

MONITORING TRENDS IN EU CO2 EMISSIONS: A CARBONIZATION INDEX THROUGH DIVISIA METHOD

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MOTIVATION

- Sustainable development provides benefits on three dimensions: economic, environmental, and social
- Climate change and other related concepts such as vulnerability, dependency, security of economies, the strain on non-renewable energy resources, and access to affordable energy for all users

Challenges of vital importance for international authorities (Objetive 20/20/20)

Decarbonization of energy and reduction in the energy intensity of economic activities

To fight climate change

Carbonization index ← Several driving forces behind changes in CO2 emissions

Appropriate theoretical framework in IDA

GOALS

I. To analyze in detail trend of the carbonization index in the EU along the last decade, identifying and quantifying a number of relevant driving forces underlying the change in aggregate CO2 emissions → **LMDI decomposition method** (*Choi & Ang*, 1997)

II. To quantify the contribution of each economic sector and Member State to the percent change in carbonization → **Attribution analysis of IDA** (Fernández González et al, 2015)

To provide useful guidelines for environmental and energy policies

DECOMPOSITION OF CHANGES IN AN AGGREGATE

- Econometrics
- Data Envelopment analysis
- Structural Decomposition Analysis (SDA)
  - IO model
  - Indirect demand effects
- **Index Decomposition Analysis (IDA)**
  - Sectorally disaggregated data are allowed
  - Usual in environmental and energy studies
  - Both additive and multiplicative decompositions are possible
  - Any specific aggregate can be decomposed
  - Little information is required

INDEX DECOMPOSITION ANALYSIS (IDA)

Given the following set of variables, evaluated at time *t*:

G_t : aggregate CO_2 emissions,

$G_{ij,t}$: CO_2 emissions from sector *i* in region *j*,

E_t : total energy consumption,

$E_{ij,t}$: energy consumption in economic sector *i* and region *j*,

Y_t : Gross Domestic Product,

$Y_{ij,t}$: production of sector *i* in region *j*,

$C_{ij,t}$: carbonization of sector *i* in region *j* ($C_{ij,t}=G_{ij,t}/E_{ij,t}$),

$S_{ij,t}$: product share of sector *i* in region *j* ($S_{ij,t}= Y_{ij,t}/Y_{jt}$),

$I_{ij,t}$: energy intensity of sector *i* in region *j* ($I_{ij,t}=E_{ij,t}/Y_{ij,t}$),

Aggregate CO2 emissions may be expressed in terms of disaggregated sector data

$$G_t = \sum_{i=1}^{k}\sum_{j=1}^{l} \frac{G_{ij,t}}{E_{ij,t}} \frac{E_{ij,t}}{Y_{ij,t}} \frac{Y_{ij,t}}{Y_{i,t}} Y_{i,t} = \sum_{i=1}^{k}\sum_{j=1}^{l} C_{ij,t} I_{ij,t} S_{ij,t} Y_{i,t} \quad \Rightarrow \quad \left(R_{tot}\right)_{0,T} = \left(R_{emf}\right)_{0,T} \left(R_{int}\right)_{0,T} \left(R_{str}\right)_{0,T} \left(R_{act}\right)_{0,T}$$

Driving forces under CO2 emissions changes

$(R_{emf})_{0,T}$ ❖ **Emission coefficient or carbonization effect**, i.e., the impact on emissions of specific carbon emissions per unit of energy. It evaluates fuel quality, fuel switching (fuel substitution), and the installation of abatement technologies.

$(R_{int})_{0,T}$ ❖ **Intensity effect**, i.e., the impact on emissions of energy requirements per unit of value added. It involves energy consumption related to some variables like energy prices, energy conservation and energy-saving investments, structure and efficiency of the energy systems, technological choices, and socio-economic behaviour.

$(R_{str})_{0,T}$ ❖ **Structural effect**, i.e., the impact of production structure. It measures changes due to the relative position of sectors/regions in an economy.

$(R_{act})_{0,T}$ ❖ **Activity effect**, i.e., the impact of economic growth. Assuming a constant (average) coefficient between GDP and CO_2 emissions, it is regarded as the theoretical CO_2 emissions caused by economic activities

Changes in G measured as ratio $(R_{tot})_{0,T} = G_T / G_0$ gives us $(R_{tot})_{0,T} = (R_{emf})_{0,T} (R_{int})_{0,T} (R_{str})_{0,T} (R_{act})_{0,T}$

$$(R_{emf})_{0,T} = e^{\left[\sum_{i=1}^{k}\sum_{j=1}^{l}\frac{G_{ij,0}}{G_{j,0}}+\beta_{ij}\left(\frac{G_{ij,T}}{G_{j,T}}-\frac{G_{ij,0}}{G_{j,0}}\right)ln\left(\frac{C_{ij,T}}{C_{ij,0}}\right)\right]}$$

$$(R_{int})_{0,T} = e^{\left[\sum_{i=1}^{k}\sum_{j=1}^{l}\frac{G_{ij,0}}{G_{j,0}}+\beta_{ij}\left(\frac{G_{ij,T}}{G_{j,T}}-\frac{G_{ij,0}}{G_{j,0}}\right)ln\left(\frac{I_{ij,T}}{I_{ij,0}}\right)\right]}$$

$$(R_{str})_{0,T} = e^{\left[\sum_{i=1}^{k}\sum_{j=1}^{l}\frac{G_{ij,0}}{G_{j,0}}+\beta_{ij}\left(\frac{G_{ij,T}}{G_{j,T}}-\frac{G_{ij,0}}{G_{j,0}}\right)ln\left(\frac{S_{ij,T}}{S_{ij,0}}\right)\right]}$$

$$(R_{act})_{0,T} = e^{\left[\sum_{i=1}^{k}\sum_{j=1}^{l}\frac{G_{ij,0}}{G_{j,0}}+\beta_{ij}\left(\frac{G_{ij,T}}{G_{j,T}}-\frac{G_{ij,0}}{G_{j,0}}\right)ln\left(\frac{Y_{i,T}}{Y_{i,0}}\right)\right]}$$

with $0 \le \beta_{ij} \le 1$

Parametric Divisia Method II

Liu et al, 1992

LMDI method

$$L(G_{ij,0}, G_{ij,T}) = \frac{(G_{ij,T} - G_{ij,0})}{ln(G_{ij,T} / G_{ij,0})}$$

Ang and Choi (1997)

Sato-Vartia Logarithmic Mean Divisia Index method (LMDI-II)

$$w^{*}_{ij,0-T} = \frac{L(G_{ij,0}, G_{ij,T})}{\sum_{i=1}^{k}\sum_{j=1}^{l} L(G_{ij,0}, G_{ij,T})}, \quad i=1,2,\ldots,k \;; \quad j=1,2,\ldots,l,$$

DECOMPOSITION METHODS BASED ON DIVISIA INDEXES

- Modified Fisher ideal index method mean (2 factor model)

  Office of Energy Efficiency of Canada, 2005

  Boyd & Roop, 2004

- Arithmetic mean Divisia index method (AMDI)

  US Energy Information Administration, 2002; ODYSEE, 2005

  Wade, 2002

- Logarithmic mean Divisia index method I (LMDI I)

  Energy agencies of Canada and Australia (Natural Resources Canada, 2006; Sandu, 2008)

  Ang, 2004; 2005

- Logarithmic mean Divisia index method II (LMDI II)

  Office of Energy Efficiency and Renewable Energy, 2005 (US)

  Lermit & Jollands, 2001

PROPERTIES OF LMDI

- Time reversal test
- Factor reversal test
- Zero values robustness
- Decomposition is complete, i.e. zero residual
- Easy to use as formulas have the same form irrespective of the number of factors
- A simple formula relates additive and multiplicative decomposition results

$$\frac{D_{tot}}{LnR_{tot}} = \frac{D_{x_1}}{LnR_{x_1}} + \frac{D_{x_2}}{LnR_{x_2}} + \ldots + \frac{D_{x_n}}{LnR_{x_n}}$$

- Multiplicative LMDI has the additive property in the log form

$$ln\left(D_{tot}\right) = ln\left(D_{x_1}\right) + ln\left(D_{x_2}\right) + \ldots ln\left(D_{x_n}\right)$$

❖ LMDI I fails proportionality while LMDI II fails the aggregation test

Multiperiod attribution analysis

$$\left(C_{tot}\right)_{0,T} = \left(R_{tot}\right)_{0,1}\left(R_{tot}\right)_{1,2}\ldots\left(R_{tot}\right)_{T-1,T}$$

$$\left(C_{emf}\right)_{0,T} = \left(R_{emf}\right)_{0,1}\left(R_{emf}\right)_{1,2}\ldots\left(R_{emf}\right)_{T-1,T}$$

$$\left(C_{int}\right)_{0,T} = \left(R_{int}\right)_{0,1}\left(R_{int}\right)_{1,2}\ldots\left(R_{int}\right)_{T-1,T}$$

$$\left(C_{str}\right)_{0,T} = \left(R_{str}\right)_{0,1}\left(R_{str}\right)_{1,2}\ldots\left(R_{str}\right)_{T-1,T}$$

$$\left(C_{act}\right)_{0,T} = \left(R_{act}\right)_{0,1}\left(R_{act}\right)_{1,2}\ldots\left(R_{act}\right)_{T-1,T}$$

where $\left(C_{tot}\right)_{0,T}$, $\left(C_{str}\right)_{0,T}$, $\left(C_{int}\right)_{0,T}$, $\left(C_{emf}\right)_{0,T}$ and $\left(C_{act}\right)_{0,T}$ are the estimated cumulative effects from 0 to *T*

DECOMPOSITION OF CHANGES IN AGGREGATE CO2 EMISSIONS. A EUROPEAN STUDY

- Methodology: Index decomposition analysis of LMDI-II
- 20 EU Member States: Portugal, Spain, France, Belgium, the United Kingdom, the Netherlands, Luxembourg, Germany, Denmark, Italy, Ireland, Czech Republic, Slovakia, Slovenia, Poland, Sweden, Lithuania, Bulgaria, Romania, and Hungary
- 2000-2010 period
- Data: Value added in real terms (in euro at basic prices in purchasing power parity); Energy consumption; CO2 emissions
- Source: Eurostat

Aggregation by Member States

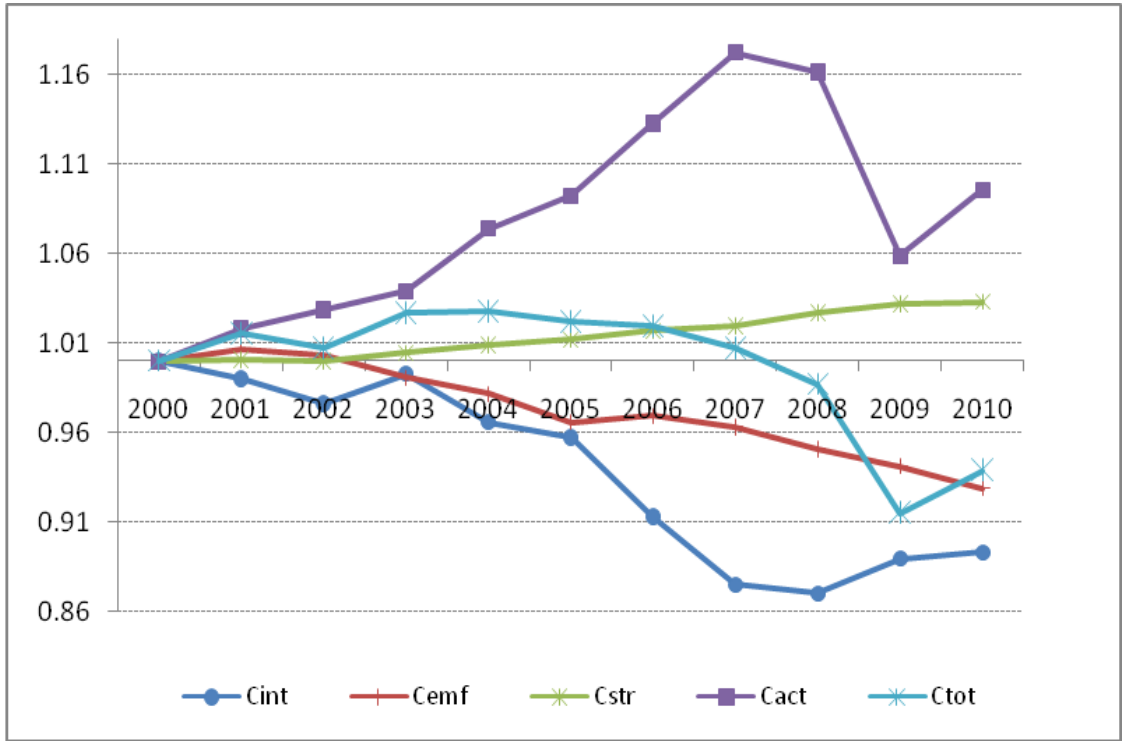


Figure 1. Multiplicative LMDI-II decomposition results of changes in CO_2 emissions in the EU when aggregating by Member States (base year = 2000).

Table 1. Time series LMDI-II decomposition results of changes in CO_2 emissions in the EU when aggregating by Member States, years 2000-2010[a].

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Year	**R_{int}**	**R_{emf}**	**R_{str}**	**R_{act}**	**R_{tot}**	**C_{int}**	**C_{emf}**	**C_{str}**	**C_{act}**	**C_{tot}**
2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2001	0.9901	1.0062	1.0011	1.0182	1.0154	0.9901	1.0062	1.0011	1.0182	1.0154
2002	0.9857	0.9964	0.9993	1.0104	0.9917	0.9759	1.0027	1.0003	1.0287	1.0070
2003	1.0173	0.9880	1.0043	1.0100	1.0195	0.9929	0.9906	1.0046	1.0390	1.0266
2004	0.9728	0.9912	1.0045	1.0335	1.0010	0.9658	0.9819	1.0092	1.0739	1.0277
2005	0.9912	0.9837	1.0029	1.0169	0.9944	0.9573	0.9658	1.0121	1.0921	1.0219
2006	0.9540	1.0037	1.0048	1.0370	0.9977	0.9133	0.9694	1.0169	1.1324	1.0195
2007	0.9583	0.9935	1.0026	1.0348	0.9878	0.8752	0.9631	1.0196	1.1718	1.0071
2008	0.9946	0.9872	1.0073	0.9906	0.9799	0.8705	0.9508	1.0270	1.1609	0.9868
2009	1.0221	0.9900	1.0048	0.9120	0.9273	0.8897	0.9413	1.0320	1.0587	0.9150
2010	1.0039	0.9870	1.0009	1.0347	1.0261	0.8932	0.9290	1.0329	1.0954	0.9389

[a] Columns (1)-(5) report periodwise results (i.e., the base year is the immediately preceding year) whereas columns (6)-(10) display time series results (with 2000 being the base year).

- Reduction in aggregate CO_2 emissions: 6.11%
- The intensity and carbonization effects contribute to that reduction by 10.68% and 7.10%, respectively

Aggregation by economic sectors

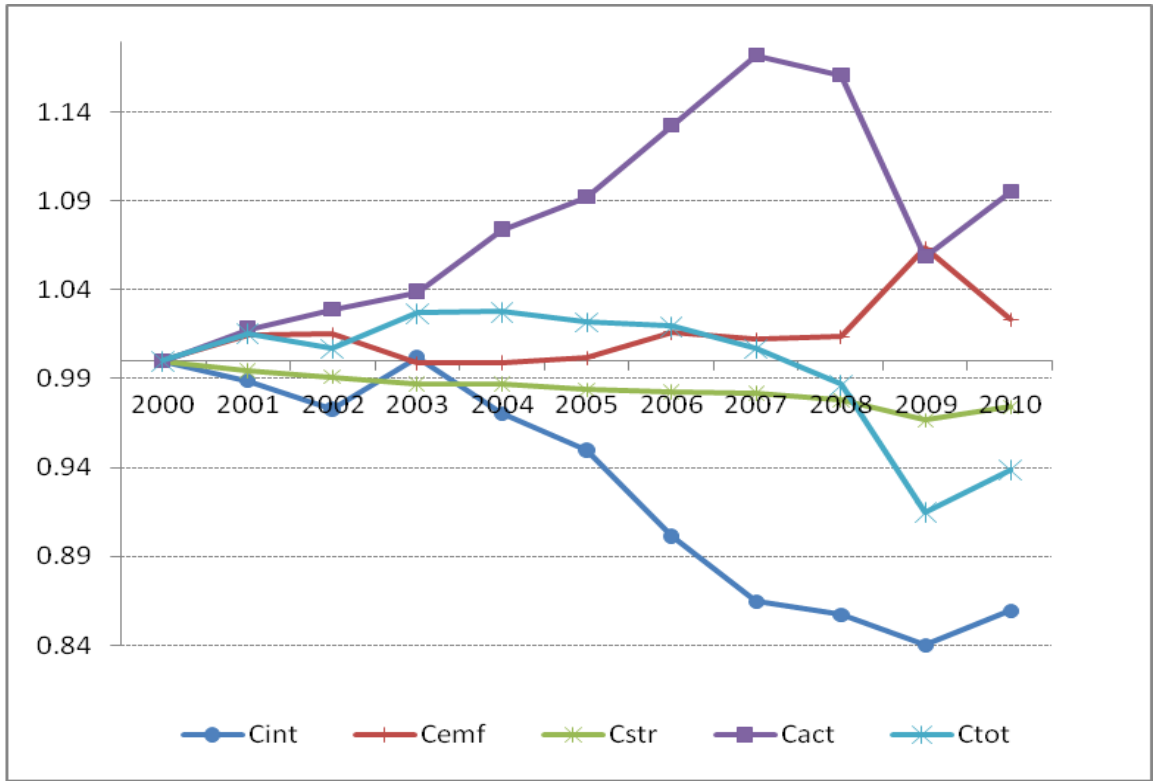


Figure 2. Multiplicative LMDI-II decomposition results of changes in EU CO_2 emissions when aggregating by sectors (base year = 2000).

Table 2. Time series LMDI-II decomposition results of changes in CO_2 emissions in the EU when aggregating by sectors, 2000-2010[a].

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Years	**R_{int}**	**R_{emf}**	**R_{str}**	**R_{act}**	**R_{tot}**	**C_{int}**	**C_{emf}**	**C_{str}**	**C_{act}**	**C_{tot}**
2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2001	0.9887	1.0142	0.9945	1.0182	1.0154	0.9887	1.0142	0.9945	1.0182	1.0154
2002	0.9838	1.0009	0.9968	0.9838	0.9917	0.9727	1.0151	0.9913	1.0287	1.0070
2003	1.0301	0.9839	0.9959	1.0301	1.0195	1.0020	0.9988	0.9873	1.0390	1.0266
2004	0.9684	1.0003	0.9998	0.9684	1.0010	0.9704	0.9991	0.9871	1.0739	1.0277
2005	0.9786	1.0024	0.9968	1.0622	0.9944	0.9497	1.0015	0.9839	1.0921	1.0219
2006	0.9493	1.0147	0.9988	0.8750	0.9977	0.9015	1.0162	0.9828	1.1324	1.0195
2007	0.9594	0.9957	0.9992	0.9594	0.9878	0.8649	1.0119	0.9820	1.1718	1.0071
2008	0.9911	1.0017	0.9963	0.9911	0.9799	0.8572	1.0136	0.9783	1.1609	0.9868
2009	0.9804	1.0492	0.9884	0.9804	0.9273	0.8404	1.0635	0.9670	1.0587	0.9150
2010	1.0228	0.9622	1.0077	1.0228	1.0261	0.8596	1.0233	0.9744	1.0954	0.9389

[a] Columns (1)-(5) report periodwise results (i.e., the base year is the immediately preceding year) whereas columns (6)-(10) display time series results (with 2000 being the base year).

- Reduction in aggregate CO_2 emissions: 6.11%
- The intensity and structural effects contribute to that reduction by 14.04% and 2.56%, respectively

Some effects when aggregating by economic sectors

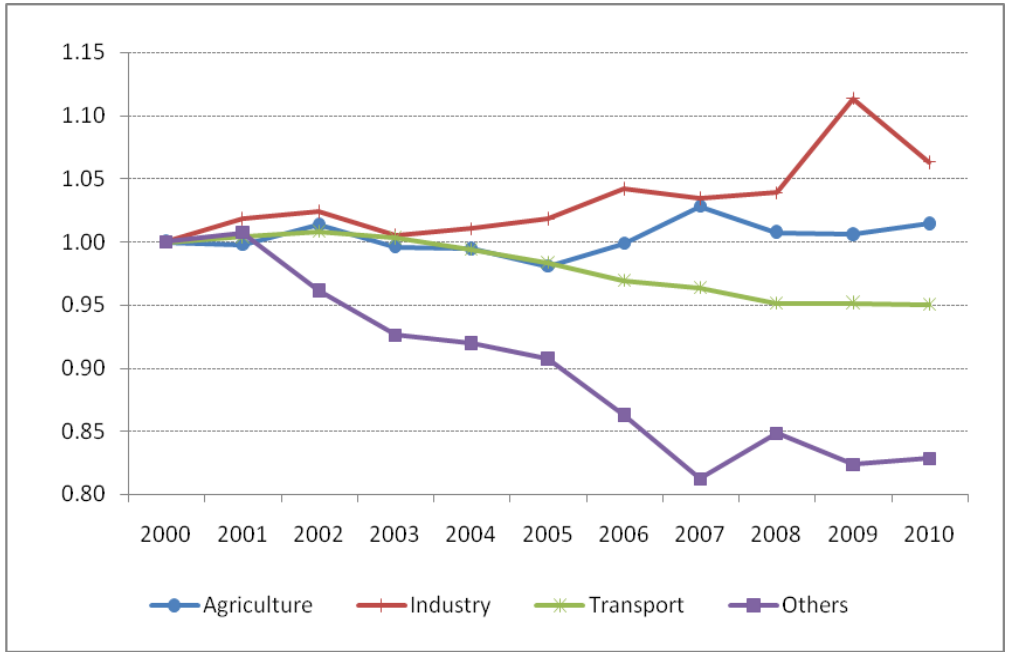


Figure 3. **Emission coefficient effect** (C_{emf}) from multiplicative LMDI-II decomposition results of changes in EU CO_2 emissions at sectoral level (base year = 2000).

- It decreased in Transport and Other sectors

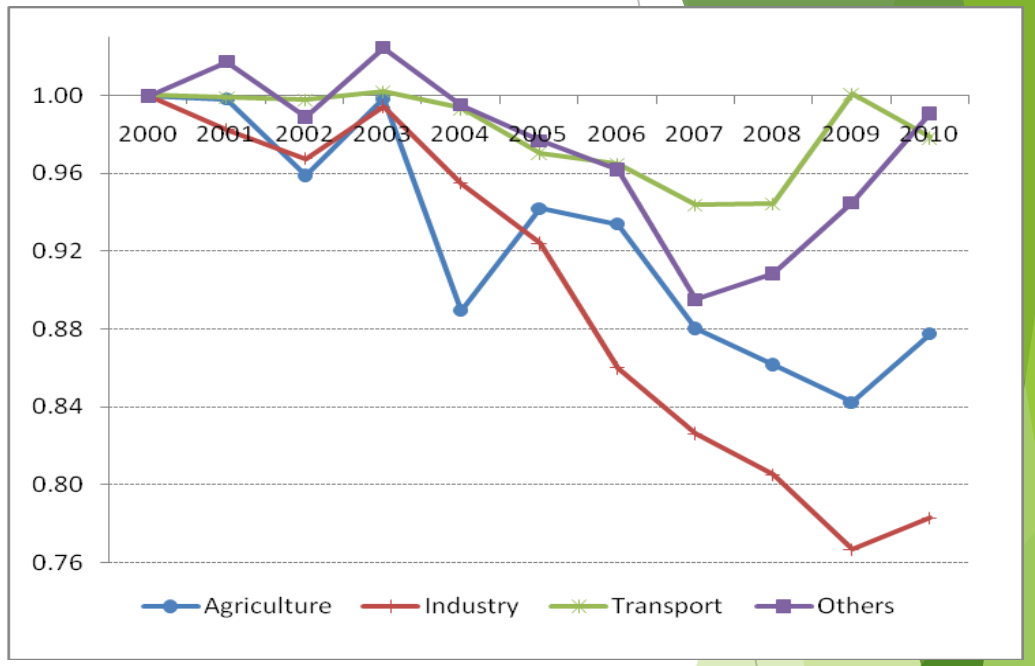


Figure 4. **Estimated intensity** effect (C_{int}) from multiplicative LMDI-II decomposition results of changes in EU CO_2 emissions at sectoral level (base year = 2000).

- It decreased in all sectors until 2007
- Significant in Industry and Agriculture

ATTRIBUTION ANALYSIS OF THE DIVISIA CARBONIZATION INDEX

Fernández González et al., 2015

The log-change form of the Divisia index of carbonization can be formulated as a geometric mean index:

$$ln\left(R_{emf}\right)_{0,T} = ln\left(\frac{R_{emf\,T}}{R_{emf\,0}}\right) = \sum_{i=1}^{k}\sum_{j=1}^{l} w_{ij} ln\left(\frac{C_{ij,T}}{C_{ij,0}}\right) \Leftrightarrow \left(R_{emf}\right)_{0,T} = \prod_{i=1}^{k}\prod_{j=1}^{l}\left(\frac{C_{ij,T}}{C_{ij,0}}\right)^{w_{ij}}$$

By defining the unknown parameters π_i and relying in Balk´s identities (2004), the geometric index is converted into an arithmetic mean:

$$\frac{R_{emf\,T}}{R_{emf\,0}} = \frac{\sum_{i=1}^{k}\sum_{j=1}^{l}\pi_{ij}C_{ij,T}}{\sum_{i=1}^{k}\sum_{j=1}^{l}\pi_{ij}C_{ij,0}}$$

By defining $a_{ij,0} \equiv \frac{\pi_{ij}I_{ij,0}}{\sum_{g=1}^{k}\sum_{h=1}^{l}\pi_{gh}I_{gh,0}}$, $a_{ij,T} \equiv \frac{\pi_{ij}I_{ij,T}}{\sum_{g=1}^{k}\sum_{h=1}^{l}\pi_{gh}I_{ghT}}$, using the identity $\sum_{i=1}^{k}\sum_{j=1}^{l}\left(a_{ij,T}-a_{ij,0}\right)=0$ and applying the definition of logarithmic mean, the following alternative log-change expression is obtained:

$$\ln\left(\frac{R_{emf\,T}}{R_{emf\,0}}\right) = \sum_{i=1}^{k}\sum_{j=1}^{l}\frac{L\left(a_{ij,T},a_{ij,0}\right)}{\sum_{g=1}^{k}\sum_{h=1}^{l}L\left(a_{gh,T},a_{gh,0}\right)}\ln\left(\frac{C_{ij,T}}{C_{ij,0}}\right) = \sum_{i=1}^{k}\sum_{j=1}^{l}\frac{\pi_{ij}L\left(C_{ij,T},C_{ij,0}\left(R_{emf}\right)_{0,T}\right)}{\sum_{g=1}^{k}\sum_{h=1}^{l}\pi_{gh}L\left(C_{gh,T},C_{gh,0}\left(R_{emf}\right)_{0,T}\right)}\ln\left(\frac{C_{ij,T}}{C_{ij,0}}\right)$$

Comparing the two log-change forms: $\pi_{ij} = \dfrac{w_{ij}}{L\left(C_{ij,T}, C_{ij,0}\left(R_{emf}\right)_{0,T}\right)}$ ⇨ Reinsdorf´s formula (Reinsdorf,1996)

Therefore, the following formula will give the attribution of carbonization index in LMDI-II:

$$\left(\frac{R_{\text{emf }T}}{R_{\text{emf }0}}-1\right)=\sum_{i=1}^{k}\sum_{j=1}^{l}a_{ij}\left(\frac{C_{ij,T}}{C_{ij,0}}-1\right)$$

where

$$a_{ij}=\frac{\pi_{ij}\,C_{ij,0}}{\sum_{g=1}^{k}\sum_{h=1}^{l}\pi_{gh}\,C_{gh,0}}=\frac{\dfrac{w_{ij}C_{ij,0}}{L\left(C_{ij,T}, C_{ij,0}\left(R_{emf}\right)_{0,T}\right)}}{\sum_{g=1}^{k}\sum_{h=1}^{l}\dfrac{w_{gh}C_{gh,0}}{L\left(C_{ghT}, C_{gh,0}\left(R_{emf}\right)_{0,T}\right)}}$$

In multiperiod attribution analysis

$$\left(\frac{R_{emf\ T}}{R_{emf\ 0}}-1\right)=\sum_{t=1}^{T}\frac{R_{emf\ t-1}}{R_{iemf\ 0}}\left(\frac{R_{emf\ t}}{R_{emf\ t-1}}-1\right)=\sum_{i=1}^{k}\sum_{j=1}^{l}\sum_{t=1}^{T}\frac{R_{emf\ t-1}}{R_{emf\ 0}}\left(a_{ij}\right)_{t-1,t}\left(\frac{C_{ij,t}}{C_{ij,t-1}}-1\right)$$

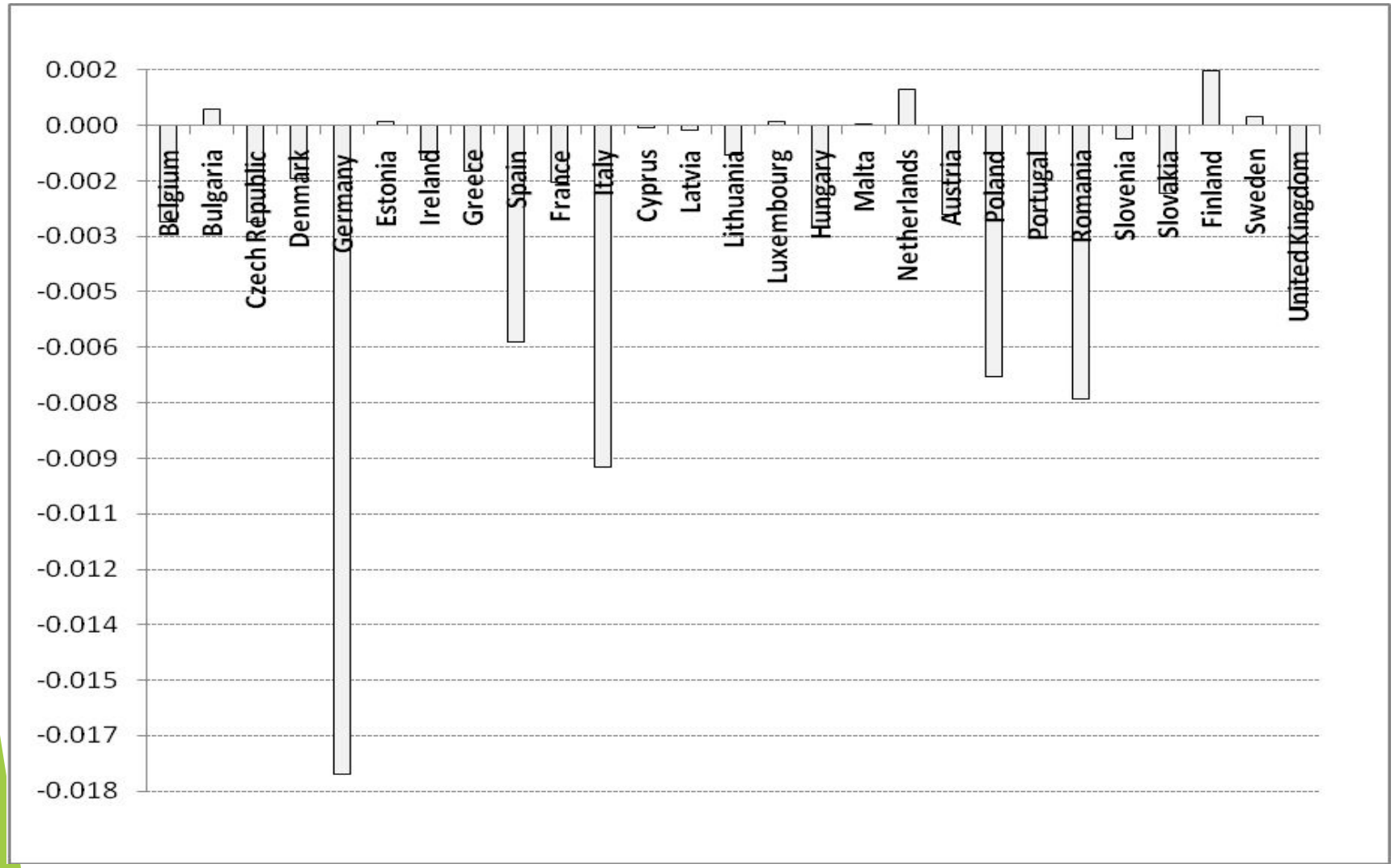
where

$$\left(a_{ij}\right)_{t-1,t}=\frac{\dfrac{\left(w_{ij}\right)_{t-1,t}C_{ij,t-1}}{L\left(C_{ij,t}, C_{ij,t-1}\left(R_{emf}\right)_{t-1,t}\right)}}{\sum_{g=1}^{k}\sum_{h=1}^{l}\dfrac{\left(w_{gh}\right)_{t-1,t}C_{ght-1}}{L\left(C_{ght}, C_{ght-1}\left(R_{emf}\right)_{t-1,t}\right)}}$$

ATTRIBUTION ANALYSIS OF THE CARBONIZATION INDEX. A EUROPEAN STUDY

- Methodology: Attribution analysis
- EU Member States: Portugal, Spain, France, Belgium, the United Kingdom, the Netherlands, Luxembourg, Germany, Denmark, Italy, Ireland, Czech Republic, Slovakia, Slovenia, Poland, Sweden, Lithuania, Bulgaria, Romania, and Hungary
- 2000-2010 period
- Sectors:
  - Agriculture/fishing
  - Industry (including construction)
  - Services
  - Transport, plus hotels and restaurants
- Source: Eurostat

Attribution analysis by Member States



Most Member States contributed to reduce the index

- **Negative contribution**

Big Western economies

Some Central and Eastern European

- **Positive contribution**

Northern Western developed countries

Small Western countries

Some Central and Eastern European

Figure 5. Periodwise contribution of each Member State to percentage changes in the carbonization factor in the EU from 2000 to 2010.

Attribution analysis by economic sectors

Table 3. Contribution of each economic sector to global changes in the carbonization factor in the EU (base year = 2000)[a].

	(1)	(2)	(3)	(4)	(5)
Period	**C_{emf}-1**	**Agriculture**	**Industry**	**Transport**	**Others**
2001	0.0142	0.0000	0.0128	0.0005	0.0010
2002	0.0151	0.0010	0.0149	0.0009	-0.0016
2003	-0.0012	-0.0006	0.0036	0.0004	-0.0045
2004	-0.0009	-0.0010	0.0066	-0.0006	-0.0059
2005	0.0015	-0.0017	0.0129	-0.0017	-0.0080
2006	0.0162	0.0008	0.0298	-0.0032	-0.0108
2007	0.0119	0.0023	0.0266	-0.0038	-0.0124
2008	0.0136	0.0022	0.0287	-0.0051	-0.0119
2009	0.0635	0.0023	0.0813	-0.0053	-0.0150
2010	0.0233	0.0015	0.0392	-0.0052	-0.0129

[a] Column (1) displays the estimated cumulated per unit change in the carbonization index (base: year 2000). The sum of columns (2-5) for each year gives column (1) (small differences are due to rounding).

Table 4. Time series attribution analysis results (a_i) of each economic sector to percentage changes in the carbonization factor in the EU (base year = 2000).

	(1)	(2)	(3)	(4)
a_i	**Agriculture**	**Industry**	**Transport**	**Others**
2001	0.05572	0.75557	0.10230	0.08642
2002	0.05518	0.75575	0.10320	0.08587
2003	0.05467	0.75649	0.10213	0.08671
2004	0.05484	0.75439	0.10359	0.08719
2005	0.05511	0.75205	0.10453	0.08830
2006	0.05413	0.74991	0.10651	0.08945
2007	0.05366	0.75198	0.10776	0.08661
2008	0.05427	0.74722	0.10855	0.08996
2009	0.05702	0.73410	0.11368	0.09519
2010	0.05540	0.74068	0.10994	0.09398

- Surprising increment, basically motivated by **Industry** (74.068%)
- **Transport** and **Other sectors**, negative contribution to the index (10.99% and 9.39%, respectively)

Joint analysis

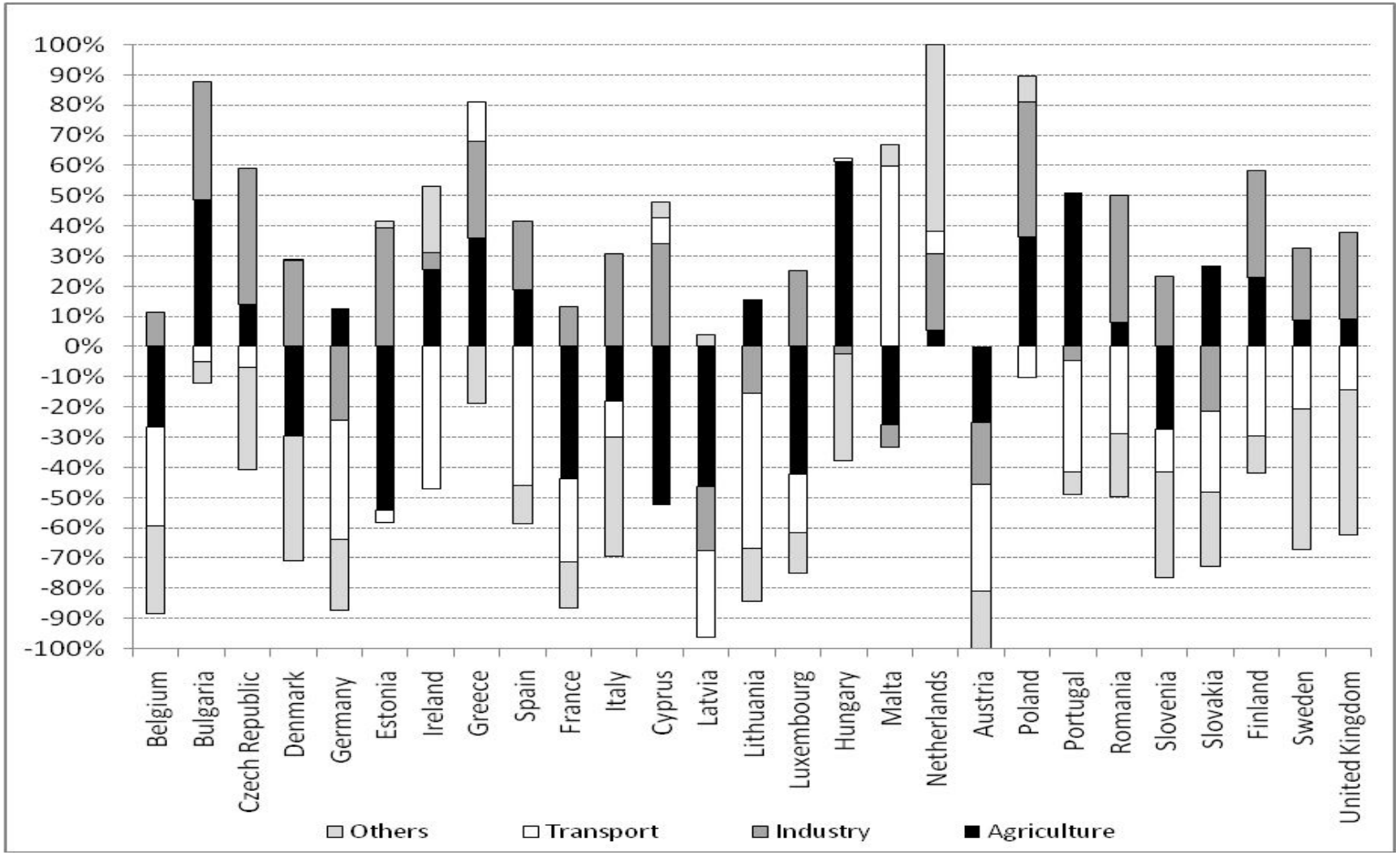


Figure 6. Contribution (in percentage, %) of sector *i* in Member State *j* to percentage changes in EU carbonization factor from 2000 to 2010.

Transport and Others sectors, relevant in most Western countries

Agriculture and Industry, more important in Central and Eastern economies

Industry attribution, positive in most Member States

Other sectors attribution, negative in most Member States

EUROPE‘S ENVIRONMENTAL POLICY

The First European Climate Change Programme (2000-2003)

identified and developed strategies in order to implement the Kyoto Protocol, working with industry, environmental organizations, and other stakeholders in order to outline cost-effective measures to reduce emissions

The EU Emissions Trade System (ETS)

covered around 45% of the EU's GHG emissions
limited emissions in flights and heavy energy-using installations in power generation and manufacturing industry

The Second European Climate Change Programme (2005-2010)

new actions and measures in order to achieve larger emission reductions beyond 2012 (e.g. strengthening the EU ETS)

Climate and energy package in 2008

- It poses limits on global land conversion for biofuel production and raises the climate benefits of biofuels used relating to the quality of petrol and diesel fuels
- It takes specific measures on the transport sector, like rolling resistance limits and tyre labelling requirements, emissions targets for new vehicles, tyre pressure mandatory monitors, and the inclusion of aviation in the EU ETS
- It establishes the Effort Sharing Decision that sets national emission targets for those sectors not included in ETS, like transport, buildings, agriculture, and waste
- It takes actions (e.g., clearer product labelling of appliances) on the power sector, from generation to transformation and from distribution to final consumption
- It pays attention to the public transport and building sectors, improving the energy performance of buildings, and imposing eco-design requirements for energy-related products and energy labelling systems to inform consumers.

CONCLUSIONS

- Energy efficiency improvement has become the main driver in emissions decline, being particularly significant in the Agriculture and Industry sectors
- Decarbonization is also a crucial driving force of CO_2 emission decreases in some specific sectors like Transport and Others sectors
- Big Western economies like Germany, Italy, Spain and the United Kingdom -as well as some ex-communist countries like Poland and Romania- as the Member States with largest potential for European decarbonization
- Western countries has reduced emissions in the Transport and Others sectors whereas Eastern nations has concentrated their corresponding reduction in the industrial sector

- ✓ Modernization and adaptation to more efficient technologies, not only in the Industry and Agriculture sectors where they have produced remarkable results, but particularly in the Transport and Others
- ✓ Research for higher quality fuels, support for use of lower carbon fuels and installation of abatement technologies (e.g., CCS) in the Transport and Others sectors, and especially in Agriculture and Industry
- ✓ Implementation of the above strategies in big Western economies and in some ex-communist Member States like Poland and Romania would potentially enable sharper declines in CO_2 emissions

FOR MORE INFORMATION

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