.
- Higher weight is given to $\bar{\beta}$ if $\hat{\beta}_i$ has higher bias or variance.

A Bootstrap Estimator for ω_i

- It is not clear how to estimate the biases using the asymptotic arguments.
- The asymptotic estimator, if available, may perform poor for the panel of short-spanned time series under study.

Risk Reductions

- To be realistic and to permit comparison, the DGP calibrated to that used in Kilian (1999) is adopted.

- Data

  It spans from 1973.I to 1997.IV.
  It contains the USD exchange rates of the Canadian dollar, the German mark, the Japanese yen, and the Swiss franc.
  The country number = 4.

Relative estimation risk (Shrinkage/LS)

Under H_0

Country/Horizons	1	4	8	12	16
MSE:					
Canada	0.686	0.733	0.730	0.755	0.772
Germany	0.547	0.617	0.591	0.611	0.615
Japan	0.572	0.644	0.607	0.618	0.634
Switzerland	0.659	0.717	0.731	0.744	0.755

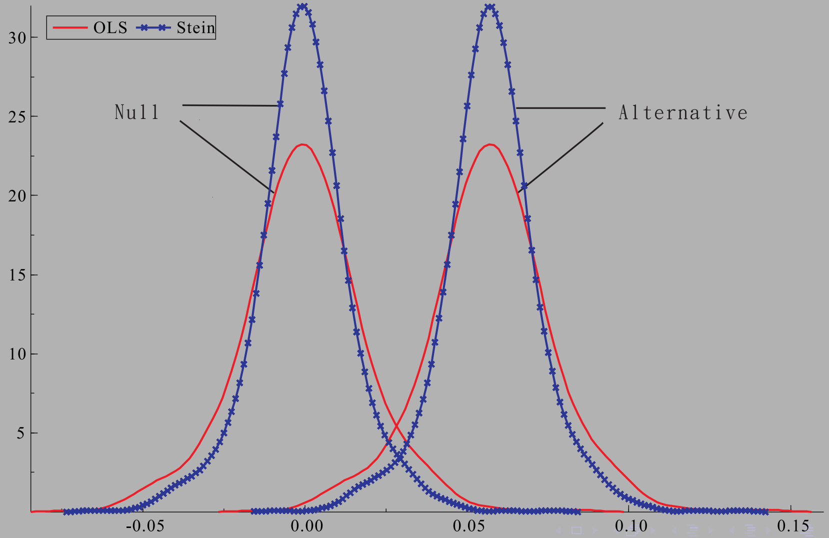
Under H_1

Country/Horizons	1	4	8	12	16
MSE:					
Canada	0.688	0.763	0.781	0.878	0.889
Germany	0.547	0.691	0.740	0.820	0.844
Japan	0.569	0.763	0.846	0.865	0.878
Switzerland	0.661	0.748	0.760	0.818	0.856

Messages that Emerges

- Under both H_0 and H_a, the shrinkage estimator dominates.
- The magnitude of the risk reductions is between 12% and 45%.
- The distributions of the shrinkage estimator are more centered.

The small-sample distributions of the shrinkage and OLS Estimators under H_0 and H_a



Power Performance of the Shrinkage Estimator

10% significance level

Country/Horizons	1	4	8	12	16
Canada	0.949	0.894	0.798	0.669	0.540
	(1.105)	(1.127)	(1.237)	(1.284)	(1.247)
Germany	0.903	0.833	0.747	0.628	0.540
	(1.313)	(1.266)	(1.284)	(1.165)	(1.127)
Japan	0.898	0.843	0.802	0.692	0.634
	(1.311)	(1.224)	(1.221)	(1.142)	(1.114)
Switzerland	0.934	0.896	0.797	0.625	0.475
	(1.104)	(1.097)	(1.191)	(1.240)	(1.247)

Power Gains

- The power gains from using the shrinkage estimator are between 10% and 30%.
- The predictability alternative can now be better detected by test statistics based on the estimator.

Testing Strategy for the Predictability

- Bootstrap inference is employed.
- The asymptotic theory for the estimator has not yet been developed in the presence of high persistence and overlapping sums.
- It follows the literature.

Full-sample Estimation Results and Tests for Cointegration

stat	$\tilde{\beta}_i$[a]	p-value[b]	R^2	p-value[c]	$\hat{\beta}_i$	$\bar{\beta}$	$\hat{\omega}_i$	std($\hat{\omega}_i$)[d]
Canada:								
1	0.035	**0.000**	0.035	**0.010**	0.030	0.048	0.713	0.222
4	0.132	**0.000**	0.103	**0.005**	0.106	0.199	0.721	0.239
8	0.289	**0.001**	0.217	**0.008**	0.238	0.420	0.720	0.214
12	0.376	**0.003**	0.192	**0.028**	0.290	0.619	0.738	0.231
16	0.384	**0.008**	0.131	**0.068**	0.291	0.789	0.812	0.263
Germany:								
1	0.047	**0.000**	0.036	**0.024**	0.045	0.048	0.044	0.268
4	0.196	**0.000**	0.119	**0.005**	0.178	0.199	0.150	0.285
8	0.421	**0.002**	0.213	**0.015**	0.385	0.420	-0.040	0.316
12	0.619	**0.003**	0.339	**0.019**	0.617	0.619	-0.046	0.331
16	0.792	**0.002**	0.483	**0.012**	0.832	0.789	0.084	0.328

Full-sample Estimation Results and Tests for Cointegration

stat	$\tilde{\beta}_i$	p-value	R^2	p-value	$\hat{\beta}_i$	$\bar{\beta}$	$\hat{\omega}_i$	std$(\hat{\omega}_i)^d$
Japan:								
1	0.048	**0.000**	0.037	**0.027**	0.049	0.048	0.044	0.274
4	0.199	**0.004**	0.121	**0.002**	0.207	0.199	0.012	0.292
8	0.418	**0.007**	0.229	**0.004**	0.454	0.420	-0.068	0.322
12	0.609	**0.010**	0.311	**0.009**	0.717	0.619	-0.109	0.330
16	0.766	**0.012**	0.375	**0.016**	0.947	0.789	-0.140	0.364
Switzerland:								
1	0.072	**0.000**	0.064	**0.001**	0.087	0.048	0.618	0.315
4	0.277	**0.000**	0.221	**0.001**	0.336	0.199	0.572	0.333
8	0.548	**0.000**	0.367	**0.004**	0.634	0.420	0.596	0.309
12	0.794	**0.000**	0.520	**0.005**	0.874	0.619	0.688	0.282
16	1.052	**0.000**	0.721	**0.001**	1.090	0.789	0.875	0.300

Full-Sample Estimations

- All the slope estimates are all shrunk toward the pooled estimates.
- The OLS estimates receive essentially "0" weight for the Germany and Japan cases.
- For the Canada case, the OLS estimates appear to be more reliable.
- $\tilde{\beta}_i$ increase with the forecast horizon k, a potential sign for the predictability.
- The estimated $\tilde{\beta}_i$ vary, a reflection of the belief.

Cointegration Testing Based on the Estimator

- No cointegration, not predictable.
- Most of the estimated coefficients are significantly different from 0 at 5%, evidence for cointegration.
- P-values of R^2 show the same pattern.
- Cointegration does not imply predictability however.

Out-of-Sample Forecast Evaluations: DM Statistic

Country	k	DM(20)	p-value	DM(20)^K	p-value
Canada	1	4.560	**0.000**	1.270	**0.027**
	4	1.802	**0.027**	1.144	**0.048**
	8	1.304	**0.071**	2.163	**0.016**
	12	-0.511	0.326	1.156	**0.070**
	16	-1.286	0.594	0.750	0.117
	max	4.560	**0.014**	2.163	**0.056**
Germany	1	1.255	**0.065**	0.244	0.141
	4	0.806	0.113	0.261	0.160
	8	0.493	0.166	-0.098	0.216
	12	0.567	0.181	-0.283	0.250
	16	0.740	0.197	-0.586	0.314
	max	1.255	0.210	0.261	0.268

Out-of-Sample Forecast Evaluations: DM Statistic

Country	k	DM(20)	p-value	DM(20)^K	p-value
Japan	1	1.154	**0.072**	0.643	0.104
	4	0.783	0.133	0.414	0.144
	8	0.868	0.145	0.620	0.133
	12	0.703	0.168	-0.215	0.269
	16	0.687	0.173	-0.976	0.433
	max	1.154	0.230	0.643	0.253
Switzerland	1	3.548	**0.004**	1.871	**0.023**
	4	3.158	**0.009**	2.026	**0.024**
	8	2.586	**0.013**	1.911	**0.039**
	12	1.988	**0.031**	1.698	**0.064**
	16	1.476	**0.081**	1.413	**0.097**
	max	3.548	**0.025**	2.026	**0.089**

Out-of-sample forecast evaluations: Theil's U

Country	k	Theil's U	p-value	Theil's U^K	p-value
Canada	1	0.972	**0.009**	0.986	**0.042**
	4	0.934	**0.023**	0.967	**0.068**
	8	0.896	**0.038**	0.912	**0.057**
	12	1.062	0.544	0.947	**0.094**
	16	1.177	0.750	0.981	0.151
	min	0.896	**0.091**	0.912	0.137
Germany	1	0.986	**0.031**	0.997	0.150
	4	0.965	**0.056**	0.989	0.169
	8	0.952	**0.082**	1.014	0.218
	12	0.871	**0.046**	1.091	0.291
	16	0.740	**0.014**	1.285	0.473
	min	0.740	**0.015**	0.989	0.283

Out-of-sample forecast evaluations: Theil's U

Country	k	Theil's U	p-value	Theil's U^K	p-value
Japan	1	0.985	**0.021**	0.990	0.118
	4	0.964	**0.063**	0.977	0.157
	8	0.925	**0.056**	0.944	0.145
	12	0.891	**0.060**	1.037	0.274
	16	0.844	**0.044**	1.278	0.534
	min	0.844	**0.052**	0.944	0.250
Swizerland	1	0.973	**0.013**	0.969	**0.017**
	4	0.920	**0.015**	0.902	**0.029**
	8	0.863	**0.013**	0.846	**0.045**
	12	0.809	**0.007**	0.751	**0.030**
	16	0.701	**0.002**	0.668	**0.026**
	min	0.701	**0.003**	0.668	**0.031**

Out-of-Sample Forecast Evaluation Adjusted for Risks

- $\text{DM} = \text{MSE(M.M.)} - \text{MSE(R.W.)}$

  $$\text{U} = \frac{\text{MSE(M.M.)}}{\text{MSE(R.W.)}}$$

- Evidence for predictability

  DM and U decrease as forecast horizons increase.

- Results for DM show short-horizon predictability for all the countries, except Swiss.

  This is similar to Kilian's findings.

Out-of-Sample Forecast Evaluation Adjusted for Risks

- With the Theil' U, clear and significant evidence for predictability, both short- and long-horizons, is established for almost all the countries.

  The findings are in contrast to what have been reported, particularly for the German and Japan Case.
- The Kilian's U results for the predictability are mixed.

Out-of-Sample Forecast Evaluation Adjusted for Risks

- Which test to look at?

  DM is subject to problems because of imprecise estimations of long-run variance (Berben and Dijk, 1998).

  The recent literature report only Theil's U now.

Conclusion

- Estimation risk matters.
- A good control of the risks converts into power gains when testing for exchange rate predictability.
- The shrinkage estimator enjoys risk reductions by exploiting cross-sectional information as the panel-based estimator, and allows for parameter heterogeneity that the panel-based estimator can not.

Conclusion

- Clear and uniform evidence for the exchange rate predictability can now be uncovered.
- Yes, fundamental helps predict exchange rate.