Driving Force of Environmental Kuznets Curve (EKC) Pattern on Energy Intensity in Taiwan at 1995-2015: Empirical Evidence of Exogenous Event Transformed to Endogenous Polices Effect

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ABSTRACT

The Environmental Kuznets curve (EKC) was proposed from aspect of the income-driven willingness-to-pay for the environment. From 1995 to 2015, the primary energy consumption-to-GDP ratio (called energy intensity) in Taiwan exhibited an EKC pattern (an inverted "U" shape of primary energy consumption along with increasing GDP), but the country's average wage remained almost unchanged over this period. Therefore, the major contribution factor on the formation of the energy EKC pattern might have been another driving force. This paper thus uses the viewpoint of historical events of international crude oil prices to obtain empirical evidence to see how the energy EKC might spur exogenous events to affect endogenous polices. The turning point of the energy EKC is at 2002, when the electricity structure started to lower the contribution from oil power plants during the same year. This paper provides an alternative consideration for the explanation of the EKC pattern formation

Keywords: EKC, Energy, GDP, Exogenous polices.

1. INTRODUCTION

The Environmental Kuznets curve (EKC) was proposed from the aspect of the income-driven willingness-to-pay for the environment [Kuznets, 1955; Grossman and Krueger, 1991; Stern, 2004; Egli and Steger, 2007; Yu and Chen, 2012; Kong and Khan, 2019]. From 1985 to 2015, the primary energy consumption-to-GDP ratio (called energy intensity) in Taiwan exhibited an EKC pattern (an inverted "U" shape of primary energy consumption along with increasing in GDP).

Figure 1 shows the energy EKC in Taiwan from 1990 to 2018. For one tail hypothesis testing, we used the 5% significance level, and then $Z^*=-1.64$. Here, H0 is observed to be 19 between 1995 to 2014, with a standard derivation of "s" years. The Kuznets infrastructural investment cycle has been estimated at 15 to 25 years, and in this paper we choose the middle value of 20 years. If H0 is not rejected, then the Z value must be larger than Z^*. The calculated value of s is 0.6 years. From Fig. 1, after 2015 the energy intensity changed again, and therefore the observed value of s is near 1.0 year, just

meeting the calculated value. Therefore, we only use 1995-2015 data for an investigation in the following sections.

The turning point occurs at 2002. From the viewpoint of sustainable production, a strange forward explanation is that manufactures decided to consume less energy or renew high energy-consumption machines [Wu et al., 2008]. Many papers used the EKC pattern formation on various applications for household waste EKC [Sterner and Bartelings, 1999], agriculture waste EKC [Zhou et al., 2015], medical waste EKC, carbon emission EKC [Wu et al., 2008], PM2.5 emission EKC, and forest resource change. Most of those papers utilized an income-driven mechanism to explain why the EKC pattern was formed, but the average wage is almost unchanged over this period for Taiwan (Figure 2).

The major contribution factor on the formation of the energy EKC pattern might be another driving force, except for the income factor. In the past three years, we employed several data analysis skills to find the driving force behind the turning point in the energy EKC pattern [Shahbaza, 2013; Li et al., 2016; Kong and Khan, 2019]. Several papers have also tried to construct a prediction method of the turning point for the EKC pattern [Egli and Steger, 2007; Kong and Khan, 2019]. Rodríguez and Pena-Boquete proposed an energy price lenses to explain that the original EKC is the primary energy price [Rodríguez and Pena-Boquete 2014], however, they did not provide any real case to prove it.
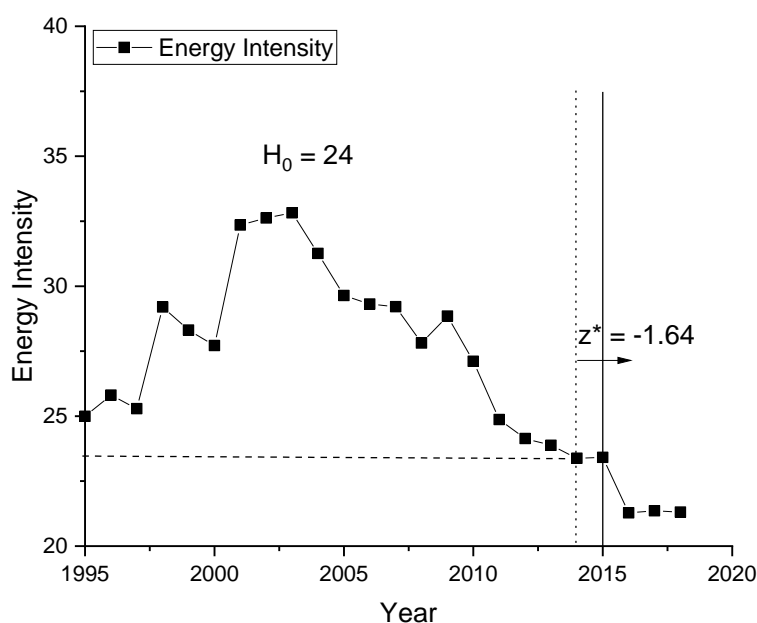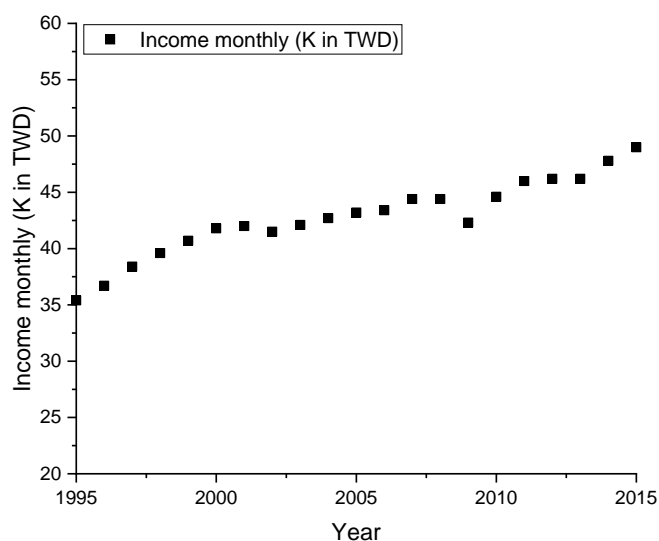

Figure 1 Energy EKC in Taiwan from 1995 to 2018.

Figure 2 Monthly income in Taiwan from 1995 to 2015.

2. METHODS AND MAIN RESULTS

This paper takes the viewpoint of historical events of international crude oil prices (Figure 3) to obtain clear and direct empirical evidence. The turning point of energy EKC is at 2002 for Taiwan, when the electricity structure started to lower the contribution from oil power plants. Under this driving force, the Taiwan government chose lower prices and a more stable source for domestic electricity generation. Since 2002, the price of power electricity (Figure 4) and that of gasoline have both been raised (Figure 5).
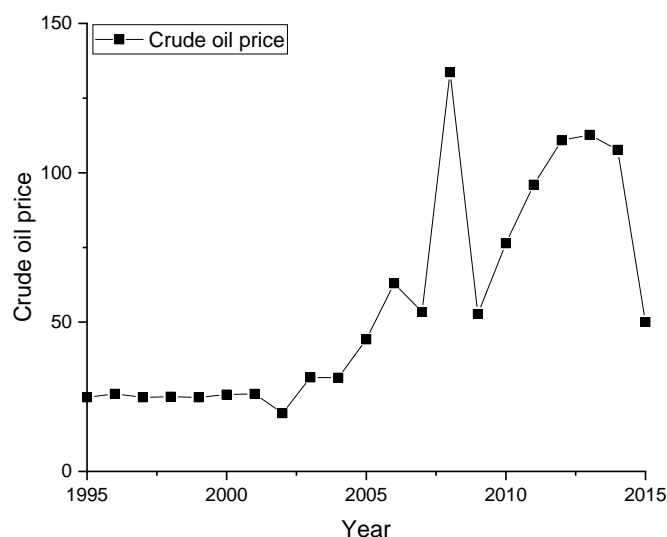

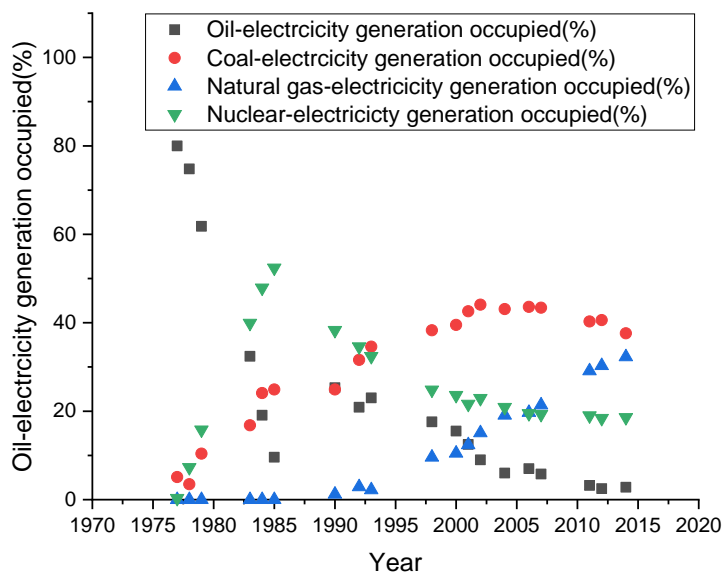**Figure 3 Global crude oil price from 1995 to 2015.**

Figure 4 Electricity generation from various primary energy sources in Taiwan from 1977 to 2014.
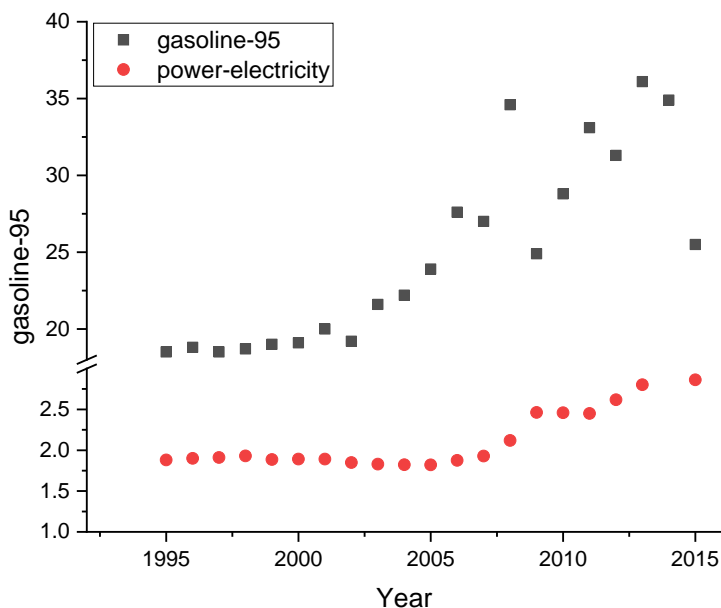

Figure 5 Gasoline price and power electricity price in Taiwan from 1995 to 2015.

Because the major contribution of electricity generation has been coal since 1993 in Taiwan, the price of power electricity price is more affected by coal prices. We see that coal prices had a slight increment at 2004 and rose from 2007 to 2008. Because

coal prices have been stable for many years, we have ignored their contribution to power electricity prices on the energy EKC pattern before 2007.

Figure 6 compares energy intensity and monthly income. The trend looks similar, but a two plate-region between years 2005-2009 and 2013-2015 run the opposite. While the comparison plot among energy intensity with gasoline prices and power electricity prices in Figure 7 is fully fitted, we suggest under such a condition that the Taiwanese people tended to reduce the consumption of primary energy for both personal use and manufacturing. Therefore, the energy EKC pattern formation in Taiwan might have an exogenous event that influenced endogenous policies [Jones and Romer, 2010] to drive it.
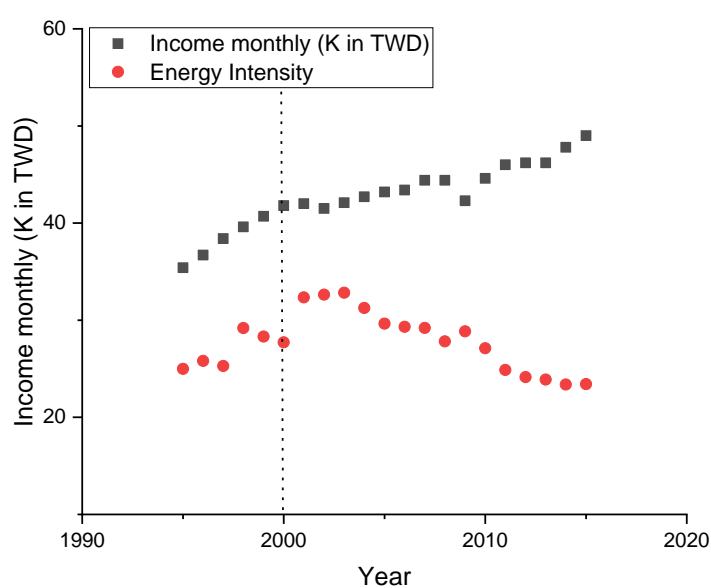

Figure 6 Comparison plot between energy intensity and monthly income in Taiwan from 1995 to 2015.
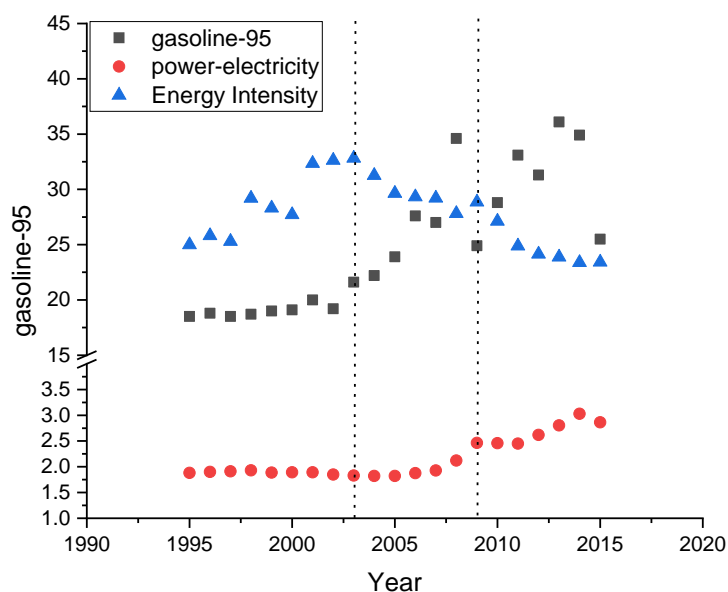
Figure 7 Comparison plot among energy intensity with gasoline price and power electricity price in Taiwan from 1995 to 2015.

3. CONCLUDING REMARKS AND POLICY IMPLICATIONS

The result found herein might provide an alternative consideration to explain the EKC pattern formation at different applications. We suggest under such a condition that the Taiwanese people tended to reduce the consumption of primary energy for both personal use and manufacturing. Therefore, the energy EKC pattern formation in Taiwan might have an exogenous event that influenced endogenous policies to drive it. In Taiwan, 95-octane gasoline is produced mostly from one government-owned company, although in 1999 a private gasoline refinery started to take some local market share, but the price difference between the firms is almost zero. Therefore, gasoline prices are considered to be unit everywhere in Taiwan. For a country, the primary energy EKC pattern actually has been driven by modulating the uniform marketing price of primary energy for 19 years.

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