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Index decomposition analysis for energy sectors in Latvia

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Abstract

This study explores the causes of changes in energy intensity in Latvia by applying logarithmic mean Divisia index decomposition analysis for energy sectors. Analysis on the latest data (2008-2012) reveals if any technological or structural changes have occurred during and after economic downturn in Latvia. The results show that the reduction in energy intensity before the year 2008 can be largely attributed to decline in energy intensities within sectors, but the increase in energy intensity after the year 2008 is regarded to expansion of energy demanding sectors.

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Keywords: decomposition analysis, Divisia index, energy intensity, energy policy, LMDI, sustainable development.

1. Introduction

Mitigation of energy intensity is an important measure in energy policy. In the European Union (EU) the convergence to low energy intensity is adopted in energy policies of member states. Despite the political will, there are countries where energy intensity is more than 2 times above an average values in the EU-27; for example Latvia, where energy intensity has been fluctuating around 299-375 ktoe per 1000 euro for past 8 year. To design sustainable energy policy and define the energy sectors, where the implementation of novel approaches (for example, artificial intelligence and industrial ecology), could give the largest benefit, the driving forces behind changes in energy intensity should be investigated.

Voigt et al. [1] explored energy intensity in 40 major economies (for the time period of 1995-2007) and concluded that technological developments are major driving forces for the reduction of energy intensity. Analysis on European countries was done by [2], but this research did not include Latvia.

The main contribution of this study is to determine the causes of changes in energy intensity in Latvia by applying index decomposition analysis for energy sectors. As the index decomposition method the logarithmic mean Divisia index is used. Moreover this study uses energy consumption at the sectorial level thus focusing on energy efficiency improvements at enterprise level. The case study on Latvia is also important, since this is one of the few countries within EU that has returned to economic growth. Analysis on the latest data for the period of 2008-2012 reveals if any technological or structural changes have occurred during and after economic downturn.

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Nomenclature

$D_{I,t+1}$	technology effect on total energy intensity at time $t+1$
$D_{S,t+1}$	structural effect on total energy intensity at time $t+1$
$D_{T,t+1}$	aggregated effect on total energy intensity at time $t+1$
$EU_{i,t}$	energy use of sector i at time t
$EU_{i,t}$	$(= \Sigma_i EU_{i,t})$ total energy consumption at time t
i	indices of sectors studied $i \in [1;6]$
$I_{i,t}$	$(= EU_{i,t}/VA_{i,t})$ energy intensity of sector i
$S_{i,t}$	$(= VA_{i,t}/VA_t)$ the activity share of sector i
t	the time period studied $t \in [1995;2012]$
$VA_{i,t}$	value added by sector i at time t
VA_t	$(= \Sigma_i VA_{i,t})$ is the total industrial activity at time t
$\omega_{i,t}$	$(= EU_{i,t}/EU_t)$ energy consumption share of sector i at time t

2. Methodology

The logarithmic mean Divisia index (LMDI) decomposition analysis is used to identify the drivers behind the changes in energy intensity. Energy intensity I at time t is expressed as a weighted average of sectorial energy intensities:

$$I_t = \sum_i [(VA_{i,t}/VA_t)(EU_{i,t}/VA_{i,t})] = \sum_i S_{i,t} I_{i,t} \tag{1}$$

Within the Eq. (1) the changes within energy intensity are associated with 2 factors: structural activity or structural effect $S_{i,t}$, where the changes in the composition of economy are accounted for, and energy intensity of sector of technology effect $I_{i,t}$, where changes within manufacturing practices in sector i at time t are exposed. The multiplicative decomposition of Eq. (1) in the period from t and $t+1$ is given as:

$$D_{T,t+1} = I_{t+1}/I_t = D_{S,t+1} D_{I,t+1} \tag{2}$$

By the application of the LMDI decomposition method suggested by Ang and Liu [3] for Eq. (1) and Eq. (2) the following identities are obtained:

$$D_{S,t+1} = \exp\left[\Sigma_i \frac{L(\omega_{i,t+1},\omega_{i,t})}{\sum_i L(\omega_{i,t+1},\omega_{i,t})} \ln\left(\frac{S_{i,t+1}}{S_{i,t}}\right)\right] \tag{3}$$

$$D_{I,t+1} = \exp\left[\Sigma_i \frac{L(\omega_{i,t+1},\omega_{i,t})}{\sum_i L(\omega_{i,t+1},\omega_{i,t})} \ln\left(\frac{I_{i,t+1}}{I_{i,t}}\right)\right] \tag{4}$$

Where the logarithmic mean weighting function L is defined as:

$$L(\omega_{i,t+1},\omega_{i,t}) = (\omega_{i,t+1} - \omega_{i,t})/(\ln \omega_{i,t+1} - \ln \omega_{i,t}) \tag{5}$$

As a statistical data source energy balance and national account from the Central Statistical Bureau of Latvia [4] was used.

Single time period attribution analysis was used for the time series decomposition. Energy intensity analysis was based on the decomposition analysis of 6 following sectors: agriculture, mining and quarrying, manufacturing, transportation and storage, construction and other consumers (except households and electricity, gas, steam air conditioning supply).

3. Results and discussion

The results reveal that decline in energy intensity in Latvia is attributed to technological improvements more than to structural effect see Fig.1.

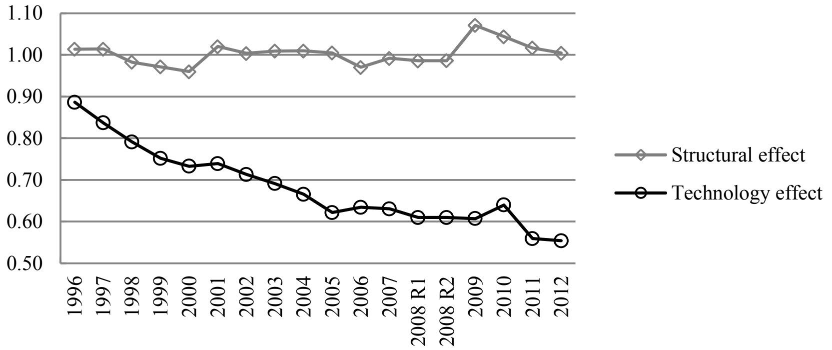

Fig. 1. Total effect in energy intensity indices: structural and technology effect, period 1995-2012 (base year = previous year) (2008 R1 depicts energy balance from Nace Rev.1.1 and 2008 R2 from Nace Rev.2)

The results in Fig.1 (dominance of technology effect) are in agreement with trends obtained by Voig et al. [1] for the time period of 1995-2007 in Latvia. As founded in this research also after the year 2007 the same major driver is governing energy intensity in Latvia.

For further decomposition of structural effect and technology effect down to sectors see Fig.2.

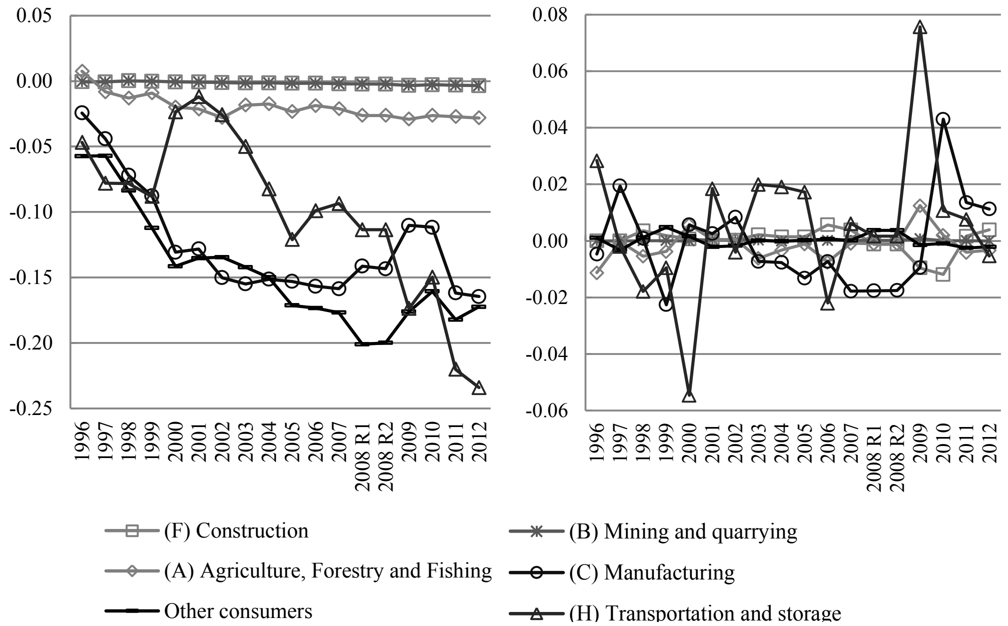

Fig. 2. Structural (on the right hand side) and technology effect (on the left hand side) decomposition on sectorial basis, period 1995-2012 (base year = previous year) (2008 R1 depicts energy balance from Nace Rev.1.1 and 2008 R2 from Nace Rev.2)

There are observed 2 general trends for technology effect on sectorial basis: either a strong declining trend or stagnation. 3 main sectors contributing the highest decline in technology effect are transportation and storage, manufacturing sectors and other consumers. No decomposition from energy use is observed for construction, mining and quarrying sectors in Latvia.

On the other side no common trend is seen for structural effect on sectorial basis. Sectorial performance fluctuates around zero axis, which explains relatively small influence of the structural effect on energy intensity given in Fig.1. The year 2008 is one of the identified thresholds within the economic structure of Latvia, since after year 2008 the increase in structural of energy demanding sectors – manufacturing and transportation is observed. This reallocation of energy resources have a potential to slow down the convergence of energy intensity or even increase energy intensity in Latvia.

4. Conclusions and future work

The results reveal the most problematic energy sectors where no improvements have been done to reduce energy intensity in Latvia. The reduction in energy intensity before the year 2008 can be largely attributed to reduction of energy intensities within sectors, but the increase in energy intensity after the year 2008 is regarded to expansion of energy demanding sectors.

In terms of future research the authors are undertaking analysis to expand current research by further decomposing energy intensity indices, for example, including the aggregate of energy carried in order to account for the shift towards renewable energy at sectorial level.

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