Energy consumption and efficiency in the manufacturing

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December 2016

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Introduction: Manufacturing and industrial statistics

Industrial development is a driver of structural change which is key in the process of economic development.

Industrial statistics:

- Help identify the key production sectors in each country
- Rank major economic zones
- Allow development to be studied
- Demanded more than ever by researchers and analysts to assess implications of the process of the globalization and update/correct policy measures.

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UNIDO Databases:

Following databaes are available on UNIDO Statistics data portal:

- **INDSTAT 2 2016** (at 2-digit level of ISIC Revision 3)
- **INDSTAT 4 2016** (at 3- and 4-digit level of ISIC Revision 3 and 4)
- **MINSTAT 2016** (at 2- and 3-digit level of ISIC Revision 3 and 4)
- **IDSB 2016** (at 4-digit level of ISIC Revision 3 and 4)
- **MVA 2016**

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Data properties

- Cover the industry sector
- Refer to economic statistics not technological or environmental data
- Include statistical data from the annual observation within the quality assurance framework (no experimental or one-time study data)
- Reflect characteristics of the units in terms of the International Standard Industrial Classification of All Economic Activities (ISIC)

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INDSTAT 2 2016

- Comprises data for 170 Countries and some country groups
- Covering years: 1963-2014
- Pertaining to the manufacturing sectors (ISIC 15-37): 23 manufacturing divisions
- Data are in current prices, national currency (can be presented in current USD)
- Compiled on eight principle indicators:
    1. Employees
    2. Wages and salaries
    3. value added
    4. Gross fixed capital formation
    5. Female employees
    6. Index numbers of industrial production
    7. Establishments
    8. Output

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MVA 2016

- Annual data (not sector wise)
- Includes GDP, MVA (at current, constant 2010 and at the United States dollars prices) and population
- Data for 206 countries and some group of economies
- Covering years: 1990-2015
- Compiled from external sources (WDI, UNSD, OECD, etc.)

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World Energy database 2016

1. World energy statistics:

- Key energy statistics for over 150 countries and regions.
- Data are provided in original units for different types of coal, oil, natural gas, renewables and waste, as well as for electricity and heat.
- Available for 1971 (1960 for OECD countries) to 2014.

2. World energy balances:

- Provides basic supply and demand values for all fuels in thousand tonns of oil equivalent (ktoe).
- Over 150 countries and regions covered.
- Available for 1971 (1960 for OECD countries) to 2014.

We use world energy balances dataset for this analysis (one common unit). Comparison between energy consumption of different industrial sectors will be much easier.

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Limitations

1. MVA (constant) is not available for industrial sectors.

Solution: We use MVA 2016 and the shares from INDSTAT 2, 2016.

2. Different manufacturing flows:

IEA Manufacturing activities distributed in different classification which is not compatible with any ISIC revision.

Solution: Add some amounts from “Energy industry own use and Losses” flows to final consumption flows to get equivalent subgroups in both datasets.

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Correspondence between Energy data and INDSTAT2 by sector: Examples

Energy Flow	Covering items in ISIC Rev.3 (INDSTAT 2)
Food and Tobacco	15: Food and beverages 16: Tobacco
Textile and leather	17: Textiles 18: Wearing apparel; dressing and dyeing f fur 19: Dressing of leather; manufacture of luggage, handbags, saddler, harness and footwear

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Missing Flows

Example 1:

Energy Flow	Covering items in ISIC Rev.3 (INDSTAT 2)
?	23: coke, refined petroleum products, nuclear

There is no equivalent sector in energy dataset to cover coke, refined petroleum products and nuclear fuel (ISIC 23) of INDSTAT 2.

Solution: More information about coke, refined petroleum products and nuclear energy used in manufacturing sectors is available in “Energy industry own use and Losses” subgroup.

- Coke ovens
- Oil Refineries
- Nuclear industry

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Example 2:

Energy Flow	Covering items in ISIC Rev.3 (INDSTAT 2)
Iron and steel	?
Non-ferrous metals	27:Basic metals

Energy dataset has two separate flows instead of basic metals in INDSTAT2: Non-ferrous metals and Iron and steel.

Solution: Combination of two sectors

Blast furnaces also counts in this category because energy consumption in the iron and steel industry does not include coke converted into blast furnace gas.

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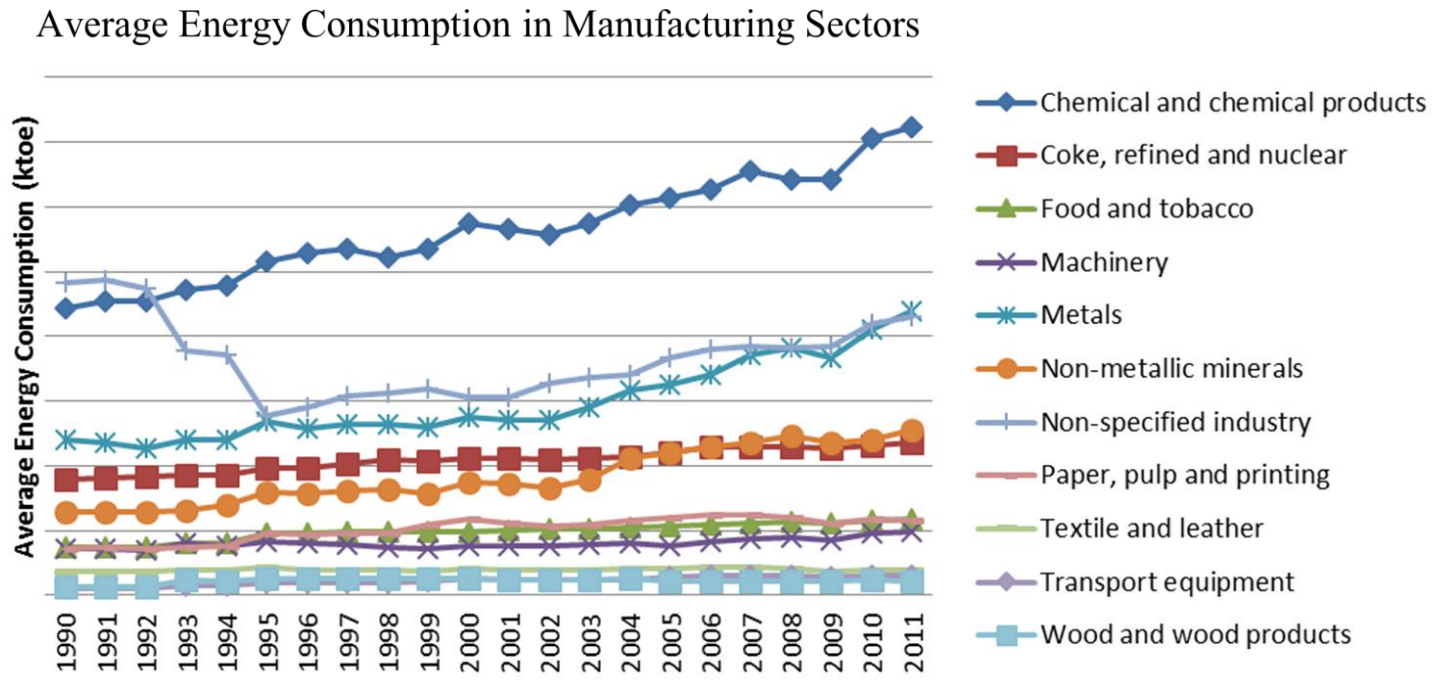
Derived databases:

Using the modified conversion table and highlighted databases, we derived a new database which:

- Calrifies energy consumption and value added in manufacturing sectors.
- Gives information about energy efficiency, energy intensity and energy intensity index for manufacturing sectors
- Covers over 100 countries



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Decomposition

- Loads of information is available by changes in energy consumption and value added in manufacturing sectors
- To get an aggregated result: Decompose total change of industrial energy consumption to 3 factors:

$$D_{\text{total Change}} = D_{Activity}\, D_{Intensity}\, D_{\text{structural}}$$

- A new energy decomposition method: Logarithmic Mean Division Index (Ang 2001, 2005)
  - Perfect in decomposition
  - Consistent in aggregation
  - Available in multiplicative and additive format

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Mathematics of LMDI

$$D_{Activity} = exp\left(\sum_i \frac{(E_i^T - E_i^0)/(\ln E_i^T - lnE_i^0)}{(E^T - E^0)/(lnE^T - lnE^0)} ln\left(\frac{Q^T}{Q^0}\right)\right)$$

$$D_{Intensity} = exp\left(\sum_i \frac{(E_i^T - E_i^0)/(\ln E_i^T - lnE_i^0)}{(E^T - E^0)/(lnE^T - lnE^0)} ln\left(\frac{\mathrm{I}_i^T}{\mathrm{I}_i^0}\right)\right)$$

$$D_{\text{structural}} = exp\left(\sum_i \frac{(E_i^T - E_i^0)/(\ln E_i^T - lnE_i^0)}{(E^T - E^0)/(lnE^T - lnE^0)} ln\left(\frac{\mathrm{S}_i^T}{S_i^0}\right)\right)$$

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Some changes in energy consumption and value added

	Change		Condition	Activity	Intensity	Structural	Total change
Level	E1 ↑			No change	↑	No change	↑
	Q1 ↑			↑	↓	↓	No change
Distribution	Q1 ↑	Q2 ↓	Q1+Q2=Constant	No change	?	?	No change
Intensity	E1 ↑	Q1 ↑	E1/Q1=Constant	↑	No change	?	↑
	E1 ↓	Q1 ↓	E1/Q1=Constant	↓	No change	?	↓

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Decomposition Result

Multiplicative

Group	Countries	Activity	Intensity	Structural	Total change
EU	Italy	0.928	1.001	0.790	0.735
EU	Denmark	1.224	0.663	0.847	0.688
Asia & Pacific	India	3.111	0.778	1.057	2.561
North America	Canada	1.205	0.866	0.980	1.024

Additive

Group	Countries	Activity	Intensity	Structural	Total change
EU	Italy	-2933.35	53.46	-9307.31	-12187.2
EU	Denmark	461.036	-936.201	-376.674	-851.838
Asia & Pacific	India	171616.9	-37808.5	8403.10	142211.5
North America	Canada	12019.88	-9196.55	-1252.81	1570.523

Conclusion

- A new merged data set which shows energy consumption in different manufacturing sectors provided
- Decomposition analysis (LMDI)
- Further researches: It’s possible to see the relationship between GDP growth and decomposed factors to update/correct some policies (using GMM models)

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