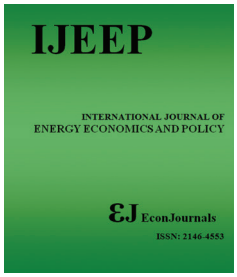

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Sources of Economic Growth and Changes in Energy Consumption: Empirical Evidence for Taiwan (2004-2016)

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ABSTRACT

Since the 1990s, Taiwan has promoted the upgrading of industrial structure, and the financial crisis has brought about major economic shocks. After Taiwan became a World Trade Organization (WTO) member in 2002, the total trade volume increased significantly under the trade liberalization economic system. The trade sector has become the main source of Taiwan's economic growth. As energy consumption expands with economic growth, the instability of international energy prices has become an important factor hindering Taiwan's future economic development. Taiwan's energy demand is over 99% dependent on imports, making Taiwan's economic growth and energy consumption really closely related. This study has found that the source of growth has transformed from domestic final demand effect and exports effect to technical coefficients effect and self-sufficiency Coefficients effect. The financial crisis has increased the "self-sufficiency" coefficient effect and the technical coefficient effect, and all other industries except the "agricultural sector" have shown significant growth. On the other hand, the source of energy consumption has changed after the financial crisis. This also confirms that Taiwan's economic growth is closely related to energy consumption, indicating that energy shortage has indeed had an important impact on Taiwan's economic development.

Keywords: Source of Economic Growth, Energy Consumption, Technical Coefficient
JEL Classifications: Q43, C6, E2, E210.

1. INTRODUCTION

Taiwan has experienced rapid economic growth since the 1960s. Although it suffered from the impact of two world oil crises, it still maintained a high level of economic growth. In 1985, the Gross domestic product (GDP) per capita reached $3,314, and in 1995 it increased to $12,906.

In the process of economic development that Taiwan has experienced many challenges came from international economic environment. Although Taiwan has overcome the "middle income trap," yet the transformation of the industrial structure remained to be a major challenge. After entering the 21st century, Taiwan's economic growth has gradually slowed down. In 2005, the GDP per capita was US$19,278. After 10 years, it only increased to US$22,288 in 2015. Although Taiwan's GDP per capita increased to US$24,318 in 2017, it faces rising costs due to high international energy prices and uncertainty about electricity supply.

The financial crisis in year 2007 has caused severe damage to the Taiwan's economy. Such event has indirectly indicated that the industrial restructuring has not been successfully accomplished (Hong and Li, 2015). This was because Taiwan's economic growth has been dependent on export sector for a long period of time, which is highly vulnerable to international financial crisis. The primary objective of this paper is to investigate that whether the industrial structure growth pattern and source has altered 10 years after the mentioned financial crisis.

In year 2016 the proportion of Taiwan's agriculture, industry and services industries was 1.82%, 35.06% and 63.13%, respectively. Taiwan's industrial sector has reached the peak of 46.06% in year 1986 and then remained declining every year. This trend is considered to be a phenomenon of "post-industrial society." This study analyzes the relationship between the source of economic growth and energy consumption in Taiwan after becoming a member of the WTO. Although the expansion of free trade has brought economic growth, it has also contributed to the fragility of Taiwan's economic structure. In addition to causing economic shocks, has the financial crisis of 10 years brought about a turning point in the upgrading of industrial structure? This study will compare the changes of the factors in the "Review" economic output before and after the financial crisis and summarize the development characteristics of the industry. It also analyzes whether the factors of energy consumption during this period have also changed, which will help to put forward more specific views and suggestions on Taiwan's economic development in the future.

2. LITERATURE REVIEW

There were many studies focused on economic growth, among which Kuznets (1966) regards the degree of industrialization as an indicator of economic growth. Some studies have pointed out that economic growth requires structural changes through inter-industry correlations (Chenery, 1979; Matthews et al., 1982; Abramowitz,1983). In addition to the above studies, the early literatures were most representative of Aka-Matsu (1962) and Vernon (1966). On the other hand, some studies argue that the redistribution of factors of production is an important factor in economic growth (Duarte and Restuccia, 2010). In addition, the main literatures that analyze economic growth from sources of output were Torii and Fukasaku (1979), Fujita and William (1997), and etc. Fujita and William (1997) estimated the impact of Indonesian manufacturing exports on employment. Their results showed that the employment position generated in the early stage is larger in manufacturing sector.

As a result of globalization that the pattern of economic growth has also changed. Gordon (2015) pointed out that the long-term stagnation of the economy may be caused by the lack of innovative technologies. Innovative technologies were deemed to be one of the important source of economic growth. Coulibaly et al. (2018) studied BRICs countries and analyzed the impact of innovation-driven policies on economic growth. Their results after the model test shows that the variables were all positive and statistically significant.

On the other hand, the analysis between economic growth and energy consumption has also accumulated numerous results (Ozturk and Acaravci, 2010; Ozturk et al., 2010; Chandran et al., 2010; Hossain, 2011; Hossein et al., 2012; Li and Zheng, 2012; Omri and Kahouli, 2014; Bildirici, 2016; Wang et al., 2016; Khan et al., 2017; Nuryartono and Rifai, 2017; Tan and Tan, 2018).

Ozturk et al. (2010) analyze the relationship between energy consumption (EC) and economic growth GDP in low-income countries and middle-income countries. The study pointed out that low-income countries have long-run Granger causality relationships from GDP to EC. In the middle-income countries, there is a bidirectional causality relationship between EC and GDP. Khan et al. (2017) Analyze energy consumption from financial development, and the results show a mixed phenomenon between different countries and regions. There are also some studies that indicate that there is no obvious causal relationship between economic growth and energy consumption, such as Dlamini et.al. (2015; 2016), Bah and Azam (2017) and other studies.

3. METHODOLOGY AND DATA

3.1. Data

The I-O Table used in this study is from 2004 to 2016. The estimation was based on the Input-Output table announced by the Directorate General of Budget, Accounting and Statistics of the Taiwan's Executive Yuan.

3.2. Methodology

In the framework of I-O model, the following balance equation can be derived (Fujita and William, 1997)

Industry (X_i) production equilibrium equation can be expressed by (1). The physical quantity bought by sector j to sector i when j produces the commodity j is denoted as X_{ij} This condition can be expressed as:

$$X = [I-(I-M)A)]^{-1}\,[(I-M)\,F + E] \quad (1)$$

If coefficients are defined in physical terms, it is assumed that $a_{ij} = \frac{x_{ij}}{X_j}$ for all i and j are stable. Where F is the amount of the domestic final demand for industry ($n \times 1$). M represents the diagonal matrix of import coefficient ($n \times n$). E is the amount of the exports for industry ($n \times 1$). I is the identity matrix ($n \times n$). A is the input coefficient matrix ($n \times n$).

t represents the base period while t+1 represents the current period. The following formula is used to calculate δX:

$$\delta X = X_{t+1} - X_t \quad (2)$$

The quantity model (2) can be written as:

$$\delta X = [I-(I-\bar{M}_{t+1})\,A_{t+1}]^{-1}\,[(I-\bar{M}_{t+1})\,F_{t+1} + E_{t+1}] - [I-(I-\bar{M}_t)\,A_t]^{-1}\,[(I-\bar{M}_t)\,F_t + E_t] \quad (3)$$

Denoting by B_t, B_{t+1} and B^* in the following matrix:

$$[I-(I-\bar{M}_{t+1})\,A_{t+1})]^{-1} = B_{t+1},\ [I-(I-\bar{M}_t)\,A_t]^{-1} = B_t$$

$$[I-(I-\bar{M}_t)\,A_{t+1}]^{-1} = B^*$$

The model in (3) can be decomposed as follows:

$$\delta X = B_{t+1}\,[(I-\bar{M}_{t+1})\,F_{t+1} - (I-\bar{M}_{t+1})\,F_t] \quad (A)$$

$$+B_{t+1}\,(E_{t+1} - E_t) \quad (B)$$

$$+B_{t+1}\,[(I-\bar{M}_{t+1})\,F_t - (I-\bar{M}_t)\,F_t] \quad (C)$$

$$+B_{t+1}-B^*)[(I-\bar{M}_t)F_t+E_t] \quad (D)$$

$$+(B^*-B_t)[(I-\bar{M}_t)F_t+E_t] \quad (E)$$

$$(4)$$

Each of the term measures the effects of a particular source of economic output growth:

(A) The first term measures the effects of changes in domestic final demand. (here after DF)
(B) The second term measures the effects of changes in exports. (here after E)
(C) The third term measures the effects of changes in final goods import Coefficients. (here after FM)
(D) The fourth term measures the effects of changes in Domestic production self-sufficiency Coefficients. (here after SS)
(E) The fifth term measures the effects of changes in input technical coefficients. (here after TC)

3.2. Energy Consumption Factor Decomposition Model

The energy consumption factor decomposition model will be established by the 3.1 source of economic output growth model combined with energy consumption. This study will use this model to estimate the amount of change in energy consumption.

The amount of energy consumptions change between the two periods can be written as (5)

$$\delta E^{con.} = E_{t+1}^{con.} X_{t+1} - E_t^{con.} X_t \quad (5)$$

$E_t^{(con.)}$ and $E_{t+1}^{con.}$ represent energy consumptions in t years and t+1 years. Establish coefficient of energy consumption $E^{con.}$ with (4). Energy consumption factor decomposition model can be written as (6)

$$\begin{aligned}
&\delta E^{con.} \\
&= E_{t+1}^{con.} B_{t+1}\left[\left(I-\bar{M}_{t+1}\right)F_{t+1}-\left(I-\bar{M}_{t+1}\right)F_t\right] \\
&\quad (a)\text{energy consumption effects of changes in domestic final demand}\left(DF^{energy}\right) \\
&+ E_{t+1}^{con.} B_{t+1}\left(E_{t+1}-E_t\right) \\
&\quad (b)\text{export changes in energy consumption}\left(E^{energy}\right) \\
&+ E_{t+1}^{con.} B_{t+1}\left[\left(I-\bar{M}_{t+1}\right)F_t-\left(I-\bar{M}_t\right)F_t\right] \\
&\quad (c)\text{energy consumption effect with changes in final import coefficients}\left(FM^{energy}\right) \\
&+ E_{t+1}^{con.}\left(B_{t+1}-B^*\right)\left[\left(I-\bar{M}_t\right)F_t+E_t\right] \\
&\quad (d)\text{self-sufficiency rate of energy consumption effect}\left(SS^{energy}\right) \\
&+(E_{t+1}^{con.}-E_t^{con.})(B^*-B_t)\left[\left(I-\bar{M}_t\right)F_t+E_t\right] \\
&\quad (e)\text{technical coefficients changes in energy consumption}\left(TC^{energy}\right)
\end{aligned} \quad (6)$$

Where the coefficient of energy consumption $e_j^{con.} = energy\,consumption_j / x_j$, and $E^{con.}$ is the diagonal matrix of the elements of the coefficient of energy consumption for various industries.

$$E^{con.} = \begin{pmatrix} e_1^{con.} & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & e_n^{con.} \end{pmatrix}$$

4. EMPIRICAL RESULTS AND DISCUSSION

The research findings of our model could be illustrated as the following two parts. The first part reveals the analysis of the changes in the output growth of the overall industry from year 2004 to 2016. The second part reveals the analysis of the changes in the source pattern of output growth before, during and after the year 2007 financial crisis.

4.1. Output Changes in 2004-2016: An Over-View

According to Table 1, although the total output value during the period of year 2004-2016 has grown.

However, the source of growth has changed. During the pre-crisis period during 2004-2006 that the source of output growth came from the two effects of DF and E. After entering the financial crisis period during year 2006-2011 that DF effect and E effect were still the main sources of output growth. Nevertheless, SS has shown a negative effect of NT$4,825.300 billion. Which suggests the decline in domestic production self-sufficiency was an important factor in economic damage.

During the year 2011-2016 financial crisis that the source of output growth has changed. The sources of growth were mainly provided by TC effect and SS effect accounting for 79.16% and 69.91% of the total growth respectively. On the other hand, the E and DF factors have turned into negative growth during the same period. Such observation may suggest that the mid-term and later stages of the global financial crisis have caused significant damage to domestic demand and exports.

4.2. Patterns of Changes in the Various Sub-Periods

Table 2 indicates the growth of output before the financial crisis that "Light Industries" (−193.214 NT$ billion) and "Agriculture-related Industries" (−8.405 NT$ billion) both showed a negative growth. Especially that "Light Industries" has negative growth in all five sources, which clearly indicates Taiwan's traditional industry lacks sufficient competitiveness when facing such financial crisis.

During the same period, "Machinery-related Industries" (2,398.520 NT$ billion) and "Service-related Industries" (2,220.813 NT$ billion) were the major growing departments. The growth source of "Machinery-related Industries" was mostly contributed by E factor (1,270.646 NT$ billion) while "Service-related Industries" was mostly affected by DF effect (1,986.085 NT$ billion).

After the financial crisis that Taiwan intended to reduce its damage impact on the economy by expanding public investment. Such attempt was reflected in the growth of industry during this period shown as Table 3. The major growth included "Infrastructure Industries" (4,164.661 NT$ billion), "Iron, Non-Iron Industries" (1,239.647 NT$ billion) and "Machinery-related Industries" (1,003.592 NT$ billion). The factors provided growth for these related industries were contributed by the increase of domestic final demand and hence the effeteness of economic policies. During this period "Agriculture-related Industries" (−256.753NT$ billion) and "Light Industries" (−106.508 NT$ billion) remained

Table 1: Sources of the total output growth in the economy (year 2004-2016)

Sectors	(A) DF effect (%)	(B) E effect (%)	(C) FM effect (%)	(D) SS effect (%)	(E) TC effect (%)	Total effect (%)
2004-2006 before crisis	3,763.647 (54.47)	3,193.003 (46.21)	−51.528 (−0.75)	−35.059 (−0.51)	39.480 (0.57)	6,909.543 (100.00)
2006-2011 during crisis	7,077.130 (96.83)	4,562.550 (62.43)	242.823 (3.32)	−4,825.300 (−66.02)	251.600 (3.44)	7,308.803 (100.00)
2011-2016 after crisis	−133.843 (−2.58)	−3,145.846 (−60.60)	732.468 (14.11)	3,629.214 (69.91)	4,109.537 (79.16)	5,191.530 (100.00)

Unit: NT$ billion

Table 2: Sources of output growth-before the financial crisis (year 2004-2006)

Sectors	(A) DF effect	(B) E effect	(C) FM effect	(D) SS effect	(E) TC effect	Total effect
Agriculture-related industries	−34.154	13.968	−5.889	−98.318	115.988	−8.405
Light industries	−46.600	−22.509	−23.368	−5.406	−95.331	−193.214
Chemical-related industries	564.094	785.090	−25.795	−132.048	138.472	1,329.812
Iron, Non-iron industries	246.075	363.688	39.404	96.539	−128.288	617.417
Machinery-related industries	817.097	1,270.646	−23.646	93.686	240.739	2,398.520
Infrastructure industries	231.050	94.973	7.355	0.539	210.681	544.598
Service-related industries	1,986.085	687.147	−19.589	9.949	−442.781	2,220.813
Total	3,763.647	3,193.003	−51.528	−35.059	39.480	6,909.541

Unit: NT$ billion

Table 3: Sources of output growth-during the financial crisis (year 2006-2011)

Sectors	(A) DF effect	(B) E effect	(C) FM effect	(D) SS effect	(E) TC effect	Total effect
Agriculture-related industries	338.800	90.300	1.647	−150.900	−536.600	−256.753
Light industries	142.520	68.380	−9.108	−101.500	−206.800	−106.508
Chemical-related industries	1,196.290	1,295.740	−29.551	−1,386.400	−326.200	749.879
Iron, Non-iron industries	604.430	642.080	54.937	−552.100	490.300	1,239.647
Machinery-related industries	1,358.910	1,611.540	155.142	−1,923.400	−198.600	1,003.592
Infrastructure industries	1,037.800	134.270	1.291	−149.700	3,141.000	4,164.661
Service-related industries	2,398.380	720.240	68.465	−561.300	2,111.500	514.285
Total	7,077.130	4,562.550	242.823	−4,825.300	251.600	7,308.803

Unit: NT$ billion

Table 4: Sources of output growth- after the financial crisis (year 2011-2016)

Sectors	(A) DF effect	(B) E effect	(C) FM effect	(D) SS effect	(E) TC effect	Total effect
Agriculture-related industries	367.419	382.091	21.653	70.897	−31.573	810.486
Light industries	−333.224	123.754	47.164	68.466	237.479	143.639
Chemical-related industries	−395.225	−1,680.829	−20.315	1,908.313	493.731	305.676
Iron, Non-iron industries	−147.539	−410.930	56.521	225.011	283.825	6.889
Machinery-related industries	−387.105	−607.645	424.899	708.814	1,318.058	1,457.021
Infrastructure industries	−494.550	−401.695	40.578	207.639	310.365	−337.664
Service-related industries	1,256.380	−550.592	161.966	440.075	1,497.651	2,805.481
Total	−133.843	−3,145.846	732.468	3,629.214	4,109.537	5,191.530

Unit: NT$ billion

to be negative in growth. Such results were most affected by SS effect and TC effect.

After nearly 10 years from the financial crisis that Taiwan's output growth sources have changed and so was the growth industry as illustrated in Table 4.

Due to the impact of the financial crisis that the DF effect (−133.843 NT$ billion) and the E effect (−3,145.846 NT$ billion) have gradually turned into negative value. This indicates that both domestic and foreign markets are affected by "negative wealth effects" to reduce demand for products. On the other hand, contributed by the improvement of SS effect (3,629.214 NT$ billion) and TC effect (4,109.537 NT$ billion) that all other industries except for "Agriculture-related Industries" (−31.573NT$ billion) have shown significant growth. Another noteworthy aspect is the negative growth of "Infrastructure Industries" (−337.664 NT$ billion). This negative growth may have been affected by the reduction of government public works and corporate investment.

4.3. Changes in Sources of Energy Consumption

It is found from Table 5 that there has been a significant change in the coefficient of energy consumption between 2004 and 2016. Overall, the coefficient of energy consumption for the period 2004-2006 was 35.806 (KLOE/NT$100 million). The coefficient of energy consumption for the period 2006-2011 fell to 34.205 (KLOE/NT$100 million), and the coefficient of energy consumption for the period 2011-2016 was 30.527 (KLOE/NT$100 million). The decline in coefficient of energy consumption indicates that energy efficiency improves as the economy grows.

The period from 2004 to 2006 was the base period, and the coefficient of energy consumption during 2006-2011 was the largest decline with "Agriculture-related Industries", followed by "Infrastructure Industries". During this period, "Chemical-related Industries" and "Iron, Non-Iron" Industries' coefficient of energy consumption did not improve much in terms of energy consumption efficiency. The main reason was that it was difficult for capital-intensive industries to significantly update production equipment in a short period of time.

During the period of 2011-2016 after the outbreak of the financial crisis, the efficiency-energy consumption of "Service-related Industries," "Machinery-related Industries" and "Infrastructure Industries" decreased significantly, and all industries fell to 76.42% before the financial crisis. The outbreak of the financial crisis has encouraged industries to reduce energy consumption and improve energy efficiency.

According to the research period (2004-2016) of this paper, Service-related Industries reduced the coefficient of energy consumption to the maximum (26.45%), followed by Machinery-related Industries (23.50%). Conversely, the decline in the coefficient of energy consumption of Chemical-related Industries was the least, only 7.27%. In addition, the I-O Table is integrated into seven major departments.

Table 6 shows the sources of energy consumption during the period 2004-2006.The largest source of energy consumption during this period was the export factor (E^{energy} effect = 153,367,604 KLOE), followed by the domestic final demand (DF^{energy} effect = 130,130,507 KLOE).The reduction in energy consumption was the highest in domestic product self-sufficiency, with a decrease of 16,852,822 KLOE. Among them, Chemical-related Industries reduced the energy consumption by 19,893,163 KLOE.

The source of energy consumption after entering the financial crisis turned to domestic final demand (DF^{energy} effect=253,539,782 KLOE). As shown in Table 7. Although Taiwan's exports were hit by the financial crisis, energy consumption still ranked second (E^{energy} effect= 237,988,280 KLOE). These two factors are most evident in the performance of "Chemical-related Industries", with an increase in energy consumption of 175,549,576 KLOE and 190,143,366 KLOE, respectively.

On the other hand, the most effective factor in the reduction of energy consumption during this period is the production of self-sufficiency and the import of final products. During the period of 2006-2011, the energy consumption of 250, 387, 492 KLOE and 438, 489 KLOE was reduced in SS^{energy} effect and FM^{energy} effect, respectively. It is particularly noted that the energy consumption sources of all industries are in a reduced state in the SS^{energy} effect.

Table 5: Change in the coefficient of energy consumption (2004-2016)

Sectors	(1) 2004-2006	(2) 2006-2011	(3) 2011-2016	(4)=(2)/(1) (%)	(5)=(3)/(1) (%)	(6)=(5)−(4) (%)
Agriculture-related industries	12.375	10.667	9.363	86.20	75.66	−10.54
Light industries	18.621	17.674	15.389	94.91	82.64	−12.27
Chemical-related industries	150.651	146.745	135.800	97.41	90.14	−7.27
Iron, Non-iron industries	34.257	33.523	30.282	97.86	88.40	−9.46
Machinery-related industries	9.678	8.639	6.364	89.26	65.76	−23.50
Infrastructure industries	11.204	9.821	7.787	87.66	69.51	−18.15
Service-related industries	13.853	12.368	8.704	89.28	62.83	−26.45
Total	35.806	34.205	30.527	91.797	76.420	−15.376

Unit: KLOE/NT$100 million

Table 6: Source of energy consumption (year 2004-2006)

Sectors	(a) DF^{energy} effect	(b) E^{energy} effect	(c) FM^{energy} effect	(d) SS^{energy} effect	(e) TC^{energy} effect	Total effect
Agriculture-related industries	−422,656	172,854	−72,876	−1,216,685	1,435,352	−104,012
Light industries	−867,739	−419,140	−435,136	−100,665	−1,775,159	−3,597,838
Chemical-related industries	84,981,325	118,274,594	−3,886,043	−19,893,163	20,860,945	200,337,658
Iron, Non-iron industries	8,429,791	12,458,860	1,349,863	3,307,137	−4,394,762	21,150,888
Machinery-related industries	7,907,865	12,297,312	−228,846	906,693	2,329,872	23,212,896
Infrastructure industries	2,588,684	1,064,077	82,405	6,039	2,360,470	6,101,676
Service-related industries	27,513,236	9,519,047	−271,366	137,823	−6,133,845	30,764,895
Total	130,130,507	153,367,604	−3,461,999	−16,852,822	14,682,873	277,866,164

Unit: KLOE

Table 7: Source of energy consumption (year 2006-2011)

Sectors	(a) DF^{energy} effect	(b) E^{energy} effect	(c) FM^{energy} effect	(d) SS^{energy} effect	(e) TC^{energy} effect	Total effect
Agriculture-related industries	3,613,980	963,230	17,569	−1,609,650	−5,723,912	−2,738,784
Light industries	2,518,898	1,208,548	−160,975	−1,793,911	−3,654,983	−1,882,422
Chemical-related industries	175,549,576	190,143,366	−4,336,461	−203,447,268	−47,868,219	110,040,994
Iron, Non-iron industries	20,262,307	21,524,448	1,841,653	−18,508,048	16,436,327	41,556,686
Machinery-related industries	11,739,623	13,922,094	1,340,272	−16,616,253	−1,715,705	8,670,031
Infrastructure industries	10,192,234	1,318,666	12,679	−1,470,204	30,847,761	40,901,136
Service-related industries	29,663,164	8,907,928	846,775	−6,942,158	26,115,032	58,590,741
Total	253,539,782	237,988,280	−438,489	−250,387,492	14,436,300	255,138,381

Unit: KLOE

Table 8: Source of energy consumption (year 2011-2016)

Sectors	(a) DF^{energy} effect	(b) E^{energy} effect	(c) FM^{energy} effect	(d) SS^{energy} effect	(e) TC^{energy} effect	Total effect
Agriculture-related industries	3,440,130	3,577,504	202,736	663,806	−295,617	7,588,560
Light industries	−5,127,947	1,904,437	725,802	1,053,616	3,654,538	2,210,445
Chemical-related industries	−53,671,555	−228,256,578	−2,758,777	259,148,905	67,048,670	41,510,665
Iron, Non-iron industries	−4,467,828	−12,443,927	1,711,589	6,813,863	8,594,889	208,585
Machinery-related industries	−2,463,633	−3,867,205	2,704,163	4,511,070	8,388,451	9,272,846
Infrastructure industries	−3,851,292	−3,128,187	316,000	1,616,982	2,416,958	−2,629,540
Service-related industries	10,935,969	−4,792,544	1,409,808	3,830,566	13,036,075	24,419,874
Total	−55,206,157	−247,006,501	4,311,321	277,638,807	102,843,963	82,581,434

Unit: KLOE

After the 2008 financial crisis, Taiwan has changed its sources of energy consumption, as shown in Table 8. The financial crisis has forced the adjustment of production methods of enterprises, although it has contributed to economic growth, but it has also increased consumption of energy. SS^{energy} effect and TC^{energy} effect are the main source of energy consumptions increase, mainly from "Chemical -related Industries." In terms of sources of energy consumption, in addition to "Agriculture-related Industries," "Light Industries" and "Service-related Industries," DF^{energy} effect and E^{energy} effect in other sectors have shown improvements in energy consumption efficiency.

5. CONCLUSIONS AND POLICY IMPLICATIONS

The above results reveal that the financial crisis has indeed changed the source of output and growth patterns. This study has found that the source of growth has transformed from DF effect and E effect to TC effect and SS effect. This transformation suggests that the future economic growth in Taiwan ought to rely on technological innovation in production to receive higher growth performance. On the other hand, this study also found that the industrial development patterns that drive economic growth have moved from "Machinery-related Industries" to "Infrastructure Industries" and then shifted to "Service-related Industries." This transformation may suggest that Taiwanese economy has entered the so-called "post-industrial society" stage. For the conclusion of the study, we propose that financial crisis has indeed caused changes in Taiwan's economic structure. The subsequences of such transformation have also changed the pattern of industrial development.

However, the financial crisis has made Taiwan's economic development model need to change. Economic sustainable development needs to improve energy consumption efficiency. The study found that the financial crisis caused changes in Taiwan's production process, which also changed the growth factor. These changes are reflected in changes in energy consumption, which indicates that Taiwan's economic development has a certain degree of relationship with energy consumption. The change in coefficient of energy consumption found that 86.20% of Agriculture-related Industries improved most before 2011, and the energy efficiency improvement of Service-related Industries was the most obvious after 2011 (62.83%).This is the financial crisis that has prompted the service industry to move towards efficiency in response to domestic consumer demand. The source of improving energy consumption efficiency is FM^{energy} effect and SS^{energy} effect before 2011, and then changed to DF^{energy} effect and E^{energy} effect after 2011. Such changes indicate that after the financial crisis, Taiwan must adjust its business model in order to cope with the competition between the domestic market and exports.

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