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Recent Significant Advances in Estimating and Forecasting Theories and Economic Modelling: With Applications to ASEAN Investment Studies

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ABSTRACT

The paper presents the basics of a new and flexible approach to statistically modelling the activities of multi-sectoral economies (Tran Van Hoa, 1992) and applies it to study investment in five major East Asian countries (ie, China, Indonesia, Korea, Malaysia and Thailand) during the period 1970-1993 using recent World Bank databases. The approach dominates the computable general equilibrium method in its data-consistent structure.

The paper also describes the fundamentals of the new two-stage hierarchical information (2SHI) estimation and forecasting theory (Tran Van Hoa, 1985, 1986a, 1993b, Tran Van Hoa and Chaturvedi, 1988, 1990, 1997) and its superior MSE properties for the general linear model and reports substantive empirical findings on estimates and ex-post forecasts of investment in these countries.

Brief discussions on the foundation of alternative current estimation and forecasting methodologies in economic modelling and policy uses, on the significance of our empirical findings, and a comparison with results obtained from well-known methods such as the OLS, the maximum likelihood and the positive-part Stein (or empirical Bayes) will also be provided.

1   Introduction

The standard theories of economics, international finance, transnational corporations, and within the accounting framework of the United Nations Standardized National Accounts (SNA) stipulate that investment plays a crucial role in influencing microeconomic decisions and macroeconomic activity, national output growth and economic development, and in shaping fiscal and monetary policy (Dornbusch and Fischer, 1990) and economic reforms in many developed, newly industrialized and especially developing countries (World Bank, 1991). Corporate and private strategies for business development and expansion in a home or host economy depend on this crucial role in a Wiener-Granger causal sense. As a result, a rigorous study and discussions of the movements or trends of these economic aggregates and their empirical relationships either in a historical context or in future predictions are amply justified.

The purpose of our paper is threefold. First, it contributes to macroeconomic analysis in general and to international business, financial studies, transnational corporations, and development economics in particular, by rigorously investigating the causal structure and empirical forecasts of a major macroaggregate, namely, investment, in some major and growing economies in the East Asian region. Once a casual effect has been established, remedies may be found for restoring investment to a level conducive to promotion of growth and other activities dependent on investment. The countries included in this study at this stage are three major economies in East Asia, namely China, Indonesia, Korea, Malaysia, and Thailand. The testable causal structure is based upon the conventional dynamic multi-equation Keynesian theory and the SNA framework.

The second purpose is methodological in nature in that the paper departs from the applied econometric modelling approaches using conventional multiple regressions, simultaneous equations, or seemingly unrelated regressions, and makes use of a fairly simple and flexible economy-wide modelling approach based on the calculus of differential analysis in economics (Tran Van Hoa, 1992a, 1992d) to provide the fundamental equations in the reduced form for better estimation and forecasting of investment. The success of this new approach is assessed via its modelling performance.

Finally, as a contribution to applications of recent advances in the statistical theory of forecasting to a better formulation of forward planning policy and strategies in finance, economics, and business in the case of China, Indonesia, Korea, Malaysia, and Thailand, forecasts of investment based on the empirical Bayes or hierarchical information (Tran Van Hoa, Tran Van Hoa, 1985, 1986a, 1993b, Tran Van Hoa and Chaturvedi, 1988, 1990) theories under different plausible scenarios are made and compared to other conventional methods. More specifically, the ex post performance (or accuracy) of these forecasts in the context of average mean squared forecasting errors (MSE) or Wald risk criteria is then evaluated against more traditional forecasts based on the ordinary least squares, the maximum likelihood, or the explicit (Baranchik, 1973) positive Stein-like (Anderson, 1984) methodologies.

The implications from our paper are twofold. First, if the modelling success of our approach is relatively superlative -- in terms of its empirical fit and turning point predictions -- then its superiority is confirmed. Secondly, if, based on the same model and dataset, a substantial improvement is achieved by the 2SHI methods in relation to other conventional procedures currently in use, then our findings will, in addition, point to a new direction of rigorous forecasting analysis for finance, economics, and business analysts in their everyday strategic corporate and individual planning applications to investment.

2 Multi-Sectoral Modelling of Investment

In an economy with interdependent sectors and activities, investment could be argued to be dependent on many varied internal and external, economic and non-economic factors in a linear, nonlinear, or mixed form. Consider for illustration in this paper a simple well-known generic five-equation Keynesian macroeconomic model of an economy

$$C_t = \alpha 11 + \alpha 12 Y_t + \alpha 13 C_{t-1} + u1_t \qquad (1)$$

$$I_t = \alpha 21 + \alpha 22 Y_t + \alpha 23 Y_{t-1} + \alpha 24 R_t + \alpha 25 R_{t-1} + \alpha 26 D_t + u2_t \qquad (2)$$

$$X_t = \alpha 31 + \alpha 32 YW_t + \alpha 33 TT_t + u3_t \qquad (3)$$

$$IM_t = \alpha 41 + \alpha 42 Y_t + \alpha 43 TT_t + u4_t \qquad (4)$$

$$Y_t = C_t + I_t + G_t + X_t - IM_t \qquad (5)$$

where C = private final consumption expenditure, Y = gross domestic product or GDP, I = private gross fixed capital expenditure, D = external debts, G = public expenditure, X = exports of goods and services, IM = imports of goods and services, YW = world income, TT = the terms of trade of the country, and R = short-term money market interest rate or its equivalent or proxy variable (eg, the US prime rate). The α's denote the structural parameters, and the u's the error terms. All value variables are expressed in terms of their constant 1987 prices.

The model (1)-(5) is a dynamic macroeconomic model (Pindyck and Rubinfeld, 1991) for an open economy and takes into account (a) a partial adjustment process in consumption behaviour encompassing the hypotheses of relative and permanent income, liquid assets, wealth, and life cycles in the sense of Duesenberry, Friedman, and Modigliani, (b) a flexible accelerator investment behaviour, augmented by foreign capital borrowings (see for further detail Tran Van Hoa and Harvie, 1998) and user's costs, (c) trade openness through exports and imports regulated by foreign and domestic demand conditions and price relativities and (d) relevance of the government sector.

In the model, consumption, investment , exports, imports and GDP are endogenous, and there are nine exegoneous and predetermined variables.

It can be verified that, using the order condition for identifiability or mathematical consistency in the theory of econometrics, the investment equation (2) in the model is identified. As a result, it can be written in its complete differential form (see Allen, 1960) in the reduced form as (see Tran Van Hoa, 1992a and 1992d, Harvie and Tran Van Hoa, 1993)

$$I\%_t = a11 + a12\, C\%_{t-1} + a13 Y\%_{t-1} + a14 R\%_t + a15 R\%_{t-1}$$

$$+ a16 D\%_t + a17 YW\%_t + a18 TT\%_t + a19 G\%_t + e1_t \qquad (6)$$

where I%, C%, Y%, R%, D%, YW%, TT% and G% indicate the rate of change of I, C, Y, R, D, YW, TT and G respectively, a's indicate the reduced form parameters, and e1 is the new error term.

Equation (6) characterizes the investment relationship from the five-equation macroeconomic model (1)-(5) above. By conventional definition, the parameters from this equation are in fact either static (or dynamic) elasticities associated with either current (or lagged) variables included in it.

The derivation of (6) by means of total differentiation of an arbitrarily functional relationship is simple and, more importantly, consistent with the procedure usually adopted for the neoclassical macroeconomic models of the applied or computable general equilibrium kind. In these neo-classical models, the endogenous and exogenous variables in the economy are linked by a (usually first order) approximate transmission mechanism in terms of the elasticities. There are however at least five important differences between our investment equation given in (6) above and the investment specification from applied or computable general equilibrium Johansen-class models

First, in our case, the important linking elasticities have to be estimated for the model as a whole using economic time series data and possibly other extraneous (prior) information such as policy switches or external non-economic factors. Our equation given in (6) thus is completely data-based, although clearly we do not preclude the use of prior or extraneous information (in the form of an oil crisis or a major war for example) in the equation in other theoretical or judgemental contexts.

Secondly, in view of the above arguments, our model is capable of accommodating sub- and add-factors as well as structural change and other institutional considerations (for a discussion supporting the use of these factors in macroeconomic models, see Johansen, 1982).

Thirdly, our equation must be mathematically consistent as required by the identifiability conditions for complete systems of structural simultaneous equations in the theory of econometrics.

Fourthly, by its construct, our modelling approach encompasses a wide class of linear and nonlinear multi-equation econometric models in which the exact functional form of each of the individual structural equations is as usual unknown or needs not be specified.

Finally, for an important group of economic variables whose first differences in logs are approximately equivalent to the rates of change, our equations by their construct include as the special cases the Granger-Wiener short term causality if these rates of changes are I(0) and the co-integration or long-term equations of the Engle-Granger (1987) class (see Tran Van Hoa, 1993c, and Harvie and Tran Van Hoa, 1993, for further detail) if the rates of change are I(1).

To evaluate the performance of (a) the investment equation in this macroeconomic model and (b) our forecasting methodology using real-life data from five major economies in East Asia, we have fitted the equation (6) to data for the period 1970 to 1995 five selected countries: China, Indonesia, Korea, Malaysia, and Thailand. This will optimally produce the necessary elasticity estimates. These estimates are then used in a comparative study which is based on stochastic simulation to measure the relative MSE performance or operational accuracy of our modelling equation and also of our new forecasting approach in relation to other current methodologies.

3   Alternative Estimating and Forecasting Methodologies

The investment equation in differential and reduced form as given in (6) can be written more generally with a sampling size T and k independent variables (possible causes) in matrix notation as

$$y \quad = \quad Z \quad \beta \quad + \quad u \tag{7}$$
$$(Tx1) \quad (Txk) \quad (kx1) \quad (Tx1)$$

where y=I% or Y%, Z=the rate of changes of the exogenous and predetermined variables (both static and dynamic), β =the parameters, and u the disturbance satisfying all standard statistical assumptions.

To estimate (7) which is essentially a general linear model (7) for structural or behavioral analysis or for direct forecasting and policy analysis (see Pindyck nd Rubinfeld, 1991), we can use the OLS, or, at a more efficient level, any of the explicit (Baranchik, 1973) Stein or Stein-rule methods as described below.

More specifically, using (7), the basic and most well known method to produce estimates and forecasts of y (or I%) is the OLS estimator of β (denoted by b) and is written as

$$b = (Z'Z)^{-1}Z'y \tag{8}$$

A more sophisticated and efficient method is the explicit Stein estimator of β (Baranchik, 1973) that is given by

$$\beta s = [1 - c(y-Zb)'(y-Zb)/b'Z'Zb] \; b$$

$$= [1 - c(1-R^2)/R^2] \; b \tag{9}$$

where c is a characterizing scalar and defined in the range $0 < c < 2(k-2)/(T-k+2)$, and R^2 is the square of the sample multiple correlation coefficient.

A still more efficient method is the explicit positive-part Stein estimator of β (Anderson, 1984) which is defined as

$$\beta+s = [1 - \min\{1 , c(y-Zb)'(y-Zb)/b'Z'Zb\}] \; b$$

$$= [1 - \min\{1 , c(1-R^2)/R^2\}] \; b \tag{10}$$

A new method to obtain estimates and forecasts of β in (7) with better properties has been proposed (see Tran Van Hoa, 1985, Tran Van Hoa and Chaturvedi, 1988 and 1990). It is in a class of explicit improved Stein-rule or empirical Bayes [also known as two-stage hierarchical-information (2SHI)] estimators for some linear regression models. This estimator includes the explicit Stein and the double k-class (Ullah and Ullah, 1981) estimators as subsets (Tran Van Hoa, 1993b). Other applications of the Stein, Stein rule, and 2SHI estimators to linear regression models with non-spherical disturbances and to Zellner's seemingly unrelated regression model have also been made (see Tran Van Hoa et al, 1993a, in the case of regressions with nonspherical disturbances, and Tran Van Hoa, 1992b, and 1992d, in the case of seemingly unrelated regressions).

The explicit 2SHI estimator is defined as

$$\text{ß}h = [1 - c(1-R^2)/R^2\} - c(1-R^2)/\{R^2(1+c(1-R^2)/R^2)\}]\ b \tag{11}$$

and its positive-part counterpart (Tran Van Hoa, 1986a) is given by

$$\text{ß+}h = [1 - \min\{1\ ,\ c(1-R^2)/R^2\} - \{1/((R^2/c(1-R^2)) + 1)\}]\ b \tag{12}$$

While all the estimators given above can be applied to the general linear model (7) for structural and forecasting analysis, their relative performance in terms of historical, ex post or ex ante (Pindyck and Rubinfeld, 1991) forecasting MSE can differ. Thus, it is well-known that, in MSE and for $k \geq 3$ and $T \geq k + 2$, ßs dominates (that is it performs better in forecasting MSE) b, and ßs is dominated by ß+s (Baranchik, 1973, Anderson, 1984). However, it has also been demonstrated (Tran Van Hoa, 1985, Tran Van Hoa and Chaturvedi, 1988) that, in MSE, ßh dominates both b and ßs, and more importantly, ß+h dominates ß+s (Tran Van Hoa, 1986a).

A further important path-breaking result of the 2SHI theory has recently been proved (see Tran Van Hoa and Chaturvedi, 1997): the dominance of the 2SHI over the OLS and Stein exists anywhere in the range $0 < c < 2(k-1)/(T-k)$. This indicates that the 2SHI method produces better (in terms of smaller Walk risk or generalized Pitman nearness) estimates and forecasts even if the estimating and forecasting equation has only one independent variable in it. *The condition for the optimal Stein dominance in the linear equation up to now requires that $0 < c < 2(k-2)/(T-k+2)$ [see Anderson, 1984].*

While some application of these forecasting methodologies to predictions of economic activity in some developed countries such as Australia (see Tran Van Hoa, 1992d) has been made, the extent of the significance of the MSE dominance, or equivalently, the informational gain or relative forecasting success between the alternative estimators above has not been investigated explicitly within an open trade theoretical framework and an empirical context using more recent economic data for the major economies in East Asia. This issue is taken up in the study below for the five economies with highly fluctuating investment and spectacular growth but are very sensitive to foreign trade and capital flows in the region (see Tran Van Hoa and Harvie, 1998).

Another interesting feature of our study is that, since all data from the Asian countries have as usual a small sample size, our study is therefore designed to look at the finite sample performance of alternative forecasting methods.

Finally, since the poor quality of economic data from the Asian countries and other less developed countries (LDC) economies is well known, one by product of our study is that we in fact investigate the performance of the alternative forecasts in the case of serious measurement errors on the variables of the macromodel of an economy however it is defined.

The substantive findings reported below are based on the five-equation macroeconomic model described earlier in (1)-(5), and the appropriate estimating equation to produce elasticity parameters or the forecasting equation to produce policy impact is given in (6) for investment. In addition, a number of well known forecasting methods is used to compare their relative performance for decision analysis.

# 4	A Comparative Analysis of Alternative Forecasts

In our study, we have fitted the investment equation in differential and reduced form (6) of the model (1)-(5) to annual data from China, Indonesia, Korea, Malaysia, and Thailand. The original dataset is from 1970 to 1997, but the effective (ie, after allowing for missing or statistically incompatible data) sample period is 1980 to 1995, giving, when the dynamic (lag) structure is taken into account, a sample size of up to 15 observations for each variable. In our comparative study, only the OLS or ML, the positive-part Stein, and the positive-part 2SHI forecasts of investment are used.

The data are in real terms at the constant 1987 prices and obtained from the 1997 World Bank World Tables Asia Pacific database, using Australia's DX extracting procedure. The performance of our reduced form investment equations is determined solely from their good fit, correct turning point predictions and forecasting MSE.

Other research strategy of our study includes a number of important features:

First, to investigate the possible accuracy improvement or informational gain under different situations from the data, the ex post forecasts (Pindyck and Rubinfeld, 1991) of investment from our macroeconomic model are derived rather pragmatically, for a lack of larger samples, for 1, 2 and 3 years only ahead. These are called Subsamples 1, 2, and 3 respectively. In other words, for our investment equation which has 15 observations and nine parameters to be estimated, the ex post forecasts are made respectively 1, 2 and 3 years ahead from 1991. The consistency of our ex post forecasts (which are based on the same historical simulation period), if existent, describes to some extent the possible presence of rationality (ie, the forecasts match the data generating process) in the forecasting investment equations.

Secondly, for each of these subsamples, the MSE of the forecasts from (6) is computed from a stochastic simulation and is based on 100 (smaller or larger simulations yielded similar results) statistical trials. In stochastic simulation, both the estimated parameters and the disturbances are allowed to vary from trial to trial (see Pindyck and Rubinfeld, 1991, for further detail). The distributions used to generate these parameter and disturbance trial-to-trial variations are based upon their OLS-based (Monte Carlo) sample distributions with 500 repetitions.

Finally, in the case of the disturbance or error term distribution, the simulation for each subsample takes respectively the value of s^2, $10s^2$, and $100s^2$, where s^2 is the sample disturbance variance. This strategy is adopted to investigate the impact of the size of the disturbance variances (or the size of the measurement errors on the possible causes or the misspecification of the investment function) on the relative performance of the various forecasting methodologies in our investment equation. This kind of analysis is particularly applicable to data from the LDCs, as is well known.

Thus, in our empirical study, the ex post forecasting MSE is obtained, by stochastic simulation, for a total of 45 sets of investment forecasts in differential and reduced form, different from each other in terms of the forecasting sample size, σ^2 (the disturbance variance), and the country of origin.

The relative performance of the OLS, positive-part Stein $\beta+s$, and positive-part 2SHI $\beta+h$ estimators for each of these equations and for each of the five countries (China, Indonesia, Korea, Malaysia, and Thailand) in East Asia between 1980 and 1995 is given in Tables 1-5. Relative performance between say the OLS and the positive-part Stein is defined formally as $R(b/\beta+s) = 100[\ MSE(b)\ /\ MSE(\beta+s)\ -1]$, and dominance or

informational gain in ex post forecasting MSE of ß+s over b exists whenever ex post forecasting R(b/ ß+s) ≥ 0, with equality somewhere in the parameter space. Similar results are used for other comparisons R(b/ ß+h) and R(ß+s/ ß+h).

It can be further verified that, for the forecasting equation of the functional form defined in (6) or (7), when historical and future values of Z (the possible causes) are known, dominant ex post forecasting MSE implied dominant ex ante forecasting MSE. *This extension is useful for policy analysis into the future.*

For ex post forecasting, the relative performance of the OLS, ß+s, and ß+h estimators for each of these models is also expressed in terms of its standard criteria such as mean per cent errors, RMS per cent errors, and per cent improvement in ex post forecasting MSE or informational gain (see Pindyck and Rubinfeld, 1991). Only the informational gain or forecasting accuracy improvement is given in Tables 1-5.

The relative performance in ex post forecasting MSE between say the OLS-based forecasts and the positive-part Stein-based forecasts, as reported in Tables 1-5, is in fact defined as R(b/ß+s) = 100[(MSE(yb-y) / MSE(ys-y))-1] with MSE(yb-y) being the MSE of the forecasting errors based on the OLS estimates, and MSE(ys-y) being the MSE of the forecasting errors based on the positive-part Stein. The calculation of MSE(yh-y) is similar.

5   Modelling and Informational Gain in Practice

From the empirical results of stochastic simulation given in Tables 1-5, we observe that the average R^2 values of 45 of our estimated investment equations are fairly high for the actual disturbance variance (from 91% to 99.5%). This confirms the empirical modelling success of the models.

In addition, investment in all five countries in our study seems affected by interest rates and foreign factors such as external debts, world demand conditions and the relativity between export and import prices.

In terms of forecasting accuracy and improvement, all values of the relative forecasting MSE criteria [ie, R(ml/s), R(ml/h) and R(s/h)] for the 45 sets of investment forecasts for China, Indonesia, Korea, Malaysia, and Thailand, are greater than zero. In other words, the positive-part Stein-based forecasts of investment uniformly dominate (or perform better than) the OLS-based forecasts. More spectacularly and significantly, the positive-part Stein-based forecasts of investment which have been claimed in the statistical literature to be unbeatable are in turn uniformly dominated by the positive-part 2SHI forecasts. Our findings establish the optimal hierarchy for selection of an appropriate forecasting theory for making better forward planning investment strategies.

Some other interesting forecasting and methodological features about the oberved investment behaviour and trends in these five major East Asian countries are briefly described below (detailed comments on the investment behaviour and trends as well as trade and business opportunities from our empirical results will be reported elsewhere).

CHINA

The estimated investment equation for China during the historical period 1980-1990 has the highest R^2 value among the five countries in our study (at 99.5%). This indicates some measure of success of our multi-sectoral econometric modelling approach for the available data.

From the evidence in Table 1, the fluctuations in investment in China during this period were affected mainly by interest rates but world income (ranked 2), terms of trade (ranked 3), external debts and government expenditure (ranked 4) all had some impact. As far as the size of the impact is concerned, external debts were a positive but the least significant factor of investment.

Using our 2SHI methodologies for forecasting investment in the short (one year) and medium (3 years) term for China, the informational gain can be as high as 8.59% in relation to the OLS and 4.01% in relation to the positive-part Stein. The gain increases generally with the size of the measurement errors on investment.

INDONESIA

The R^2 values for the estimated investment equation for Indonesia during 1980-1990 reach as high as 98.7%. This is a notch below the modelling success with China, but the value indicates nevertheless a credible result for the model.

From the findings reported in Table 2, investment in Indonesia during this period was determined by (lagged) domestic income (ranked 1) and interest rates (ranked 2) and foreign demand or world income (ranked 3). Other factors (eg, past consumption, external debts, terms of trade and government spending) hardly had any effect on investment. All effects on investment (except from lagged domestic income) were small or negligible however.

The use of 2SHI for the investment equations for Indonesia yields a gain of up to 19.18% in relation to the OLS and up to 10.56% relative to the positive-part Stein. Again, the improvement in smaller forecasting MSE increases generally with the increasing size of measurement errors on investment.

KOREA

Data for Korea give two more observations in the dataset from 1980 to 1995, but for consistency in comparison, the historial sample we used is still from 1980 to 1990. And the forecasting sample is still up to 3 years ahead, from 1993 to 1995. From Table 3, the R^2 values can be as high as 98.4% or as low as 91.0% (the lowest R^2 for all 45 simulation experiments).

Also from the results given in Table 3, investment in Korea during 1980-1990 was determined mainly by interest rates (ranked 1) followed in the descending order by respectively world income or foreign demand, government spending, terms of trade and external debts. Among these variables, the only one with a large and positive estimated elasticity is external debts (1.167). In other words, investment in Korea was driven by external debts and not by any other factors. If investment is considered the main driving force of growth, then growth in Korea was induced mainly by external debts. The implications of this finding in the case of economic crises are obvious.

The application of the 2SHI methodologies to the investment equation here produces a gain of up to 36.46% in relation to the OLS and up to 14.07% relative to the positive-part Stein. The gain rises generally with the increase in measurement errors on investment.

MALAYSIA

Data for Malaysia are available only for the period 1980 to 1993. The R^2 values for the investment equation range however from 97.9% to 99.3%, a very high goodness of fit.

From the findings given Table 4, it appears that fluctuations in investmnent during 1980 to 1990 were very sensitive to the movements in the interest rates, followed by foreign demand conditions then lagged domestic income. The only positive effects (elasticities) on investment in Malaysia are this lagged domestic income (15.889) and government expenditure (3.039). Growth (transmitted via increases in investment) here was driven by domestic demand and government budget and much less by other factors, domestic or foreign.

In forecasting future investment movements, the 2SHI methodologies would provide an improvement in accuracy by up to 22.59% compared to the OLS and up to 9% to the positive-part Stein. The improvement also rises generally with the increases in measurement errors of investment.

THAILAND

The data for Thailand are available from 1980 to 1995, giving again a sample size of 15. Using however a consistent historial sample size of 10 (from 1980 to 1990), the R^2 values for the estimated investment equation range from 92.6% to 99.1%, indicating a good success in our modelling approach.

From the results given in Table 5, it appears that interest rates played the most important part in the movements of investment in Thailand during 1980 to 1990, followed in descending order by government expenditure, lagged consumption, external debts, world demand for Thailand's exports, wealth (or lagged domestic income), and the terms of of trade. Thailand's growth (transmitted as usual via increases in investment) was almost equally contributed by domestic consumption (9.318) and external debts (7.031) and terms of trade (3.542).

Using the conventional OLS method of forecasting for investment in Thailand in this case would generate an informational loss of up to 20.40% in relation to the positive-part Stein and up to 40.14% relative to the 2SHI theory.

The informational gain of the 2SHI over the positive Stein is uniform in all 9 simulation models and of up to 16.39%. The gain again rises generally with increases in the measurement errors on investment.

6   References

Allen, R.G.D. (1960), Mathematical Analysis for Economists, London: Macmillan.

Anderson, T.W. (1984), An Introduction to Multivariate Statistical Analysis, 2nd Edition, New York: Wiley.

Baranchik, A.J. (1973), "Inadmissibility of Maximum Likelihood Estimators in some Multiple Regression Problems with Three or More Independent Variables", Annals of Statistics, Vol. 1, 312-321.

Chaturvedi, A. and Tran Van Hoa (1997), "The dominance of the 2SHI estimator under generalized Pitman nearness", Communications in Statistics, Vol. 26, Issue 5, 1997, pp. 1227-1238.

Dornbusch, D. and Fischer, S. (1990), Macroeconomics, 5th Edition, Sydney: McGraw Hill.

Engle, R.F. and Granger, C.W.J. (1987), "Co-integration and Error Correction: Representation, Estimation and testing", Econometrica, Vol. 55, 251-276.

Harvie, C. and Tran Van Hoa (1993), "Long Term Relationships of Major Macrovariables in a Resource-Related Economic Model of Australia: a Cointegration Analysis", Energy Economics, Vol. 15, 257-262.

Johansen, L. (1982), "Econometric Models and Economic Planning and Policy: Some Trends and Problems", in M. Hazewinkle and A.H.G. Rinnooy Kan (eds.), Current Developments in the Interface: Economics, Econometrics, Mathematics, Boston: Reidel.

Pindyck, R.S. and Rubinfeld, D.L. (1991), Econometric Models and Economic Forecasts, Sydney: McGraw-Hill.

Tran Van Hoa (1985), "The Inadmissibility of the Stein Estimator in Normal Multiple Regression Equations", Economics Letters, Vol. 19, 39-42.

Tran Van Hoa (1986a), "The Inadmissibility of the Stein Estimator in Normal Multiple Regression Models: Analytical and Simulation Results", 15th Anniversary of the NBER-NSF Seminar on Bayesian Inference in Econometrics, ITAM, Mexico City, 16-18 January 1986.

Tran Van Hoa (1986b) "Effects of Monetary and Fiscal Policy on Inflation: Some Evidence from the J-Test", Economics Letters, Vol. 22, 187-190.

Tran Van Hoa and Chaturvedi, A. (1988), "The Necessary and Sufficient Conditions for the Uniform Dominance of the Two-Stage Stein Estimators", Economics Letters, Vol. 28, 351-355.

Tran Van Hoa and Chaturvedi, A. (1990), "Further Results on the Two-Stage Hierarchical Information (2SHI) Estimators in the Linear Regression Models", Communications in Statistics (Theory and Methods), Vol A19, No. 12, 4697-4704.

Tran Van Hoa (1992a), "Modelling Output Growth: A New Approach", Economics Letters, Vol. 38, pp. 279-284.

Tran Van Hoa (1992b) "Energy Consumption in Thailand: Estimated Structure and Improved Forecasts to 2000" (in Thai), Thammasat Economic Journal (Thailand), Vol. 10, 55-63..

Tran Van Hoa (1992c), "A Multi-equation Model of Energy Consumption in Thailand", International Journal of Energy Research, Vol. 16, pp. 381-385.

Tran Van Hoa (1992d), "A New and General Approach to Modelling Short-Term Interest Rates: With Application to Australian Data 1962-1990", Journal of Economics and Finance: Proceedings, Vol. 16. 327-335.

Tran Van Hoa (with Chaturvedi, A. and Shukla, G.) (1993a), "Performance of the Stein-rule Estimators when the Disturbances are Misspecified as Spherical", Economic Studies Quarterly (Japan), Vol. 44, 601-611.

Tran Van Hoa (1993b), "The Mixture Properties of the 2SHI Estimators in Linear Regression Models", Statistics and Probability Letters, Vol. 16, 111-115.

Tran Van Hoa (1993c), "Effects of Oil on Output Growth and Inflation in Developing Countries: The Case of Thailand 1966:1 to 1991:1", International Journal of Energy Research, Vol. 17, 29-33.

Tran Van Hoa and Chaturvedi, A. (1997), "Performance of the 2SHI Estimator under the Generalized Pitman Nearness Criterion", Communications in Statistics (Theory and Method), Vol. 26, Issue 5, 1227-1238.

Tran Van Hoa and Harvie, C (1998), Causes and Impact of the Asian Financial Crisis, London: Macmillan.

Ullah and Ullah (1978), "Double k-class Estimators of Coefficients in Linear Regression", Econometrica, Vol. 46, pp. 705-722.

World Bank (1991), The Challenge of Development, World Development Report, Oxford: Oxford University Press.

World Bank World Tables (1997).

TABLE 1
Forecasting Investment in Five Major East Asian Economies
Results of Stochastic Simulation

CHINA: 1980 TO 1993
INVESTMENT

I% Equation	Const	C%$_{t-1}$	Y%$_{t-1}$	R%$_t$	R%$_{t-1}$	D%$_t$	YW%$_t$	TT%$_t$	G%$_t$
OLS Parameter	-38.596	-3.168	-2.244	85.796	170.255	1.391	12.637	-7.055	4.106

Average R²

0.993	0.992	0.989		0.993	0.991	0.992		0.995	0.991	0.991

OLS-based disturbance variance {$s1^2$ $s2^2$ $s3^2$}

70.95		709.582		7095.82

Estimation period   1980 to 1990
Forecasting period

1991 to 1991			1991 to 1992			1991 to 1993		
$\sigma1^2$	$\sigma2^2$	$\sigma3^2$	$\sigma1^2$	$\sigma2^2$	$\sigma3^2$	$\sigma1^2$	$\sigma2^2$	$\sigma3^2$

Ex Post Forecasting Relative MSE - Informational Gain (%)

	$\sigma1^2$	$\sigma2^2$	$\sigma3^2$	$\sigma1^2$	$\sigma2^2$	$\sigma3^2$	$\sigma1^2$	$\sigma2^2$	$\sigma3^2$
R(ml/s)	3.52	3.85	4.33	3.15	3.73	3.25	2.82	3.03	4.40
R/ml/h)	6.96	7.45	8.43	6.24	7.39	6.35	5.47	5.94	8.59
R/s/h)	3.32	3.47	3.93	3.00	3.53	3.00	2.58	2.82	4.01

NOTES. b = OLS, ßs = positive-part Stein (STEIN), ßh = positive-part 2SHI. R(ml/s)=R(b/ßs)= 100[MSE(b)/MSE(ßs)-1], where MSE(b) = E(b-ß)'(b-ß) with ß calculated from the OLS estimates of each equation using 500 repetitions (with the error terms only random from trial to trial), and used as the true parameter vector. Similarly for ßh and ßs, i.e., R(ml/h)=R(b/ßh) and R(s/h)=R(ßs/ßh). Relative efficiency in ex post forecasting MSE of say ßh over ßs exists whenever R(s/h) = R(ßs/h) ≥ 0. σ² = OLS-based disturbance variance. In our stochastic simulation study, all results are based on 100 statistical trials and c is arbitrarily set c = (k-2) /(T-k+2). All data are from the 1997 World Bank World Tables DX database. For the derivation of the I% equation above, see (6) in text. The parameter estimates of this equation are obtained as the mean parameters from 100 stochastic simulations with the equation variances equal the actual residual variance σ².

TABLE 2
Forecasting Investment in Five Major East Asian Economies
Results of Stochastic Simulation

INDONESIA: 1980 TO 1993
INVESTMENT

I% Equation	Const	$C\%_{t-1}$	$Y\%_{t-1}$	$R\%_t$	$R\%_{t-1}$	$D\%_t$	$YW\%_t$	$TT\%_t$	$G\%_t$
OLS Parameter	-0.069	0.000	-3.165	0.098	-0.052	0.000	0.016	0.003	0.000

Average R²

0.983	0.987	0.969		0.985	0.971	0.979		0.984	0.979	0.978

OLS-based disturbance variance {$s1^2$ $s2^2$ $s3^2$}

0.594712E-03	0.594712E-02	0.594712E-01

Estimation period   1980 to 1990
Forecasting period

1991 to 1991			1991 to 1992			1991 to 1993		
$\sigma1^2$	$\sigma2^2$	$\sigma3^2$	$\sigma1^2$	$\sigma2^2$	$\sigma3^2$	$\sigma1^2$	$\sigma2^2$	$\sigma3^2$

Ex Post Forecasting Relative MSE - Informational Gain (%)

R/ml/s)	5.75	6.83	9.39	7.83	14.65	9.70	7.79	8.62	10.74
R/ml/h)	11.32	13.56	17.29	15.02	26.76	18.55	14.87	16.46	19.18
R/s/h)	5.27	6.30	7.22	6.67	10.56	8.07	6.56	7.21	7.63

TABLE 3
Forecasting Investment in Five Major East Asian Economies
Results of Stochastic Simulation

KOREA: 1980 TO 1995
INVESTMENT

I% Equation	Const	$C\%_{t-1}$	$Y\%_{t-1}$	$R\%_t$	$R\%_{t-1}$	$D\%_t$	$YW\%_t$	$TT\%_t$	$G\%_t$
OLS Parameter	35.641	0.029	0.227	-0.972	-4.694	1.167	-4.058	-1.649	-2.026

Average R²

0.984	0.976	0.971		0.978	0.973	0.975		0.944	0.910	0.921

OLS-based disturbance variance {$s1^2$ $s2^2$ $s3^2$}

46.3838	463.838	4638.38

Estimation period   1980 to 1990
Forecasting period

1991 to 1991			1991 to 1992			1993 to 1995		
$\sigma1^2$	$\sigma2^2$	$\sigma3^2$	$\sigma1^2$	$\sigma2^2$	$\sigma3^2$	$\sigma1^2$	$\sigma2^2$	$\sigma3^2$

Ex Post Forecasting Relative MSE - Informational Gain (%)

R(ml/s)	6.90	8.89	12.71	6.45	13.74	12.16	16.42	19.63	19.13
R(ml/h)	13.56	17.32	23.66	11.29	25.25	21.22	29.93	36.46	34.75
R/s/h)	6.23	7.75	9.71	4.55	10.12	8.08	11.61	14.07	13.11

TABLE 4
Forecasting Investment in Five Major East Asian Economies
Results of Stochastic Simulation

MALAYSIA: 1980 TO 1993
INVESTMENT

I% Equation	Const	C%$_{t-1}$	Y%$_{t-1}$	R%$_t$	R%$_{t-1}$	D%$_t$	YW%$_t$	TT%$_t$	G%$_t$
OLS Parameter	127.509	-2.826	15.889	151.138	-264.919	-2.025	-45.380	-1.094	3.039

Average R²

0.989	0.986	0.979		0.992	0.982	0.985		0.993	0.985	0.988

OLS-based disturbance variance {$s1^2$ $s2^2$ $s3^2$}

155.089   1550.89   15508.9

Estimation period 1980 to 1990
Forecasting period

1991 to 1991				1991 to 1992				1991 to 1993		
$\sigma1^2$	$\sigma2^2$	$\sigma3^2$		$\sigma1^2$	$\sigma2^2$	$\sigma3^2$		$\sigma1^2$	$\sigma2^2$	$\sigma3^2$

Ex Post Forecasting Relative MSE - Informational Gain (%)

R(ml/s)	4.62	6.31	12.47		5.82	5.68	5.32		4.81	5.97	4.51
R(ml/h)	8.49	11.76	22.59		11.19	10.11	10.37		9.49	11.45	8.29
R(s/h)	3.69	5.13	9.00		5.07	4.19	4.79		4.47	5.17	3.61

TABLE 5
Forecasting Investment in Five Major East Asian Economies
Results of Stochastic Simulation

THAILAND: 1980 TO 1995
INVESTMENT

I% Equation	Const	C%$_{t-1}$	Y%$_{t-1}$	R%$_t$	R%$_{t-1}$	D%$_t$	YW%$_t$	TT%$_t$	G%$_t$
OLS Parameter	-23.900	9.138	-4.509	-104.791	-13.494	7.061	-6.824	3.542	-10.755

Average R²

0.989	0.985	0.979		0.991	0.978	0.985		0.946	0.926	0.927

OLS-based disturbance variance {$s1^2$ $s2^2$ $s3^2$}

132.355   1323.55   13235.5

Estimation period 1980 to 1990

Forecasting period

1991 to 1991				1991 to 1992				1993 to 1995		
$\sigma1^2$	$\sigma2^2$	$\sigma3^2$		$\sigma1^2$	$\sigma2^2$	$\sigma3^2$		$\sigma1^2$	$\sigma2^2$	$\sigma3^2$

Ex Post Forecasting Relative MSE - Informational Gain (%)

R(ml/s)	5.97	6.96	5.18		4.39	5.25	5.10		11.99	18.37	20.40
R(ml/h)	11.28	12.50	9.32		8.48	10.15	9.43		23.53	36.52	40.14
R(s/h)	5.01	5.18	3.94		3.92	4.65	4.12		10.30	15.33	16.39