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Article

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Decomposition of Growth Factors in High-tech Industries and CO_2 Emissions: After the World Financial Crisis in 2008

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ABSTRACT

Taiwan's economic development faces two problems, one is the imbalance of the economic structure, and the other is that the industrial structure must be upgraded. This is a problem that has existed since the 1990s, but it has not been solved for a long time. The outbreak of the world financial crisis in 2008 severely damaged the international economy and finance, and Taiwan suffered a huge economic shock. In the face of an economic predicament, Taiwan attempts to transform the unbalanced economic system through technological innovation through public investment and the updating of corporate equipment, and sets the goal of sustainable development, of which high-tech industries have become the focus of economic development. This paper takes the financial crisis as the research period, analyzes the growth of the industries and their causes through the economic growth decomposition model, and estimates the CO_2 emissions generated, which will help understand Taiwan's future economic development. The research results show that the growth of high-tech industries after the financial crisis is dominated by semiconductors and power equipment-related industries. The growth factor is innovation of input technology and the improvement of self-sufficiency. At the same time, CO_2 emissions are mainly caused by these two factors.

Keywords: High-tech Industries, CO_2 Emissions, Input Technology, Growth Decomposition Model
JEL Classifications: Q43, C6, E2, E210

1. INTRODUCTION

From 1981 to 2016, Taiwan underwent liberalization, internationalization, and global economic changes. In the course of economic development during these 35 years, except for the Internet bubble economy in the United States in 2002 and the impact of the global financial crisis in 2009, Taiwan has shown economic growth. After joined the World Trade Organization (WTO) in 2002, Taiwan became a member of the WTO, and expanding international trade has changed the industrial structure. In 1981, the GDP of agriculture, industry, and services accounted for 7.35%, 43.83%, and 48.82% of the overall industry. By 1988, the service industry had exceeded 50%, and the proportion of agricultural output value had dropped significantly. The proportion of primary industries has gradually declined and the proportion of tertiary industries has gradually increased. By 2016, the agricultural, industrial and service industries' GDP ratios were 1.82%, 35.06% and 63.13%, respectively. In other words, Taiwan's industrial structure has changed a lot after joining the WTO.

After the 1960s, Taiwan's sustained high growth was through employment creation and economic development through the trade export industry. However, in the 1980s, liberalization and market opening, the pace of industrial innovation could not keep up with competitors' price strategies, and Taiwan 's economy could not be as fast as in the past continue to grow. Since import and export trade has become the main economic structure, the volume of trade has become an important factor in the change of industrial structure. Especially after the Plaza Agreement in 1985, the appreciation of the currency led to a substantial increase in trade volume. Imports and exports have gradually become an important factor in Taiwan's economic growth. In 2005, it exceeded 200 billion US dollars, and the value of imports and exports has expanded.

The crisis of the world financial tsunami was triggered in September 2008. The export trade volume has fallen sharply from a growth of more than 10% in the first 8 months, and has begun to turn negative growth in the third quarter. By the first quarter of 2009, Taiwan's exports The decline was expanded to −26.87%. In order to respond to economic losses caused by financial shocks, Taiwan has implemented multiple fiscal policies and expanded public investment so that economic growth can gradually return to stability. Among them, Taiwan attaches great importance to the research and innovation of high-tech industries and plays an important role in economic development. The total value of trade in 2014 was a record high of $ 601.9 billion. Judging from the GDP value of imports and exports, imports and exports accounted for 43.28% and 46.24% each in 1981, and have increased to 43.51% and 52.90% in 2016.

The financial crisis has raised Taiwan's focus on the development of high-tech industries. In addition, energy policies are also adjusted under environmental protection. Taiwan's investment in renewable energy generation systems attempts to provide more sources of electricity to achieve economic development and environmental protection. In order to achieve research objectives, this paper will analyze the growth factors of high-tech industries after the financial crisis, and discuss the relationship between power consumption and CO_2 emissions, which will help to understand the direction of Taiwan's industrial structure adjustment in the future. In order to obtain more specific data to analyze the research topic of this thesis, a factor decomposition model of the high-tech industry will be established in section 3 to establish two factor decomposition models of CO_2 emissions.

2. LITERATURE REVIEW

The past literature on the relationship between the economy and the environment can be divided into several stages of research. The early literature focused on the relationship between economic growth and environmental pollutants. The analytical point of view is represented by the Environmental Kuznets Curve (EKC) (Lee and Lee, 2009; Ang, 2007; Saboori et al., 2012). The EKC hypothesis suggests that the level of environmental pollution will increase with the country's economic development, but will start to decrease as the national income increases beyond the turning point (Dinda, 2004).

With the rapid increase of energy consumption caused by economic development, the research focus has gradually shifted to the impact of energy (electricity) use on environmental loads (e.g. Kraft and Kraft, 1978; Payne, 2010a; Payne, 2010b; Ozturk, 2010 Ozturk and Acaravci, 2011; Farhani et al., 2014; Bella et al., 2014; Dogan, 2015; Njoke et al., 2019; Sunde, 2020). In addition, many studies often use Granger causality to analyze the relationship between economic growth and energy consumption, and further analyze the relationship between economic growth, energy consumption and environmental pollution. However, in many studies, the relationship between economic development, energy consumption, and pollution in different countries has different results.

Njoke et al. (2019) points out the relationship between Cameroon's power consumption, carbon emissions and economic growth from 1971 to 2014. The study indicates that there is a significant relationship between CO_2 emissions and economic growth, whether short-term or long-term. However, studies have shown different results. For example, Ozturk and Acaravci (2011) pointed out that there is no relationship between electricity consumption and economic growth in most Middle East and North Africa countries. There are also numerous studies analyzing the relationship between energy consumption and environmental damage, such as Yavuz and Yilanci (2013), Presno et al. (2018), and Aydin and Esen (2018).

Because economic growth brings changes in the industrial structure, and the relationship between the economy and the environment is often subject to the influence of industrial structure styles, changes in the industrial structure will cause different results. In addition, attention has been paid to the adjustment of power sources. In recent years, there has been an increasing trend in research on renewable energy (Dogan, 2015; Bölük and Mert, 2015). However, with the development of globalized economy, economic growth has indeed caused significant environmental impacts (Dreher, 2006; Managi and Kumar, 2009; Jorgenson and Givens, 2014; Li et al., 2015; Doytch and Uctum, 2016; You and Lv, 2018; Saint Akadiri et al., 2019). Managi and Kumar (2009) research pointed out that trade does have an adverse effect on CO_2 emissions, and Doytch and Uctum (2016) also believe that improper investment activities will cause environmental damage. In addition, Dreher (2006) proposed that the global economy should invest in green related industries to improve the environment.

3. METHODOLOGY AND DATA

This research model is a factor decomposition model established by I-O Tables (Input-Output Tables) in different periods. It is considered that there are changes in prices and quantities in economic growth in different periods. In addition, the analysis period of this paper is set between 2011 and 2016. Therefore, the establishment of the model of this paper needs to be processed through substantial processes in order to make the two periods industry price benchmarks are consistent. This section uses Fujita and William (1997), Hong et al. (2018), and Hong et al. (2019) to build the following three models.

3.1. The Decomposition Model of High-tech Industries Growth

The equilibrium equation of the I-O model of the high-tech industry can be expressed by the quantity equations (1).

$$X = \left[I - \left(I - \bar{M} \right) A \right]^{-1} \left[\left(I - \bar{M} \right) F + E \right] \tag{1}$$

Where, the definition of each variable in the equation is as follows

X is a vector representing the total output of the industry ($n \times 1$); A represents the input coefficient matrix ($n \times n$). As matrix A

reflects technology of production, it is usually called technological matrix; F is the domestic final demand vector ($n \times 1$); E is the export vector ($n \times 1$); $\bar{M}$ is the diagonal determinant of the import coefficient ($n \times n$).

t and $t+1$ represent the base year and the comparative year. The changes in the two periods can be written as:

$$\delta X = \left[I-\left(I-\bar{M}_{t+1}\right)A_{t+1}\right]^{-1}\left[\left(I-\bar{M}_{t+1}\right)F_{t+1}+E_{t+1}\right]$$
$$-\left[I-\left(I-\bar{M}_{t}\right)A_{t}\right]^{-1}\left[\left(I-\bar{M}_{t}\right)F_{t}+E_{t}\right] \quad (2)$$

When $\left[I-\left(I-\bar{M}_{t+1}\right)A_{t+1}\right]^{-1}=B_{t+1}$ and $\left[I-\left(I-\bar{M}_{t}\right)A_{t}\right]^{-1}=B_{t}$ are substituted into equation (2), resulting in the following modifications:

$\delta X = B_{t+1}\left[\left(I-\bar{M}_{t+1}\right)F_{t+1}-\left(I-\bar{M}_{t+1}\right)F_{t}\right]$ (changes in domestic final demand)

$+B_{t+1}\left(E_{t+1}-E_{t}\right)$ (changes in exports)

$+B_{t+1}\left[\left(I-\bar{M}_{t+1}\right)F_{t}-\left(I-\bar{M}_{t}\right)F_{t}\right]$ (changes in final goods imports)

$+\left(B_{t+1}-B^{*}\right)\left[\left(I-\bar{M}_{t}\right)F_{t}+E_{t}\right]$ (changes in self-sufficiency)

$+\left(B^{*}-B_{t}\right)\left[\left(I-\bar{M}_{t}\right)F_{t}+E_{t}\right]$ (changes in input technology) (3)

Where, $\left[I-\left(I-\bar{M}_{t}\right)A_{t+1}\right]^{-1}=B^{*}$..

3.2. The Decomposition Model of CO_2 Emissions Growth

This section uses equation (3) to establish a CO_2 emissions growth model. This will require an estimation of the industry's CO_2 emissions coefficient. The model building process is shown below.

CO_{2t} and CO_{2t+1} represent CO_2 emissions in t years and t+1 years.

$$CO_{2t} = C_t X_t = C_t\left[I-\left(I-\bar{M}_{t}\right)A_{t}\right]^{-1}\left[\left(I-\bar{M}_{t}\right)F_{t}+E_{t}\right] \quad (4)$$

$$CO_{2t+1} = \hat{C}_{t+1}X_{t+1} = \left[I-\left(I-\bar{M}_{t+1}\right)A_{t+1}\right]^{-1}$$
$$\left[\left(I-\bar{M}_{t+1}\right)F_{t+1}+E_{t+1}\right] \quad (5)$$

$$CO_{2t+1}-CO_{2t}=\delta CO_2 \quad (6)$$

Where the emissions coefficient $c_j = {CO_{2_j}}/{x_j}$, and $\hat{C}$ is the diagonal matrix of the elements of the emissions coefficients for various industries.

$$\hat{C}=\begin{pmatrix} c_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & c_n \end{pmatrix}$$

$$\delta CO_2 = \hat{C}_{t+1}B_{t+1}\left[\left(I-\bar{M}_{t+1}\right)F_{t+1}-\left(I-\bar{M}_{t+1}\right)F_{t}\right] \quad (a)$$
$$+\hat{C}_{t+1}B_{t+1}\left(E_{t+1}-E_{t}\right) \quad (b)$$
$$+\hat{C}_{t+1}B_{t+1}\left[\left(I-\bar{M}_{t+1}\right)F_{t}-\left(I-\bar{M}_{t}\right)F_{t}\right] \quad (c)$$
$$+\hat{C}_{t+1}\left(B_{t+1}-B^{*}\right)\left[\left(I-\bar{M}_{t}\right)F_{t}+E_{t}\right] \quad (d)$$
$$+\left(\hat{C}_{t+1}B^{*}-\hat{C}_{t}B_{t}\right)\left[\left(I-\bar{M}_{t}\right)F_{t}+E_{t}\right] \quad (e)$$

(a) The CO_2 emissions of changes in domestic final demand;(b) The CO_2 emissions of changes in exports;(c) The CO_2 emissions of changes in final import coefficients;(d) The CO_2 emissions of changes in self-sufficiency coefficients;(e) The CO_2 emissions of changes in production input technical coefficients. From the five factors (a) to (e), we can estimate the scale of CO_2 emissions, which will help promote the future development of the industries.

4. EMPIRICAL RESULTS AND DISCUSSION

4.1. Analysis of Growth Factors of High-tech Industries after the Financial Crisis

The growth of the high-tech industry since the 1990s has been the main factor driving Taiwan's economic development. This section empirically analyzes whether this trend has changed after the financial crisis. At the same time, what factors will change the high-tech industry? On the other hand, does the growth of high-tech industries also change in CO_2 emissions? This will also be the focus of this section. Because high-tech industries include a variety of different industries, in order to be able to more fully identify the characteristics of industrial development, this section divides high-tech industries into three major industrial groups according to the nature of the industry, namely "semiconductor related industries," "computer and electronics related industries," and "power system related industries."

4.1.1. Growth factors of semiconductor related industries

Table 1 shows the growth scale of "semiconductor related industries" during 2011–2016. From Table 1, we can see that the semiconductors industry has the largest growth, which accounts for 75.04% (NT$ 1,315,252 million) of "semiconductor related industries," while the passive electronic components sector has the least growth, only NT$ 46,873 million.

The biggest factor in the growth of the semiconductors industry comes from the improvement of self-sufficiency, which is increasing the proportion of domestic industrial manufacturing, which means that this sector has improved the integrity of the domestic production chain after the financial crisis. In addition, the improvement of input technology created the semiconductors industry by NT$ 306,952 million, which accounted for 23.34% of the total. On the other hand, the biggest factor driving the growth of "semiconductor related industries" is the technological innovation of input technology, which contributed NT$ 638,346 million, which accounted for 36.42% of the total growth (=NT$ 638,346 million/NT$ 1,752,843 million).

4.1.2. Growth factors of computer and electronics related industries

The computer and electronics industries are the foundation of high-tech industries. However, after the 1990s, these related industries were largely transferred from Taiwan to Chinese production. From Table 2, we can see that the changes in computer and electronics related industries have shown negative growth (-NT$ 541,763 million). The largest reduction was in the communications industry, which was about NT $ 472,008 million. The biggest factor that caused the reduction of the communication industry was exports (-NT$ 466,976million), followed by domestic final demand (-NT$ 102,949 million).

Despite the negative growth of "computer and electronics related industries," there are also growing industries, which include Computer products, Computer peripherals and Measurement, navigation, control and other industries. The main factor for these growing industries comes from input technology, which shows that technological innovation is still a necessary condition for Taiwan's industrial development.

4.1.3. Growth factors of power system related industries

Taiwan has promoted the transformation of power generation systems from 2017, and it is particularly important to observe the growth and changes of "power system related industries." Table 3 shows the growth of power system related industries between 2011 and 2016. It can be seen from the table that the growth of other power equipment and transportation related industries is the largest, accounting for about 142.00% and 67.85% of the "power system related industries."

After the financial crisis, innovation in input technology was the biggest factor driving the growth of "power system related industries." This factor created a total value of NT$ 436,951 million, and self-sufficiency and final goods imports factors also created NT$ 202,381 million, NT$ 78,302 million. The transformation of energy sources requires new technologies and investments, as well as changes in the relevant legal systems of energy supply. This is a major reform project. Therefore, Table 3 shows that the related industries of the power system have improved significantly in terms of technological innovation and self-sufficiency.

4.2. Analysis of CO_2-emissions Changes of High-tech Industries after the Financial Crisis

Economic growth and increased energy consumption may also lead to more CO_2 emissions. This section estimates the scale of CO_2 emissions from economic growth in Section 4.1.

4.2.1. The CO_2 emissions factors of the semiconductor-related industries

Table 4 shows the CO_2 emissions increased by "semiconductor related industries" during the period of 2011-2016, and it can be known from the data that this industry group has increased by a total of 5,446,876 tons during the 5-year period. This result is mainly due to the improvement of input technology to increase production. Among them, the growth rate of the Semiconductors industry is the most obvious, with a total increase of CO_2 emissions of about 4,087,083 tons.

Table 1: Growth factors of semiconductor related industries (2011-2016)

Classification of industries	Changes in factors				
	(a) Changes in domestic final demand	(b) Changes in exports	(c) Changes in final goods imports	(d) Changes in self-sufficiency	(e) Changes in input technology
Semiconductors	248,559	240,202	185,046	334,493	306,952
Passive electronic components	11,836	2,452	8,054	16,208	8,323
Printed circuit board	−47,685	30,034	8,788	13,920	54,682
Optoelectronic materials and components	−174,725	85,884	12,699	8,958	213,717
Other electronic components	39,179	520	37,031	53,047	54,673
Total	77,163	359,091	251,617	426,626	638,346

Unit: NT$ million

Table 2: Growth factors of computer and electronics related industries (2011-2016)

Classification of industries	Changes in factors				
	(a) Changes in domestic final demand	(b) Changes in exports	(c) Changes in final goods imports	(d) Changes in self-sufficiency	(e) Changes in input technology
Computer products	4,260	9,445	3,370	892	13,820
Computer peripherals	−14,382	14,055	−3,670	−69	24,649
Communication	−102,949	−466,976	3,027	2,124	92,766
Audiovisual electronics	−4,770	−26,809	3,155	2,764	4,678
Blank data storage media	−14,864	−40,546	−28	634	8,750
Measurement, navigation, control	20,359	−109,974	58,225	29,738	17,551
Radiation and electronic medical equipment, optical instruments	−11,788	−114,372	17,971	21,691	15,510
Total	−124,134	−735,177	82,050	57,774	177,724

Unit: NT$ million

On the whole, although "semiconductor related industries" can also create industry growth after the financial crisis, CO_2 emissions are also showing positive growth from the five factors in the table.

4.2.2. The CO_2 emissions factors of computer related industries

The performance of CO_2 emissions in the "computer and electronics related industries" group is shown in Table 5. It can be seen from the table that the largest increase in CO_2 emissions is in the computer-related industries. Among them, Computer products and Computer peripherals increased by 98,777 tons and 63,962 tons respectively.

Due to the impact of the financial crisis, the negative wealth effect reduced the demand for domestic final demand and exports, which indirectly contributed to the reduction of CO_2 emissions. These two factors reduced CO_2 emissions by 385,741tons and 2,284,528 tons, respectively.

4.2.3. The CO_2 emissions factors of power system related industries

Economic development requires electricity security and stable supply, while also taking into account environmental preservation to improve the quality of life. The analysis period of this paper is only up to 2016, and it does not include the energy transition policies after 2017. Therefore, the growth of "power system related industries" in Table 6 is only reflected in the estimated data under the past power generation system.

Due to the reduction of domestic final demand and exports caused by the financial crisis, these two factors have reduced CO_2 emissions by 1,142,499 tons and 396,940 tons, of which the professional machinery industry is the most significant. The wires, cables and wiring related industries reduced CO_2 emissions by 475,015 tons. On the other hand, the main industries with increased CO_2 emissions are other power equipment (980,619 tons) and Transportation related (468,523 tons).

Table 3: Growth factors of power system related industries (2011-2016)

Classification of industries	Changes in factors				
	(a) Changes in domestic final demand	(b) Changes in exports	(c) Changes in final goods imports	(d) Changes in self-sufficiency	(e) Changes in input technology
Power generation, transmission and distribution	−58,713	−13,213	4,196	474	16,805
Battery	−1,257	−599	985	6,733	3,121
Wires, cables and wiring	−141,364	−11,499	1,727	−6,537	41,386
Lighting device	−10,437	−2,478	−107	167	5,129
Household appliances	−6,883	1,008	−1,107	216	7,956
Other power equipment	106,333	−38,276	20,305	172,743	54,465
Professional machinery	−250,847	−125,380	71,456	46,963	177,987
Transportation related	−4,496	62,699	−19,153	18,378	130,102
Total	−367,664	−127,738	78,302	202,381	436,951

Unit: NT$ million

Table 4: CO_2 emissions factors of the semiconductor-related industries (2011-2016)

Classification of industries	Changes in factors				
	(a) Changes in domestic final demand	(b) Changes in exports	(c) Changes in final goods imports	(d) Changes in self-sufficiency	(e) Changes in input technology
Semiconductors	772,385	746,416	575,022	1,039,421	953,839
Passive electronic components	36,780	7,619	25,027	50,366	25,863
Printed circuit board	−148,179	93,329	27,308	43,256	169,922
Optoelectronic materials and components	−542,950	266,880	39,462	27,837	664,116
Other electronic components	121,747	1,616	115,072	164,841	169,894
Total	239,780	1,115,858	781,888	1,325,720	1,983,630

Unit: Tons

Table 5: CO_2 emissions factors of computer related industries (2011-2016)

Classification of industries	Changes in factors				
	(a) Changes in domestic final demand	(b) Changes in exports	(c) Changes in final goods imports	(d) Changes in self-sufficiency	(e) Changes in input technology
Computer products	13,238	29,350	10,472	2,772	42,945
Computer peripherals	−44,691	43,675	−11,404	−214	76,596
Communication	−319,909	−1,451,106	9,406	6,600	288,266
Audiovisual electronics	−14,823	−83,308	9,804	8,589	14,537
Blank data storage media	−46,189	−125,995	−87	1,970	27,190
Measurement, navigation, control	63,265	−341,739	180,931	92,409	54,539
Radiation and electronic medical equipment, optical instruments	−36,631	−355,406	55,844	67,404	48,197
Total	−385,741	−2,284,528	254,967	179,530	552,269

Unit: Tons

Table 6: CO_2 emissions factors of power system related industries (2011-2016)

Classification of industries	Changes in factors				
	(a) Changes in domestic final demand	(b) Changes in exports	(c) Changes in final goods imports	(d) Changes in self-sufficiency	(e) Changes in input technology
Power generation, transmission and distribution	−182,448	−41,059	13,039	1,473	52,221
Battery	−3,906	−1,861	3,061	20,922	9,698
Wires, cables and wiring	−439,282	−35,733	5,367	−20,313	128,605
Lighting device	−32,432	−7,700	−332	519	15,938
Household appliances	−21,389	3,132	−3,440	671	24,723
Other power equipment	330,425	−118,941	63,097	536,791	169,247
Professional machinery	−779,495	−389,612	222,046	145,935	553,086
Transportation related	−13,971	194,834	−59,517	−57,109	404,286
Total	−1,142,499	−396,940	243,320	628,889	1,357,805

Unit: Tons

5. CONCLUSIONS AND POLICY IMPLICATIONS

Taiwan's economic development is facing an imbalance between the economic structure and the industrial structure. The world financial crisis in 2008 caused huge economic losses and increased unemployment. In the future, Taiwan's economic planning will focus on the economic goals of industrial restructuring and sustainable development. The key to accomplishing this economic goal lies in the success of the development of high-tech industries in the future. This research is to analyze the economic and industrial changes after the financial crisis, and to analyze the factors of industrial growth and change with the industry's composition model. This will help to understand and follow the trend of Taiwan's economic development, and can provide specific suggestions. From the above empirical results, the following points are summarized.

The high-tech industry is centered on machinery-related industries. The growth during the 5 years after the financial crisis (2011-2016) created an increase of NT $ 1,433,312 million, accounting for 27.61% of GDP growth. In the high-tech industry, Semiconductors, power equipment and electronic components-related industries have grown the most. In addition, the growth of high-tech industries is mainly affected by the innovation of input technology and the improvement of self-sufficiency. The former can improve production efficiency and industrial upgrading, while the latter can improve domestic employment opportunities and industrial structure transformation. Therefore, after the financial crisis, although Taiwan's economy suffered great economic damage, it also stimulated technological innovation and increased the proportion of domestic industrialization. Nevertheless, under the dual goals of environmental protection and economic growth, how to reduce CO_2 emissions is an important issue for Taiwan at present. Empirical evidence shows that the high-tech industry is still subject to the financial crisis and has shown significant growth, which has also increased CO_2 emissions. Among them, Semiconductors have increased the most, accounting for more than 90% of the total high-tech.

REFERENCES

Akadiri, S.S., Lasisi, T.T., Uzuner, G., Akadiri, A.C. (2019), Examining the impact of globalization in the environmental Kuznets curve hypothesis: The case of tourist destination states. Environmental Science and Pollution Research, 26, 12605-12615.

Ang, J.B. (2007), CO_2 emissions, energy consumption, and output in France. Energy Policy, 35, 4772-4778.

Aydin, C., Esen, Ö. (2018), Does the level of energy intensity matter in the effect of energy consumption on the growth of transition economies? Evidence from dynamic panel threshold analysis. Energy Economics, 69, 185-195.

Bella, G., Massidda, C., Mattana, P. (2014), The relationship among CO_2 emissions, electricity power consumption and GDP in OECD. Journal of Policy Modeling, 36, 970-985.

Bölük, G., Mert, M. (2015), The renewable energy, growth and environmental Kuznets curve in Turkey: An ARDL approach. Renewable and Sustainable Energy Reviews, 52, 587-595.

Dinda, S. (2004), Environmental Kuznets curve hypothesis: A survey. Ecological Economics, 49, 431-55.

Dogan, E. (2015), The relationship between economic growth and electricity consumption from renewable and non-renewable sources: A study of Turkey. Renewable and Sustainable Energy Reviews, 52, 534-546.

Doytch, N., Uctum, M. (2016), Globalization and the environmental impact of sectoral FDI Economic Systems. Economic Systems, 40(4), 582-594.

Dreher, A. (2006), Does globalization affect growth? Evidence from a new index of globalization. Applied Economics, 38(10), 1091-1110.

Farhani, S., Chaibi, A., Rault, C. (2014), CO_2 emissions, output, energy consumption, and trade in Tunisia. Economic Modelling, 38, 426-434.

Fujita, N., William, E.J. (1997), Employment creation and manufactured exports in Indonesia: 1980-90. Bulletin of Indonesian Economic Studies, 33(1), 103-115.

Hong, C.Y., Lee, Y.C., Tsai, M.C., Tsai, Y.C. (2018), Agricultural sector input technical coefficients, demand changes and CO_2 emissions after the financial crisis: Environmental input-output growth factor model approach. International Journal of Energy Economics and Policy, 8(6), 339-345.

Hong, C.Y., Yen, Y.S., Chien, P.C. (2019), Sources of economic growth and changes in energy consumption: Empirical evidence for Taiwan (2004-2016). International Journal of Energy Economics and Policy, 9(3), 346-352.

Jorgenson, A.K., Givens, J.E. (2014), Economic globalization and environmental concern: A multilevel analysis of individuals within 37 nations. Environment and Behavior, 46(7), 848-871.

Kraft, J., Kraft, A. (1978), On the relationship between energy and GNP. The Journal of Energy and Development, 3, 401-403.

Lee, C.C., Lee, J.D. (2009), Income and CO_2 emissions: Evidence from panel unit root and cointegration tests. Energy Policy, 37, 413-23.

Li, Z., Xu, N., Yuan, J. (2015), New evidence on trade-environment

linkage via air visibility. Economics Letters, 128, 72-74.
Managi, K., Kumar, S. (2009), Energy price-induced and exogenous technological change: Assessing the economic and environmental outcomes. Resource and Energy Economics, 31(4), 334-353.
Njoke, M.L., Wu, Z., Tamba, J.G. (2019), Empirical analysis of electricity consumption, CO_2 emissions and economic growth: Evidence from Cameroon. International Journal of Energy Economics and Policy, 9(5), 63-73.
Ozturk, I. (2010), A literature survey on energy-growth nexus. Energy Policy, 38(1), 340-349.
Ozturk, I., Acaravci, A. (2011), Electricity consumption and real GDP causality nexus: Evidence from ARDL bounds testing approach for 11 MENA countries. Applied Energy, 88, 2885-2892.
Payne, J.E. (2010a), Survey of the international evidence on the causal relationship between energy consumption and growth. Journal of Economic Studies, 37, 53-95.
Payne, J.E. (2010b), A survey of the electricity consumption-growth literature. Applied Energy, 87, 723-731.
Presno, M.J., Landajo, M., González, P.F. (2018), Stochastic convergence in per capita CO_2 emissions. An approach from nonlinear stationarity analysis. Energy Economics, 70, 563-581.
Saboori, B., Sulaiman, J., Mohd, S. (2012), Economic growth and CO_2 emissions in Malaysia: A cointegration analysis of the environmental Kuznets curve. Energy Policy, 51, 184-191.
Sunde, T. (2020), Energy consumption and economic growth modelling in SADC countries: An application of the VAR Granger causality analysis. International Journal of Energy Technology and Policy, 16(1), 41-56.
Yavuz, N.C., Yilanci, V. (2013), Convergence in per capita carbon dioxide emissions among G7 countries: A TAR panel unit root approach. Environmental and Resource Economics, 54(2), 283-291.
You, W., Lv, Z. (2018), Spillover effects of economic globalization on CO_2 emissions: A spatial panel approach. Energy Economics, 73, 248-257.