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Forecasting Inflation and GDP Growth: Automatic Leading Indicator (ALI) Method versus Macro Econometric Structural Models (MESMs)

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Asian Development Bank

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FORECASTING INFLATION AND GDP GROWTH: AUTOMATIC LEADING INDICATOR (ALI) METHOD VERSUS MACRO ECONOMETRIC STRUCTURAL MODELS (MESMS)

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FOREWORD

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ABSTRACT

This paper compares the forecast performance of the automatic leading indicator (ALI) method with the macro econometric structural model (MESM) and seeks ways of improving the ALI method. Inflation and gross domestic product growth form the forecast objects for comparison, using data from People's Republic of China, Indonesia, and Philippines. The ALI method is found to produce better forecasts than MESMs in general, but the method is found to involve greater uncertainty in choosing indicators, mixing data frequencies, and utilizing unrestricted vector auto-regressions. Two possible improvements are found helpful to reduce the uncertainty: (i) give theory priority in choosing indicators and include theory-based disequilibrium shocks in the indicator sets; and (ii) reduce the vector auto-regressions by means of the general → specific model reduction procedure.

The fox knows many things, but the hedgehog knows one big thing.

Archilochus

1. INTRODUCTION

Accurate and timely information on the current conditions of an economy is needed for good economic policy making. Unfortunately, many countries face the perennial problem of scarce macroeconomic data, often released with considerable delay and many at low frequency. To address this problem, conventionally, structural econometric models have been and still are used widely to forecast key macroeconomic variables as well as to do policy simulations. These models are constrained, however, to use data of the same frequency—either quarterly or annual—and at the same aggregative level, which is determined by a priori theories. As more and more micro and financial data become available at higher frequencies, alternative procedures have been explored that can better utilize various kinds of available data to extract the key signals timely and efficiently. This is best reflected in the recently mounting interest in dynamic factor models.

Although economic leading indicators were developed nearly a century ago and factor analysis was used in economics as early as the 1940s,[1] these methods were marginalized in econometric research for decades. The recent revival of leading indicator models is largely due to the work of Stock and Watson (1989 and 1991), who proposed to extract, by means of dynamic factor analysis, from a large pool of variables a latent "leading indicator", or an "index of coincident indicators" as they call it, for the United States economy.[2]

The "automatic leading indicator" (ALI) model proposed by Camba-Mendez et al. (2001) makes use of very similar techniques as in Stock and Watson (1989).[3] However, the angle of application has been reoriented. Camba-Mendez et al. (2001) focus their attention on short-term forecasts of certain officially released variables of interest, e.g., real GDP growth of selected European countries.[4] These variables are excluded from the pool of variables from which a few dynamic factors are extracted. These factors are then used as forcing variables in forecasting the variables of interest by means of a vector auto-regression (VAR) model, instead of producing one unobserved core index of the economy.

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[1] W. M. Persons is known as the pioneer of leading indicators; F. V. Waugh and J. R. N. Stone are among the first to apply factor analysis to economic data. See (Gilbert and Qin (2006) for the history of these econometric methods.

[2] For a recent survey of dynamic factor models (DFMs), see Stock and Watson (2005).

[3] According to the authors, the model derives its name from the fact that the information is selected automatically from the set of indicators.

[4] Another example is to forecast inflation in the United Kingdom by Kapetanios (2002).

Various applications of the ALI method show that its forecasting performance can be significantly better than that of traditional VAR models, (e.g., Banerjee et al. 2003). However, as with the traditional VAR model, it is highly sensitive to the choice of variables, and the variable set is frequently limited by finite sample size in practice. As a result, such models are often not well specified in terms of economic structure.

In this paper, we compare the forecasting performance of the ALI method with that of the macro econometric structural models (MESMs) and experiment with ways to improve the ALI with reference to the MESM method. The comparison is experimented on forecasting two key macro variables, inflation and GDP growth, of three countries, namely People's Republic of China (PRC), Indonesia, and Philippines, as macroeconometric models for these countries have been built recently by the Asian Development Bank (ADB). The main comparison is based on short-run forecasts, as the ALI was developed for this in particular. But in addition, we hope to address the following issues. How does the forecasting performance of each type of models progress as the forecasting horizon is extended? How do variables that are included in the ALI, but not in the MESM, affect the ALI forecasts? How much does the use of higher frequency data of ALI (monthly) improve the forecasts as compared to those by quarterly-data-based MESMs?

Through the comparison experiments, we also seek possible ways of improving the ALI method with respect to the MESM method, as the former is relatively new. One key feature of MESMs is the presence of a long-run, theory-based equilibrium-correction mechanism (ECM) in all the behavioral equations, whereas ALI models only consider common movement among short-run changes of a pool of variables. Hence, we try to see whether the forecasting performance of ALI improves if deviations from the long-run co-trending movement, as embodied by the ECM terms in the MESMs, are added into the ALI models. Another feature of MESMs is that every fitted equation in an MESM is obtained through a parsimonious-specification reduction process (e.g., see Hendry 1995 and Hendry and Krolzig 2001). In contrast, the VAR model used in the ALI suffers from overparameterization in general. Hence, we try to see whether Hendry's reduction process will be able to help sharpen the performance of the VAR by pruning out the overparameterized part of the VAR.

The rest of the paper is organized as follows. The next section will describe briefly the ALI method,[5] the choice of variable sets and related data, the basic structure of the MESMs, and the design of the comparison experiments. Empirical results for the comparison experiments are discussed in Section III. The following section discusses possible ways of reducing the uncertainty involved in using the ALI method by adopting two key features from the MESM modeling method. The last section summarizes the results and gives some concluding remarks.

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[5] For detailed theoretical description of the ALI, see Camba-Mendez et al. (2001); for detailed description of how to apply the method, see the Practitioners' Note attached at the end of the paper.

II. MODELS, CHOICE OF ALI INDICATORS, FORECAST VARIABLES, AND SCENARIOS FOR COMPARISON

A. Automatic Leading Indicator

Let Y_t be the variable of forecasting interest and Z_t the set of n variables, often referred to as indicator variables, form the pool for the extraction of dynamic factors. Economically, there are no set theories to restrict the choice of the n indicator variables. Statistically, all the variables used in the ALI are required to be stationary. Hence, Y_t and Z_t are normally transformed by taking their growth rates (denoted by y_t, and z_t), and z_t is also standardized. However, they do not need to be observed at the same frequency, e.g., some z_t can be quarterly and others monthly time series.

The ALI method consists of two steps: factor extraction and forecasting. The first step is to extract m factors, f_t, using the following dynamic factor model (DFM) in the form of the state space model representation:

$$\begin{aligned} z_t &= \mathrm{B}\, f_t + e_t \\ f_t &= \mathrm{A}\, f_{t-1} + \mathrm{u}_t \end{aligned} \tag{1}$$

where A and B are parameter matrices to be estimated, and e_t and u_t are error terms. To determine the number of factors, m, two recently developed statistical tests are utilized, one by Bai and Ng (2005) and the other by Onatski (2005).[6] Note that the latter test is computationally easier and more flexible than the former test. The Bai-Ng test requires that the panel data set is balanced and contains large enough n to enable a comparative judgment of m against a max $m_{(max)}$. As our full data sets are mostly unbalanced and contain relatively small numbers of indicator variables, we are often constrained by the restriction of $(n-m)^2 > (n+m)$ for the identification of the residual covariance matrix of e_t (see Steiger 1994), a matrix that the Bai-Ng test is based upon. Nevertheless, both tests are calculated and the larger number is normally adopted as m when the two test results differ. Next, the factor extraction is carried out by the Kalman filter algorithm, with the initial parameter estimates obtained via principal component analysis (PCA).

The second step is to run a standard VAR model to forecast y_t and f_t in combination:

$$\begin{pmatrix} \mathrm{y} \\ \mathrm{f} \end{pmatrix}_t = \Pi_1 \begin{pmatrix} \mathrm{y} \\ \mathrm{f} \end{pmatrix}_{t-1} + \cdots + \Pi_p \begin{pmatrix} \mathrm{y} \\ \mathrm{f} \end{pmatrix}_{t-p} + \varepsilon_t \tag{2}$$

where the minimum lag order p should be such as to entail the residuals e_t to satisfy the classical assumptions.

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[6] Onatski's test exploits ideas from random matrix theory, similar to the approach explored by Kapetanios (2004).

B. Indicators

A wide range of economic factors is believed to be correlated with inflation and GDP growth, such as monetary and finance variables, variables from the real sector such as industrial production, not to disregard all those micro factors that affect prices of individual commodities, which comprise the consumer price index (CPI), the indicator from which inflation is measured.

In the present exercise, the indicators are chosen mainly at the macro level, such as the index of industrial production, monetary aggregates, unemployment, average labor wage rate, and short-run interest rate. Consumer confidence index or business confidence index is also used when such survey data are available. Monthly series of the indicators are used whenever possible. Otherwise, the series are in quarterly observations. A detailed list of the indicators and data sources for all the three countries, i.e., PRC, Indonesia, and Philippines, is given in the Appendix. All the indicator variables are processed into standardized stationary series. The details of how the series are processed are given in the Practitioners' Note attached at the end of this paper.

C. Modeling Consumer Price Index and Gross Domestic Product in MESMs

The MESM of each of the three countries comprise about 70-80 variables, covering private consumption, investment, government, foreign trade, the three production sectors of the economy, labor, prices, and monetary blocks.[7] The ECM form is used for all the behavioral equations, which are obtained through the general→specific dynamic specification approach. Mostly individually estimated by least squares (LS) method using quarterly data starting from the early 1990s, these equations in combination behave very similarly to a structural VAR model in dynamic simulation.[8]

The CPI is modeled essentially as a simple mark-up of producer/wholesale prices in the long run. Import price may also play a part. The producer prices are explained by factor prices and/or labor productivity. In the case of the PRC and Indonesia, an indicator called GDP gap is found to impact on inflation. The GDP gap is defined as the ratio of a long-run GDP trend, generated by a simple production function, to GDP.

The real GDP is modeled via its three sectors—primary, secondary, and tertiary sectors. The secondary sector output follows a simple production function in the long run. The tertiary sector output is demand-driven, i.e., explained by income and relative prices. The primary sector output in the PRC model is also demand-driven, and follows basically an autoregressive process in the other two models. Various short-run demand factors like cross-section demand factors sometimes also impact on these output equations.

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[7] For more detailed description of the PRC model, see Qin et al. (2005), and for the Philippine model, see Cagas et al. (2006). These two models are relatively mature whereas the ADB Indonesia model is the latest being developed. The Indonesia model is structurally similar to the Philippine model.

[8] As far as the main difference in the estimation method is concerned, it is long known that parameter estimates by simultaneous-equation maximum likelihood (ML) or single-equation least squares (LS) methods do not tend to differ significantly under small samples. Indeed, this is checked and verified in the cases when variables are simultaneously determined, such as import and export prices.

D. Forecast Variables and Comparison Statistics

We choose inflation (measured by CPI growth) and GDP growth as the forecast variables of interest mainly because these two are the most frequently quoted and the most monitored macroeconomic indicators of an economy, and are the objects of investigation in most of the literature on leading indicators modeling methods. Moreover, they present us with a very different experimental setting. While CPI data are available at a monthly frequency, GDP data is only available at a quarterly frequency. In terms of the ADB MESMs, inflation is endogenously determined by an equation in the price block, whereas GDP is derived as the sum of the outputs of the three sectors, each endogenously determined by an equation in the output block. These differences are expected to broaden the generality of the comparison results.

However, certain features of the data samples may pose a challenge particularly to the ALI method. Specifically, both Indonesia and the Philippines suffered from the East Asian financial crisis in the late 1990s. As a result, the related inflation series and many of the indicator series are more volatile than what are expected of normally distributed series (see Figure 1). Another data feature is the pronounced seasonal pattern in the GDP data, as well as in some of the associated indicators, of all the three countries (see Figures 1 and 2). As the MESMs are built to forecast the published GDP series as they are, seasonal adjustment of the raw data cannot be applied.

Standard root mean square error (RMSE) statistics are used for the evaluation of model forecast performance and are calculated for out-of-sample forecasts, covering the period 2002Q1-2005Q1.[9] These are supplemented by graphs of forecast series and errors. In order to find answers to the questions raised in the previous section, the following four scenarios are designed for the comparison exercise:

(i) Scenario A: The indicator set includes all the indicator variables listed in the Appendix

(ii) Scenario B: The indicator set only includes those variables that are used in the MESMs

(iii) Scenario C: The indicator set only includes those variables having monthly observations

(iv) Scenario D: The indicator set is the same as in Scenario C but the monthly frequency is integrated into quarterly frequency

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[9] In the case of the MESMs, this also involves revising data on exogenous variables from actual to what would have been reasonable forecasts at the time they are to be made.

FIGURE 1
VARIABLES OF FORECAST INTEREST

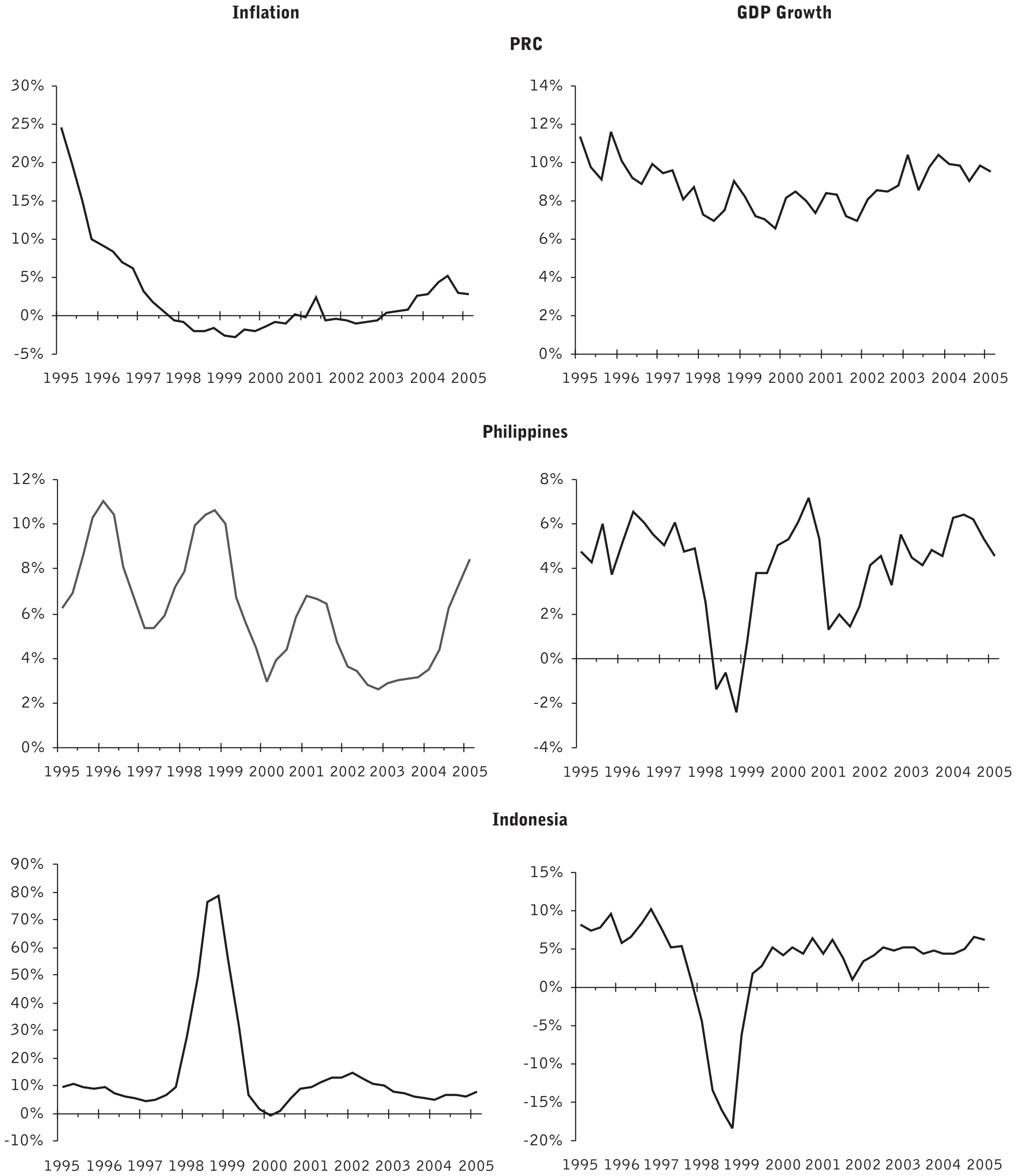
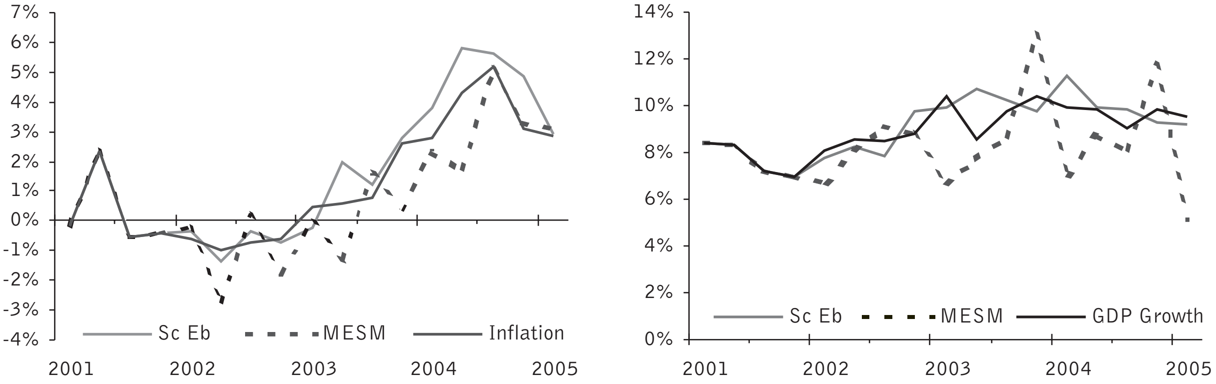


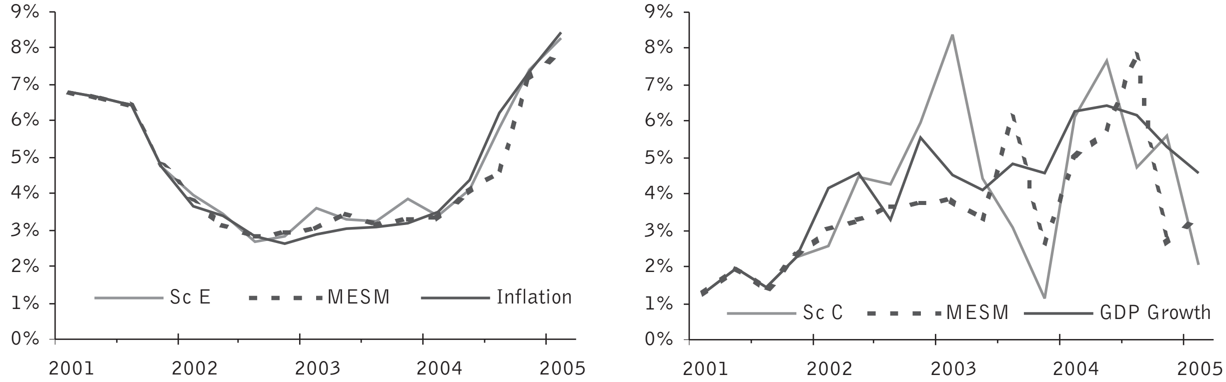
FIGURE 2
8-STEP FORECAST RESULTS

Inflation **GDP Growth**

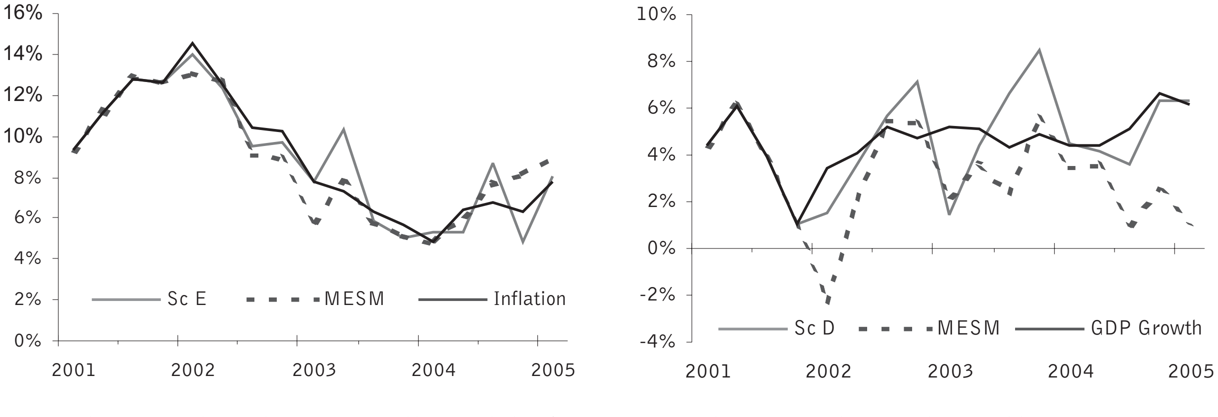
PRC



Philippines



Indonesia



Note: The scenarios (shortened as 'Sc') presented here are the best fitting ALI scenarios by parsimoniously restricted VAR models for the three countries.

III. COMPARISON OF FORECAST RESULTS

Note that the ALI indicator sets finally presented here differ from country to country due mainly to data availability (see Table 1 and the Appendix). These differences may contribute to the different results in model comparison.[10] Another issue to note is that the ALI method can provide monthly forecasts whereas the MESMs only give quarterly forecasts. To compare their results, we integrate those monthly ALI forecasts into quarterly forecasts. Table 2 reports the two test results for the number of factors, *m*. Table 3 reports the numbers of lags, *p*, used in the VARs based on residual mis-specification tests. These test statistics are not reported here to keep the paper short.

TABLE 1
ALI INFORMATION: NUMBER OF INDICATORS USED

	PRC		PHILIPPINES		INDONESIA	
	INFLATION	GDP GROWTH	INFLATION	GDP GROWTH	INFLATION	GDP GROWTH
Scenario A	13	12	16	17	14	13
Scenario B	8	8	11	14	8	8
Scenario C or D	10	10	13	14	11	10
Scenario E	16	14	23	19	16	15
Scenario Eb	11	10	—	—	10	10

A. Short-term Forecast Comparison

It is easily discernible from Table 4, as well as Figure 2, that ALI models can generate more accurate short-run forecasts (i.e., in terms of smaller RMSEs) than the MESMs on the whole.[11] The only exception is in the case of Philippine GDP growth forecasts.

However, the main factor that has improved the forecasts turns out not to be the addition of indicators that are not included in the MESMs. If we compare the RMSEs of Scenario A with those of Scenario B, we see that the exclusion of the additional indicators (Scenario B) actually reduces the forecast errors in most of the cases, especially in the cases of the PRC. This suggests that MESMs do not suffer much from the missing-variable problem; that better forecasts do not necessarily follow from an expansion of the indicator set; and that priority should be given to indicator variables with *a priori* theory underpinning when it comes to choosing indicators.

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[10] One factor that might have caused the PRC results to differ from those of the other two countries is the unique way that the monthly consumer price index (CPI) data are released. It is based on the current year, rather than having a set base year, thus making it impossible to convert monthly series into quarterly series without imposing extra assumptions.

[11] The RMSEs for GDP forecasts by the MESMs are calculated on the basis of the sum of forecast errors of the three sector output.

TABLE 2
ALI: TEST RESULTS FOR THE NUMBER OF FACTORS (BAI & NG TEST / ONATSKI TEST)

	PRC	PHILIPPINES	INDONESIA
Inflation			
ALI scenario A	1 / 4	1 / 5	2 / 4
ALI scenario B	4 / 3	4 / 4	4 / 3
ALI scenario C	1 / 4	1 / 4	2 / 4
ALI scenario D	1 / 4	4 / 4	4 / 4
ALI scenario E	1 / 5	1 / 4	6 / 5
ALI scenario Eb	4 / 4	—	4 / 4
GDP Growth			
ALI scenario A	4 / 4	3 / 5	5 / 4
ALI scenario B	3 / 4	4 / 4	3 / 3
ALI scenario C	4 / 4	3 / 4	2 / 4
ALI scenario D	2 / 4	3 / 4	1 / 4
ALI scenario E	4 / 4	3 / 5	5 / 4
ALI scenario Eb	4 / 4	—	4 / 5

TABLE 3
ALI: NUMBER OF LAGS USED IN THE VAR

	PRC	PHILIPPINES	INDONESIA
Inflation			
ALI scenario A	12	5	6
ALI scenario B	10	5	6
ALI scenario C	12	5	6
ALI scenario D	4	2	4
ALI scenario E	12	6	5
ALI scenario Eb	10	—	6
GDP Growth			
ALI scenario A	9	7	6
ALI scenario B	9	7	9
ALI scenario C	9	7	9
ALI scenario D	4	3	4
ALI scenario E	9	7	6
ALI scenario Eb	9	—	6

TABLE 4
RMSES FOR ONE-QUARTER AHEAD FORECASTS

	PRC	PHILIPPINES	INDONESIA
Inflation			
MESM	*1.295*	*0.515*	*1.092*
ALI scenario A (by reduced VAR)	1.273(1.206)	0.461(0.551)	1.053(1.061)
ALI scenario B (by reduced VAR)	0.909(0.866)	0.430(0.408)	0.968(1.037)
ALI scenario C (by reduced VAR)	1.299(1.233)	0.414(0.420)	0.967(1.000)
ALI scenario D (by reduced VAR)	1.176(0.997)	0.657(0.877)	2.360(1.513)
ALI scenario E (by reduced VAR)	1.214(0.928)	0.308(0.343)	0.947(0.872)
ALI scenario Eb (by reduced VAR)	0.879(0.859)	—	0.960(1.026)
GDP Growth			
MESM	*2.147*	*1.417*	*2.969*
ALI scenario A (by reduced VAR)	1.537(1.850)	1.897(2.166)	2.232(1.980)
ALI scenario B (by reduced VAR)	1.361(1.474)	1.913(1.797)	2.115(2.208)
ALI scenario C (by reduced VAR)	1.528(1.550)	1.711(1.837)	1.806(1.899)
ALI scenario D (by reduced VAR)	1.524(1.241)	2.487(2.083)	1.791(1.870)
ALI scenario E (by reduced VAR)	1.574(1.441)	1.873(2.370)	2.173(2.037)
ALI scenario Eb (by reduced VAR)	1.169(0.879)	—	2.026(1.998)

Note: The figures are generated by unrestricted VARs using the lag numbers given in Table 3. The figures in parentheses are generated by the reduced VARs.

As for the contribution of higher-frequency data (i.e., comparison of Scenarios C and D), the results are mixed. The inflation forecasts of Indonesia and the Philippines clearly show that short-term forecasts are more accurate when based on monthly data than on quarterly data. However for GDP forecasts, this observation is only true for the Philippines. In the other two cases, the change in data frequency hardly shows any effects, due probably to the data features of GDP series being low frequency (quarterly) and highly seasonal (see Figure 1). Relatively, the case of inflation forecast of the PRC shows clearly that higher-frequency data might exacerbate forecast errors by bringing too much unwanted data volatility.[12] This serves as a warning against the common belief that utilization of higher-frequency information (e.g., monthly data) will generate more accurate short-run forecasts.

In summary, the better short-run accuracy of the ALI forecasts compared to those of the MESMs appear to derive from the greater capacity of the ALI method itself to capture short-run dynamics. The results also show, however, that this capacity can be subdued by false inclusion of irrelevant indicators or false exclusion of relevant indicators. Careless selection of the variable set is indeed one of the most important factors to induce forecast failure (see Clements and Hendry 2002).

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[12] It is possible that the inferior result of scenario C to that of scenario D in the PRC case is due partly to the undesirable volatility brought in by those monthly indicators in scenario A, which are excluded in scenario B. But it is difficult to verify this postulate here as exclusion of those monthly indicators from scenario C would result in too small an indicator set (5 indicators) to carry out the ALI properly.

B. Longer-term Forecast Comparison

The main results are summarized in the RMSEs of the 8-step ahead forecasts in Tables 5 and 6, as well as Figure 3. To keep the paper short, only two scenarios of the ALI are reported here: Scenario A and the best scenario selected for each case as compared with the MESM results.

From the inflation results in Table 5, we can see that the superior forecasting record of the ALI models fades away rapidly as the forecast horizon widens, roughly within two quarters or 6 months when compared with the forecasting record of the MESMs. On the other hand, GDP forecasts in Table 6 show mixed results. For the Philippines, the forecast performance of the MESM remains the best. The ALI forecasts outperform those of the MESMs in the PRC and Indonesia cases, quite independent of the extension of the forecast horizon. In comparison with the inflation series, one factor that has very probably contributed to the persistence of good ALI forecasts over multiple steps is the dominant seasonality in the GDP growth rates, as shown in Figure 1.

On the other hand, there is one important difference between the ALI forecasts and the MESM forecasts. The MESMs produce forecasts on GDP levels and price indices whereas the ALI only forecasts growth rates. In other words, the MESMs operate largely in a nonstationary world where many nonstationary variables could randomly drift away from the forecasted stochastic trend, known as "unanticipated location shifts",[13] whereas the ALI is largely immune from the location-shift problem by operating within the stationary world as the stochastic trends in the data series have already been filtered out. This means that the ALI forecasts could outperform the MESM forecasts over a multiperiod horizon when the forecasts suffer from location shifts. To check whether our MESM forecasts suffer from location shifts, *h*-step forecast errors on the GDP levels and CPI series are plotted in Figure 4. It is evident from the figure that the GDP level forecasts drift apart from their actual values more than the CPI forecasts, and that the drifts are most severe in the case of Indonesia and mildest in the case of the Philippines. These help explain why the ALI multistep forecasts can outperform those of the MESMs in the cases of GDP growth forecasts in the PRC and Indonesia.

C. Comparison of Forecast Methods

The ALI forecasts presented here are actually chosen from a huge amount of modeling experiments with different indicator variable sets, different *m* and *p* as well. This is mainly because of the high flexibility of the method and the relatively low computational costs. However, flexibility also implies uncertainty. As seen, the forecasting performance of the ALI is sensitive to the choice of indicators and frequency mix, and there are no *a priori* rules to narrow down the choice. Furthermore, it is difficult to judge how robust the forecasting capacity of each factor is in the VAR. In fact, forecasts by the existing MESMs have actually served as a benchmark for the selection of the ALI trials.

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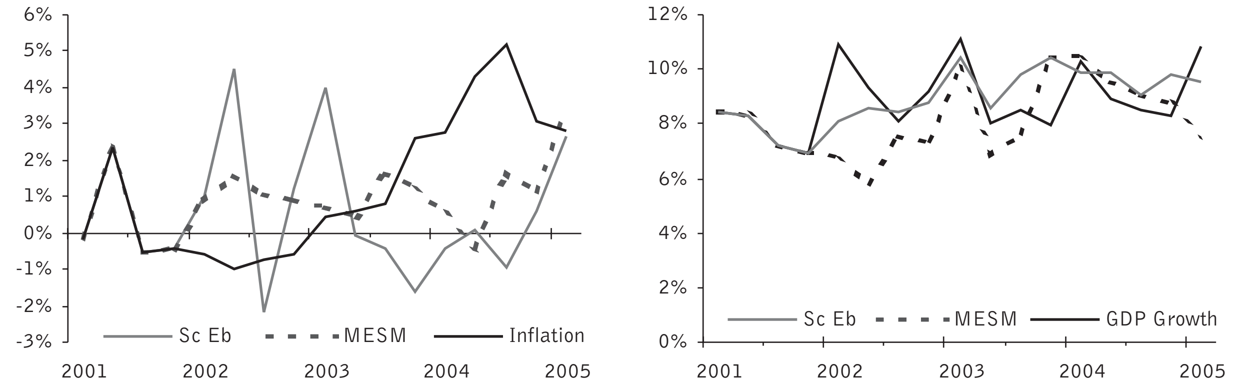
[13] The location shifts form a common type of forecast failures in structural econometric modeling. They are due frequently to historically specific events, or institutional changes, which are excluded from theories and are totally unanticipated *ex ante* (e.g., see Hendry 2004 and 2005).

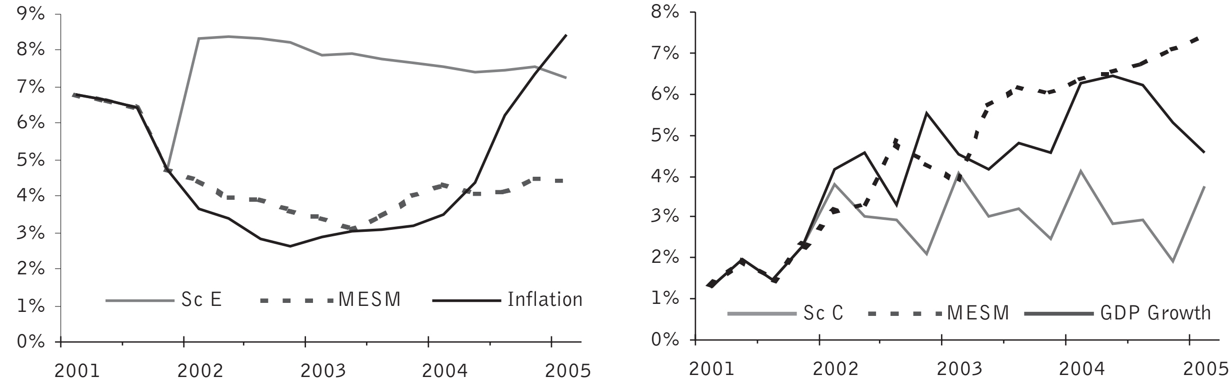
FIGURE 3
8-STEPS FORECAST RESULTS

Inflation **GDP Growth**

PRC



Philippines



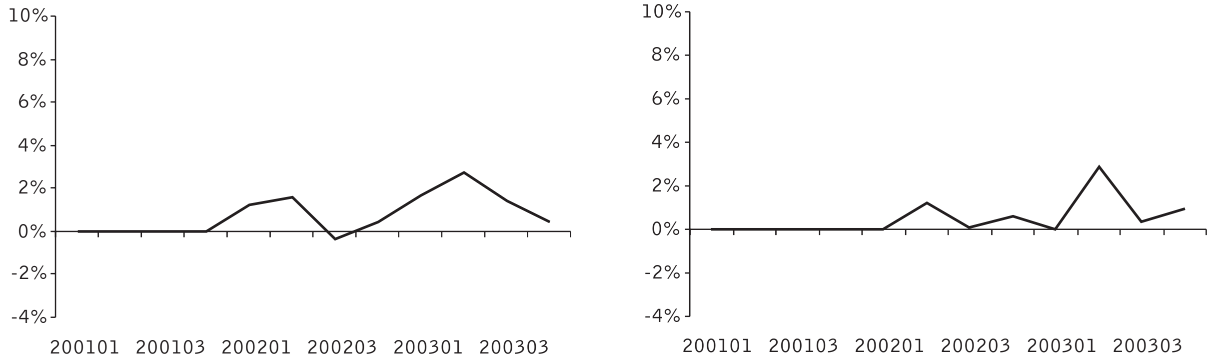
Indonesia

Note: The scenarios (shortened as 'Sc') presented here are the best fitting ALI scenarios by parsimoniously restricted VAR models for the three countries.

FIGURE 4
MESM H=STEP FORECAST ERRORS
(AS PERCENTAGE TO THE ACTUAL VALUES)

Constant-price GDP **CPI Index**

PRC



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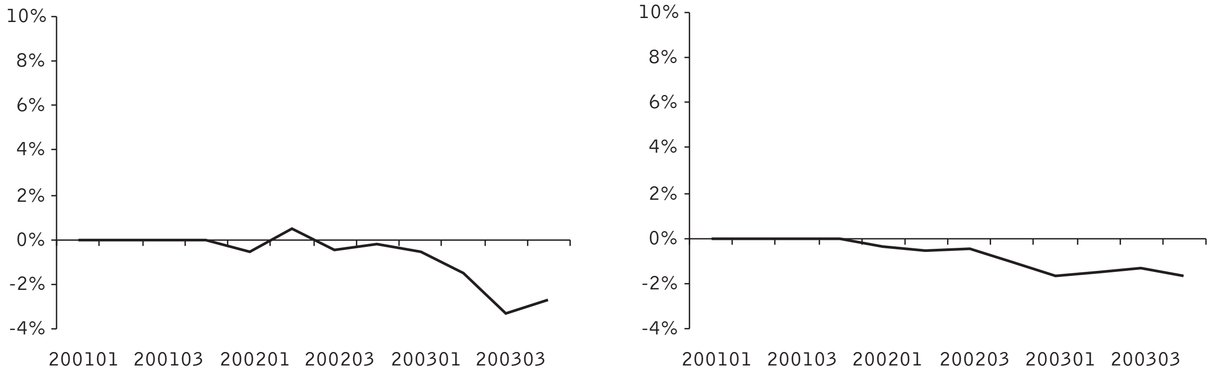

Indonesia

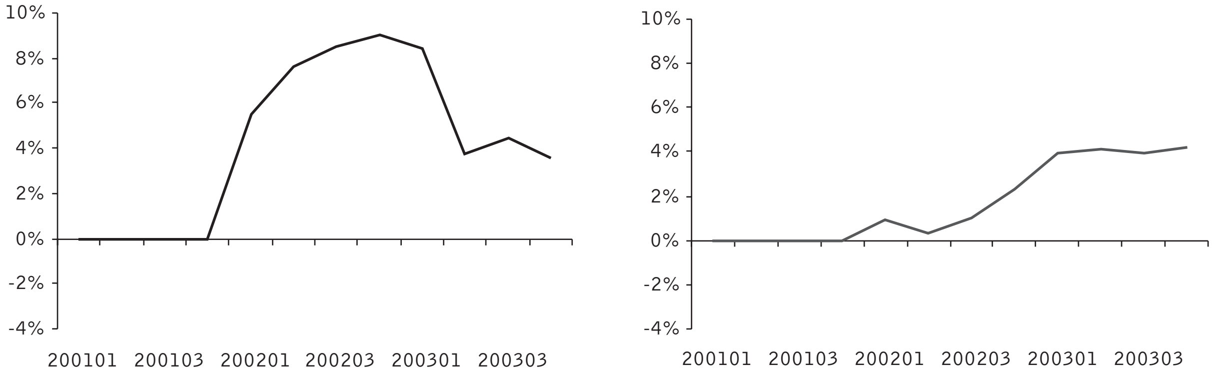

TABLE 5
RMSES FOR H-QUARTERS AHEAD FORECASTS: INFLATION

QUARTERS AHEAD	1	2	3	4	5	6	7	8
PRC								
MESM	*1.295*	*1.689*	*2.009*	*2.208*	*1.910*	*1.990*	*2.188*	*2.170*
ALI: Scenario A	1.273	2.825	4.450	6.348	3.414	2.442	2.862	3.515
ALI: Scenario B	0.909	1.968	3.199	4.528	3.796	4.563	5.371	6.306
ALI: Scenario E	1.214	2.787	4.534	6.739	5.461	6.437	7.494	8.706
ALI: Scenario Eb	0.879	1.840	3.054	4.177	3.688	4.384	5.143	6.025
Using parsimoniously restricted VAR:								
ALI: Scenario A	1.206	2.226	2.495	3.477	2.808	2.474	2.844	3.125
ALI: Scenario B	0.866	1.089	1.417	2.185	2.502	2.941	3.543	3.787
ALI: Scenario E	0.928	1.338	1.362	2.122	2.120	2.549	3.480	3.304
ALI: Scenario Eb	0.859	1.147	1.423	2.178	2.494	2.856	3.374	3.582
Philippines								
MESM	*0.515*	*0.912*	*1.319*	*1.507*	*1.604*	*1.643*	*1.634*	*1.615*
ALI: Scenario A	0.461	0.971	2.012	3.025	3.927	4.454	4.532	4.583
ALI: Scenario C	0.414	0.940	1.914	2.943	3.784	4.339	4.483	4.564
ALI: Scenario E	0.308	0.665	1.468	2.421	3.377	3.944	4.086	4.175
Using parsimoniously restricted VAR:								
ALI: Scenario A	0.553	1.259	2.108	2.979	3.652	4.006	4.179	4.325
ALI: Scenario C	0.420	0.891	1.647	2.495	3.189	3.489	3.605	3.651
ALI: Scenario E	0.343	0.745	1.532	2.424	3.438	3.962	4.103	4.203
Indonesia								
MESM	*1.092*	*2.036*	*2.649*	*4.479*	*4.445*	*3.776*	*3.266*	*3.498*
ALI: Scenario A	1.053	2.450	3.152	3.836	4.251	5.294	6.353	7.233
ALI: Scenario C	0.967	2.041	2.426	3.044	3.497	4.298	4.813	5.113
ALI: Scenario E	0.947	2.196	3.537	4.997	6.094	6.762	6.837	6.686
ALI: Scenario Eb	0.960	2.429	3.910	5.767	7.194	7.639	7.457	7.077
Using parsimoniously restricted VAR:								
ALI: Scenario A	1.061	2.406	3.151	3.822	4.547	5.947	7.115	8.014
ALI: Scenario C	1.000	2.279	3.061	4.060	4.996	6.394	7.323	7.767
ALI: Scenario E	0.872	1.836	2.681	3.382	3.732	3.756	3.913	3.659
ALI: Scenario Eb	1.026	2.275	3.111	4.656	6.038	6.699	6.618	6.125

Table 6
RMSEs for H-Quarters Ahead Forecasts: GDP Growth

QUARTERS AHEAD	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
PRC								
MESM	*2.147*	*2.181*	*2.070*	*1.605*	*1.326*	*1.379*	*1.299*	*1.393*
ALI: Scenario A	1.537	0.885	1.180	1.020	1.067	0.975	1.072	1.046
ALI: Scenario B	1.361	0.917	1.229	1.039	1.106	0.58	1.036	0.987
ALI: Scenario E	1.574	1.058	1.112	0.980	1.099	1.233	1.174	1.030
ALI: Scenario Eb	1.169	1.034	1.213	1.190	1.127	1.003	1.182	1.101
Using parsimoniously restricted VAR:								
ALI: Scenario A	1.850	2.217	2.352	1.917	1.784	1.419	1.440	1.683
ALI: Scenario B	1.474	0.967	1.239	1.246	1.239	1.482	1.655	1.665
ALI: Scenario E	1.441	1.526	1.907	1.637	1.159	0.997	1.195	1.104
ALI: Scenario Eb	0.879	1.010	1.039	0.917	1.157	1.137	1.297	1.316
Philippines								
MESM	*1.417*	*1.228*	*1.028*	*1.249*	*1.324*	*1.255*	*1.411*	*1.381*
ALI: Scenario A	1.897	2.543	2.097	2.077	2.166	2.203	2.167	2.261
ALI: Scenario C	1.711	2.245	2.222	2.158	2.228	2.118	2.128	2.195
ALI: Scenario E	1.873	2.538	2.093	2.084	2.168	2.212	2.172	2.266
Using parsimoniously restricted VAR:								
ALI: Scenario A	2.166	2.512	2.518	2.135	2.000	1.877	1.894	1.964
ALI: Scenario C	1.837	2.453	2.071	2.080	2.244	2.205	2.183	2.212
ALI: Scenario E	2.370	3.088	2.610	2.088	1.928	1.978	2.031	1.969
Indonesia								
MESM	*2.969*	*3.554*	*5.016*	*4.624*	*3.942*	*4.163*	*4.941*	*3.655*
ALI: Scenario A	2.232	2.106	2.459	1.633	2.334	2.307	2.275	1.964
ALI: Scenario D	1.791	2.780	3.369	3.741	3.976	2.958	2.335	3.362
ALI: Scenario E	2.173	2.281	2.479	1.777	1.643	1.584	1.423	0.951
ALI: Scenario Eb	2.026	2.271	2.096	1.808	2.279	2.250	1.720	1.190
Using parsimoniously restricted VAR:								
ALI: Scenario A	1.980	2.215	2.635	2.129	1.578	1.251	1.363	1.028
ALI: Scenario D	1.870	3.199	3.234	2.472	2.188	1.627	1.721	1.794
ALI: Scenario E	2.037	2.457	2.620	2.316	1.396	1.101	1.038	0.960
ALI: Scenario Eb	1.998	2.486	2.548	2.098	1.804	1.893	1.183	0.974

IV. MODIFIED ALI METHOD

Two key features of the MESM method emerge as potentially beneficial to the ALI method during the comparison of the two modeling methods. The first is the ECM specification; the second is the general→simple model reduction procedure.

Let us first consider the ECM representation from the perspective of a VAR model of (y_t, z_t). The ECM representation of the y_t equation in the VAR should be:

$$y_t = \sum_{i=0}^{p} \Gamma_i z_{t-i} + \sum_{j=1}^{p} \Phi_j y_{t-j} + \phi \underbrace{(Y - \beta Z)_{t-1}}_{\text{ECM}} + v_t \qquad (3)$$

The above equation decomposes the endogenous variable into three types of systematic shocks: exogenous short-run shocks, own lagged short-run shocks, and ECM shocks, known also as errors of "cointegration", and often explained as disequilibrium from a theory-based long-run relation. If we compare (3) with an ALI model, we may regard the factors, *f*, in (1) as a summary representation of exogenous short-run shocks, i.e., type one shocks, and the own lags of the forecast variable in (2) as covering own lagged short-run shocks, i.e., type two shocks. However, type three shocks are not explicitly included in the ALI. It seems that the ALI method only summarizes co-movement in the form of covariance of a pool of variables, whereas according to many equilibrium economic theories, co-movement in the form of co-trend among certain variables plays an important role in driving the dynamics of endogenous variables.[14]

Therefore, a new scenario, designated as Scenario E, is proposed to see if the ALI results can be improved when deviations from such co-trend, i.e., the third type of shocks, are added to the indicator set of Scenario A. The third type of shocks is adopted from the ECM terms embedded in certain relevant equations in the MESMs.[15] Notice that the extension can be executed in two ways. One is to add the ECM terms as indicator variables in the first step; the other is to extend the VAR model by the ECM terms during the second step. However, experiments show that the latter way is undesirable due to the data-frequency problem. Since all the ECM terms are at quarterly frequency, extension of VARs by these terms forces us to reduce the VARs from monthly to quarterly models, making the forecasts significantly worse than those by the former way. Hence, Scenario E is carried out by treating the ECM terms as indicators.

In terms of short-run forecasts, the addition of the ECM terms to the ALI indicator sets improves the forecast accuracy in most cases, especially in comparison with Scenario A, albeit

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[14] See Forni et al. (2004) for a detailed discussion between DFMs and structural VARs.

[15] The ECM terms derive from long-run relationships postulated by economic theory. On many occasions, the long-run coefficients are imposed.

sometimes marginally (Table 4).[16] The improvement is more discernible in the inflation forecasts, as the inflation series are more random and less seasonal than the GDP growth series.

When it comes to multiple-step forecasts (see Tables 5 and 6), the addition of the ECM terms generates mixed results. The additions help significantly in delaying the deterioration of ALI forecasts in the cases of inflation forecasts of the Philippines and GDP growth forecasts of Indonesia. However, it can also make the forecasts worse, as in the case of inflation forecasts in the PRC. It has not made significant differences for the rest of the cases. On balance, it seems worthwhile to take into consideration in the ALI indicator sets, disequilibrium shocks guided by economic theories. Nevertheless, caution should be exercised in choosing which disequilibrium shocks are the most relevant to include.

In view of the finding that results of scenario B are better than those of scenario A in the cases of the PRC and Indonesia, another scenario (Eb) is set up that adds ECM terms to scenario B. This scenario is carried out only for the relevant two countries. Comparison of the results (see Tables 4, 5, and 6) reveals the dominance of scenario Eb over scenario E, especially in the case of inflation forecasts in the PRC, where both the number of factors and the VAR lag number are smaller in scenario Eb compared to scenario E.[17] This experiment suggests that it is desirable to augment an indicator set by the ECM terms embodying the relevant long-run theories when the set is chosen under *a priori* theoretical guidance and this is shown to produce relatively good forecasts.

Let us now look at how the general→simple model reduction procedure can help reduce the uncertainty in the ALI forecasts. Although the DFMs have the power of significantly reducing a large number of indicators into a few common factors, a VAR model used in the second step can still easily run up to over a hundred parameters when there are more than three factors involved, making it difficult to decide how robust the VAR is in producing the forecasts. To combat the curse of dimensionality of VARs, the general→simple modeling procedure is adopted here to reduce unrestricted VARs into parsimoniously reduced VARs. Specifically, the computer-automated approach of PcGets is utilized to carry out the reduction efficiently (see Hendry and Krolzig 2001).

The advantages of this modification of the ALI method are immediately noticeable from the drastic reduction of the number of parameters reported in Table 7. As the parameter number in each equation of a VAR shrinks to a manageable size, it becomes possible for us to examine how much and in what manner each factor contributes to the forecasts and how robust the VAR is by means of various model specification tests. In particular, parameter constancy can be checked via recursive estimation and parameter instability tests in view of the forecasting requirement.[18] The results reveal that some of the VAR equations in certain scenarios suffer significantly from structural shifts, mostly due to the East Asian financial crisis,

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[16] For the details of the ECM terms added, see the Appendix.

[17] The only exceptional case here not showing better results is inflation forecasts of Indonesia. However, it should be noted that the VAR of scenario E contains six factors whereas the VAR of scenario Eb only four factors in this case.

[18] PcGive is used for detailed parameter analyses. None of these model specification and reduction statistics are reported here in order to keep the paper short.

TABLE 7
NUMBERS OF PARAMETERS REDUCED FROM UNRESTRICTED VARS TO PARSIMONIOUSLY REDUCED VARS

	PRC	PHILIPPINES	INDONESIA
Inflation			
ALI scenario A	300 → 52	180 → 32	150 → 47
ALI scenario B	250 → 38	125 → 25	150 → 46
ALI scenario C	300 → 39	125 → 28	150 → 52
ALI scenario D	100 → 41	50 → 14	100 → 44
ALI scenario E	432 → 73	210 → 27	245 → 61
ALI scenario Eb	250 → 43	—	150 → 46
GDP Growth			
ALI scenario A	225 → 77	252 → 75	216 → 75
ALI scenario B	225 → 52	175 → 55	144 → 41
ALI scenario C	225 → 54	175 → 60	225 → 59
ALI scenario D	100 → 41	75 → 20	100 → 34
ALI scenario E	225 → 61	252 → 70	216 → 76
ALI scenario Eb	225 → 74	—	216 → 81

Note: Unrestricted VARs mean the VARs using the lag numbers given in Table 3.

and that some factors are largely unpredictable in the VARs. Such information enables us to assess the reliability of the VAR in generating the forecasts.

The advantages of VAR reduction is also noticeable from various RMSEs reported in Tables 4–6. In view of the one-step ahead forecasts (Table 4), the VAR reduction has brought down the RMSEs in about half of the cases. The improvement is more marked for a number of cases in the eight-step ahead forecasts (Tables 5 and 6), e.g., the inflation forecasts of the PRC and the Philippines, and the GDP growth forecasts of Indonesia. The improvement seems due to the fact that model reduction has significantly reduced unwanted noises in the unrestricted VAR from getting into the forecasts. It is also found that the cases where model reduction has not helped improve forecast accuracy tend to suffer from parameter shifts in the reduced VAR as well as from low forecastability of one or more of the factors in the related VAR.

V. CONCLUSION

This paper investigates the comparative forecast performance of the ALI method versus the MESMs and seeks ways of improving the ALI method. Inflation and GDP growth are used as the objects of the forecast comparison. PRC, Indonesia, and Philippines are used as the cases of the investigation. The following key results can be summarized from a huge amount of ALI experiments that have been carried out.

(i) The ALI method can generally outperform MESMs in short-run forecasts provided that the indicator variable sets, the number of factors and the VAR lag orders are carefully selected. However, its forecasting advantage tends to fade away as the forecast horizon increases. MESMs can be more robust for longer-run forecasts in comparison.

(ii) Freer inclusion of data information into the ALI indicator variable sets, as compared with the more theory-guided variable selection in the MESMs, may help improve forecast accuracy, but may also spoil it by bringing in unwanted noise. On balance, both theory and good economic sense are required in choosing indicator variables, and the tendency of including whatever data is available should be avoided.

(iii) Use of higher frequency data can help improve forecast accuracy, but it also carries the risk of bringing in unwanted higher frequency noise. To avoid such risk, it is advisable to consider carefully the data features of the forecast target when choosing indicator variables. The common belief that higher frequency information will always help improve forecasts is unwarranted.

(iv) Inclusion of disequilibrium shocks as additional indicator variables in the ALI may help improve the forecast accuracy, especially for multiple step forecasts. This finding suggests that DFMs may perform better if they include theory-based disequilibrium shocks in addition to variable own shocks.

(v) The ALI method can produce models that generate better forecasts than those by MESMs, but the method involves greater uncertainty than the MESMs. One way of reducing the uncertainty related to the unrestricted VAR used in the second step of the ALI is to adopt the general→simple model reduction procedure from the MESMs. The procedure not only helps to trim out unwanted noise from entering the ALI forecasts but also enables modelers to examine and assess closely the robustness of the VAR model specification.

(vi) As formulation and specification uncertainty about econometric models is known to be hard to assess with respect to the evolving economic reality, it is thus more desirable to compare and utilize forecasts from both modeling sources than to choose a single method.

APPENDIX
VARIABLES AND DATA SOURCES

VARIABLES	FREQUENCY	INFLATION	GDP GROWTH	SOURCE
Philippines				
91-day Treasury Bill Rate	Monthly	✓	✓	Datastream
Brent Crude - Current Month, FOB U$/BBL	Monthly	✓	✓	Datastream
Consumer Price Index (1994=100)	Monthly		✓	SPEI
Consumer Price Index (1994=100) ECM term	Quarterly	✓		PHI Model
Domestic Credit	Monthly	✓	✓	BSP
Domestic Credit CB & DMB ECM terms	Quarterly	✓		PHI Model
Exports (pesos, FOB)	Monthly		✓	FTS
Foreign Exchange Rate	Monthly	✓	✓	SPEI
Government Expenditure (million pesos)	Monthly		✓	SPEI
Gross Domestic Product (in 1994 constant price) NAP	Quarterly	✓		
Imports (pesos, CIF)	Monthly	✓	✓	FTS
Imports ECM term	Quarterly	✓		PHI Model
Imports of Consumer Goods (pesos, CIF)	Monthly	✓		FTS
Interest Rate Differential (domestic rate net of US prime lending rate) Datastream	Monthly	✓		

continued.

Appendix. *continued.*

VARIABLES	FREQUENCY	INFLATION	GDP GROWTH	SOURCE
Job Vacancies	Monthly	✓	✓	SPEI
M1 (million pesos)	Monthly	✓	✓	SPEI
M1 ECM term	Quarterly	✓		PHI Model
Overseas Workers Remittances	Monthly	✓		BSP
Prime Lending Rate	Monthly	✓	✓	SPEI
Rainfall Index	Quarterly	✓	✓	PAGASA
Savings Deposit Rate	Monthly	✓	✓	SPEI
Secondary Sector Value-Added (in 1994 constant price) ECM term	Quarterly	✓	✓	PHI Model
Stock Composite Index	Monthly	✓	✓	PSE
Tertiary Sector Value-Added (in 1994 constant price)	Quarterly		✓	NAP
Tertiary Sector Value-Added ECM term	Quarterly	✓	✓	PHI Model
Unemployment Rate	Quarterly	✓	✓	LFS
Value of Production Index in Manufacturing (1994=100)	Monthly	✓	✓	Datastream

Note: "✓" indicates that the variable is used as an indicator for Inflation or GDP growth.
BSP means Bangko Sentral ng Pilipinas.
FTS means Foreign Trade Statistics.
LFS means Labor Force Survey.
NAP means National Account of the Philippines.
PSE means Philippine Stock Exchange.
SPEI means Selected Philippine Economic Indicators.
SSI means Survey of Selected Industries.

continued.

Appendix. *continued.*

VARIABLES	FREQUENCY	INFLATION	GDP GROWTH	SOURCE
THE PRC				
Average Repo Rate	Monthly	✓		PBC
Balance of Trade	Monthly		✓	Computed from IMF
Base Money (million yuan, M0 plus RSV)	Monthly	✓	✓	QB
Base Money Supply (million yuan, net foreign assets plus net government claims and borrowed reserve by financial institutions at PBC)	Monthly	✓	✓	QB
Brent Crude - Current Month, FOB U$/BBL	Monthly	✓	✓	Datastream
Chinese Renminbi to US$ (GTIS)	Monthly	✓		CMEI
Consumer Confidence Index	Monthly	✓	✓	NBS
Consumer Price Index (1992Q1=1)	Monthly	✓		NBS
Consumer Price Index (1992Q1=1) ECM term	Quarterly	✓		PRC Model
Government Expenditure	Monthly		✓	CMEI
Gross Domestic Product (in 1992Q1 price)	Quarterly	✓		CMEI
Investments	Monthly		✓	CMEI
Loans	Monthly		✓	CMEI

continued.

Appendix. *continued.*

VARIABLES	FREQUENCY	INFLATION	GDP GROWTH	SOURCE
M1	Monthly	✓	✓	QB
M1 ECM term	Quarterly	✓		
Net Industrial Production (Value Added) Current Price	Monthly	✓	✓	CMEI & NBS
Real Effective Exchange Rate Index - CPI Based	Monthly	✓		IMF
Real Estate Climate Index	Monthly	✓		Datastream
Secondary Sector Value-Added (in 1992Q1 price) ECM term	Quarterly	✓	✓	PRC Model
Shanghai Composite Stock Index	Monthly	✓		NBS
Tertiary Sector Value-Added (in 1992Q1 price) ECM term	Quarterly		✓	PRC Model
Total Retail Sales Current Price	Monthly	✓	✓	CMEI
Unemployment Rate	Quarterly	✓	✓	Computed from CSY

CMEI means *China Monthly Economic Indicators*.
CSY means *China Statistics Yearbook*.
IMF means International Monetary Fund.
NBS means National Bureau of Statistics.
PBC means People's Bank of China.
QB means *Quarterly Banking*.

continued.

Appendix. *continued.*

VARIABLES	FREQUENCY	INFLATION	GDP GROWTH	SOURCE
Indonesia				
Brent Crude - Current Month, FOB U$/BBL	Monthly	✓	✓	Datastream
Consumer Price Index	Monthly		✓	BI
Consumer Price Index ECM term	Quarterly	✓		INO Model
EOP Consumer Confidence Index	Monthly	✓	✓	CEIC
EOP Interbank Call Rate	Monthly	✓	✓	BI
Interest Rate Differential (domestic rate net of US prime lending rate)	Monthly	✓		Datastream
EOP Jakarta Stock Exchange Composite Index	Monthly	✓	✓	BI
Exchange Rate–Indonesian Rupiah to US $ (GTIS)	Monthly	✓	✓	BI
Total Exports	Monthly		✓	Datastream
Total Imports	Monthly	✓	✓	Datastream
Imports of Consumer Goods	Monthly	✓		Datastream
Gross Domestic Product (constant price)	Quarterly	✓		BI
Industrial Labor Wage Index	Quarterly	✓	✓	CEIC

continued.

Appendix. *continued.*

VARIABLES	FREQUENCY	INFLATION	GDP GROWTH	SOURCE
Volume of Production Index in Manufacturing	Monthly	✓	✓	CEIC
M1	Monthly	✓	✓	BI
M1 ECM term	Quarterly	✓		INO Model
Commercial Bank Total Outstanding Credits (net of credits to individuals)	Monthly	✓	✓	Datastream
Primary Sector Value-Added (constant price)	Quarterly		✓	BI
Secondary Sector Value-Added ECM term	Quarterly		✓	INO Model
Tertiary Sector Value-Added ECM term	Quarterly		✓	INO Model
Unemployment rate	Quarterly	✓	✓	Computed from CEIC

BI means Bank Indonesia.
CEIC means????__________________________________.

PRACTITIONER'S NOTE: STEP-BY-STEP MENU OF DOING THE ALI

This makes heavy reference to the project report "An Automatic Leading Indicator Model of Chinese Inflation" by Mitchell (2004). However, the computing procedure has been greatly improved at the Macroeconomics and Finance Research Division of the Economics and Research Department, Asian Development Bank, to ease the implementation of the ALI procedure. The data preparation part is now processed in Excel with tailor-made macros. The ALI part is prepared with user-friendly programs in EViews.

1. Data Preparation

The first step is to select the indicator variables, Z, that will be used to extract the factors in the automatic leading indicator (ALI) models. The choice may vary from country to country depending on both the variable of forecasting interest, Y, and data availability. As the ALI is able to accommodate and combine data measured at different frequencies through state-space modeling, the indicators can be monthly, quarterly, or annual series.

All the variables in Z must be stationary to be used in an ALI model. Hence, nonstationary variables are transformed appropriately to achieve stationarity. This is usually done by transforming the variables into growth rates, which can be approximated by taking differences of the variables in their natural logarithms. For those variables whose growth rates are not yet stationary, a second differencing is necessary to transform them into their stationary acceleration rates.

Each of the transformed variables is then examined for the possible presence of seasonality and outliers. Seasonality can be removed using any existing technique in EViews known as "seasonal adjustment." Outliers can be detected with the aid of the TRAMO-SEATS algorithm (available from the website of Bank of Spain). Here, it is important to use economic judgment in deciding whether to remove all the visually high volatilities as outliers. For example, high volatilities are expected during the period of the Asian financial crisis, and should obviously not be considered as outliers to be removed.

Finally, normalization of the transformed Z is done by subtracting the corresponding mean from each indicator and dividing by the standard deviation. We denote the standardized indicators as z . Note that the transformed y is not normalized.

2. Running the ALI: Step One

In order to operate the Kalman filter algorithm, we have to supply the dynamic factor model (DFM) (1) with initial values for the factors, the coefficient matrices, and the variance matrices of the error vectors. This can be done by utilizing the principal components analysis (PCA).

Notice that PCA does not allow for mixed frequency data set. Remove the lower frequency series from z before running the PCA and only keep those zs that are of the highest frequency, e.g., for a set of monthly and quarterly zs, select only the monthly zs. This way, we maximize the gain from information contained in the monthly zs. The information coverage of the factors derived from the PCA can be used to help us decide how many factors, i.e., m, to be used in the DFM (1).

In (1), the first equation refers to the signal or observation equation and the second refers to the state equation. Notice that the number of lags in the state equation may be extended, but normally one lag is adequate.

While estimated *m* principal components are used as initial values for the factors in DFM, initial conditions for the coefficients and the variances of the error terms are obtained by regressing *z* on the *m* principal components. More precisely, regressing the *m* principal components on their lags gives the initial conditions for *A* in (1). The initial condition for the variance of u_t is set to 1.

Having provided necessary initial conditions, the state space model is estimated using the Kalman filter algorithm. This algorithm is used to come up with smooth estimates of the factors and their forecasts.

3. Running the ALI: Step Two

The *m* factors obtained from the first step are used in forecasting *y* by using the VAR (2). The lag order, *p*, in the VAR can be extended as deemed necessary. The length of the lag can be determined using statistical criteria such as the Bayesian Information Criterion (BIC) or the Root Mean Square Error (RMSE).

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