Asian Development Outlook growth and inflation forecast errors

Introduction

This technical note is the third of a series of such notes that evaluates the forecast performance of the *Asian Development Outlook (ADO)*. Previous evaluations have focused on measuring forecasting quality. Current- and next-year forecasts of real gross domestic product (GDP) growth and inflation were assessed in terms of numerical and directional accuracy. Two points emerge. First, forecast accuracy has improved over time although there is a tendency for *ADO* to underpredict growth and overpredict inflation. Second, although *ADO* has been fairly successful in predicting the direction of change, large forecast errors are still observed during sharp changes in outcomes, especially during downturns.

Working from the above results, this note identifies the possible sources of forecast errors. Given that the structures of both local and global economies have been changing, is there a relationship between the behavior of other macroeconomic variables and forecast errors? And if so, how can this information be used to improve forecasting?

General statistical features of forecast errors

Inference in this note will be drawn from a sample of 15 economies in developing Asia[1] with available forecasts for real GDP growth and inflation for the period 1990–2007. Forecasts are compared to first-release actual figures of GDP growth and inflation to avoid mixing the question of forecast quality with problems of data revisions.

As in previous technical notes, forecast errors are defined as outcomes less forecasts, so that a positive error indicates underprediction and a negative error indicates overprediction. Two types of forecast errors are considered—current- and next-year. The current-year forecast error in year *t* is the difference between the actual number in year *t* and the forecast made in *ADO* year *t*. The next-year forecast error is the difference

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between the actual number in year *t* and the forecast made in *ADO* year *t-1*. As an example, the current-year forecast error in GDP growth in 2007 is the difference between actual growth in 2007 and the forecast made in *ADO 2007*. The next-year forecast error is the difference between actual growth in 2007 and the forecast made in *ADO 2006*.

Seven general measures to evaluate forecasts of real GDP growth and inflation of the 15 economies as a whole, for the period 1990–2007, are presented in Table 4.1.1. The mean forecast error measures the average deviation of the forecast from its realization. It is commonly used to measure forecast accuracy but suffers from sensitivity to extreme values as it may give misleading results if positive and negative forecast errors cancel each other out. Alternative measures that disregard arithmetic signs are the mean absolute error (MAE) and the root-mean-square error (RMSE). The MAE gives equal weight to all errors while the RMSE gives greater weight to large errors. This means that the RMSE is most useful when large errors are particularly undesirable.

Used together, the MAE and the RMSE can be used to evaluate the variation in the forecast errors. The greater the difference between these two measures, the greater the variance in individual errors. The variance of forecasts errors should be expected to decline as the forecast horizon shortens.

The last four measures as given in Table 4.1.1 are often used to check on the presence of bias and to evaluate the efficiency of forecasts. The fraction of positive errors indicates the degree of overestimation or positive bias. This is further tested by regressing the forecast error on a constant α. Unbiasedness requires α=0.

4.1.1 Forecast errors, 1990–2007

	Real GDP growth				Inflation			
	Current-year		Next-year		Current-year		Next-year	
Mean	0.24		-0.23		-0.40		-0.12	
Mean absolute error	1.51		2.05		2.15		3.21	
Root mean square error	2.32		3.32		4.17		6.22	
Fraction of positive errors	0.66		0.52		0.39		0.47	
α	0.24	*	-0.23		-0.40		-0.12	
	(1.73)		(-1.13)		(-1.60)		(-0.31)	
β	0.05	**	-0.06	*	-0.01		0.03	
	(1.96)		(-1.76)		(-0.36)		(0.70)	
δ	0.06		0.14	**	0.27	***	-0.05	
	(0.95)		(2.32)		(4.86)		(-0.89)	

Notes: *, **, *** denote significance of the coefficient at the 90%, 95%, and 99% levels, respectively.
α = Coefficient obtained by regressing forecast errors on a constant. β = Coefficient obtained by regressing forecast errors on the forecasts. δ = First-order autocorrelation.
Source: Staff calculations.

The tests for efficiency involves regressions of the forecast errors on the forecasts themselves and the current forecast error on its lag value. Efficiency requires that both β and δ are not significantly different from zero (OECD 1993). In other words, the forecast error should be uncorrelated with the forecast and should be independent of past error values.

Forecast errors for real GDP growth

The current-year mean forecast error is relatively small, at less than a quarter percentage point. It is positive with *ADO* forecasts underestimating real GDP growth by 0.2 percentage points on average.

The majority of the current-year forecasts are underpredicted, as shown by the high fraction of positive errors. This positive bias is reaffirmed by the statistical significance of α. Aside from being biased, current-year forecasts are found to be positively correlated with the forecast (β being significantly different from zero). In other words, current-year forecast errors are predictable and a forecaster can very well reduce the errors by not making large forecasts.

Next-year mean forecast errors are negative. But this does not mean that next-year's overall mean forecast error is smaller and hence more accurate than current-year forecasts. It is just that large positive and negative forecast errors cancel each other out. In fact, the MAE and the RMSE are larger for next-year forecasts and their difference higher, suggesting greater volatility of the errors. Though not biased like current-year forecasts, they are nonetheless inefficient as next-year forecast errors are negatively correlated with the forecast and positively correlated with its past values (i.e, β and δ are both statistically significant).

Forecast errors for inflation

A negative overall mean forecast error suggests a general tendency for *ADO* to overpredict inflation. But again this measure may be affected by the presence of outliers as indicated by a relatively large RMSE. In terms of the proportion of current-year forecasts making positive errors, only 39% are underestimates. The proportion increases to 47% for next-year forecasts. Both current- and next-year forecasts are unbiased but the former do not take sufficiently into account the size and structure of past errors (in most cases, overpredictions of inflation). The forecasters may have failed to realize that the inflation environment has already changed and the parameters on which they are basing their forecasts are no longer consistent with it.

Magnitude of forecast errors

Although forecast errors are small on average, their range varies widely across countries and years. Furthermore, large forecast errors tend to be concentrated in certain years (Table 4.1.2), suggesting a possible case for analyzing domestic and external developments. For example, both GDP growth and inflation forecasts tend to be overestimated in 1997 and 1998 when the Asian financial crisis revealed fundamental weaknesses in the structure of several regional economies. Southeast Asian currencies came under severe speculative attack and depreciated substantially. (There were also some contagion effects as the crisis was not limited to Southeast Asia.) Some countries simultaneously implemented tight monetary policies to counter capital outflows and stabilize their currencies. In contrast in 1999, growth was underpredicted while inflation remained overpredicted as forecasters failed to anticipate the speed and magnitude of recovery that resulted from expansionary macroeconomic policies, improved external demand, and the lowering of prices due to increased agricultural production and exchange rate stability.

4.1.2 Years with large forecast errors

Economy	GDP growth				Inflation			
	Current year		Next-year		Current year		Next-year	
PRC	1990	-	1990	-	1990	-	1993	+
	1991	+	1992	+	1991	-	1994	+
	1992	+	1993	+	1993	+	1995	+
	1997	-			1994	+	1997	-
							1998	-
							1999	-
HKG	1998	-	1998	-	1990	+	1991	+
	1999	+	2000	+	1991	+	1999	-
	2000	+	2001	-	1999	-	2002	-
	2001	-	2004	+	2000	-		
					2001	-		
KOR	1990	+	1998	-	1990	+	1990	+
	1998	-	1999	+	1992	-	1991	+
	1999	+	2000	+	1995	-	1993	-
					1998	-	1999	-
					2001	+	2005	+
TAP	1991	+	2001	-	1991	-	1991	-
	2001	-	2007	+	1992	+	1994	+
					1994	+	1997	-
					1997	-	2003	-
					2004	+	2004	+
							2005	+
BAN	1991	-	1990	+	1990	-	1990	-
	1994	-	1991	-	1991	-	1993	-
	1996	+	1999	-	1992	-	1995	+
	1998	-	2002	-	1995	+	1998	+
	1999	+	2004	+	1998	+	2001	-
	2000	+	2006	+				
			2007	+				
IND	1991	-	1991	-	1991	+	1991	+
	1994	+	1997	-	1994	+	1994	+
	1997	-	2002	-	1996	-	1996	-
	2000	-	2005	+	1997	-	1997	-
	2002	-	2006	+	1999	-	1998	-
	2003	+					1999	-
	2005	+						
	2006	+						
NEP	1990	+	1991	+	1990	-	1991	+
	1998	-	1995	-	1991	+	1992	+
	2002	-	1998	-	1993	-	1993	-
			2000	+	1994	+	1998	-
			2005	-	1998	-	1999	+
					1999	+	2000	-
					2001	-	2006	+
PAK	1993	-	1992	+	1990	-	1990	-
	1997	-	1993	-	1992	+	1991	+
	2001	-	1997	-	1994	+	1995	+
	2004	+	2001	-	1995	+	1999	-
	2005	+	2004	+	1996	-	2000	-
			2005	+	1998	-	2005	+
					1999	-		
					2005	+		
SRI	1990	+	1996	-	1990	+	1990	-
	2001	-	2001	-	1991	-	1991	+
	2006	+	2006	+	1999	-	1995	+
					2003	-	1999	-
					2004	+	2000	-
					2007	+	2005	+
INO	1997	-	1998	-	1998	+	1998	+
	1998	-						
MAL	1998	-	1998	-	1990	-	1998	+
	1999	+	2000	+	1991	+	2000	-
	2001	-	2001	-	1999	-	2001	-
					2000	-	2005	+
					2005	+	2006	+
PHI	1990	-	1991	-	1992	-	1990	+
	1991	-	1992	-	1993	-	1991	+
	1992	-	1998	-	2004	+	1992	-
	1998	-	2004	+	2005	+	2007	-
	2004	+	2007	+				
	2007	+						
SIN	1993	+	1994	+	1998	-	1990	+
	1998	-	1998	-	2004	+	1994	+
	1999	+	2000	+	2007	+	1998	-
	2001	-	2001	-			1999	-
							2002	-
							2004	+
THA	1997	-	1997	-	1998	-	1998	+
	1998	-	1998	-	1999	-	1999	-
	1999	+	2003	+			2000	-
	2002	+						
VIE	1990	-	1991	-	1990	-	1990	-
	1991	+	1992	+	1991	-	1991	+
	1992	+	1993	+	1994	+	1992	-
	1997	-	1997	-				
			1998	-				
			1999	-				

+ = underestimation; - = overestimation. BAN = Bangladesh; PRC = China, People's Rep. of; HKG = Hong Kong, China; IND = India; INO = Indonesia; KOR = Korea, Rep. of; MAL = Malaysia; NEP = Nepal; PAK = Pakistan; PHI = Philippines; SIN = Singapore; SRI = Sri Lanka; TAP = Taipei,China; THA = Thailand; VIE = Viet Nam.

Note: "Large" in the table title denotes a forecast error differing by more than one standard deviation from the mean.

Source: Staff calculations.

Large forecast errors were made not only during the financial crisis but also during the early 1990s, when many countries were adversely affected by generally slower growth in the world economy and higher oil prices following the onset of the Gulf crisis.

Sources of forecast errors

The estimation procedure in this note follows essentially that of Andersen (1997) who analyzed the relationship between next-year forecast errors and financial developments using individual time-series data of the G7 countries. His results show that unexpected changes in nonfinancial variables are the primary source of forecast errors. However, forecasts can also be improved by using information on changes in the yield curve and information on movements in exchange rates and asset prices.

This note regresses forecast errors not only on financial and monetary variables but also on variables that pertain to domestic and political stability, globalization, and external vulnerability. Data are pooled across countries and across years to overcome sample size problems and provide more robust estimates. Separate regressions on current- and next-year forecast errors on real GDP growth and inflation are done.

$$Y_{it} = \alpha + W_{it}'\beta + X_{it}'\gamma + Z_{it}'\delta + \lambda_i + \varepsilon_{it}$$

where

Y	=	forecast error on real GDP growth or inflation for country i for year t
W	=	vector of variables representing domestic factors
X	=	vector of variables representing external factors
Z	=	vector of "technical" variables
λ	=	cross-section differential intercepts
ε	=	random error of regression

Domestic factors

%ΔM2	annual percentage change of M2 or M3 money supply
LENDRATE	lending rate
EXCHRATE	annual average exchange rate
EXCHVOLA	standard deviation of the month-on-month percentage change of the exchange rate
STOCKVOLA	standard deviation of the month-on-month percentage change of the stock price index
GAP	difference between actual and potential real GDP (constructed using a Hodrick-Prescott filter), expressed as a percentage of potential real GDP
OPENNESS	total trade as a percentage of GDP

Changes in money supply and interest rates capture the effects of changes in monetary policies. Increasing inflation pressures force central banks to tighten monetary policies to damp demand. This in turn negatively affects output. The ability to predict the magnitude and the length of the transmission lags from monetary policy to output and inflation has a bearing on the precision of forecasts.

The exchange rate affects aggregate demand and prices. Depending

on the reasons for and the persistence of exchange rate movements, central banks determine the appropriate monetary policy response. The volatility of exchange rates and stock prices serves as a measure of the economic and political stability of a country (Schwert 1989, Bittlingmayer 1998, Schnabl 2007). The output gap is included in the inflation forecast equation to account for domestic demand pressures. If output gap is positive, meaning there is excess demand, there will be upward pressure on the costs of the factors of production as the economy increases its utilization, which will then lead to higher prices of goods and services.

Trade openness is used as an indicator of trade policy measures in the growth forecast equation. According to di Giovanni and Levchenko (2006) trade openness has a positive and significant effect on output volatility. They estimate its impact to be five times more in developing countries than in developed ones. In the same vein, Bowdler and Malik (2005) find a negative relationship between trade openness and inflation volatility. According to them, trade openness reduces inflation volatility by providing incentives for policy makers to create a more stable macroeconomic framework and by providing a wider variety of goods and services, thus avoiding sector-specific price shocks. Increases in output and inflation volatility add to the complexity of forecasting and consequently the possibility of committing forecast errors.

External factors

OILVOLA	standard deviation of the month-on-month percentage change of Brent crude prices
FOODVOLA	standard deviation of the year-on-year percentage change of the International Monetary Fund commodity food price index
DELTAUSGDP	change in GDP growth of the United States (US) (in percentage points)

These variables capture the effect of changes in global factors in the accuracy of the forecasts. The change in the real GDP of the US is put as a control variable for the forecast error in the growth forecast equation given the size of the US in the global economy. Indeed, the changing structure of the world economy introduces new and unpredictable sources of error that further complicate the job of the forecaster.

"Technical" variables

"Technical" variables are nonfinancial and nonmonetary variables that try to capture the biases and inefficiencies of the forecasters in making their forecasts. Three variables are included:

DELTAGDP/ DELTAINF	change in GDP growth or change in rate of inflation (in percentage points);
LAGERROR	lagged forecast error; and
ERROR14	average forecast error for the other 14 economies

The change in GDP growth or in inflation is included to validate the observation in *ADO 2006 Update* (p. 134) that "forecasts tend to miss the

mark most when there are sharp changes in outcomes." Forecasters are said to be biased against deviating too much from the mean or against taking extreme positions. This variable can also be a measure of the forecasters' assessment of the speed by which output or prices respond to policy changes. Past forecast errors are included to test if forecasters make use of past information in predicting the future while the average forecast error for the other 14 economies tests if forecast errors are correlated across economies.

Admittedly, the list of variables is not exhaustive. There are numerous sources of forecast errors and it will be impossible to identify all or even most of them.[2] Another limitation is borne out by the fact that the dependent variable is a derived variable, i.e., it is the difference between the actual outcome of an unknown real world model and the predicted outcome of a forecasting model. Consequently, it is difficult to assign the precise meaning to an estimated coefficient—whether it is due to a shock or a model specification error (Andersen 1997). The value then of the exercise is to provide guideposts as to how forecasts can be improved.

Empirical results

Tables 4.1.3 and 4.1.4 show the results of pooled regressions for both current- and next-year forecasts over the period 1990–2007. The regressions use the White estimator to correct for heteroskedasticity and serial correlation in the residuals. Corresponding t-statistics are italicized and recorded below the coefficient estimates. The asterisks indicate the rejection of the null hypothesis that the coefficient is equal to zero.

From these tables, one can see the improvement of the estimation as more variables are included. In particular, the inclusion of the technical variables greatly improves the estimation as the standard errors are markedly reduced and R^2 rises significantly. This is more evident in the growth forecast equation than in the inflation forecast equation where one can see the improvement of the adjusted R^2 from 29% to 86% (36% to 95%) in the current-year (next-year) GDP growth forecast error equation versus an improvement from 39% to 64% (35% to 77%) in the current-year (next-year) inflation forecast error equation.

These results highlight the greater difficulty of identifying potential sources of errors in inflation forecasts. This can be attributed to the change in the reaction function of the monetary authorities in response to inflation signals given by the significant variables and to feedback effects of changes in monetary instruments (Andersen 1997). But for both real GDP and inflation equations, the predictive power of the variables chosen is higher for next-year than current-year forecast errors.

Technical variables explain a greater part of the current-year forecast errors for GDP growth but not for inflation. Suppressing financial and monetary variables in the estimation, "technical" variables explain 81% of current-year GDP growth forecast errors as compared to 26% of current-year inflation forecast errors. In other words, domestic variables (which are mostly financial and monetary policy variables) have more influence on forecast errors for inflation than for GDP growth.

4.1.3 Regression results (real GDP growth forecast errors)

Real GDP growth forecast	Current year						Next year					
	A		B		C		A		B		C	
Common intercept term	0.62		-0.72		0.67		-0.05		-2.32		-0.51	
	0.47		-0.56		1.68	*	-0.02		-0.99		-0.85	
Nonfinancial/technical factors												
DELTAGDP					0.58	***					0.99	***
					15.15						39.15	
LAGERROR					0.36	***					0.73	***
					12.03						20.58	
ERROR14					0.05						0.11	***
					1.05						2.81	
Domestic factors												
%ΔM2	0.03		0.03		0.02	***	0.02		0.02		0.01	
	1.41		1.48		2.79		0.57		0.64		1.55	
LENDRATE	-0.13	**	-0.11	*	-0.05	**	-0.14		-0.11		0.03	*
	-2.23		-1.93		-4.63		-1.34		-1.03		1.80	
EXCHVOLA	-0.38	***	-0.37	***	-0.02		-0.68	***	-0.66	***	-0.05	**
	-5.20		-5.21		-0.63		-5.80		-5.84		-2.00	
EXCHRATE	0.00	***	0.00	***	0.00	***	0.00	***	0.00	***	-0.00	
	-9.97		-10.45		-3.35		-8.93		-9.15		-0.87	
OPENNESS	0.01		0.01		0.00		0.02		0.02		0.00	
	1.22		1.30		0.30		1.31		1.34		0.35	
STOCKVOLA	0.05		0.05		0.03	***	0.05		0.06		-0.01	
	0.94		1.08		2.74		0.49		0.58		-0.92	
External factors												
OILVOLA			0.09	*	-0.06	**			0.12		0.02	*
			1.86		-2.01				1.60		0.57	
FOODVOLA			0.06	**	0.00				0.15	***	-0.04	
			2.20		-0.12				3.81		-1.38	
DELTAUSGDP			0.28	***	-0.07				0.31	***	0.13	***
			3.42		-1.45				3.97		3.31	
Adj. R^2	**0.29**		**0.31**		**0.86**		**0.36**		**0.39**		**0.95**	
Standard error	**1.97**		**1.93**		**0.88**		**2.78**		**2.72**		**0.79**	

Notes: *, **, *** denote significance of the coefficient at the 90%, 95%, and 99% levels, respectively. A = Forecast error regressed against domestic factors only. B = Forecast error regressed against domestic and external factors only. C = Forecast error regressed against all variables.

Source: Staff calculations.

GDP growth

The first set of results (Table 4.1.3, column A) focuses on the influence of domestic factors by suppressing all the other variables. The most significant domestic variable is the movement of the exchange rate, which enters the equation negatively. A more volatile exchange rate is associated with the overestimation of GDP growth. Exchange rate volatility is often linked to uncertainty, which negatively affects growth via its effects on trade, investment, and macroeconomic stability (Schnabl 2007). It is the underestimation of these transmission effects that results in an overestimation of GDP growth. In the same manner, currency appreciation is associated with an overestimation of GDP growth, but the effect is almost nil. The forecasters may be associating a strong currency with strong growth, hence the overestimation of GDP growth. By the same token, a tighter monetary policy, as exemplified by a higher lending

rate, is associated with the overestimation of GDP growth, and in this case, this may reflect the tendency of forecasters to underestimate the damping effect of tight monetary policy on aggregate demand.

The second regression (Table 4.1.3, column B) now adds external factors. The explanatory power of the equation improves, as seen by the increase in the R^2 and the decrease in the standard errors, though the improvement is marginal. The same set of domestic factors is found to be significant. The significance of DELTAUSGDP suggests the tendency for forecasters to underestimate the positive effect of a US economic expansion to Asian economies, while the volatility of global commodity prices makes it more difficult to estimate the pass-through effects of global inflation to the real economy.

Technical variables are then included in the third regression (Table 4.1.3, column C). Note the significant changes in the R^2 and standard errors. Also, some of the domestic and external factors that appear significant in the first two equations are now insignificant or appear with the sign reversed (such as OILVOLA). The most significant variable is the change in the growth rate (DELTAGDP), reflecting the difficulty of predicting sudden and sharp changes in outcomes and the forecasters' reluctance to predict "large" changes relative to historical rates. Past forecast errors also are significant, confirming what was said in *ADO 2006 Update* "that the future is often assumed to be much like the present" (p. 135). Positive correlation between forecast errors and that of the other economies is observed but is statistically insignificant.

In addition to lending rate and exchange rate, changes in money supply and stock price volatility enter the equation positively. A faster growth of monetary aggregates than in the previous period is associated with underestimation of GDP growth. This suggests that forecasters may be underestimating the stimulating effect on spending of a rise in money supply growth. The damping effect of political uncertainty (as captured by the volatility of stock prices) on the real economy is overstated, again leading to an underprediction of real GDP growth.

The change in the sign of the oil volatility variable can indicate possible correlation with the technical variables. Taken as it is, the effect of the uncertainty in the global economy to the real economy (or the vulnerability of the real local economy to global risk factors) is understated, leading to an overprediction. However, despite an R^2 of 0.86, the equation may still be misspecified, as the positive and significant common constant term indicates additional but unknown sources of underprediction.

With regard to next-year forecast errors, only ERROR14 (the correlation with errors of other economies) is added to the set of variables affecting next-year forecast errors. This may reflect the herd mentality of forecasters (their tendency not to go against the tide). This is particularly true for forecasting variables with less available information to base forecasts on. In an earlier study, Ashiya and Doi (2001) link the herd behavior of Japanese economists to the characteristic of Japanese society to criticize nonconformists. They further cite anecdotal evidence of Japanese economists being questioned by supervisors only when they make forecasts different from other forecasters in the same industry. Thus to avoid being in this situation, they make forecasts similar to others'.

4.1.4 Regression results (inflation forecast errors)

Inflation forecast	Current year						Next year					
	A		B		C		A		B		C	
Common intercept term	-1.56		-2.65	**	1.75		-4.53	***	-6.58	***	-4.53	*
	-1.56		-2.30		*0.99*		*-5.46*		-5.30		-1.77	
Nonfinancial/technical factors												
DELTAINF					0.32	***					0.72	***
					4.19						14.90	
LAGERROR					0.16						0.29	*
					1.26						1.75	
ERROR14					-0.13						0.19	***
					-1.00						2.73	
Domestic factors												
%ΔM2	0.07		0.07		0.03		0.13	***	0.13	***	-0.03	
	1.34		1.34		0.92		2.70		2.74		-0.92	
LENDRATE	-0.05		-0.03		-0.14		0.16	*	0.17	**	0.45	**
	-0.74		-0.46		-1.40		1.84		2.09		2.21	
EXCHVOLA	0.75	***	0.77	***	0.52	***	0.92	***	0.94	***	0.18	**
	4.96		5.23		3.52		5.50		6.03		2.22	
EXCHRATE	0.00	*	0.00		0.00	***	0.00	**	0.00	**	0.00	***
	1.66		1.58		2.70		2.20		2.56		2.64	
GAP	0.01		0.00		0.05		-0.09		-0.09		-0.01	
	0.14		-0.05		0.76		-0.71		-0.78		-0.24	
STOCKVOLA	-0.08		-0.07		-0.06		-0.11		-0.10		-0.05	
	-0.80		-0.75		-0.83		-1.03		-0.93		-0.81	
External factors												
OILVOLA			0.00		-0.25	**			0.11		-0.01	
			0.06		-2.28				1.11		-0.06	
FOODVOLA			0.14	*	0.09				0.15		0.04	
			1.80		1.34				1.63		0.67	
Adj. R^2	**0.39**		**0.39**		**0.64**		**0.35**		**0.35**		**0.77**	
Standard error	**2.81**		**2.81**		**2.20**		**4.60**		**4.60**		**2.80**	

Notes: *, **, *** denote significance of the coefficient at the 90%, 95%, and 99% levels, respectively. A = Forecast error regressed against domestic factors only. B = Forecast error regressed against domestic and external factors only. C = Forecast error regressed against all variables.

Source: Staff calculations.

Inflation

The explanatory variables are similar to those identified for output growth but the results are quite different in the sense that suppression of external factors and technical variables leaves the exchange rate (movement and level) as the only significant factor. Most of the underprediction of inflation is attributed to the underprediction of the impact of the exchange rate on inflation. Although the exchange rate is only marginally significant, the sign of the coefficient implies that the inflation effect of the depreciation of a currency is larger than predicted. The equation including all variables points to an underprediction of the degree of deceleration (DELTAINF), together with an overprediction of the effects of the uncertainty in global oil prices as additional sources of forecast errors.

The result of regressions on next-year forecast errors reveals an interesting result—the lag effects of monetary policy on inflation. This may be compared with the insignificance of the current monetary

policy variables on current-year forecast errors. For next-year forecast errors, regressions on domestic factors only and then on domestic and external factors reveal the same significant effects of money supply growth, lending rate, and exchange rate. The effect of money supply growth is understated. Similarly, the damping effect of tighter monetary conditions (higher lending rate) is overstated (or assumed to happen with a shorter time lag), leading to an underestimation of inflation. Ignoring exchange rate effects on inflation also causes actual inflation to exceed the predicted rate. However, R^2 is only 0.35, suggesting the need to include technical variables in indentifying possible sources of prediction errors.

The significance of money supply disappears when technical variables are included. All technical variables are significant and tend to be underpredicted. The positive significant influence of changes in the inflation rate (in both current- and next-year forecast errors) suggests that forecasters may be overestimating the speed with which inflation respond to changes in monetary policy. Information on past inflation errors is not sufficiently taken into account. Similar to next-year growth forecast errors, there is evidence that next-year inflation errors are correlated across countries, possibly reflecting the inclination not to deviate from majority or consensus opinion.

Although there is much improvement in the explanatory power when external factors and technical variables are included in next-year forecast error equations, the negative significant intercept term is indicative of additional unknown sources of overestimation.

Summary and conclusions

This technical note has examined the relationship between economic and noneconomic factors on the one hand and forecast errors on the other, and identifies the possible sources of such errors. The hope has been to provide ways to improve forecasts of GDP and inflation. Although the type of analysis in the note does not allow unambiguous isolation of the factors that have caused the errors in forecasting, the analysis points to several conclusions that may be worth considering in order to improve GDP and inflation forecasts.

First, the empirical results show that there is a relationship between the behavior of macroeconomic variables and forecast errors. The domestic variables that are most frequently related to forecast errors are money supply, interest rates, and exchange rates. There is also empirical evidence that external factors are relevant to the determination not only of output but also of domestic inflation. These large exogenous shocks can cause a structural break in the economy that requires a new way of looking at things (or in terms of model specification, new parameter estimates), which if not done by the forecaster can lead to large forecast errors. This underscores the importance of monitoring intensively and studying not only local conditions, but also global external developments.

Second, the results show that not only known determinants of output and inflation affect forecast accuracy, but also "technical" variables. In all cases, the explanatory power of the equation significantly increases with the inclusion of these variables. But how can one make use of these variables to improve forecast accuracy? One, recognize that the analysis

of past forecast errors is a way of assessing one's understanding of the economy. As forecast errors must be random, a systematic under- or overestimation of projections implies that one does not fully grasp the workings of the economy. Two, although it is true that it is difficult to predict sudden and sharp changes in outcomes and prices (as confirmed by the significance of DELTAGDP and DELTAINF for both current- and next-year forecast errors), it may well make sense to look back and find out when the mark was missed most, analyze the circumstances leading to and surrounding these exceptional periods, and from this analysis think of ways to improve the forecasts. Three, include past forecast errors in the forecasting method to correct for biases in the forecasts. Granger (1996) discusses various ways of doing this, including the incorporation of past forecast errors of other variables that have been found to have cointegrating relation with the variable being examined. Four, consider the forecasts of others with caution. The significance of ERROR14 shows the tendency of forecasters to move in the same direction as other forecasters. Although there may be some merit to this (especially during times of great uncertainty), as they may have access to other or newer relevant information, this should not be done to the neglect of economic fundamentals. One must also realize that most forecasts are conditional forecasts—they are based on certain assumptions. Therefore, a careful assessment of the underlying assumptions of and the risks surrounding these forecasts is warranted before attaching any weight to them.

Third, financial and monetary policy variables explain more the forecast errors for inflation than those for GDP growth. A possible reason is that financial and monetary policies affect prices (and therefore inflation) more directly than economic growth. Economic growth is based more on structural and institutional factors as it takes more time for the financial and monetary policy levers of the authorities to affect the real sector. The relatively poor fit of the inflation equation may be due to incorrect lag assumptions or unexpected changes in monetary policies or feedback effects of monetary variables. Further work is clearly needed to identify more precisely the channels and assess the transmission mechanisms by which macroeconomic variables affect output and inflation.

Fourth, the presence of forecast errors does not undermine the usefulness of forecasts in guiding policy making. But forecasters must emphasize the conditionality of the projections to avoid being misinterpreted. It will greatly benefit the users of the forecasts if the underlying suppositions on which the forecasts rest and the associated uncertainties are clearly stated so they can properly weigh the risks at stake.

The final point is that one cannot fully automate forecasting. Indeed, although formal modeling techniques are useful, their results should be subjected to reality checks and adjusted accordingly. For countries that do not have enough data to support the formulation of such models, forecasters must make value judgments on the basis of an informed assessment of how things will progress. From the regression exercise done on this paper, it may be worth analyzing the behavior and movements of monetary aggregates, interest rates, exchange rates, global commodity prices, and the US economy, among others. As new information becomes available, existing economic relationships will have to be reassessed.

Endnotes

1 Bangladesh; People's Republic of China (PRC); Hong Kong, China; India; Indonesia; Republic of Korea; Malaysia; Nepal; Pakistan; Philippines; Singapore; Sri Lanka; Taipei,China; Thailand; and Viet Nam.

2 Errors can primarily be attributed to erroneous assumptions regarding key economic variables and economic policies, unanticipated changes in policies and behavior of economic agents, and revision of data (OECD 1993).

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