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Measuring the macroeconomic performance of the Taiwanese economy

C.A. Knox Lovell*

Department of Economics, University of Georgia, Athens, GA 30602, USA

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Abstract

In this paper I construct a scalar-valued summary measure of the macroeconomic performance of an economy. The measure combines any number of conventional but noncommensurate performance indicators. The basic idea behind the procedure is to use mathematical programming techniques of efficiency measurement to construct a "best practice" macroeconomic performance frontier, and then to measure performance in terms of an indicator-based efficiency score. The procedure is applied to a set of ten Asian economies over the past two decades, with special attention paid to Taiwan.

1. Introduction

The first objective of this paper is to describe the construction of a summary measure of macroeconomic performance that combines a number of popular but noncommensurate performance indicators. The second objective is to illustrate the procedure with an application to a number of Asian economies, with particular emphasis on Taiwan.

Others have proposed such summary macroeconomic performance indexes, although the imperfections in their indexes have encouraged me to join the game. Perhaps the most popular index is Okun's "misery index", the sum of a nation's unemployment rate and its inflation rate. A similar index is the Calmfors index, the difference between a nation's unemployment rate and its trade balance normalized by its gross national product. A third index is the OECD's "magic diamond", constructed from values of a nation's growth, trade balance, inflation and unemployment positioned on the axes of a four-quadrant diagram.

Each of these indexes is informative but flawed. The OECD approach uses all four of the main indicators, but they are measured in different units, and diamonds can intersect. The Calmfors and Okun indexes use only two of the four main indicators, and although they are measured in the same units and thus can be aggregated, each index attaches equal weights to the two indicators. What is desired is a scalar-valued index that aggregates all four indicators without attaching a priori weights to the indicators. The procedure proposed in this paper comes close.[1]

* Tel.: (706) 542-3689. Fax: (706) 542-3376. E-mail: knox@rigel.econ.uga.edu.

[1] Melyn and Moesen [1] use a similar procedure to evaluate macroeconomic performance in a sample of OECD countries.

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The basic idea behind the procedure is to adapt the techniques of the efficiency measurement literature to the problem at hand. I construct a "best practice" macroeconomic performance frontier, using national economies as units of observation and the four performance indicators as the outputs produced by these observations. I evaluate performance in terms of dominance relationships, and a productive efficiency score, which has a radial component and a nonradial slack component. It is the presence of slack that explains why the procedure only comes close to achieving its objective.

The procedure is described in Section 2. It is then applied to data described in Section 3. These data describe the macroeconomic performance of ten Asian economies during much of the past two decades. The economies are those of the Four Dragons (Hong Kong, Singapore, South Korea and Taiwan), perhaps the next dragon (Thailand), Japan, Australia, and three less advanced economies (Indonesia, Malaysia and the Philippines). The close linkages that exist among these economies make an evaluation of their relative performance of more than mere academic interest. The time period contains enough ups and downs to show how various economies perform in both good times and bad. Empirical findings are discussed in Section 4. Section 5 concludes.

2. Methodology

For most of this section the methodology is presented in the general context of production analysis.[2] Only at the end is the general framework adapted to the problem at hand.

A collection of producers, indexed $i = 1, \ldots, I$, uses inputs $x^i = (x_1^i, \ldots, x_n^i) \in \mathbb{R}_+^n$ to produce outputs $y^i = (y_1^i, \ldots, y_m^i) \in \mathbb{R}_+^m$. Their objective is assumed to be to produce maximum outputs with given inputs; without price information no further objectives are entertained. The problem is to construct a production possibilities set $T = \{(y, x)$: x can produce $y\}$ from the observed data $\{(y^i, x^i)$, $i = 1, \ldots, I\}$. For this, assumptions are required. The only assumption made here is that of free disposal. A production possibilities set satisfies free disposal if $(x, y) \in T \Rightarrow (x', y') \in T$ for all $x' \geqslant x$, $y' \leqslant y$. Notice that convexity of T is not assumed. Notice also that no assumption about scale economies is imposed. The absence of restrictive assumptions concerning convexity and scale enables the production possibilities set to surround the data as closely as possible, consistent only with the strong disposability property.

The objective of producers being assumed to be output maximization from given inputs, producer performance is evaluated on the basis of the ability to meet that objective. Performance evaluation has two components: dominance and efficiency. A producer is dominated by all producers using no more of each input to produce no less of each output. That same producer dominates all producers using no less of each input to produce no more of each output. The important feature of dominance is its frequency. It is more impressive to dominate many producers than to dominate few. Although it is similarly less impressive to be dominated by many producers than by few, dominating producers may serve as role models, and having more role models to emulate may be more useful than having few. A second feature of dominance is comparability, although comparability is difficult to characterize analytically. The basic idea is that there may be much to be learned from comparable dominating producers, and little to be learned from other dominating producers whose environment makes them noncomparable.

The efficiency of a producer is evaluated by comparing its input–output vector with that of the most dominant of the producers that dominate it. Recalling that the objective of producers is to maximize outputs with given inputs, efficiency is measured in part as the ratio of observed outputs to the maximum feasible equiproportionate expansion of outputs. However, nonradial inefficiency in the form of slack remains after radial inefficiency is measured. The radial component of efficiency is independent of units of measurement, and one measure applies to all outputs. The nonradial slack component of

[2] The general methodology is nonparametric and nonstochastic, and goes by the name FDH, for free disposal hull (of the data) analysis. It was first proposed as a procedure for measuring efficiency by Deprins et al. [2]. A recent exposition is provided by Tulkens [7].

efficiency is denominated in the units in which inputs and outputs are measured, and so the slack component cannot generally be aggregated, and must generally be reported separately for each input and output.

In practice, the dominance enumeration problem and the efficiency measurement problem are solved simultaneously. The efficiency measurement problem may be expressed as

$$\max_{\theta^0, \lambda^0} \quad \theta^0$$

$$\text{s.t.} \quad \sum_{i=1}^{I} \lambda_i^0 y_j^i \geqslant \theta^0 y_j^0, \quad j = 1, \ldots, m,$$

$$\sum_{i=1}^{I} \lambda_i^0 x_j^i \leqslant x_j^0, \quad j = 1, \ldots, n,$$

$$\lambda_i^0 \geqslant 0, \quad \sum_{i=1}^{I} \lambda_i^0 = 1,$$

$$\lambda_i^0 \in \{0, 1\}, \quad i = 1, \ldots, I,$$

where the superscript "0" denotes the producer being evaluated, there being I producers in all.[3] The optimum $\theta^{0*} \geqslant 1$ shows the amount by which all m outputs of the producer being evaluated can be feasibly equiproportionately increased. The reciprocal value $(\theta^{0*})^{-1} \leqslant 1$ measures the radial component of the efficiency of the producer being evaluated. The optimal $\lambda^{0*} = (0, \ldots, 0, 1, 0, \ldots, 0)$ identifies with its nonzero element the most dominant producer for the producer being evaluated. The nonradial slack component of efficiency is provided by the constraints $(y_j^k - \theta^{0*} y_j^0) \geqslant 0$, $j = 1, \ldots, m$, and $(x_j^0 - x_j^k) \geqslant 0, j = 1, \ldots, n$, where the kth element of λ^{0*} is nonzero.

The above problem is a mixed integer programming problem to be solved I times, once for each producer. The computational burden can be reduced substantially by solving a set of I vector comparison problems as follows. For producer (x^0, y^0), define the set $D(x^0, y^0)$ of all dominating producers for which $y^i \geqslant y^0$ and $x^i \leqslant x^0$, $i = 1, \ldots, I$. Then the output constraints in the mixed integer programming problem can be rewritten as

$$\theta^0 \leqslant \sum_{i=1}^{I} \lambda_i^0 (y_j^i / y_j^0), \quad j = 1, \ldots, m,$$

$$= \underset{i \in D(x^0, y^0)}{\text{maximize}} \left\{ \underset{j=1, \ldots, m}{\text{minimize}} \{ y_j^i / y_j^0 \} \right\}.$$

The minimization operator identifies the radial efficiency possible relative to each dominating producer. The maximization operator identifies the most dominant producer. To summarize, the vector comparison procedure identifies $D(x^0, y^0)$, the set of all dominating producers for producer (x^0, y^0). The maximum procedure identifies the most dominant producer and the radial efficiency score, after which slacks in at most $(m + n - 1)$ variables are determined residually.

The problem at hand is a slight modification of the problem just described. In this problem each country produces four outputs, the four indexes of macroeconomic performance: growth, trade balance, price stability and employment. In the production of these outputs each country uses only one input: its macroeconomic decision-making apparatus, which I collectively refer to as its helmsman [4, 5]. Thus $m = 4$, $n = 1$. Moreover, each country uses only one helmsman, and so $x^i = 1, i = 1, \ldots, I$. The mixed integer programming problem becomes[4]

$$\max_{\theta^0, \lambda^0} \quad \theta^0$$

$$\text{s.t.} \quad \sum_{i=1}^{I} \lambda_i^0 y_j^i \geqslant \theta^0 y_j^0, \quad j = 1, \ldots, 4,$$

$$\lambda_i^0 \geqslant 0, \quad \sum_{i=1}^{I} \lambda_i^0 = 1,$$

$$\lambda_i^0 \in \{0, 1\}, \quad i = 1, \ldots, I,$$

which is solved I times, once for each country. Output of the exercise includes dominance information, a radial efficiency score, and slack information for four outputs, for each country.

[3] Some readers may recognize this problem as a variable returns to scale data envelopment analysis (DEA) model, originally proposed by Banker et al. [3], augmented with the constraint $\lambda_i^0 \in \{0, 1\}$. It is this constraint which transforms a convex DEA production possibilities set into a nonconvex FDH production possibilities set.

[4] The old input constraints $\sum_{i=1}^{I} \lambda_i^0 x_j^i \leqslant x_j^0$, $j = 1, \ldots, n$ become $\sum_{i=1}^{I} \lambda_i^0 x^i \leqslant x^0$ since $n = 1$, and $\sum_{i=1}^{I} \lambda_i^0 \leqslant 1$ since $x^i = 1$ for all producers, which is redundant since $\sum_{i=1}^{I} \lambda_i^0 = 1$.

3. The data

Data have been collected for ten Asian countries over the 19-year period 1970–1988, although missing data have reduced the sample size to 130. The countries include Japan, the Four Dragons (Hong Kong, Singapore, South Korea and Taiwan), perhaps the next dragon (Thailand), Australia, and three less advanced countries (Indonesia, Malaysia and the Philippines). The latter three countries are at a somewhat earlier stage of economic development than the first seven countries. However, the close trade relationships that link all ten economies, and their roughly similar economic and political institutions, make most of them comparable potential role models for each other. There is little doubt that the laggards, whoever they may be, can learn from the economic policies adopted by the more successful economies in this sample.

The four variables selected to reflect the macroeconomic performance of the economies are defined as follows.[5]

Growth: The rate of growth of gross domestic product per capita, using constant prices measured in local currencies and the mid-year population.

Employment: The ratio of civilian employment to the civilian labor force above a certain age.

Trade balance: The ratio of merchandise exports in fob prices to merchandise imports in cif prices, both measured in local currencies.

Price stability: One minus the rate of growth of the consumer price index.

The indicators of employment, trade balance and price stability each take on strictly positive values for all 130 observations. The growth indicator takes on negative values for some observations, and neither FDH nor DEA is capable of dealing with negative values. Consequently all four output indicators have been transformed to a [0, 100] scale prior to analysis.[6,7]

4. The results

The performance of 130 economies has been evaluated, covering ten countries during part or all of the period 1970–1988. General results are discussed first, and a focus on Taiwan follows.

In terms of dominance, Taiwan stands out, followed by Japan and, recently, Singapore and South Korea. The upper figures in each cell of Table 1 are counts of the number of times a particular country–year dominates other country years, and the lower figures in each cell are counts of the number of times a particular country–year is dominated by other country–years. Thus, for example, Japan's

[5] There are exceptions to the uniform definitions in the text, primarily in the calculation of unemployment. Most countries use the civilian labor force aged 15 and above, but, for example, South Korea used age 14 and above prior to 1980, and Indonesia includes its armed forces in its figures. Complete details are available on request.

[6] Recall that the only maintained assumption in FDH in free disposability of all outputs. It has been conjectured that not all outputs might be freely disposable, despite their desirability. For example, although faster growth may be inflationary, it may also raise employment. It is not possible to test this conjecture using FDH, although it would be possible using DEA.

[7] Data for Taiwan are taken from *Statistical Yearbook of Republic of China 1990*, Council for Economic Planning and Development, Republic of China. All other data are taken from various issues of *Statistical Yearbook for Asia and the Pacific*, Economic and Social Commission for Asia and the Pacific, Bangkok, Thailand. Variable transformations are given by

$$\text{Transformed output} = \alpha + \beta(\text{Raw output}),$$

where $\alpha = 100(\text{min}/(\text{max} - \text{min})$, $\beta = 100/(\text{max} - \text{min})$, and minimum and maximum raw scores for the four outputs are

	min	max
Growth	−0.083	0.128
Employment	0.897	0.991
Trade balance	0.601	2.211
Price stability	0.496	1.020

The dominance analyses presented in Tables 1 and 7 are invariant with respect to the data transformations. Neither the radial efficiency analysis in Table 2 nor the slack analyses in Tables 3–6 are numerically invariant with respect to the data transformations. Although output translation in an output-oriented model generates the same classification of observations as efficient or inefficient, the ranking of inefficient observations is not invariant to the translation. For an extensive analysis of translation invariance in FDH, see [6].

Table 1
Dominance analysis

	Hong Kong	Singapore	South Korea	Taiwan	Indonesia	Malaysia	Philippines	Thailand	Japan	Australia	Mean
1970		0/0		35/2					38/0	22/2	24/1
1971		0/3		65/0			6/24		46/0	6/8	24/7
1972		1/0		66/0			0/48		48/0	16/5	26/11
1973		0/16		42/0			3/20		19/2	21/1	17/8
1974		0/42		0/9			0/56		3/7	3/21	1/27
1975		3/13		12/11			1/29		4/15	4/32	5/20
1976		8/0		59/0			1/43		17/10	5/20	18/15
1977		12/15		35/3					22/6	2/26	18/13
1978	15/17	13/15		47/0	30/0		3/40	13/0	32/1	2/27	19/13
1979	10/20	19/9	2/36	24/1	4/1		0/46	4/1	20/5	4/28	10/16
1980	8/18	11/14	0/80	7/4	10/0		0/66	0/1	11/14	3/22	6/24
1981	9/19	8/15	2/35	8/3	13/0		0/74	3/6	18/7	3/36	7/22
1982	5/42	9/11	9/27	15/2	3/11		0/74	5/30	14/4	0/49	7/28
1983	7/26	18/0	20/7	47/3		8/14	0/67	2/19	22/4	0/51	14/21
1984	14/14	24/5	24/8	71/0		6/7	0/84	2/4	34/3	2/14	20/15
1985	5/17	3/3	17/6	34/1	7/0	2/3	1/77	2/29	33/3	1/18	11/16
1986	41/4	1/0	38/1	72/0	18/3	1/7	1/6		21/1	0/36	21/6
1987	35/0	15/1	47/2	85/0		2/5	0/30		36/0		31/5
1988		29/2	39/2	58/0		4/3					33/1
Mean	15/18	9/9	20/20	41/2	12/2	4/7	1/41	4/11	24/4	6/22	15/15

1970 performance dominated 38 other country–year performances, and was dominated by none. The country means are mostly unsurprising, although the persistently poor performance of Australia is a minor surprise. The annual means are also as expected, with the recessionary periods of 1974–1975 and 1980–1982 exhibiting virtually no dominance.

Radial efficiency scores are useful because they provide a summary performance measure aggregated across all four indicators. Since they ignore nonradial slack, which may be large and which may be distributed nonrandomly across country–years and variables, radial efficiency scores must be interpreted with some caution, however. These scores are reported in Table 2. Again Taiwan performs best, followed closely by Japan and Singapore. The relatively high scores of Indonesia, Malaysia and Thailand are based on short time spans that avoid the 1974–1975 downturn and most of the 1980–1982 downturn. Again the Philippines is the worst performer, lagging behind Australia, South Korea and Hong Kong. An annual analysis of the radial efficiency scores provides an initial indication of the extent to which the 1974–1975 and the 1980–1982 periods lagged behind the rest of the 1970–1988 period. Performance in these two periods was roughly 6% beneath the 1970–1988 average, and roughly 8% beneath the average achieved during the good years.

Radial efficiency scores can be misleadingly incomplete if slack is large or if it exhibits an interesting pattern. Tables 3–6 report radial and nonradial inefficiencies by country and by year, for each performance indicator. In these tables inefficiencies are expressed not as a fraction of the efficient radial projection, as in Table 2, but as a fraction of the actual output of the most dominant observation. Thus in Table 3, for example, in 1970 Taiwan had a 1% radial shortfall, and a 10.9% nonradial shortfall, in its growth indicator relative to the growth achieved by the most dominant of the country–years that dominated it. To summarize Tables 3–6 briefly, the nonradial slack component of inefficiency is large, and it does exhibit an interesting pattern.

For three of the four output indicators, the nonradial component of inefficiency is larger than the radial component. Of the nearly 25% average inefficiency in the growth indicator, almost 18% is nonradial. The disparity is even greater for the trade balance indicator. This suggests that a performance evaluation based on radial efficiency scores reported in Table 2 may indeed be misleading. Overall shortfalls on the order of 25%, 19%, 39% and 12% are much larger than the 9% radial inefficiency reported in Table 2. Moreover, the overall shortfalls are not symmetric with respect to the four output indicators, being most serious for the trade balance indicator and least serious for the price stability indicator.

It is difficult to rank countries by total (radial plus nonradial) efficiency because nonradial efficiencies cannot be aggregated across variables. Nonetheless a general impression emerges that the radial rankings are not much distorted by the inclusion of slack. Taiwan has the smallest total inefficiency in three of the four indicators, and Japan has the least total inefficiency in the price stability indicator. Singapore also performs well (except for the trade indicator) and Australia (except for the price stability indicator) and the Philippines perform poorly.

The temporal pattern of total efficiency is quite different from the temporal pattern of radial efficiency, the difference being attributable to variation across indicators in the nonradial component. Although there is inter-country variation, as a general rule the brunt of the two recessions was borne almost exclusively by the growth and trade balance indicators. The nonradial slack component of these two indicators increased dramatically during the two recessions, while the nonradial slack component of the employment and price stability indicators actually declined during the two recessions.

I have alluded more than once to the relatively strong showing of Taiwan. More detail can be obtained by reading down the "Taiwan" column in Tables 1–6. The overall impression one gets is that Taiwan weathered the two recessionary periods somewhat worse than most countries, but that the impact of the recessions was very unevenly distributed across indicators. The impact on the employment indicator was absolutely small, and much smaller than average. The impact on the trade balance indicator was absolutely large and larger

Table 2
Radial efficiency analysis

	Hong Kong	Singapore	South Korea	Taiwan	Indonesia	Malaysia	Philippines	Thailand	Japan	Australia	Mean
1970		1		0.989					1	0.989	0.994
1971		0.968		1			0.928		1	0.947	0.969
1972		1		1			0.856		1	0.931	0.957
1973		0.820		1			0.717		0.990	0.966	0.899
1974		0.670		0.959			0.701		0.979	0.844	0.831
1975		0.939		0.923			0.853		0.917	0.740	0.874
1976		1		1					0.936	0.760	0.924
1977		0.927		0.968			0.819		0.936	0.773	0.885
1978	0.898	0.906		1			0.854	1	0.977	0.845	0.935
1979	0.840	0.939	0.744	1	0.970		0.745	0.990	0.957	0.833	0.891
1980	0.880	0.875	0.593	0.990	1		0.670	1	0.936	0.814	0.853
1981	0.783	0.890	0.710	0.990	1		0.724	0.960	0.945	0.823	0.869
1982	0.800	0.923	0.865	0.968	0.875		0.776	0.886	0.958	0.802	0.872
1983	0.802	1	0.958	0.979		0.937	0.796	0.918	0.976	0.814	0.909
1984	0.859	0.958	0.948	1		0.917	0.368	0.960	0.964	0.927	0.878
1985	0.937	0.990	0.958	1	1	0.990	0.542	0.918	0.968	0.875	0.918
1986	0.967	1	0.978	1	0.920	0.979	0.979		1	0.833	0.962
1987	1	1	0.968	1		0.979	0.917		1		0.979
1988		0.968	0.943	1		0.958					0.967
Mean	0.869	0.935	0.865	0.988	0.966	0.960	0.765	0.954	0.969	0.854	0.909

Table 3
Slack analysis: Growth

	Hong Kong	Singapore	South Korea	Taiwan	Indonesia	Malaysia	Philippines	Thailand	Japan	Australia	Mean
1970		0/0		0.010/0.109					0/0	0.007/0.382	0.004/0.123
1971		0.031/0.011		0/0			0.067/0.070		0/0	0.027/0.498	0.025/0.116
1972		0/0		0/0			0.142/0.175		0/0	0.039/0.426	0.036/0.089
1973		0.180/0		0/0			0.283/0		0.010/0.012	0.022/0.359	0.099/0.074
1974		0.317/0.040		0.019/0.528			0.265/0.112		0.007/0.641	0.105/0.328	0.143/0.330
1975		0.047/0.235		0.065/0.161			0.144/0.014		0.050/0.387	0.206/0.207	0.102/0.201
1976		0/0		0/0					0.057/0.108	0.204/0.147	0.065/0.064
1977		0.068/0.061		0.028/0.120			0.180/0		0.055/0.135	0.207/0.088	0.108/0.081
1978	0.082/0.197	0.089/0.048		0/0	0/0		0.112/0.231	0/0	0.105/0.335	0.123/0.174	0.053/0.123
1979	0.137/0.142	0.061/0	0.247/0.033	0/0.244	0.024/0.203		0.213/0.164	0.005/0.462	0.039/0.089	0.132/0.208	0.095/0.172
1980	0.198/0.010	0.122/0.022	0.191/0.530	0.009/0.188	0/0		0.272/0.174	0/0.520	0.052/0.190	0.169/0.088	0.112/0.191
1981	0.217/0	0.104/0.054	0.290/0	0.009/0.105	0/0		0.241/0.124	0.024/0.398	0.046/0.161	0.123/0.304	0.117/0.127
1982	0.124/0.378	0.058/0.246	0.111/0.183	0.023/0.281	0.061/0.513		0.165/0.264	0.067/0.412	0.023/0.445	0.154/0.221	0.087/0.327
1983	0.183/0.073	0/0	0.040/0.054	0.019/0.098		0.046/0.269	0.114/0.443	0.078/0.042	0.015/0.365	0.081/0.566	0.064/0.212
1984	0.141/0	0.034/0.184	0.049/0.049	0/0		0.070/0.159	0/1	0.039/0.029	0.027/0.243	0.056/0.233	0.046/0.211
1985	0.027/0.572	0.005/0.541	0.032/0.233	0/0.017	0/0	0.004/0.611	0.083/0.819	0.058/0.291	0.020/0.348	0.102/0.182	0.033/0.361
1986	0.033/0	0/0	0.022/0	0/0	0.047/0.412	0.012/0.423	0.013/0.370		0/0.461	0.134/0.195	0.029/0.207
1987	0/0	0/061	0.041/0.022	0/0		0.018/0.140	0.082/0		0/0		0.020/0.032
1988		0.030/0.054	0.056/0.011	0/0		0.035/0.146					0.030/0.053
Mean	0.114/0.137	0.060/0.082	0.108/0.111	0.009/0.097	0.019/0.161	0.031/0.292	0.149/0.238	0.034/0.269	0.023/0.218	0.111/0.271	0.068/0.179

Table 4
Slack analysis: Employment

	Hong Kong	Singapore	South Korea	Taiwan	Indonesia	Malaysia	Philippines	Thailand	Japan	Australia	Mean
1970				0.011/0.021					0/0	0.011/0.011	0.005/0.008
1971		0.012/0.625		0/0			0.055/0.239		0/0	0.053/0	0.024/0.173
1972		0/0		0/0			0.093/0.352		0/0	0.068/0	0.032/0.070
1973		0.140/0.220		0/0			0.254/0.102		0.010/0	0.034/0	0.088/0.064
1974		0.030/0		0.041/0			0.299/0		0.021/0	0.156/0	0.169/0
1975		0.053/0.133		0.077/0			0.147/0		0.082/0	0.242/0.072	0.120/0.041
1976		0/0		0/0					0.064/0	0.219/0.084	0.071/0.021
1977		0.064/0.120		0.032/0			0.164/0.093		0.064/0	0.818/0.201	0.101/0.083
1978	0.102/0	0.088/0.060		0/0	0/0		0.137/0.060	0/0	0.023/0	0.094/0.390	0.056/0.064
1979	0.159/0	0.058/0.048	0.253/1.011	0/0	0.025/0.173		0.255/0	0.010/0	0.042/0	0.106/0.362	0.101/0.066
1980	0.189/0.055	0.125/0	0.406/0	0.010/0	0/0		0.329/0	0/0	0.064/0	0.129/0.303	0.139/0.040
1981	0.213/0.021	0.109/0.011	0.277/0.044	0.010/0	0/0		0.264/0.040	0.040/0	0.055/0	0.124/0.300	0.121/0.046
1982	0.198/0.011	0.076/0.011	0.119/0.121	0.031/0.011	0.125/0		0.197/0.120	0.114/0	0.042/0	0.098/0.505	0.111/0.087
1983	0.184/0.072	0/0	0.033/0.216	0.020/0.012		0.036/0.421	0.196/0.040	0.069/0.160	0.024/0	0.009/0.953	0.063/0.208
1984	0.127/0.102	0.040/0.034	0.046/0.121	0/0		0.047/0.034	0.618/0.021	0.037/0.080	0.036/0	0.012/0.811	0.107/0.180
1985	0.060/0.036	0.008/0.165	0.035/0.157	0/0.013	0/0	0.005/0.542	0.447/0.024	0.063/0.227	0.030/0.046	0.038/0.698	0.069/0.191
1986	0.030/0.068	0/0	0.017/0.194	0/0	0.079/9	0.005/0.730	0.011/0.469		0/0.012	0.056/0.666	0.022/0.238
1987	0/0	0/0.289	0.038/0.090	0/0		0.005/0.730	0.013/0.834		0/0		0.008/0.278
1988		0.027/0.136	0.057/0	0/0		0.011/0.723					0.024/0.215
Mean	0.126/0.037	0.059/0.097	0.128/0.095	0.012/0.003	0.033/0.025	0.018/0.597	0.217/0.150	0.041/0.058	0.031/0.003	0.096/0.316	0.079/0.117

Table 5
Slack analysis: Trade balance

	Hong Kong	Singapore	South Korea	Taiwan	Indonesia	Malaysia	Philippines	Thailand	Japan	Australia	Mean
1970		0/0		0.007/0.358					0/0	0.008/0.220	0.004/0.145
1971		0.000/0.982		0/0			0.019/0.740		0/0	0.043/0.197	0.012/0.384
1972		0/0		0/0			0.032/0.778		0/0	0.048/0.294	0.016/0.214
1973		0.161/0.105		0/0			0.176/0.378		0.009/0.114	0.033/0.017	0.076/0.123
1974		0.297/0.100		0.022/0.469			0.182/0.389		0.014/0.303	0.156/0	0.134/0.252
1975		0.023/0.622		0.039/0.493			0/1		0.079/0.038	0.207/0.203	0.070/0.471
1976		0/0		0/0					0.049/0.238	0.220/0.082	0.067/0.080
1977		0.019/0.735		0.028/0.111			0.038/0.787		0.059/0.078	0.161/0.291	0.061/0.400
1978	0.031/0.692	0.023/0.753		0/0	0/0		0.014/0.904	0/0	0.016/0.311	0.094/0.393	0.022/0.381
1979	0.094/0.412	0.017/0.717	0.086/0.665	0/0.167	0.030/0		0.057/0.776	0.009/0.099	0.023/0.449	0.109/0.344	0.047/0.403
1980	0.168/0.158	0.032/0.743	0.201/0.506	0.010/0.038	0/0		0.051/0.845	0/0.500	0.035/0.443	0.137/0.259	0.070/0.388
1981	0.132/0.392	0.042/0.616	0.101/0.375	0.008/0.235	0/0		0.144/0.475	0.024/0.390	0.045/0.186	0.109/0.385	0.076/0.339
1982	0.077/0.615	0.026/0.661	0.060/0.551	0.031/0.026			0/1	0.029/0.746	0.021/0.498	0.076/0.616	0.048/0.537
1983	0.101/0.490	0/0	0.016/0.621	0.017/0.184		0.039/0.368	0.023/0.888	0.008/0.902	0.018/0.266	0.099/0.468	0.036/0.465
1984	0.068/0.518	0.011/0.728	0.024/0.528	0/0		0.066/0.203	0.631/0	0.035/0.121	0.030/0.162	0.042/0.428	0.101/0.299
1985	0.035/0.431	0.003/0.705	0.020/0.510	0/0.017	0/0	0.007/0.308	0.261/0.431	0.082/0	0.026/0.156	0.076/0.390	0.051/0.295
1986	0.014/0.553	0/0	0.012/0.451	0/0	0.071/0.103	0.015/0.259	0.006/0.685		0/0.015	0.085/0.488	0.023/0.284
1987	0/0	0/0.653	0.025/0.393	0/0		0.018/0.120	0.019/0.774		0/0		0.009/0.277
1988		0.010/0.677	0.036/0.361	0/0		0.037/0.102					0.021/0.285
Mean	0.072/0.426	0.035/0.463	0.066/0.496	0.008/0.110	0.030/0.032	0.103/0.227	0.103/0.678	0.023/0.345	0.024/0.181	0.100/0.299	0.051/0.336

Table 6
Slack analysis: Price stability

	Hong Kong	Singapore	South Korea	Taiwan	Indonesia	Malaysia	Philippines	Thailand	Japan	Australia	Mean
1970		0/0		0.011/0					0/0	0.011/0	0.005/0
1971		0.031/0		0/0			0.072/0		0/0	0.053/0	0.031/0
1972		0/0		0/0			0.144/0		0/0	0.066/0.031	0.042/0.006
1973		0.140/0.221		0/0			0.253/0.105		0.009/0.072	0.030/0.126	0.086/0.105
1974		0.330/0		0.003/0.925			0.169/0.433		0.015/0.276	0.154/0.011	0.134/0.329
1975		0.061/0		0.076/0.010			0.145/0.010		0.082/0	0.260/0	0.125/0.004
1976		0/0		0/0					0.062/0.034	0.239/0	0.075/0.008
1977		0.073/0		0.030/0.044			0.177/0.020		0.064/0	0.227/0	0.114/0.013
1978	0.098/0.042	0.094/0		0/0	0/0		0.146/0	0/0	0.022/0.042	0.155/0	0.064/0.010
1979	0.156/0.222	0.061/0	0.255/0	0/0.037	0.029/0.032		0.235/0.077	0.010/0.012	0.042/0	0.167/0	0.106/0.020
1980	0.200/0	0.112/0.042	0.394/0.032	0.008/0.266	0/0		0.326/0.010	0/0.2963	0.064/0	0.185/0	0.144/0.072
1981	0.213/0.022	0.110/0	0.284/0.022	0.008/0.224	0/0		0.275/0	0.356/0.086	0.054/0.021	0.177/0	0.129/0.042
1982	0.200/0	0.077/0	0.135/0	0.032/0	0.116/0.074		0.224/0	0.114/0	0.0421/0	0.198/0	0.126/0.008
1983	0.198/0	0/0	0.042/0	0.021/0		0.062/0	0.204/0	0.082/0	0.024/0.010	0.185/0	0.091/0.001
1984	0.140/0.010	0.042/0	0.052/0	0/0		0.083/0	0/1	0.040/0	0.036/0.010	0.073/0	0.052/0.113
1985	0.062/0	0.010/0	0.042/0	0/0	0/0	0.010/0	0.458/0	0.082/0	0.031/0	0.125/0	0.082/0
1986	0.032/0.010	0/0	0.021/0.021	0/0	0.077/0.031	0.020/0	0.020/0		0/0	0.167/0	0.038/0.007
1987	0/0	0/0	0.042/0	0/0		0.020/0	0.082/0		0/0		0.021/0
1988		0.031/0	0.053/0.074	0/0		0.042/0					0.031/0.018
Mean	0.130/0.011	0.062/0.014	0.132/0.015	0.010/0.079	0.032/0.019	0.040/0	0.183/0.103	0.045/0.049	0.030/0.026	0.145/0.010	0.083/0.037

than average in 1974–1975, and absolutely small and smaller than average in 1980–1982. The impact on the growth and price stability indicators was absolutely large and much larger than average in both recessionary periods. This evidence is unavailable in Table 2 because, at least in the case of Taiwan, most of the intertemporal performance variation has been nonneutral with respect to the four performance indicators.

Additional detail concerning Taiwan is provided in Tables 7 and 8. Table 7 contains dominance information showing that Taiwan dominated many economies and was rarely dominated itself. When Taiwan was dominated, it was dominated by itself in another year (six times) or by Japan (four times). Table 8 shows the improvement in Taiwan's performance that would have occurred had Taiwan performed up to the standards of the economies that dominated it. In 9 of 19 years no improvement was feasible since Taiwan was undominated in these years. In most of the dominated years the potential improvement was small. In 1970, for example, had Taiwan performed up to its potential its rate of

Table 7
Dominance information for Taiwan

	Dominating country/year	Number of dominating country/years	Number of dominated country/years
1970	Taiwan 1972	2	35
1971		0	65
1972		0	66
1973		0	42
1974	Japan 1970	9	0
1975	Taiwan 1988	11	12
1976		0	59
1977	Taiwan 1972	3	35
1978		0	47
1979	Taiwan 1973	1	24
1980	Japan 1970	4	7
1981	Japan 1971	3	8
1982	Taiwan 1988	2	15
1983	Taiwan 1984	3	47
1984		0	71
1985	Japan 1987	1	34
1986		0	72
1987		0	85
1988		0	58

Table 8
Potential improvement in Taiwan's macroeconomic performance

	Growth $(y_1^{DOM} - y_1^T)$	Employment $(y_2^{DOM} - y_2^T)$	Trade balance (y_3^{DOM}/y_3^T)	Price stability $(y_4^{DOM} - y_4^T)$
1970	0.023	0.002	1.223	0.005
1971				
1972				
1973				
1974	0.093	0.004	1.270	0.403
1975	0.031	0.007	1.367	0.040
1976				
1977	0.029	0.003	1.081	0.040
1978				
1979	0.047	0.000^+	1.083	0.017
1980	0.034	0.001	1.022	0.119
1981	0.016	0.001	1.140	0.103
1982	0.043	0.004	1.035	0.017
1983	0.021	0.003	1.120	0.014
1984				
1985	0.001	0.001	1.005	0.000^+
1986				
1987				
1988				

growth of GDP per capita would have been 2.3 percentage points higher than it actually was, its unemployment rate would have been 0.2 percentage points lower than it actually was, and so on. With the exception of the miserable 1974–1975 years, the performance gaps reported in Table 8 are generally small. These results suggest that even when Taiwan was dominated by another economy, not much was sacrificed.

5. Conclusions

The purpose of this study has been to introduce a performance evaluation methodology, and to illustrate its working with an application to the analysis of the macroeconomic performance of a collection of Asian economies. The technique is commonly used in the evaluation of performance at the micro level of aggregation, but its use at the macro level is new.[8] The technique has a number of commendable features. Foremost among them is the fact that it easily accommodates multiple inputs and multiple outputs that are measured in their own units and are difficult to aggregate. Additional features include the fact that it imposes minimal structure on the underlying technology by which inputs are transformed into outputs, and the fact that it imposes no unwarranted behavioral objective on the production units.

In the application of the technique I have attempted to evaluate the performance of those who have directed the macroeconomies of a group of Asian nations during much of the past two decades. In this application there are no inputs as such, and I have specified four outputs, the four conventional macroeconomic performance indicators: growth, employment, trade balance, and price stability. Since the ten countries are observed for varying lengths of time, it is difficult to come up with a convincing overall performance ranking. Nonetheless it is pretty clear who the star performers are – Taiwan and Japan –, and who the laggards are – the Philippines and Australia. It is also apparent that the group of economies as a whole has been more successful at controlling employment and price stability than at promoting growth and trade. Finally, the magnitudes of the gaps between observed and best practice performance are large, with unweighted mean deviations varying from 12% for price stability of 39% for the trade balance.

Two final remarks are in order, and they may suggest fruitful avenues for future research. The first remark concerns the structure of the model, which contains no inputs and four outputs. It is of course possible to add or delete or redefine outputs if it is felt that the four outputs included do not adequately reflect the real targets of macroeconomic policy. It is also possible to add additional control variables that are not outputs but which capture essential features of the environment in which macroeconomic policy is conducted. The second remark concerns macroeconomic policy itself. The purpose of the analysis presented here is to evaluate outcomes. No attempt has been made to explain how these outcomes were achieved. An examination of the fiscal, monetary and other policies adopted by nations might shed valuable light on the causes of the variation in national macroeconomic performance.

[8] For an illustration of the application of this performance evaluation methodology at the micro level, see [7].

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