Drivers of CO2 Emissions in the Slovak Economy

Bratislava 27/10/2016

Matej Korček
Goals

1) to quantify the contributions of main driving factors responsible for decreasing of CO2 emissions in Slovakia during the period of high economic growth and shifts in structure of economy.

2) to compare the individual factors that have been shaping the development of GHG emissions CE countries and reveal the drivers of emission as well as probable areas where countries should focus their attention with respect to energy policy application.
## International Commitments

<table>
<thead>
<tr>
<th>Country</th>
<th>Slovakia</th>
<th>Hungary</th>
<th>Poland</th>
<th>Czech Republic</th>
<th>Austria</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG emissions (MT CO₂eq)</td>
<td>50,3</td>
<td>42,7</td>
<td>78,4</td>
<td>59,7</td>
<td>146,0</td>
</tr>
<tr>
<td>GHG per capita (t CO₂ eq./cap)</td>
<td>9,4</td>
<td>7,9</td>
<td>7,8</td>
<td>6,0</td>
<td>14,3</td>
</tr>
<tr>
<td>GHG per GDP (g CO₂ eq./PPS in €)</td>
<td>690</td>
<td>400</td>
<td>548</td>
<td>348</td>
<td>802</td>
</tr>
<tr>
<td>Energy intensity (kgoe per 1 000€)</td>
<td>494</td>
<td>337</td>
<td>311</td>
<td>257</td>
<td>431</td>
</tr>
<tr>
<td>Est. actual development</td>
<td>-24,7%*</td>
<td>-28,2%*</td>
<td>-26,2%*</td>
<td>-26,7%*</td>
<td>+6% (2011)</td>
</tr>
<tr>
<td>2013 ESD target (% vs base year)</td>
<td>+2,3%</td>
<td>-4,8%</td>
<td>+9,1%</td>
<td>+0,7%</td>
<td>-9,4%</td>
</tr>
<tr>
<td>2013 ESD emissions (% vs base year)</td>
<td>-8%</td>
<td>-20,7%</td>
<td>+11,5%</td>
<td>-1,6%</td>
<td>-11,4%</td>
</tr>
</tbody>
</table>
Key indicators

CAGR (2004-2013)

Economic growth
Energy consumption
GHG emissions
## Final energy consumption

<table>
<thead>
<tr>
<th>Country</th>
<th>CZ</th>
<th>HU</th>
<th>AT</th>
<th>PL</th>
<th>SK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Final energy consumption</strong></td>
<td><strong>2004</strong></td>
<td><strong>2013</strong></td>
<td><strong>2004</strong></td>
<td><strong>2013</strong></td>
<td><strong>2004</strong></td>
</tr>
<tr>
<td><strong>Mtoe</strong></td>
<td>47,0</td>
<td>43,6</td>
<td>25,5</td>
<td>21,7</td>
<td>33,0</td>
</tr>
<tr>
<td>Coal</td>
<td>45%</td>
<td>38%</td>
<td>13%</td>
<td>11%</td>
<td>12%</td>
</tr>
<tr>
<td>Oil</td>
<td>20%</td>
<td>20%</td>
<td>25%</td>
<td>26%</td>
<td>44%</td>
</tr>
<tr>
<td>Gas</td>
<td>17%</td>
<td>16%</td>
<td>46%</td>
<td>35%</td>
<td>23%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>15%</td>
<td>18%</td>
<td>12%</td>
<td>18%</td>
<td>0%</td>
</tr>
<tr>
<td>Renewables</td>
<td>4%</td>
<td>8%</td>
<td>4%</td>
<td>9%</td>
<td>20%</td>
</tr>
<tr>
<td>Heat</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Waste</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>Electricity</td>
<td>-3%</td>
<td>-3%</td>
<td>3%</td>
<td>5%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Legend:
- Green: Increase
- Red: Decrease
Sources of CO2 emissions

- Transport
- Residential buildings and commercial and public services
- Other Sectors
- Manufacturing industries and construction
- Electricity and heat production
- CO2 emissions
- GDP
Methodology

- IDA (index decomposition analysis), LMDI (logarithmic mean divisia index)

\[
c = \sum_{ij} c_{ij} \sum_i \sum_j \frac{Q_i}{Q} \times \frac{E_i}{Q_i} \times \frac{E_{ij}}{E_i} \times \frac{C_{ij}}{E_{ij}} \times Q
\]

1. \( \Delta C_{\text{Act}} \) - economic activity
2. \( \Delta C_{\text{Int}} \) - energy intensity
3. \( \Delta C_{\text{Str}} \) - economic mix
4. \( \Delta C_{\text{Mix}} \) - energy mix
5. \( \Delta C_{\text{Emf}} \) – emission factors
Data

- 35 energy sources and five sectors of economy (agriculture, construction, industry, services and households =56% of gross inland energy consumption
- Data on energy consumption were retrieved from EUROSTAT table $[nrg_{100a}]$ and covers on average 98% of energetic demands
- Data on emissions - IPCC guidelines.
- Electricity and heat - WB's statistics on power generation mix and Eurostat's statistics on derived heat sources as a base for our calculation and calculated the emission intensity as a simple weighted average.
- Economic activity - gross value added in 2005 constant prices was retrieved from Eurostat table $[nama_nace10_k]$. The data on household consumption originates from $[nama_fcs_k]$. 
Results

- **Activity** +32% of emission development, only negative in 2009
- **Structural** +12% of emission development, growth of industry, diminishing influence with lower influx of FDIs in recent years
- **Intensity** -50% of emission development, lower after crisis, high especially in early 2000’s, during strong influx of FDIs
- **Mix** +1% of emission development
- **EMF** -5% of emission development, power and heat generation energy mix
Results

<table>
<thead>
<tr>
<th></th>
<th>Activity</th>
<th>Structural</th>
<th>Intensity</th>
<th>Mix</th>
<th>EMF</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>-25%</td>
<td>12%</td>
<td>-25%</td>
<td>-17%</td>
<td></td>
<td>-705</td>
</tr>
<tr>
<td>CZ</td>
<td>-53%</td>
<td>13%</td>
<td>-53%</td>
<td>-3%</td>
<td></td>
<td>-12.030</td>
</tr>
<tr>
<td>HU</td>
<td>-52%</td>
<td>6%</td>
<td>-52%</td>
<td>-6%</td>
<td></td>
<td>-7.038</td>
</tr>
<tr>
<td>PL</td>
<td>-45%</td>
<td>6%</td>
<td>-45%</td>
<td>-1%</td>
<td></td>
<td>2.244</td>
</tr>
<tr>
<td>SK</td>
<td>-50%</td>
<td>12%</td>
<td>-50%</td>
<td>1%</td>
<td></td>
<td>-3.188</td>
</tr>
</tbody>
</table>

CO₂ kTon (Σ 2004-2013)
Conclusions

- Slovakia was able to significantly decrease its CO2 emissions during the recent period and with large margin fulfilled its commitments of multiple international agreements.
- In our opinion Act, Str, Int effects were to large extent driven by exogenous factors in form of FDIs and therefore with certain caution it can be stated that as much as 94% of determinants of CO2 emissions development happened to large extent regardless of national energy policy.
- As Austrian case suggests, as energy efficiency of V4 countries improves, these countries will likely have to rely more on changes in energy mix in order to meet their environmental commitments which might be more challenging to achieve.
- As our results further shows, changes in energy mix (at least those in power and heat generation) start playing more significant role in fighting CO2 emissions during current period of slower growth that seemed to be accompanied by lower gains in energy efficiency.
Thank you for your attention!
Backup slides
Additive decomposition

$$\Delta C_{\text{tot}} = C^T - C^0 = \Delta C_{\text{Act}} + \Delta C_{\text{Int}} + \Delta C_{\text{Str}} + \Delta C_{\text{Mix}} + \Delta C_{\text{Emf}}$$

\[
\Delta C_{\text{Act}} = \sum_i \frac{c_{ij}^T - c_{ij}^0}{\ln c_{ij}^T - \ln c_{ij}^0} \ln \left( \frac{Q^T}{Q^0} \right)
\]

\[
\Delta C_{\text{Str}} = \sum_i \frac{c_{ij}^T - c_{ij}^0}{\ln c_{ij}^T - \ln c_{ij}^0} \ln \left( \frac{S_i^T}{S_i^0} \right)
\]

\[
\Delta C_{\text{Int}} = \sum_i \frac{c_{ij}^T - c_{ij}^0}{\ln c_{ij}^T - \ln c_{ij}^0} \ln \left( \frac{I_i^T}{I_i^0} \right)
\]

\[
\Delta C_{\text{Int}} = \sum_i \frac{c_{ij}^T - c_{ij}^0}{\ln c_{ij}^T - \ln c_{ij}^0} \ln \left( \frac{I_i^T}{I_i^0} \right)
\]

\[
\Delta C_{\text{Emf}} = \sum_i \frac{c_{ij}^T - c_{ij}^0}{\ln c_{ij}^T - \ln c_{ij}^0} \ln \left( \frac{U_{ij}^T}{U_{ij}^0} \right)
\]
Multiplicative decomposition

\[ D_{\text{tot}} = \frac{C^T}{C^0} = D_{\text{Act}} D_{\text{Int}} D_{\text{Str}} D_{\text{Mix}} D_{\text{Emf}} \]

\[
D_{\text{Act}} = \exp \left( \sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \ln \left( \frac{Q_i^T}{Q_i^0} \right) \right)
\]

\[
D_{\text{Str}} = \exp \left( \sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \ln \left( \frac{S_i^T}{S_i^0} \right) \right)
\]

\[
D_{\text{Int}} = \exp \left( \sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \ln \left( \frac{I_i^T}{I_i^0} \right) \right)
\]

\[
D_{\text{Mix}} = \exp \left( \sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \ln \left( \frac{M_{ij}^T}{M_{ij}^0} \right) \right)
\]

\[
D_{\text{Emf}} = \exp \left( \sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \ln \left( \frac{U_{ij}^T}{U_{ij}^0} \right) \right)
\]
Results

Austria

- CO2 emissions -6,8 - + 8,3 % YoY
- Act before 2009 + 2,4%, po + 1,3%
- Str before 2009 + 0,6% po + 1,5%
- EMF most consistent – 1,4%

Czech Republic

- CO2 emissions -7,1 - + 2,4 % YoY
- MIX – 0,2%, EMF – 0,6%, Int -4,2%
- Inudstry – 46% int (2004-2013)
- Str +1,1%, Act +2,3%
- Before 2009 Act +5%, Int – 8%
- After 2009 Int contributes to emissions growth
- EMF -1,1%
Results

**Hungary**

- Act +0.3%
- Int -1.3% (>0 in 4 years)
- EMF – 0.9% most consistent

**Poland**

- CO2 emisie + 2 244 kton (200-2012)
- ACT +3.6% (6657 y-o-y)
- Str +0.5%
- Int -3.4%
- MIX & EMF -0.1% & -0.4%