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Decomposition analysis of the change of energy intensity of manufacturing industries in Thailand

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ABSTRACT

The study computes and analyses the sources of the change of energy intensity of the manufacturing industries in Thailand during the period (1991–2011) using the decomposition method. The Logarithmic Mean Divisia Index is computed and the results show that the energy intensity in the period (1991–2000) increased greatly from the increased energy intensity of each industry. In the more recent period (2000–2011) the energy intensity declined a little. However the decline was mainly from the structural change effect with negligible contribution from decreased energy intensity of each industry. The findings imply the need to balance industrial restructuring policies with efforts to reduce energy intensity for a sustainable economic development. Besides, there is much room for individual industries to improve their energy efficiency. Policies on restructuring energy prices and other non-price related measures should be devised to induce individual industries, particularly the highly energy intensive ones, to reduce their energy intensity.

1. Introduction

Thailand is an agro-based country which has steadily been transforming to a newly industrialized economy since the 1980s. As a result of industrialization energy consumption has grown in line with the expanded industrial activity at a rapid rate. During the period (1991–2011), among major sectors the manufacturing industry is one of the largest consumer of energy, second only to the transport sector.[1] The industry's huge energy consumption led to high CO_2 emission. It's energy consumption grew at 5% a year leading the CO_2 emission to increase at 6%.[2] This implies that an effort to conserve energy can at the same time save the environment from the global warming effect.

To conserve energy the manufacturing industries should improve the efficiency of their energy use. A simple measurement of energy efficiency which is commonly used is industrial output per unit of energy consumption or the inverse of energy intensity shown in Equation (1) of Section 3. An industry with high energy intensity reflects it's high energy consumption per unit of production but it does not necessarily imply a lack of energy efficiency. Rather, it is the change in energy intensity which could suggest energy wastage. Our study intends to first measure the energy intensity of major sectors and individual manufacturing industries in Thailand, followed by computation of the changes of energy intensity. Finally, we will analyze the sources of the energy intensity change using the decomposition method.

An attempt to use the decomposition method to quantify the effect of structural change of production on aggregate energy demand of industries began in the 1970s when there were large energy price increases and policy-makers sought to find effective channels to save on energy usage. Ang [2], and Ang and Zhang [3] provide an excellent survey of works using the index decomposition technique in the analysis of energy consumption and intensity from 1970s to the late 1990s. Among all studies the ones by Boyd et al. [4], Park [5], Ang [6], and Ang and Liu [7] are considered pioneer works in which the decomposition methods were

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[1] During the period 1991 to 2011 the transportation sector consumed the highest amount of energy, 37% of total energy consumption, followed by the manufacturing sector at 34%. See Section 3 for more explanation on energy consumption by major sector.

[2] The growth rates are computed from the database [1]. The relationship between energy use and CO2 emission of the industrial sector is further analyzed in Section 3.

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developed to become the techniques widely used by researchers today. Ang [8] and Ang [9] separate the source of the changes of the energy intensity into two major components namely, the structural change effect and the effect of changes of energy intensity of individual sub-sectors. The methods can be classified into two groups namely, the one linked to the Laspeyres index and the other to the Divisia Index. The method of each group can be divided further to be the one calculated by using the additive approach and the other the multiplicative approach. Among many methods the one that has been used the most is the LMDI (logarithmic mean Divisia Index) and it has also been employed in our study. The method has the benefits of leaving no unexplained residuals and it can handle the problem of zero values well.

Empirical studies on decomposition of energy intensity change, particular the ones using the Divisia index method, is vast. Liu and Ang [10] provide an extensive list of the past empirical literature. The main finding is that over the last three decades, most industrial countries experienced a decrease in the energy intensity although the changes varied in developing countries. Moreover the key driver behind changes in the industrial energy intensity of the industrial countries was sub-sector energy intensity changes whereas the structural change effect often dominated the intensity effect in developing countries.

There are many studies on energy intensity decomposition of industries in developed countries. Examples of the most recent ones are studies by Hammond and Norman [11] and Hassanbeigi et al. [12]. Hammond and Norman [11] study energy-related carbon emission from UK manufacturing industries and find that the emissions fell by about 2% per year over the period (1990–2007) due to improvement of energy intensity. In turn the energy intensity improvement was driven by the sub-sector energy intensity change effect rather than the structure change effect. Hassanbeigi et al. [12] study energy intensity of industries in California using the LMDI decomposition method and find that the energy intensity of the state declined during the period (1997–2008). The reduction was due to both the structural and the energy intensity effects. The structural effect comes from a decrease in the share in total industry value-added in sub-sectors with high energy intensity such as oil and gas extraction and oil refineries, but an increase in the share of sub-sectors with low energy intensity namely, electric and electronic industry. Regarding the intensity effect, the reduction of energy intensity was due to the surge of energy prices since 2000 putting pressure on industries in California to improve energy efficiency to reduce production costs.[3]

In contrast to the studies in most of the industrial countries the source of the change in energy intensity in developing countries, both at the economy-wide and the industry levels, skews towards the effect of structural change. Inglesi-Lotz and Pouris [16] study the decomposition of energy efficiency in South Africa at the economy-wide level and find that the energy intensity declined during the period (1993–2006). The structural change effect led to an increase in the energy intensity whereas the sectoral intensity change effect had the effect in the opposite direction. However, Nie and Kemp [17] find that the energy intensity in the Chinese economy fluctuated for the overall period (2000–2009) and the fluctuation was due mainly to technology changes which were essentially the intensity change effect. However, they note that the temporary increase in energy intensity during the period (2002–2004) partly emanated from structural change effect which is the result of a shift towards energy intensive products for domestic consumption and export.

For studies at the industry level, Choi and Oh [18] investigate the energy intensity of the manufacturing industry of South Korea for the period (1981–2010). They find that the aggregate energy intensity index decrease and the decline was due to two major factors namely, energy intensity effect and structural change effect. While the improvement of real energy efficiency (the intensity effect) decreased the aggregate energy intensity by 86%, the structural change effect increased it by 70%. The negative structural change effect was explained by the increased share of energy-intensive industries in Korea's manufacturing production structure during 1981–2010. From their study results the authors concluded that the change of industrial structure can be an important aspect for improving energy efficiency in Korea. Reddy and Ray [19] investigate the energy intensity in Indian manufacturing industries during the period (1992–2005). It is found that the energy intensity was decreasing, and the reduction was mainly driven by structural change effect rather than actual improvement in energy efficiency. Hasanbeigi et al. [20] analyze factors that influence the energy use of the manufacturing sector in China during 1995–2010. They find that energy intensity reduction was not the only reason for reduced energy use in Chinese manufacturing. Structural effects, which came from the shift in the share of each subsector value added from total manufacturing value added, played an important role in reducing energy demand between 1995 and 2000 and a minor role between 2005 and 2010. However, during 2000–2005 the structure effect was positive and drove manufacturing energy use upward primarily because the share of value added from top energy-intensive sectors such as smelting and pressing of ferrous metals and chemicals and chemical products in total manufacturing value added increased during this period. By and large the decomposition analysis of energy intensity changes of industries in developing countries points to the significant contribution of the structural change effect and supports the benefit of combining industrial policies with energy efficiency improvement programs.

There are very few studies in the case of Thailand. Puttachart [21] studies energy consumption changes in selected Asian countries, including Thailand. Shresta and Timilsina [22] study emission in the power sector. Recently, Ussanarassamee and Bhattacharyya [23] analyze the change in energy demand in Thai industry for the period (1981–2000), and Bhattacharyya and Ussanarassamee [24] analyze the trend in energy intensity of Thai industry during the same period. It was found that the energy intensity of industry followed a U-shaped curve during the period (1981–2000). The structural change and the changes in energy intensity effects often went in opposite directions from 1986 to 2000 resulting in a slight reduction of the overall effect of the aggregate intensity. Wiboonchutikula et al. [25] find that energy intensity of the steel industry in Thailand fluctuated during the period (2001–2010) and the structural change effect is much stronger than the energy intensity effect.

Our study aims to contribute to the knowledge on the source of the change in energy intensity of the industrial sector in developing countries by focussing on the case of Thailand. We first measure the

[3] Actually, there are many more studies in developed countries at both the economy-wide and the sectoral levels, which conclude that the sectoral or sub-sectoral energy intensity change effect is stronger than the structural change effect. Most studies use the decomposition analysis to obtain the findings. However, the decomposition exercise is based on either energy consumption data or computed figures of energy intensity. For instance, Salta et al. [13] study the change of energy consumption in Greek manufacturing using LMDI method and find that the energy use is mainly driven by industrial production growth and energy intensity changes with small effects from other sources. Mulder and Groot [14] evaluate energy intensity developments across 18 OECD countries and 50 sectors over the period 1970-2005. The results show that in general changes in energy intensity at the aggregate economy level have been influenced more by (technology-driven) efficiency improvements within sectors than by structural changes. Ramirez et al. [15] analyze the decomposition of energy intensity change in non-energy intensive manufacturing sector in Netherlands for the period 1988 to 1999. It was found that energy consumption increased by 30% whereas the energy intensity slightly increased by 2%. The main driver came from changes of energy intensity but not structural changes.

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