A LONGITUDINAL ANALYSIS OF INDUSTRIAL PERFORMANCE OF TAIWAN: A MULTI-FACTOR ANALYSIS

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ABSTRACT

This paper analyzes and evaluates the industrial performance of Taiwan over a period of 45 years spanning from 1965 to 2009. The paper performs the necessary calculations in Data Envelopment Analysis (DEA). The preponderance of evidence shows a highly efficient economy for the state of Taiwan.

Keywords: Data Envelopment Analysis (DEA); Taiwan's industrial performance; simple efficiency; cross-efficiency; and cone-ratio efficiency.

INTRODUCTION

Geographically, Taiwan (also known as Republic of China, Chinese Taipei, and Formosa) lies 100 miles east of the Mainland China, 695 miles south of the main Japanese islands, and 199 miles north of the Philippines. Taiwan's land area is approximately 13,884 square miles -- about the combined size of the states of Maryland, Delaware, and Rhode Island or a trifle smaller than Switzerland. No country in the Pacific Rim region has experienced more major political and economical challenges than has Taiwan. The case of Taiwan is indeed unique because of its current political and economic status as well as its short history as an independent nation in the East China Sea. A brief review of other Asian Pacific Rim countries such as South Korea and Singapore reveal that these countries enjoy international recognition, political identity, and trade with a large number of countries across the globe. This does not seem to be the case for Taiwan -- at least with regard to international recognition and political identity. Therefore, it is essential to explore the industrial performance of Taiwan in light of these political and economic developments over a long period of time. The goal of this paper is to study the effect of these political and economic challenges and to determine the underlying causes of Taiwan's success as a regional power.

According to Taiwan's Central Bank, in 1995 Taiwan had about US $100 billion in foreign exchange reserves -- second only to Japan in the world. Moreover, Taiwan’s foreign exchange

reserves hit a record high of US $372.06 billion at the end of August 2010. The figure makes Taiwan the fourth-largest holder of foreign exchange reserves.

REVIEW OF LITERATURE

Taiwan is a unique country and its economy has received some attention in academia. There is, however, very little research is conducted in industrial performance of Taiwan. Macro-econometric models for Taiwan have been constructed by the Council of Economic Planning and Development of Taiwan and researchers in order to forecast the economy and design economic plans (Tiao *et al.* 1998). In this study, they showed how to apply statistical and econometric tools to traditional macro-econometric models for Taiwan to improve the forecasting accuracy by using quarterly Taiwan economic data. This work focused on forecasting instead of evaluating the Taiwan's economy over time. While the past works on Taiwan show how one particular factor affects Taiwan's economy and how to forecast and design economic plan, our work contributes to the literature by considering multiple inputs and outputs to evaluate the overall industrial performance of Taiwan over a long period of time. Our work also identifies the underlying causes of the changes in the industrial performance of Taiwan.

The objective, methodology, scope, and organization of the paper

The objective of this paper is to evaluate the industrial performance of Taiwan over a period of 45 years. Forty-five years of data points spanning from 1965 to 2009 were obtained from several sources including National Statistics of Republic of China (Taiwan), National Science Council of Republic of China (Taiwan), Central Bank of Republic of China (Taiwan), and Council for Economic Planning and Development of Republic of China (Taiwan). The main source of the data came from the Taiwan Statistical Data Book (TSDB 2009) and the Industrial Development Bureau under the Ministry of Economic Affairs. The TSDB publication, published by the Council of Economic Planning and Development, was the basis for most of the analyses performed in this paper.

In order to establish content validity, three university academicians and two practitioners were specifically asked to check for content validity of the input and output selected for this study. The data obtained were crosschecked for reliability purposes.

The inputs considered are Labor (L) and Gross Capital Formation (GCF). The Labor is an average number of people, expressed in thousands, employed in all the industries in Taiwan per year. GCF is expressed in millions of Taiwanese dollars. GCF is composed of amounts invested in capital equipment, new technologies, etc.

The outputs utilized are Industrial Production Index (IP), per capita Gross National Product (GNP), Gross Domestic Product (GDP), and per capita National Income (NI). IP is computed and normalized using an index of 100 with 2006 as the base period. The GDP is expressed in millions of Taiwanese dollars. The per capita GNP and per capita NI are expressed in Taiwanese dollars. The per capita GNP, GDP, and per capita NI are adjusted for inflation with 2006 as the base period. Please see Table 1 for the inputs and outputs.

Table 1. Taiwan input and output data

DMU	Year	Labor (INPUT 1)	GCF (09) (INPUT 2)	IP (09) (OUTPUT 1)	Per Capital GNP (OUTPUT 2)	GDP (OUTPUT 3)	Per Capita NI (OUTPUT 4)
1	1965	3763	25652	3.09	31,647	641,207	51,774
2	1966	3856	26847	3.58	32,859	697,100	54,936
3	1967	4050	35983	4.17	35,309	769,666	59,123
4	1968	4225	42764	5.1	37,852	838,906	63,126
5	1969	4390	48446	6.12	39,288	911,591	67,024
6	1970	4576	58147	7.36	41,670	1,008,247	71,844
7	1971	4738	69434	9.08	45,262	1,133,818	78,940
8	1972	4948	81525	11.01	49,991	1,282,919	87,339
9	1973	5327	119951	12.79	55,222	1,434,647	95,544
10	1974	5486	216142	12.22	57,456	1,461,291	92,451
11	1975	5521	180166	13.37	59,062	1,540,574	94,985
12	1976	5669	217671	16.49	63,831	1,747,790	107,153
13	1977	5980	234791	18.69	67,332	1,938,019	116,020
14	1978	6231	281356	22.9	73,314	2,199,476	127,619
15	1979	6432	395167	24.36	80,000	2,375,737	135,730
16	1980	6547	505941	26.03	82,586	2,549,742	139,769
17	1981	6672	532633	26.94	84,970	2,714,355	143,697
18	1982	6811	490261	26.71	87,438	2,822,229	146,938
19	1983	7070	530731	30.09	91,078	3,057,050	157,090
20	1984	7308	562150	33.66	97,280	3,341,961	171,229
21	1985	7428	489140	34.56	100,472	3,477,891	176,064
22	1986	7733	572782	39.39	106,146	3,860,608	201,849
23	1987	8022	729921	43.58	115,904	4,272,887	222,807
24	1988	8107	896435	45.43	129,349	4,510,963	233,685
25	1989	8258	979185	47.14	144,965	4,974,759	255,701
26	1990	8283	1079424	47.04	155,378	5,316,579	269,990
27	1991	8439	1224332	50.52	164,229	5,735,769	289,950
28	1992	8632	1484942	52.75	178,244	6,169,225	305,524
29	1993	8745	1666512	54.78	190,974	6,584,559	320,724
30	1994	8939	1775141	58.4	205,811	7,084,404	338,655
31	1995	9045	1942245	61.2	216,098	7,536,283	352,142
32	1996	9068	1894666	62.31	229,157	7,953,510	371,273
33	1997	9176	2150484	66.14	242,941	8,389,017	391,288

34	1998	9289	2392515	68.37	255,878	8,679,815	403,597
35	1999	9385	2409154	73.43	266,726	9,198,098	415,606
36	2000	9491	2615640	78.38	277,200	9,731,208	431,974
37	2001	9383	1970319	71.8	277,964	9,570,584	413,565
38	2002	9454	2013786	77.15	285,477	10,074,337	433,483
39	2003	9573	2129586	84.18	292,492	10,443,993	445,230
40	2004	9786	2693089	92.03	306,475	11,090,474	461,044
41	2005	9942	2667855	95.49	314,206	11,612,093	467,391
42	**2006**	**10111**	**2776953**	**100**	**317,583**	**12,243,471**	**478,968**
43	2007	10294	2855809	107.86	322,873	12,975,985	493,766
44	2008	10403	2879208	105.94	319,905	13,070,904	466,269
45	2009	10279	2177299	97.4	323,225	12,821,384	474,530

The labor and capital inputs, as the two most important economic factors, are good indicators of measuring industrial performance of Taiwan. Dendrions (1982) also used labor and capital to obtain the aggregate output of urban economics. Our work was corroborated by the three university academicians and two practitioners. Similarly, the IP index, per capita GNP, GDP, and per capita NI are fairly reasonable and widely used indicators of a country's industrial performance. GDP represents the total of goods and services produced in a country. Per capita national income is often used as a measure of the wealth of a nation. Per capita income is the numerical ratio of national production by population. The GNP (Gross National Product) per capita of a country shows the average value of goods and services produced by each person each year. This figure is then divided by the total population in order to get Per capita GNP.

Under the general umbrella of Data Envelopment Analysis (DEA), the "Window Analysis" technique is utilized to analyze and evaluate the performance of each Decision Making Unit (DMU) annually over a period of 45 years. The DEA analyses include: simple efficiency, cross-efficiency, and cone-ratio.

Section 2 of the paper presents the concept of DEA and its extensions as they apply to this paper. By the use of available literature, Section 2 also shows the application of DEA to real-life problems. Section 3 provides the analysis and evaluation of Taiwan's industrial performance by using input and output factors. Section 4 includes perspectives and insights as to what the results mean and presents the underpinnings of policies that effectuate these results. Section 5 presents a conclusion and assessment including the theoretical insights and future research directions.

DATA ENVELOPMENT ANALYSIS (DEA)

DEA is a fractional programming model that estimates the relative efficiencies of a homogeneous set of units by considering multiple sets of inputs and outputs. The efficiency is obtained by computing the ratio of the weighted sum of outputs to the weighted sum of inputs.

Since Charnes *et al.* developed DEA (Charnes *et al.* 1978, 1979), this methodology has been utilized extensively for comparing the relative efficiencies of DMUs such as schools, hospitals, bank branches, air force bases, police forces, distribution centers, and other environments (Charnes *et al.* 1994, Ross and Droge 2002, Sun 2004, Narasimhan *et al.* 2005). Researchers have also employed DEA to measure the efficiency of information use (Bendoly *et al.* 2009), the performance of information technology investments (Shafer and Byrd 2000, Chen *et al.* 2006), the performance of R&D project (Mahmood *et al.* 1996, Verma and Kingshuk 2002), and distribution facilities (Ross et al. 1998), and to measure the suppliers' strategic strength and weakness (Ross *et al.* 2009) and vehicle maintenance productivity (Clarke 1992). Moreover, a large number of researchers have expanded the methods and concepts of DEA, see (Cooper *et al.* 2000, Cooper *et al.* 2006) and references therein.

Moreover, most papers on the application of the DEA methodologies employ one of the existing methods; in contrast, our work utilizes three methodologies and compares the results in addition to providing the underlying causes for the changes in Taiwan's industrial performance.

The relative efficiency of a DMU p is obtained by solving the following fractional programming model.

$$\text{Max} \quad \sum_{k=1}^{s} v_k y_{kp} \Big/ \sum_{j=1}^{m} u_j x_{jp} \qquad (1)$$

$$\text{s.t} \quad \sum_{k=1}^{s} v_k y_{ki} \Big/ \sum_{j=1}^{m} u_j x_{ji} \le 1 \quad \text{for } i = 1 \,..\, p \,..\, n$$

$$v_k, u_j \ge 0 \quad \text{for } k = 1 \,....\, s, \text{ and } j = 1 \,....\, m$$

Where p is the DMU being analyzed, k represents the number of outputs, j represents the number of inputs, i is the number of decision making units, y_{ki} is the amount of output k produced by DMU i, x_{ji} is the amount of input j used by DMU i, v_k is the weight given to output k, and u_j is the weight given to input j.

Formulation (1), which is referred to as the ratio model, can easily be converted to the linear programming (LP) model as shown below:

$$\text{Max} \quad \sum_{k=1}^{s} v_k y_{kp} \qquad (2)$$

$$\text{s.t} \quad \sum_{j=1}^{m} u_j x_{jp} = 1$$

$$\sum_{k=1}^{s} v_k y_{ki} - \sum_{j=1}^{m} u_j x_{ji} \le 0 \quad \text{for } i = 1 \,..\, p \,..\, n$$

$$v_k, u_j \ge 0 \quad \text{for } k = 1 \,....\, s, \text{ and } j = 1 \,....\, m$$

A relative efficiency score of 1 indicates that the DMU under consideration is ratio efficient, whereas scores less than 1 indicate that they are ratio inefficient.

ANALYSIS, CONCLUSION AND FUTURE RESEARCH DIRECTIONS

The various models used, the solution procedures, the analyses, conclusions, assessment, the future research results, and the tables are available upon request from the authors.

REFERENCES

References are available upon request from the authors.