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Energy Efficiency and EU Industrial Competitiveness:

Energy Costs and their Impact on Manufacturing Activity

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Abstract

Environmental objectives of the EU and the widened energy price gap between the EU and the United States have recently given rise to concerns about the competitiveness of European manufacturing industries, particularly those in energy-intensive branches. This study demonstrates that industrial end-user prices for gas and electricity in the EU have indeed gone up strongly relative to some of its main competitors, largely on account of the network costs component. At the same time, over the past two decades there have been marked advances in energy efficiency in response to energy price shocks. These advances have been driven primarily by technological improvements, (although in the NMS, a structural shift has also played a role), particularly in the case of electricity and in the long run. However, they did not fully offset the energy price increase, so that the energy cost shares have generally gone up. The study empirically demonstrates that this has had some detrimental effect on industrial competitiveness, although this has generally been overshadowed by the impact of other cost components such as labour costs.

Keywords: energy sector, energy prices, energy costs, energy intensity, industrial competitiveness

JEL classification: Q40, Q41, Q4

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LIST OF ABBREVIATIONS

CPA	Classification of Products by Activity
CPA 10	coal
CPA 11	crude oil and natural gas (CPA 11)
CPA 23	coke, refined petroleum and nuclear fuels
CPA 40	electrical energy, gas, steam and hot water
EBITDA	earnings before interest, taxes, depreciation and amortization
ECR	European Competitiveness Report
ETS	Emissions Trading System
EU-27	the 27 EU Member States as of 30 June 2013, i.e. without Croatia (Austria, Belgium, Bulgaria , Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom)
EU-12	the 12 new EU Member States acceding in 2004 and 2007 respectively (Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia)
EUR	euro
Eurostat	the statistical office of the European Union
GDP	gross domestic product
IEA	International Energy Agency
IO tables	input-output tables
LNG	liquefied natural gas
MBtu	one thousand BTU, British thermal units
MJoule	megajoule (one million joules)
MWh	mega watt-hour (one million watt-hours)
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne (Statistical classification of economic activities in the European Community)
NACE Rev. 1	the first revision (1990) of the original NACE (1970)
NACE Rev. 1 15t37	manufacturing
NACE Rev. 1 23	coke, refined petroleum, and nuclear fuel
NACE Rev. 1 24	chemicals and chemical products
NACR Rev. 1 26	other non-metallic mineral
NACE Rev. 1 27t28	basic and fabricated metals
NAICS	North American Industry Classification System
OECD	Organisation for Economic Co-operation and Development
OECD-Europe	Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom. Prior to 1995 the Czech Republic, Estonia, Hungary, Poland, the Slovak Republic and Slovenia are excluded
PPI	producer price index
PPPs	purchasing power parities
pps	percentage points

SMEs	small- and medium-sized enterprises
SUTs	supply and use tables
TJ	terajoule
USD	US dollar
VAT	value-added tax
wiiw	The Vienna Institute for International Economic Studies
WIOD	World Input-Output Database

Introduction

Environmental objectives and rising fuel prices have made energy efficiency improvement an important policy goal of the European Union. For instance, the Europe 2020 strategy explicitly stipulates a 20 per cent improvement in energy efficiency in the EU as one of its objectives. Recently, the European Commission has prepared a new energy and climate framework for the period up to 2030.[1] To facilitate the development of the new framework, a public consultation was launched with the release of a Green Paper adopted by the Commission on 27 March 2013.[2] One part of the Green Paper stipulated that 'one of the fundamental objectives of EU energy policy is to ensure that the energy system contributes to the competitiveness of the EU economy by ensuring competitive domestic and international energy markets and prices which are internationally competitive and represent affordable energy for final consumers'. The consultation finished last July and one of the questions addressed to industry, citizens, academia and NGOs referred to 'specific drivers in observed trends in energy costs and to the extent that the EU could influence them'.

In May 2013 the European Council welcomed the Commission's Green Paper and again emphasised the need to strengthen competitiveness, jobs and growth. In this vein it called on the Commission 'to present an analysis of the composition and drivers of energy prices and costs in Member States before the end of 2013, with a particular focus on the impact on households, SMEs and energy intensive industries, and looking more widely at the EU's competitiveness vis-à-vis its global economic counterparts'. Concerns about the external competitiveness of European industry have been particularly reinforced by the recent 'shale gas revolution' in the United States. The latter has resulted in plunging prices of natural gas and electricity, benefiting in particular energy-intensive industries such as metals and chemicals, and potentially leading to a revival of manufacturing in the US.

The relative weight of energy in manufacturing inputs has generally shown an overall decrease during recent years. The European Competitiveness Report (ECR) 2012 has shown that manufacturing in the European Union moderately increased its gross output while at the same time maintaining fairly constant energy use due to continuous technical improvement in the previous decade. The present study builds on the work developed in ECR 2012 and on-going related work within the European Commission, focusing on the increasing globalisation of production and vertical specialisation within manufacturing, in conjunction with the trend within European economies to reduce their relative exposure to potential external competitiveness losses due to increasing energy prices. The main purpose of the study is to provide a comparative analysis of the relative energy costs amongst EU Member States and their international trading partners, as well as the content and efficiency levels in key manufacturing sectors during the past two decades, with a view to identifying future trends in production and energy efficiency strategies. The study is based on the latest version of the World Input-Output Database (WIOD) which combines national supply and use tables and international trade data to allow both a cross-country and cross-sector perspective.

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1 See http://ec.europa.eu/clima/policies/2030/index_en.htm.

2 See European Commission (2013b).

The study has the following structure. Task 1 provides a comparison of energy cost shares and energy intensities for total economy and manufacturing in the EU Member States and its main trading partners: the US, Japan, Russia, and China. In order to analyse the drivers behind the changes in energy intensity over time, we perform decomposition analysis which allows us to disentangle a proper energy intensity effect and a structural change effect. Further, we differentiate between individual energy products in total energy consumption by industry. Task 2 provides a detailed comparative analysis of oil, gas and electricity prices across EU member countries, in time and in comparison with the major EU competitors, and identifies the drivers of energy price dynamics. Task 3 quantifies the short-run and long-run impact of energy price shocks on the energy intensity of individual manufacturing industries using a panel of 30 OECD countries over a time period of 15 years. It estimates, among other things, own- and cross-price elasticity of energy intensity for gas and electricity. Finally, following on from the modelling exercise in Task 3, Task 4 analyses how changes in energy intensity have affected industrial competitiveness using various alternative definitions of competitiveness, and derives policy recommendations based on the estimation results.

The present study should be considered in the context of two other reports which have recently been published by the European Commission: 'Energy economic developments in Europe' (European Commission, 2014a) prepared by DG ECFIN and 'Energy prices and costs report' (European Commission, 2014b) prepared by DG Energy. On the one hand, there are important synergies between those two reports and the present study, but the latter also complements them in several important ways. For instance, in Task 1 it provides alternative methodologies of calculating energy intensities (gross output vs. value-added, exchange rates vs. PPPs) and demonstrates the sensitivity of obtained results to the methodology used. In Task 2, it puts relatively strong emphasis on the energy price developments in the main EU industrial competitors other than the United States, such as Russia and China. Finally, the forward-looking modelling approach adopted in European Commission (2014b) is complemented in Tasks 3 and 4 of the present study by econometric estimations based on historical time series data.

Task 1: Patterns and trends of energy cost shares and energy intensities

1.1 ENERGY COST SHARES

1.1.1 INTRODUCTION

The main purpose of this task is to provide a descriptive comparative analysis at country and industry levels concerning the relevance of energy costs in production and the patterns and changes of energy efficiency across countries and over time. As a first step, this section provides a comparison of energy cost shares in gross output. For this we rely on the national supply and use tables which provide information on inputs by energy product: coal (CPA 10), crude oil and natural gas (CPA 11), coke, refined petroleum and nuclear fuels (CPA 23), and electrical energy, gas, steam and hot water (CPA 40). These data are available from the WIOD project in both basic and purchaser prices. The analysis is undertaken both at the level of the EU-27 and the individual Member States, pointing towards differences in the patterns of energy cost shares. Furthermore, the EU as a whole is compared with its main trading partners included in the WIOD. A more detailed analysis is undertaken for the manufacturing industries (NACE Rev. 1.1 15 – 37) according to the industry details provided in WIOD. Though these comparisons highlight an important aspect of competitiveness related to costs of inputs, it should be stressed that competitiveness has many more dimensions including quality of products, product differentiation, etc. which need to be taken into account when considering competitiveness pressures across countries. These aspects are related to the quality of workforce, skills and training, provision of high-quality intermediates, etc. which goes beyond the simple considerations of single cost items.

1.1.2 COMPARISONS OF ENERGY COST SHARES IN THE MAJOR ECONOMIES

As a first step, we analyse the cost shares of energy inputs in total production of the various countries. Table 1.1 shows the energy cost shares for the EU-27 and other countries over the period 1995-2011 both for the total economy and manufacturing industries only. With respect to the latter, Table 1.1 also provides shares without industry NACE Rev. 1 23 (coke, refined petroleum, and nuclear fuel), which is an energy-intensive industry. The cost shares are calculated from the tables in basic prices.

Table 1.1 / Energy cost shares in the major economies, in % of gross output in basic prices

	Total economy				Manufacturing				Manufacturing*			
	1995	2000	2007	2011	1995	2000	2007	2011	1995	2000	2007	2011
EU-27	3.0	3.2	4.1	4.6	3.8	4.8	6.3	7.5	2.3	2.2	2.8	3.0
China	5.2	5.9	7.7	7.7	6.2	7.0	7.8	8.1	4.4	4.7	5.7	5.9
Japan	2.8	3.3	4.8	5.1	3.4	4.6	7.3	8.0	2.9	3.3	4.6	5.4
USA	2.8	3.6	4.6	4.6	4.8	6.5	10.2	11.3	2.3	2.8	3.1	2.9

Note: * not including NACE Rev. 1 23 coke, refined petroleum and nuclear fuel.
Source: WIOD; wiiw calculations.

The figures in Table 1.1 reveal some important aspects. The energy cost shares in the EU-27 in 2011 stood at 4.6% for the total economy and at 7.5% for manufacturing. For the total economy, these are in line with Japan (5.1%) and the US (4.6%); only China shows a higher energy cost share with 7.7%. However, for manufacturing, the shares in the EU-27 (7.5%) are more in line with those of Japan (8.0%) and China (8.1%), with the US showing a much higher share of 11.3%. Energy cost shares in manufacturing (NACE Rev. 1 15-37) tend to be higher as compared to the total economy due to the generally low energy intensity of the services sector (though e.g. the transport industry is energy-intensive). In nearly all cases, these cost shares have been on the rise over the time period considered. It is furthermore worth noting that in manufacturing, energy cost shares have increased in the US (+6.5 pps) and Japan (+ 4.6 pps) more than in the EU-27 (+ 3.7 pps) and China (+ 1.9 pps). However, these results are quite sensitive to the inclusion of industry coke, refined petroleum and nuclear fuel (NACE Rev. 1 23). Excluding this sector from total manufacturing implies that energy cost shares fall to only about 3% in the EU-27 and 2.9% in the US, although they are higher in China (5.9%) and Japan (5.4%). Again, these energy cost shares have been increasing over time, though much less as compared to total manufacturing (i.e. including industry coke, refined petroleum and nuclear fuel).[3]

Table 1.2 / Structure of production costs in % of gross output by type of input, 2011

	Energy	Agriculture etc.	Mining and utilities	Low-tech	Medium-low tech	Medium-high and high-tech	Construc-tion	Non-tradable market services	Transport and communi-cation	Busines s services	Non-market service s	Value-added
						Total economy						
EU27	4.6	1.2	0.4	3.4	5.0	5.7	2.4	9.2	4.7	12.3	1.0	50.3
China	7.7	4.1	1.9	9.1	13.0	16.7	0.3	5.5	3.7	4.3	0.4	33.2
Japan	5.1	1.2	1.0	4.2	6.7	7.6	1.0	8.1	3.2	9.5	0.3	52.0
USA	4.6	1.3	0.3	3.0	3.0	4.4	0.7	9.0	2.9	14.1	0.4	56.3
						Manufacturing industries						
EU27	7.5	2.9	0.9	6.2	12.7	14.0	0.4	12.0	3.4	8.8	0.3	30.8
China	8.1	5.6	3.1	11.9	16.8	23.2	0.0	4.3	2.5	3.1	0.3	21.2
Japan	8.0	2.9	1.3	5.9	16.0	18.7	0.5	7.7	2.6	5.3	0.1	31.1
USA	11.3	4.6	0.6	6.8	9.8	12.9	0.3	6.8	2.5	9.0	0.0	35.4
						Manufacturing industries*						
EU27	3.0	3.2	0.9	6.7	13.7	14.9	0.4	12.2	3.4	9.2	0.3	32.1
China	5.9	5.7	3.2	12.3	17.4	23.8	0.0	4.3	2.5	3.2	0.3	21.3
Japan	5.4	3.1	0.7	6.2	17.1	19.9	0.5	8.2	2.6	5.6	0.1	30.6
USA	2.9	5.3	0.7	7.8	11.2	14.7	0.4	7.6	2.7	10.3	0.1	36.5

* Excluding NACE Rev. 1 23 coke, refined petroleum and nuclear fuel.
Source: WIOD; wiiw calculations.

Thus, at this aggregate level the share of energy costs in total production costs is relatively small, though at a more disaggregate level there are industries and firms with a much larger energy cost

[3] These cost shares might be somewhat different when using purchaser prices (i.e. including domestic tax and trade and transport margins). In this case shares tend to be higher, with the differences of 1-2 percentage points on average: for example, the energy cost shares for the EU-27 were 5.6% in 1995 and 7% in 2011 for the total economy and about 4% in both years in manufacturing (not including NACE Rev. 1 23). Further, note that e.g. for the US, the respective numbers in basic and purchaser prices are the same, as the US tables are only available in basic prices (see Timmer et al., 2012 for details).

component (see e.g. Renda, 2013; Riker, 2012). These energy cost shares have to be compared with other cost components which enter the production process either as intermediate inputs or as payments to primary factors like labour and capital. These costs shares in per cent of gross output are reported in Table 1.2. Considering again the category of manufacturing excluding NACE Rev. 1 23, one finds that value-added, i.e. the labour and capital income, stands at about 30% (in China 21%) of overall production costs and is the largest cost component, closely followed by services inputs. Non-tradable market services, transport and communication services, and business services together account for about 25% in the EU-27, 20% in the US, 16% in Japan and 10% in China. The third most important cost component are inputs of medium-low and medium-high and high-tech industries, with the cost shares in the EU-27 of about 14 and 15% respectively.

This leads to the question as to whether there are any substantial differences in energy cost shares for individual manufacturing industries, which for four major economies are shown in Table 1.3. In the EU-27, energy cost shares stand between slightly above 1% in transport equipment, electrical and optical equipment and machinery and about 7% in chemicals and other non-metallic mineral products. In the US, energy cost shares are lower than in the EU-27 in almost all industries (important exceptions are NACE Rev. 1 20 wood and products of wood and NACE Rev. 1 24 chemicals and chemical products). The other two countries – Japan and China – show much higher energy cost shares in chemicals and chemical products (NACE Rev. 1 24), other non-metallic mineral (NACE Rev. 1 26), and basic and fabricated metals (NACE Rev. 1 27t28). Industry NACE 23 (coke, refined petroleum and nuclear fuels) obviously has a much higher energy cost share, ranging in 2011 from 47% in Japan to more than 70% in China. The EU-27 (62%) has a lower share than the US (68%).

Table 1.3 / Energy cost shares by manufacturing industry in basic prices in the major economies (in % of gross output)

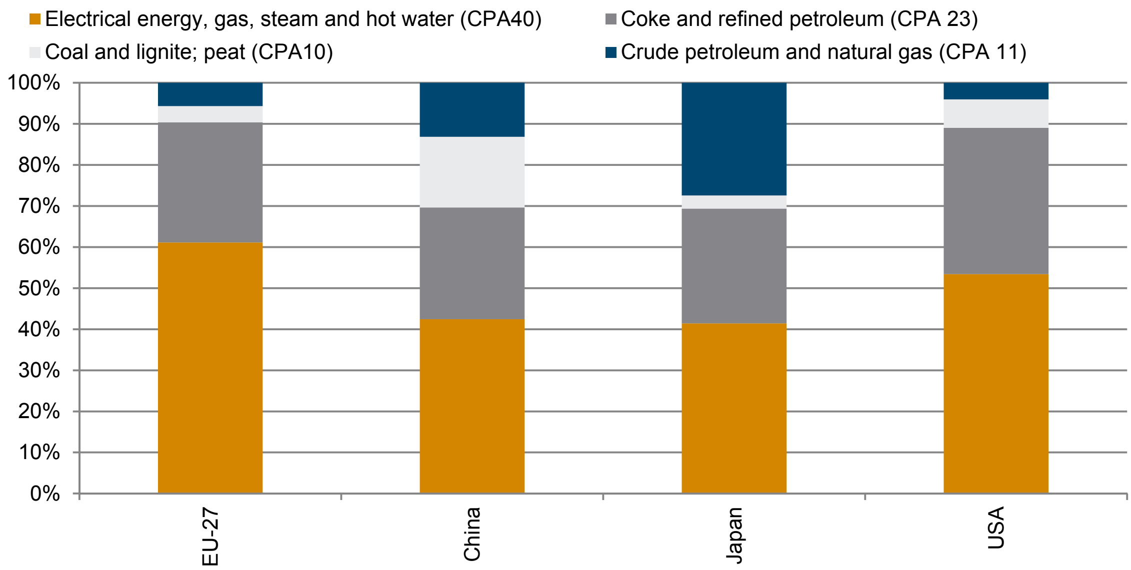
	EU-27		China		Japan		USA	
	1995	2011	1995	2011	1995	2011	1995	2011
Food, Beverages and Tobacco	1.7	2.5	1.3	1.5	1.5	2.3	1.8	2.0
Textiles and Textile Products	2.2	3.1	1.2	2.2	2.2	3.3	1.7	2.2
Leather, Leather and Footwear	1.1	1.4	0.5	1.2	1.6	2.0	1.2	0.8
Wood and Products of Wood and Cork	2.0	2.8	3.1	3.1	1.9	2.5	2.1	3.1
Pulp, Paper, Printing and Publishing	2.5	3.2	3.8	3.6	3.4	4.8	2.4	3.2
Coke, Refined Petroleum and Nuclear Fuel	47.8	62.0	56.9	72.2	20.8	47.0	62.2	67.9
Chemicals and Chemical Products	4.4	7.4	9.9	18.9	6.8	13.1	5.9	7.8
Rubber and Plastics	2.5	3.5	2.8	3.3	3.1	3.3	3.0	2.5
Other Non-Metallic Mineral	5.6	7.4	10.5	15.5	9.2	16.8	4.6	5.8
Basic Metals and Fabricated Metal	3.7	4.1	7.7	9.8	4.4	10.2	3.3	4.2
Machinery, n.e.c.	1.2	1.3	2.8	3.5	1.2	1.5	1.1	1.0
Electrical and Optical Equipment	1.0	1.1	1.3	1.4	1.6	2.2	1.3	0.5
Transport Equipment	1.2	1.1	1.8	1.6	1.2	1.6	0.7	0.8
Manufacturing, n.e.c.; Recycling	1.4	2.1	1.9	1.9	2.0	3.0	1.2	0.8

Note: Figures do not include NACE Rev. 1 23 coke, refined petroleum and nuclear fuel.
Source: WIOD; wiiw calculations.

Countries also differ with respect to the structure of energy cost shares according to the four CPA (Classification of Products by Activity) categories used here. Table 1.4 provides these shares (in % of total energy costs) for the total economy, manufacturing industries and manufacturing excluding coke, refined petroleum and nuclear fuel (NACE Rev. 1 23). The differences in energy cost shares across countries are highlighted in Figure 1.1. In the EU-27, about 60% of total energy costs are for CPA 40 (electrical energy, gas, steam and hot water) and about 23% for coke and refined petroleum (CPA 23). The other two categories account for only 4% (coal) and 5.7% (crude oil and gas). This pattern is rather similar to other advanced countries such as the US and Canada, which have a higher share of coke. Japan is different, with the share of electrical energy, gas, steam and hot water (CPA 40) standing at about 40%, and those of crude oil and gas (CPA 11) and coke and refined petroleum (CPA 23) at about 27-28%.

Figure 1.1 / Structure of energy costs by CPA categories in manufacturing (excl. NACE Rev. 1 23) in the major economies

Costs in % of total energy costs, 2011



Note: Figures do not include NACE Rev. 1 23 coke, refined petroleum and nuclear fuel.
Source: WIOD; wiiw calculations.

1.1.3 COMPARISONS OF ENERGY COST SHARES ACROSS EU MEMBER STATES

The shares of energy costs in total production costs also differ widely across EU Member States. The respective cost shares for the total economy, manufacturing and manufacturing excluding NACE Rev. 1 23 (Coke, etc.) are presented in Table 1.4, with Figure 1.2 highlighting the patterns across EU Member States for the latter group of industries.

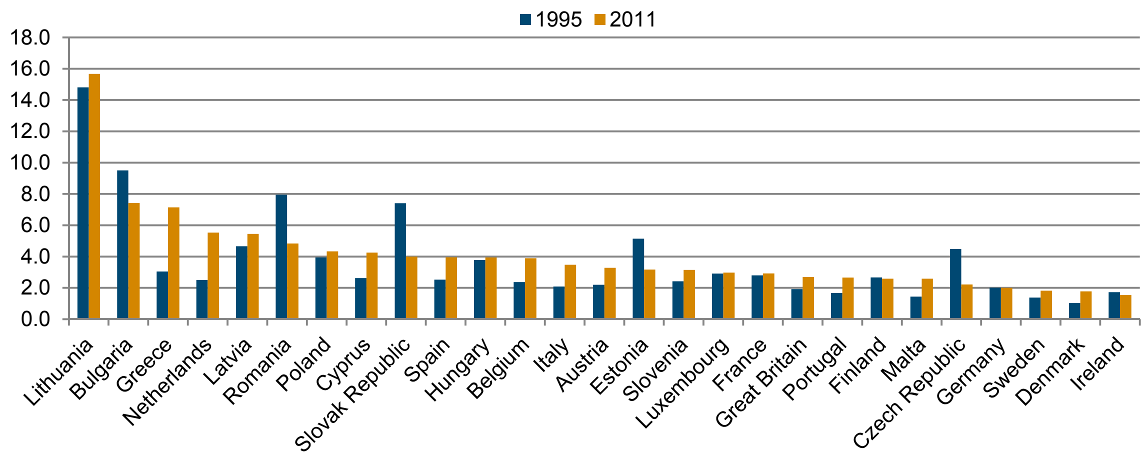
The shares of energy costs in manufacturing (without NACE Rev. 1 23) range between 15% in Lithuania and 2%, or even less, in Germany, Sweden, Denmark and Ireland, with the majority of countries having shares of between 2 and 4%. Concerning the trends in these shares over time, the picture is rather mixed. In just over half of the countries these shares have been rising, particularly so in Greece and the Netherlands. The share of energy costs in gross output of industries presented in Figure 1.2 has been considerably declining in most Eastern European countries, particularly in Bulgaria, Romania, the Slovak Republic, Estonia and the Czech Republic.

Table 1.4 / Energy cost shares in EU Member States in basic prices (in % of gross output)

	Total economy				Manufacturing				Manufacturing*			
	1995	2000	2007	2011	1995	2000	2007	2011	1995	2000	2007	2011
Austria	3.2	3.1	5.2	6.9	3.3	3.5	4.6	5.9	2.2	1.9	2.5	3.3
Belgium	2.8	3.6	5.0	5.7	3.8	6.4	10.7	13.6	2.4	2.6	3.4	3.9
Bulgaria	10.4	12.6	11.4	10.4	15.4	22.0	18.5	17.2	9.5	11.2	7.7	7.4
Cyprus	2.9	4.7	3.2	3.5	6.3	12.7	4.0	4.3	2.6	3.6	4.0	4.3
Czech Republic	7.9	6.3	4.6	3.7	6.8	5.4	4.4	3.6	4.5	3.2	2.5	2.2
Germany	1.9	2.1	3.0	2.5	2.8	3.4	4.1	2.8	2.0	2.0	2.4	2.0
Denmark	1.7	2.4	3.3	4.2	2.6	4.2	5.3	6.3	1.0	1.0	1.2	1.8
Spain	3.2	3.9	4.4	5.9	4.5	6.1	7.5	10.6	2.5	2.4	3.1	4.0
Estonia	6.4	4.6	3.8	4.9	5.2	3.0	3.0	3.7	5.1	2.6	2.6	3.2
Finland	3.2	3.3	4.1	5.3	4.0	4.4	6.0	8.7	2.7	2.1	2.1	2.6
France	3.5	2.8	3.5	4.6	4.2	4.7	6.3	9.5	2.8	1.7	2.3	2.9
Great Britain	3.2	3.2	3.8	4.0	3.5	4.4	6.7	8.1	1.9	1.8	2.9	2.7
Greece	3.3	5.0	5.8	5.3	6.8	12.7	18.1	16.9	3.0	3.7	6.5	7.1
Hungary	5.2	5.0	5.7	6.8	5.4	5.4	6.0	7.4	3.8	2.9	3.3	3.9
Ireland	2.1	1.3	2.0	2.3	2.0	1.1	2.2	2.1	1.7	1.0	1.5	1.5
Italy	2.8	3.4	4.5	5.6	3.7	5.1	6.5	8.7	2.1	2.4	3.0	3.5
Lithuania	13.4	10.2	10.3	12.8	20.1	20.9	21.0	29.7	14.8	10.8	13.9	15.7
Luxembourg	1.5	1.1	1.3	1.3	2.9	2.7	2.9	3.0	2.9	2.7	2.9	3.0
Latvia	6.2	4.5	4.3	5.4	5.0	4.4	4.6	5.5	4.7	4.0	4.4	5.5
Malta	3.5	4.3	6.3	6.0	1.4	1.3	2.1	2.6	1.4	1.3	2.1	2.6
Netherlands	4.1	4.8	6.3	7.6	5.8	9.0	12.7	16.4	2.5	3.0	4.9	5.5
Poland	5.8	5.6	5.2	6.1	5.7	6.8	5.7	7.5	3.9	4.2	3.5	4.3
Portugal	3.8	4.3	6.5	6.0	4.0	5.5	8.5	8.1	1.7	1.8	2.7	2.7
Romania	10.4	9.5	7.2	6.7	12.8	11.8	7.5	7.4	8.0	7.4	5.0	4.8
Slovak Republic	10.7	11.3	8.8	8.6	10.9	10.5	8.8	8.1	7.4	4.7	4.4	4.0
Slovenia	2.9	2.8	3.1	3.4	2.7	2.7	2.9	3.1	2.4	2.5	2.9	3.1
Sweden	1.8	2.2	2.6	3.0	2.7	3.8	4.8	5.8	1.4	1.2	1.6	1.8
EU-27	3.0	3.2	4.1	4.6	3.8	4.8	6.3	7.5	2.3	2.2	2.8	3.0

Note: * not including NACE Rev. 1 23 coke, refined petroleum and nuclear fuel.
Source: WIOD; wiiw calculations.

Figure 1.2 / Energy cost shares in manufacturing (excl. NACE Rev. 1 23) in EU Member States, in % of gross output



Note: Figures do not include NACE Rev. 1 23 coke, refined petroleum and nuclear fuel.
Source: WIOD; wiiw calculations.

Again, this has to be compared to other cost components, which is done in Table 1.5. The pattern here is similar to the one found above for the EU-27 as a whole: value-added, services and medium-tech and high-tech inputs are the most important cost components.

Table 1.5 / Structure of production costs in manufacturing (excl. NACE Rev. 1 23) in EU Member States in %, 2011

	Energy	Agriculture etc.	Mining and utilities	Low tech	Medium - low tech	Medium-high and high tech	Construc-tion	Non-tradable market services	Transport and communi-cation	Business services	Non-market services	Value-added
Austria	3.3	3.0	0.4	6.8	16.0	13.3	1.1	12.3	3.4	6.2	0.1	34.0
Belgium	3.9	2.9	1.8	6.7	13.5	14.7	0.7	15.7	4.3	7.8	0.2	27.9
Bulgaria	7.4	4.5	4.3	12.1	16.8	10.1	1.7	6.7	5.4	4.0	0.1	27.0
Cyprus	4.3	6.8	2.2	12.6	14.2	5.9	1.2	10.5	0.6	10.4	0.0	31.4
Czech Republic	2.2	2.6	0.7	8.0	18.4	26.9	0.3	8.3	2.4	3.2	0.1	26.8
Germany	2.0	2.2	0.8	3.9	14.8	18.7	0.3	9.9	2.9	8.9	0.4	35.3
Denmark	1.8	6.7	0.3	6.2	9.2	11.9	0.4	17.2	3.1	7.5	0.3	35.5
Spain	4.0	4.5	1.2	9.2	14.5	11.3	0.5	12.1	5.2	8.0	0.3	29.2
Estonia	3.2	7.5	0.7	10.6	9.9	9.8	0.3	13.5	7.9	5.1	0.2	31.4
Finland	2.6	4.4	2.5	6.0	11.1	16.0	0.2	11.0	5.0	10.7	0.7	30.0
France	2.9	3.7	0.8	6.7	16.1	14.2	0.2	12.9	3.0	13.5	0.3	25.7
Great Britain	2.7	2.4	0.6	6.3	10.7	11.2	0.2	14.0	3.3	7.8	0.3	40.4
Greece	7.1	3.7	0.8	7.6	11.8	5.3	0.6	12.3	1.1	6.9	0.0	42.8
Hungary	3.9	4.2	0.8	4.8	11.2	29.5	0.6	6.3	2.0	7.7	0.5	28.7
Ireland	1.5	2.5	0.3	4.5	2.6	22.0	0.1	7.6	1.1	24.3	0.2	33.1
Italy	3.5	2.7	0.7	9.3	14.7	11.3	0.5	14.9	4.4	7.6	0.1	30.3
Lithuania	15.7	4.1	1.0	13.5	5.5	3.8	0.4	10.2	3.4	2.3	0.2	39.8
Luxembourg	3.0	2.8	0.6	5.3	19.8	11.5	0.5	14.9	0.8	8.8	0.0	32.1
Latvia	5.5	6.3	0.5	17.9	9.1	5.2	1.1	13.0	3.8	4.8	0.2	32.7
Malta	2.6	3.4	0.8	7.1	6.8	29.7	0.3	6.5	2.3	5.2	0.2	35.2
Netherlands	5.5	4.1	0.7	8.1	7.0	10.9	0.2	17.1	2.1	11.7	0.4	32.2
Poland	4.3	5.3	0.6	10.2	15.1	12.0	0.9	14.4	3.5	5.5	0.4	27.8
Portugal	2.7	6.0	1.1	12.4	11.7	13.1	0.9	11.3	2.1	6.9	0.2	31.7
Romania	4.8	5.6	1.8	11.4	12.5	7.5	0.5	6.9	2.9	4.9	0.2	41.1
Slovak Rep.	4.0	2.4	0.9	5.2	13.4	24.5	0.8	10.7	3.5	4.7	0.1	29.8
Slovenia	3.1	1.6	0.6	10.2	18.5	11.2	0.4	12.6	2.7	5.4	0.3	33.5
Sweden	1.8	3.2	1.4	5.1	10.6	16.6	0.4	11.7	5.5	11.9	0.5	31.3

Note: * not including NACE Rev. 1 23 coke, refined petroleum and nuclear fuel.
Source: WIOD; wiiw calculations.

Finally, Table 1.6 reports the structure of energy cost shares in the EU Member States in 2011. In the majority of EU countries, electrical energy, gas, etc. (CPA 40) accounts for the largest share of total energy costs, which often exceeds 50%. Exceptions to this are Denmark, Ireland and Lithuania. The second biggest share stems from coke and refined petroleum (CPA 23), again with some notable differences across countries. The remaining two categories account for only small shares, though there are distinct country-specific patterns.

Table 1.6 / Energy cost shares by CPA in % of total energy costs in EU Member States, in basic prices, 2011

	Total economy				Manufacturing				Manufacturing*			
	Coal (CPA 10)	Crude oil and gas (CPA 11)	Coke etc. (CPA 23)	Electrical energy, gas, etc. (CPA 40)	Coal (CPA 10)	Crude oil and gas (CPA 11)	Coke etc. (CPA 23)	Electrical energy, gas, etc. (CPA 40)	Coal (CPA 10)	Crude oil and gas (CPA 11)	Coke etc. (CPA 23)	Electrical energy, gas, etc. (CPA 40)
Austria	1.1	22.1	9.6	67.1	2.2	58.0	9.3	30.5	0.7	25.8	16.9	56.5
Belgium	2.3	39.6	34.2	23.9	2.5	57.5	24.8	15.2	10.5	0.4	30.5	58.7
Bulgaria	7.7	32.1	40.3	19.9	3.9	56.5	22.8	16.8	10.9	11.3	39.6	38.2
Cyprus	5.2	42.8	10.7	41.3	8.8	0.0	10.6	80.6	8.8	0.0	10.6	80.6
Czech Rep.	9.0	12.0	32.3	46.7	9.3	24.4	32.0	34.3	6.6	0.4	44.0	49.1
Germany	4.6	5.9	43.2	46.3	3.3	12.9	42.8	41.0	1.8	2.6	38.5	57.1
Denmark	1.7	39.1	44.8	14.3	0.2	70.8	18.4	10.6	0.7	0.0	60.3	39.0
Spain	1.9	30.3	23.9	44.0	0.7	51.9	22.0	25.4	2.1	0.1	23.9	73.9
Estonia	0.0	25.6	27.9	46.5	0.0	20.2	13.1	66.7	0.0	9.8	14.9	75.3
Finland	5.6	34.6	31.5	28.3	2.9	59.2	20.6	17.3	10.5	6.0	24.9	58.5
France	1.2	29.5	41.8	27.4	1.7	49.7	33.7	14.9	1.6	0.1	47.5	50.8
Great Britain	2.4	46.4	10.3	41.0	0.3	66.5	5.3	27.9	0.8	0.5	12.7	86.0
Greece	4.5	40.1	27.0	28.4	0.3	71.0	9.5	19.2	0.7	26.9	19.8	52.6
Hungary	1.7	39.3	26.5	32.6	2.9	40.5	25.7	30.9	0.4	4.5	36.5	58.6
Ireland	35.8	0.0	10.9	53.3	73.4	0.0	2.1	24.5	63.7	0.0	2.9	33.4
Italy	1.5	49.1	17.0	32.4	1.8	60.9	7.2	30.0	4.6	0.0	16.0	79.4
Lithuania	0.5	55.6	19.8	24.0	0.0	76.3	12.0	11.6	0.1	53.3	22.9	23.7
Luxembourg	0.7	18.7	17.8	62.7	3.5	0.0	4.2	92.2	3.5	0.0	4.2	92.2
Latvia	2.1	14.6	30.4	52.9	0.6	8.7	32.3	58.5	0.6	8.7	32.3	58.5
Malta	0.1	0.0	40.8	59.0	1.4	0.1	6.2	92.4	1.4	0.0	6.2	92.5
Netherlands	1.4	46.5	23.5	28.5	0.9	65.1	25.3	8.7	3.3	24.5	43.3	28.9
Poland	12.2	25.0	26.3	36.5	10.5	46.9	15.3	27.2	6.4	21.0	22.0	50.5
Portugal	1.4	22.5	22.8	53.2	0.1	62.4	14.2	23.3	0.4	0.0	24.8	74.8
Romania	4.3	26.5	8.1	61.0	2.5	28.4	9.1	60.0	4.0	0.0	12.8	83.1
Slovak Rep.	3.0	26.4	11.1	59.6	5.3	49.2	12.3	33.2	11.3	3.2	18.1	67.4
Slovenia	7.7	11.4	26.6	54.3	1.4	21.1	14.8	62.7	1.4	21.1	14.7	62.8
Sweden	3.2	45.1	18.5	33.2	2.7	69.9	6.8	20.5	9.0	0.0	22.2	68.8

Note: * not including NACE Rev. 1 23 coke, refined petroleum and nuclear fuel.
Source: WIOD; wiiw calculations.

1.2 ENERGY INTENSITIES

1.2.1 INTRODUCTION

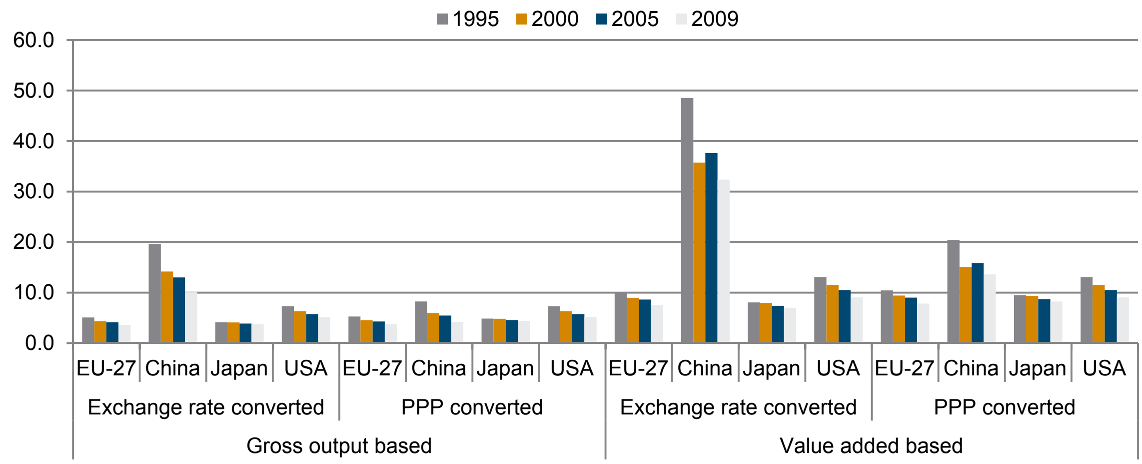
The general focus of the study is on energy intensities, with this section just focusing on their evolution over time in a comparative manner across countries. In addition to the SUTs and IO tables, the WIOD provides energy accounts, i.e. energy flows (gross energy use) in terajoule (TJ), with the same country and sectoral coverage over the period from 1995 till 2009. These satellite energy accounts of the WIOD provide details of energy use in TJ by sector and energy type. The WIOD includes 26 different energy types, which for the sake of presentation will be consolidated into a few categories. First, we provide a detailed descriptive assessment concerning energy inputs per unit of gross output. Second, aiming at studying the changes in energy efficiency, in the next step we conduct decomposition analysis. The latter disentangles change in energy efficiency into an energy intensity and structural change effect, using a so-called log mean Divisia index method which is the preferred method in energy decomposition analysis (see Ang, 2004; Mulder and deGroot, 2012).

1.2.2 PATTERNS OF ENERGY INTENSITIES

Figure 1.3 presents these energy intensities for the total economy in four selected economies: the EU-27, the US, Japan and China. The graphs show energy intensities with respect to both gross output and value-added, using both exchange rates and PPPs to convert into a common currency. The base year for deflation is 2005. As can be seen, the results are highly sensitive to the above-mentioned choices. Due to the undervaluation of the Chinese currency, converting at exchange rates results in energy intensity being more than twice as high as energy intensity obtained when converting at PPPs. When converting with PPPs, energy intensity levels for China are not significantly different from those for the other countries using gross output as a base. For the other countries, where exchange rates are more in line with the price levels, the differences are smaller. This is also true when using a value-added-based measure. Although China shows significantly higher energy intensities compared to the other countries irrespective of whether exchange rates or PPPs are used, in the former case China's energy intensity levels are much higher. Based on value-added, the EU-27 and Japan show the lowest energy intensity levels. The difference between the gross output-based and value-added-based measures is explained by the share of intermediate inputs, which accounts for approximately 50% but is larger in China.

As value-added better reflects the part of the production process which is actually being undertaken, using value-added as a base seems to be a better choice.[4] This is particularly the case when an industry uses a significant amount of intermediate inputs (e.g. in manufacturing industries), a large portion of which can be imported. However, energy intensity levels could be biased upwards in cases where the low share of value-added is driven by the low wages paid. In the remainder of the study, we refer to results based on energy inputs relative to value-added.

Figure 1.3 / Energy intensities of total economy (in TJ per USD million of gross output or value-added, base year 2005)



Source: WIOD; wiiw calculations.

4 This is in analogy with unit labour costs being calculated using value-added instead of gross output.

BOX 1.1 / MEASURING ENERGY INTENSITY LEVELS

Energy intensity in a sector i at time t is defined as energy input (measured in terajoule) relative to an output measure such as gross output or value-added (or even other intermediate inputs depending on the assumptions concerning substitutability). The output measure is in current nominal currency terms; thus, it has to be deflated to provide a constant price series over time, and converted into a common currency by either using nominal exchange rates or purchasing power parities (PPPs) to make them comparable across countries. Denoting energy use as E_{it} and the respective output measures as Y_{it}, energy intensity in sector i at time t is defined as

$$I_{it} = \frac{E_{it}}{Y_{it}} \qquad (1)$$

An aggregate of energy intensities (e.g. for the total economy or manufacturing) can be calculated by using the sectoral shares (in the respective aggregate), i.e. $s_i = \frac{Y_{it}}{Y_t}$ where Y_t denotes the respective total gross output measure, and summing them up, i.e.

$$I_t = \sum_i s_i \frac{E_{it}}{Y_{it}} = \sum_i \frac{Y_{it}}{Y_t}\frac{E_{it}}{Y_{it}} = \frac{E_t}{Y_t} \qquad (2)$$

A decision has to be made on whether to express energy intensity as a ratio to gross output (i.e. including intermediate inputs) or to value-added (or even only intermediate inputs). A second issue concerns the deflation procedure applied. The WIOD data provide price deflators for constant 1995 prices which could be rebased to another base year (e.g. 2005). It is worth noting that in a constant price series, choosing another base year also does change the growth rates and therefore the indexed series; thus the dynamics, e.g. the convergence or divergence patterns, might look different when choosing different base years. Third, currency conversion at either exchange rates or PPPs (for the respective price year chosen) affects the levels of energy intensities across countries because of the under- or overvaluation of nominal currencies. Data converted at PPPs rather than exchange rates give a better measure of constant price output levels across countries.

Table 1.7 / Energy intensities in the major economies (TJ per million USD of value-added in PPPs 2005)

	Total economy		Manufacturing		Manufacturing*	
	1995	2009	1995	2009	1995	2009
EU-27	10.4	7.8	31.1	24.6	12.2	9.1
EU-15	9.8	7.6	30.1	25.9	11.0	9.4
EU-12	15.8	9.7	39.1	18.7	23.4	7.8
China	20.4	13.6	38.3	20.4	26.4	13.3
Japan	9.5	8.3	25.0	22.9	11.2	9.9
USA	13.1	9.0	46.7	34.6	16.4	11.1

Note: * not including NACE Rev. 1 23 coke, refined petroleum and nuclear fuel.
Source: WIOD; wiiw calculations.

Furthermore, as indicated above when describing the cost shares (see Table 1.1), there can be substantial differences when considering manufacturing only and depending on whether NACE Rev. 1 23 (coke, refined petroleum and nuclear fuel) is included or not. In Table 1.7, energy intensities are presented for the total economy, manufacturing and manufacturing excl. NACE Rev. 1 23, now also differentiating between EU-15 and EU-12 countries. At the total economy level, energy intensity is the lowest in the EU-15 and the EU-12, with intensity levels in Japan and the US being above the EU-27 level by 6% and 15% respectively. The energy intensity level in China is almost double that of the EU-27. Notably, energy intensity has decreased in all regions and countries considered, particularly so in the EU-12 (from 15.8 to 9.7 TJ per million USD) and China (from 20.4 to 13.6 per million USD). Considering manufacturing only, energy intensity levels are much higher, ranging from around 20 per million USD in the EU-12, China and Japan to 25.9 in the EU-27, and up to 34.6 in the US. Again, these have decreased substantially since 1995. Considering manufacturing without coke, refined petroleum and nuclear fuel, the energy intensity levels are only slightly higher than for the total economy, with the same patterns and dynamics observable. This is not surprising, as manufacturing industries tend to be more intensive in energy use as compared to services (with the exception of transport services). Surprisingly, in manufacturing (including NACE Rev. 1 23), China's energy intensity is even lower than in the more advanced countries due to a much lower energy intensity in NACE Rev. 1 23. However, when considering manufacturing without this sector, the energy intensity in China is higher than in the more advanced countries. Similarly, the energy intensity of manufacturing in the EU-12 is lower than in the EU-15. The higher energy intensity in US manufacturing as compared to the EU-27 is explained by the larger share of industry NACE Rev. 1 23 in the US (about 10% versus 3% in the EU-27). However, even without this industry, the energy intensity of manufacturing in the EU-27 is still lower than in the US, which also holds for almost all individual sectors.

Table 1.8 / Energy intensities in EU Member States (TJ per million USD of value-added in PPPs 2005)

	Total economy		Manufacturing		Manufacturing*	
	1995	2009	1995	2009	1995	2009
Austria	6.9	6.1	23.0	18.9	9.6	10.5
Belgium	14.2	12.0	47.5	47.1	18.5	15.5
Bulgaria	26.6	15.6	59.5	29.4	33.7	10.0
Cyprus	9.2	5.5	36.4	7.9	10.5	7.9
Czech Republic	13.8	10.8	28.1	15.1	20.3	8.2
Germany	9.5	7.6	22.4	19.3	9.1	7.5
Denmark	10.8	7.4	25.8	21.1	6.8	4.6
Spain	8.7	6.9	29.7	28.2	10.0	10.3
Estonia	23.2	12.9	45.9	20.2	42.0	19.8
Finland	18.3	15.7	54.1	37.8	25.4	17.0
France	10.1	7.7	40.6	26.8	14.9	8.6
Great Britain	9.1	5.8	28.6	25.7	8.5	7.8
Greece	9.5	7.6	48.5	44.9	8.9	7.1
Hungary	11.7	9.1	25.7	18.8	14.5	7.4
Ireland	6.6	4.6	12.3	6.0	5.9	2.6
Italy	7.8	7.0	24.1	25.2	8.9	8.3
Lithuania	22.3	16.0	50.2	51.2	18.2	8.0
Luxembourg	4.8	5.5	21.0	14.1	21.0	14.1
Latvia	12.0	5.5	18.5	11.3	18.1	11.3
Malta	14.4	7.1	2.5	2.1	2.5	2.1
Netherlands	15.5	10.9	67.8	46.7	25.2	24.0
Poland	15.3	9.0	49.7	17.1	29.0	6.9
Portugal	9.4	7.5	38.0	31.0	12.5	11.8
Romania	19.0	8.8	43.5	17.9	21.7	6.9
Slovak Republic	16.2	10.8	46.8	25.8	32.8	12.4
Slovenia	8.8	6.3	12.7	5.9	8.6	5.9
Sweden	17.0	11.7	48.2	33.2	21.1	13.4

Note: * not including NACE Rev. 1 23 Coke, Refined Petroleum and Nuclear Fuel.
Source: WIOD; wiiw calculations.

Table 1.8 presents energy intensities in 1995 and 2009 for the EU Member States for the total economy, manufacturing and manufacturing without industry coke, refined petroleum and nuclear fuel. Overall patterns are similar to those already reported in Table 1.7. In particular, the numbers show a significant decline of energy intensity in the EU-12 countries, with some of them now having even lower levels than some EU-15 countries.

1.2.3 DECOMPOSITION OF CHANGES

In this section, the changes in energy intensities are discussed in more detail. As just seen above, there appears to be a convergence of energy intensities across countries, and within the EU-27 in particular. Such convergence can be driven by two factors. First, energy intensities in each industry might decline; second, the structure of the economy may shift towards less energy-intensive activities or industries. To analyse this in more depth, we apply the log mean deviation index (see Ang, 2004; Mulder and deGroot, 2012) allowing one to split changes in energy use per unit of output into an intensity and structural effect.

BOX 1.2 / DECOMPOSITION APPROACH

The decomposition starts with equation (2) above which is rewritten here as

$$I_t = \sum_i \frac{Y_{it}}{Y_t} \frac{E_{it}}{Y_{it}} = \sum_i s_{it} I_{it} \qquad (3)$$

The log mean Divisia index method in its additive form decomposes a change in aggregate energy intensity, i.e. ΔI_t, between two periods into an efficiency effect (i.e. a decline in intensity) denoted by $\Delta I_{int,t}$ and a structure effect denoted by $\Delta I_{str,t}$ according to

$$\Delta I_{int,t} = \sum_i w_i \ln\left(\frac{I_{i,T}}{I_{i,0}}\right) \quad \text{and} \quad \Delta I_{str,t} = \sum_i w_i \ln\left(\frac{s_{i,T}}{s_{i,0}}\right), \qquad (4)$$

where $w_i = \frac{I_{t-1} - I_t}{\ln(I_{t-1}/I_t)}$ defines a weighting function; index 0 and T denote the first and last period respectively. The advantages of this type of decomposition are discussed in detail in Mulder and deGroot (2012). It should be further emphasised that for this type of analysis it does not matter whether one converts with exchange rates or PPPs. However, one should also be aware that this analysis may overstate the intensity effect, as it cannot capture structural shifts within the 2-digit industries considered here.

Analogously to above, first we present the changes in energy intensities for the major economies: the EU-27, the US, Japan and China. Again, results for the total economy, the manufacturing industry and manufacturing industry without NACE Rev. 1 23 are presented separately (Table 1.9), with numbers indicating the average annual changes in percentages. At the total economy level, the largest declines in energy intensities are observed for the EU-12 (-3.5%) and China (-2.9%). This is followed by the US (-2.6%), EU-15 (1.9%) and Japan (-1.0%). In the EU-27, the structural effect (-1.5%) has been however much more important, with the intensity effect (efficiency increase) contributing less. This is different to China where the intensity effect has been much stronger (-4%) compared to the structural effect, which has been even slightly positive. This has also been the case in the US. The energy intensity decline in

Japan has been however again mostly driven by the structural effect (with the intensity effect being even slightly positive).

Considering manufacturing only, one observes that the general decline of energy intensity has been even lower in the EU-15, with the intensity effect dominating. However, for the EU-12 the decline was stronger in manufacturing as compared to the total economy, with the structural effect being again more important (-3.8%) than the intensity effect (-1.5%). The stronger gain in energy efficiency in manufacturing has also been observed for China, with the intensity effect being more important – similarly to the total economy. In Japan, the structural effect has been more important (-1.7%) whereas the intensity effect has, on the contrary, been strongly positive (+1.1%), thus resulting in an overall decline of energy intensity by -0.6% only. The opposite pattern could be observed in the US where the intensity effect (-5.3%) has been partly offset by the positive structural effect (+3.2%), resulting in an overall decline of energy intensity by 2.1%.

Table 1.9 / Results from the decomposition analysis of changes in energy intensity

Annualised growth rates in %, 1995-2009

	Total economy			Manufacturing			Manufacturing*		
	Total	Intensity effect	Structural effect	Total	Intensity effect	Structural effect	Total	Intensity effect	Structural effect
EU-27	-2.1	-0.5	-1.5	-1.7	-0.5	-1.2	-2.1	-2.2	0.1
EU-15	-1.9	-0.7	-1.1	-1.1	-0.8	-0.3	-1.2	-1.5	0.3
EU-12	-3.5	-0.8	-2.7	-5.3	-1.5	-3.8	-7.8	-6.6	-1.2
China	-2.9	-4.0	1.1	-4.5	-4.3	-0.2	-4.9	-4.8	-0.1
Japan	-1.0	0.2	-1.1	-0.6	1.1	-1.7	-0.9	-0.2	-0.7
USA	-2.6	-3.0	0.4	-2.1	-5.3	3.2	-2.8	-1.5	-1.2

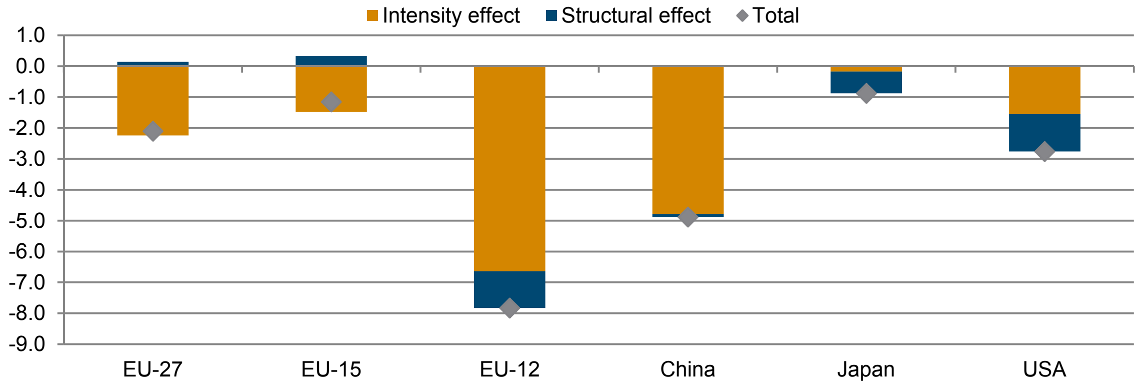
Note: * not including NACE Rev. 1 23 Coke, Refined Petroleum and Nuclear Fuel.
Source: WIOD; wiiw calculations.

However, the relative importance of the structural versus the intensity effect is to some extent sensitive to the inclusion of the most energy-intensive sector, NACE Rev. 1 23 (coke, refined petroleum and nuclear fuel), which is further characterised by declining shares in value-added, thus giving more weight to the structural effect. Focusing on the manufacturing industries, excluding this sector, provides a slightly different picture and is shown in Figure 1.4 (based on results reported in Table 1.9).

Again, an increase in overall energy efficiency has been observed for all countries and regions. This results from the declines in energy intensities ranging from -0.2% per year in Japan, -1.5% in the EU-15 and the US, -4.8% in China to -6.6% in the EU-12. Thus, in this case, the intensity effect dominates in all countries with the exception of Japan. The structural effect points towards a slight decrease in manufacturing energy efficiency in the EU-15, which is explained by a structural shift towards the chemical industry as this tends to be relatively more energy-intensive compared to the other industries. In the EU-12, Japan and the US, the negative contribution of the structural effect is mostly explained by a strong shift towards high-tech industries such as electrical and optical equipment and transport equipment. Surprisingly, structural shifts are negligible in China. The reason for this is that though there has been a significant shift towards the electrical and optical equipment sector over this period, the initial energy intensity of this industry was rather high (though strongly declining).

Figure 1.4 / Results from the decomposition analysis of changes in energy intensity for manufacturing industries excl. NACE Rev. 1 23 in the major economies

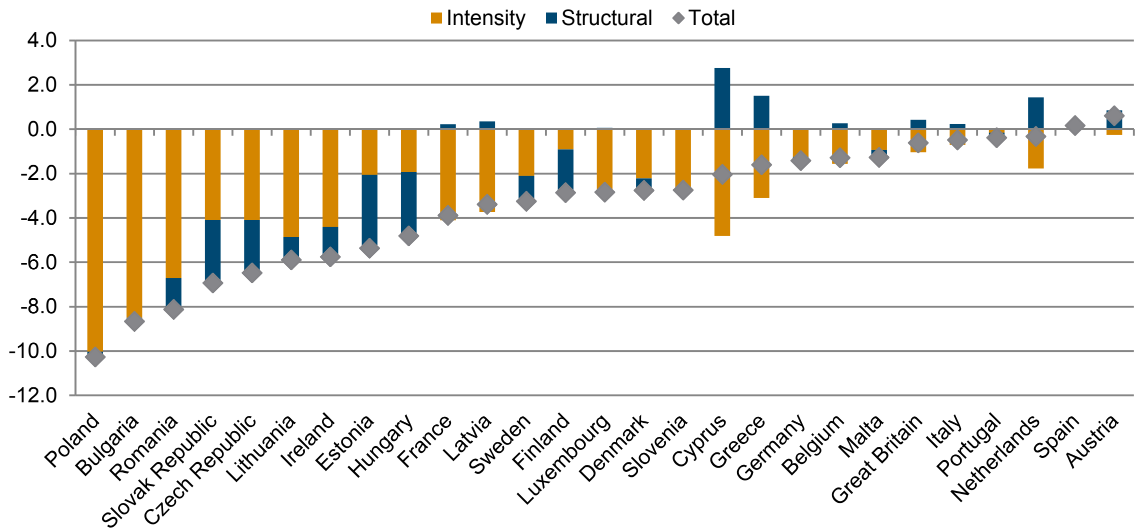
Annualised growth rates in %, 1995-2009



Note: Figures do not include NACE Rev. 1 23 Coke, Refined Petroleum and Nuclear Fuel.
Source: WIOD; wiiw calculations.

Figure 1.5 / Results from decomposition analysis for manufacturing industries excl. NACE Rev. 1 23 in EU Member States

Annualised growth rates in %, 1995-2009



Source: WIOD; wiiw calculations.

The decomposition of changes in energy intensities over time is also performed for individual EU member countries, with results for the manufacturing industries, excluding NACE Rev. 1 23, presented in Figure 1.5. As already demonstrated in Figure 1.4, the largest declines in energy intensities took place in the Eastern European countries, with Poland leading (-10%), followed by the Slovak Republic (-8.6%) and the other countries with declines between -7.2% (Estonia) and -5.2% (Latvia). Only Slovenia showed a lower decline with -2.8% per annum. In most of these countries, the intensity effect dominates though the structural effect also plays an important role due to the shift towards the higher-tech industries. Exceptions to that are Poland, Bulgaria and Latvia, where only the intensity effect matters. The reason in Poland is that although there has been a structural shift away from textiles and textile products and towards transport equipment, the initial energy intensity levels have been rather similar, so that the structural shift does not show up in a change in overall energy intensity. Similarly, in Bulgaria the structural shifts have been stronger but also across sectors with similar levels of initial intensity. In the other countries, the overall changes in energy intensities were between -4% in France and even slight increases such as in Spain and Austria. In eight countries the declines in energy intensity have been negligible or slightly positive. For those countries where the change in energy intensity has been significant, the intensity effect has dominated, with the exceptions of Finland and Sweden. In Cyprus, Greece and Netherlands the structural effect has even been positive. In Cyprus and Greece, there has been a strong shift towards non-metallic mineral products (and basic and fabricated metals in the case of Greece), which have relatively high energy intensities. In the case of the Netherlands, a shift towards chemicals and chemical products has driven the positive structural effect.

1.2.4 PATTERNS AND CHANGES IN ENERGY MIX

Finally, this section provides a quick overview of the energy mix in direct inputs in the respective countries. Table 1.10 reports the structure of direct energy inputs for the major world economies, with the EU-27 as a whole. In the EU-27, petroleum accounts for the largest share in direct energy inputs, with 51.1% in 1995 and 48% in 2009. The second most important energy input is electricity with 21.8% and 16.3% respectively. Coal inputs show the most significant decline from 16.3% in 1995 to 12.1% in 2009, whereas the share of gas increased from 11% to almost 14%, and that of renewables from 1.3% to 3.2%. This can be compared to the US where about half of direct energy inputs is also accounted for by petroleum, but the share of electricity is somewhat smaller (17% in 2009) and that of coal is higher (16.4%). The share of gas is similar to the one in the EU-27. China is different: the share of coal makes up 57.3%, with the share of petroleum being much smaller (only about 24% in 2011).

Table 1.10 / Shares of direct energy inputs by energy type in the major economies (in % of total energy inputs in TJ)

	Petroleum		Electricity		Coal		Gas		Renewables		Distribution loss	
	1995	2009	1995	2009	1995	2009	1995	2009	1995	2009	1995	2009
EU-27	51.1	48.0	19.1	21.8	16.3	12.1	11.0	13.9	1.3	3.2	1.1	1.0
China	25.5	24.3	10.4	14.3	61.1	57.3	2.2	3.3	0.1	0.1	0.7	0.7
Japan	58.4	48.3	18.3	20.1	13.6	17.1	8.5	13.0	0.6	0.9	0.5	0.6
USA	50.9	48.9	15.3	17.0	17.3	16.4	13.8	14.7	2.0	2.2	0.8	0.8

Source: WIOD; wiiw calculations.

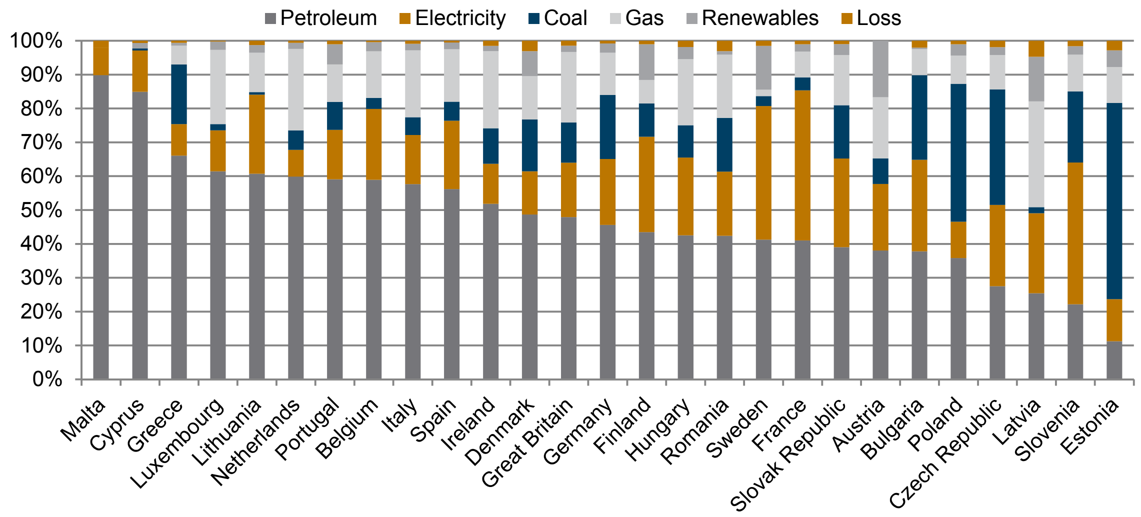
The share of petroleum in the energy mix ranges from about 90% in Malta and Cyprus to about 20% in Slovenia and Estonia. Electricity plays an important role in Sweden, France, and Slovenia, with more than 30%, but has only a minor share in Estonia, Poland, Greece, Cyprus and Malta. Finally, the share of gas ranges from 30% in Latvia to less than 10% in France, Greece and Portugal, and is almost non-existent in Sweden.

Table 1.11 / Shares of direct energy inputs by energy type in EU Member States (in % of total energy inputs in TJ)

	Petroleum		Electricity		Coal		Gas		Renewables		Distribution loss	
	1995	2009	1995	2009	1995	2009	1995	2009	1995	2009	1995	2009
Austria	45.7	38.0	19.4	19.7	10.1	7.6	16.9	18.0	7.9	16.7	0.0	0.0
Belgium	59.6	58.9	18.5	20.9	10.2	3.3	10.4	13.7	0.9	2.7	0.4	0.4
Bulgaria	36.2	37.8	26.9	27.0	21.3	25.0	13.6	7.7	0.2	0.4	1.9	2.0
Cyprus	90.0	84.9	6.6	12.2	2.5	0.6	0.0	0.0	0.6	1.6	0.4	0.7
Czech Republic	25.4	27.5	18.1	24.0	43.5	34.1	10.5	10.1	0.8	2.3	1.7	1.9
Germany	46.8	45.6	17.4	19.5	23.7	18.9	10.8	12.5	0.4	2.8	0.9	0.8
Denmark	57.3	48.7	8.3	12.8	20.0	15.3	9.0	12.8	3.1	7.4	2.3	3.1
Spain	64.8	56.2	17.0	20.2	11.5	5.6	4.7	15.5	1.1	2.0	1.0	0.5
Estonia	17.1	11.2	8.8	12.4	55.2	58.0	10.9	10.6	2.3	5.0	5.7	2.8
Finland	42.5	43.5	26.0	28.1	14.4	9.8	6.8	7.0	9.2	10.5	1.1	1.0
France	45.6	41.0	40.1	44.3	5.4	3.9	7.0	7.6	1.1	2.1	0.9	1.1
Great Britain	54.4	47.9	14.6	16.1	16.0	11.9	13.3	20.8	0.5	1.8	1.2	1.5
Greece	69.9	66.0	6.7	9.4	22.1	17.6	0.1	5.5	0.6	0.8	0.7	0.6
Hungary	45.5	42.5	19.4	23.0	12.7	9.5	19.2	19.5	0.6	3.6	2.6	1.8
Ireland	52.5	51.8	8.6	11.8	19.7	10.5	17.1	22.7	0.5	1.6	1.6	1.5
Italy	70.0	57.7	9.8	14.5	5.8	5.3	13.5	19.8	0.2	1.9	0.8	0.9
Lithuania	47.5	60.7	32.8	23.4	1.6	0.8	13.7	11.6	0.5	2.2	4.0	1.3
Luxembourg	50.2	61.4	19.4	12.1	7.4	1.8	20.9	21.9	1.0	2.5	1.0	0.2
Latvia	36.9	25.4	22.4	23.6	5.4	1.8	21.4	31.3	7.0	13.2	6.9	4.7
Malta	92.7	89.9	4.9	8.0	1.7	0.0	0.0	0.0	0.0	0.0	0.7	2.1
Netherlands	62.6	59.9	6.2	7.9	6.6	5.7	23.6	24.0	0.5	1.8	0.5	0.6
Poland	23.6	35.8	10.4	10.7	56.9	40.8	5.7	8.3	1.8	3.4	1.6	1.0
Portugal	75.8	59.1	8.2	14.6	10.8	8.2	0.3	11.1	4.1	6.0	0.9	1.0
Romania	38.1	42.4	13.0	18.9	17.2	15.9	27.0	18.7	1.0	1.0	3.7	3.1
Slovak Republic	32.7	39.1	23.4	26.2	22.6	15.7	18.7	14.9	1.2	3.2	1.5	1.0
Slovenia	26.9	22.2	39.5	41.9	19.1	21.0	11.6	10.9	1.9	2.5	1.0	1.6
Sweden	43.7	41.3	42.0	39.5	3.3	2.9	1.2	1.9	8.2	13.0	1.6	1.5

Source: WIOD; wiiw calculations.

Figure 1.6 / Shares of different energy types in EU Member States, 2011, in % of total energy inputs



Source: WIOD; wiiw calculations.

1.3 SUMMARY

Summarising, this overview demonstrates that energy cost shares are generally relatively small in overall terms, standing at slightly less than 5% of gross output in the advanced countries considered here (the EU-27, Japan and the US), though they have been generally increasing over time. When considering manufacturing (NACE Rev. 1 15-37) only, the energy cost shares are higher, though this heavily depends on the inclusion of the industry coke, petroleum and nuclear fuel (NACE Rev. 1 23). Excluding this industry from manufacturing reduces overall energy cost shares to about 3%, which is even less than the energy cost share for the total economy. Concerning the structure of energy costs, in the EU-27, electricity and gas account for about 60% of energy-related expenditures, coke for about 30%, and coal for only 5%, though there are significant cross-country differences.

This would suggest that other cost components, e.g. labour costs, costs of high-tech intermediates, business services, etc., are probably more important from an overall EU competitiveness perspective than energy costs. Besides, other important determinants and dimensions of competitiveness such as the product quality, product differentiation, and the quality of the labour force, go beyond a simple pure cost consideration. However, as the notion of competitiveness also depends on the level of disaggregation (EU, country, industry or firm level), there might be significant impacts of changing energy costs and intensities on some specific sectors. These impacts have to be investigated at a more disaggregated industry level.[5]

Concerning energy intensity, the first important finding is that there has been a strong convergence process taking place across the major economies and particularly within Europe where the EU-12 countries have been successful in decreasing their energy intensities (or increasing energy efficiency). For the manufacturing industries excluding NACE Rev. 1 23 coke, refined petroleum and nuclear fuel, this has been mostly driven by a technological reduction of energy intensities, although a structural shift towards higher-tech industries has also played a role, particularly in the EU-12 countries. On the contrary, in the EU-15, a structural shift towards chemicals and chemical products (NACE Rev. 1 24) has constrained the scope of energy intensity reductions, which have been driven exclusively by technological improvements.

5 For a detailed assessment of energy costs see European Commission (2014b).

Task 2: Energy price developments

This chapter provides a detailed comparative analysis of gas and electricity prices across EU member countries, over time, and in comparison with the major EU external competitors: the US, Japan, China and Russia.

2.1 OIL PRICES

The dynamics of gas and electricity end-user prices for industry in the countries and regions covered by the present study has been affected to varying degrees by the dynamics of global oil prices. After the two oil ‘price shocks’ in the 1970s, the world oil price declined substantially by the mid-1980s and remained at generally depressed levels until the end of the 1990s. However, it surged dramatically during 2000-2008, reflecting partly supply bottlenecks in the face of persistently growing oil demand (especially from emerging economies such as China), geopolitical conflicts in the oil-rich areas such as Iraq and also increasing speculation in the global oil markets, particularly the latter in the run-up to the 2008 financial crisis when the volume of oil sold in the financial markets was often a multiple of the global production. As a result, by mid-2008 the oil price climbed to some USD 130-140 per barrel. The global financial and economic crisis initially resulted in sharply falling oil prices (to levels below USD 30 per barrel by early 2009). However, they resumed their upward trend soon thereafter, arguably fuelled not least by the ultra-loose monetary policy of the US Federal Reserve which contributed towards abundant global liquidity conditions. Over the past three years, the price of Brent oil – the benchmark oil blend traded in Europe – has been hovering around or exceeding USD 100 per barrel (although the price of the main US blend, West Texas Intermediate, has been somewhat lower).

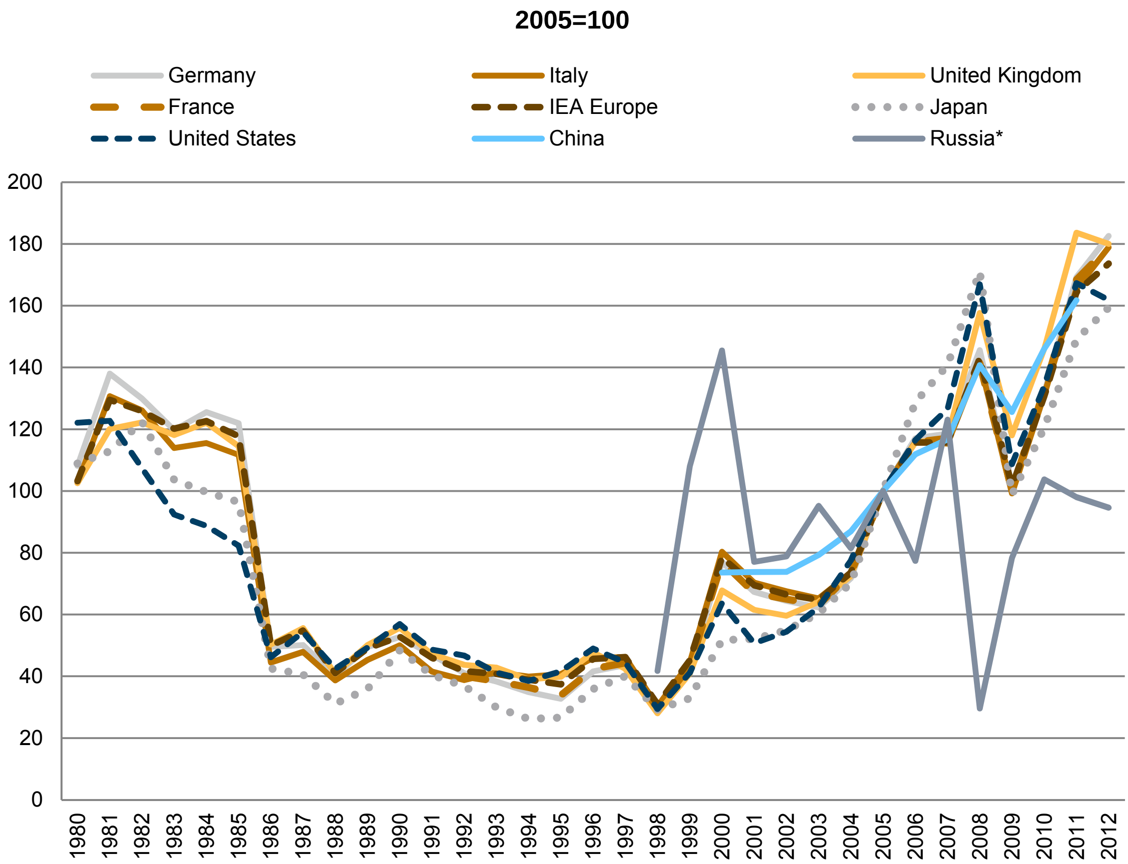
The impact of the global oil price dynamics varied however across individual countries and regions, depending on the exchange rate movements with respect to the US dollar. For instance, the trend appreciation of the euro against the US dollar during the pre-crisis years cushioned the impact of rising oil prices on Europe. Further, during 2002-2005 the oil price increase in euro terms was some 40% lower than in US dollar terms. In China whose currency was largely pegged to the US dollar[6] oil prices followed those in US dollar terms, while in Japan the surge in the US-dollar oil prices was magnified by the depreciation of the Yen against the US dollar during the pre-crisis years (Morgan and Emoto, 2007).

By and large, the developments in nominal oil prices have been accompanied by the corresponding developments in real (PPI-deflated) prices (Figure 2.1). However, the pass-through from oil to end-user gas and electricity prices has been highly uneven – both across countries/regions and over time. As illustrated by Figure 2.2, the pass-through to gas prices has been generally greater than to electricity prices. This is plausible given that oil and gas can often be used as substitutes, whereas electricity production represents the next stage in the value chain where other inputs also play a role. Besides, electricity can be generated from a number of sources other than oil and gas, such as coal as well as hydro and nuclear power.

6 A switch of the exchange rate peg of the Chinese Yuan from the US dollar to a basket of currencies in July 2005 resulted however in a minor appreciation of the Yuan, which dampened the oil price rise in China.

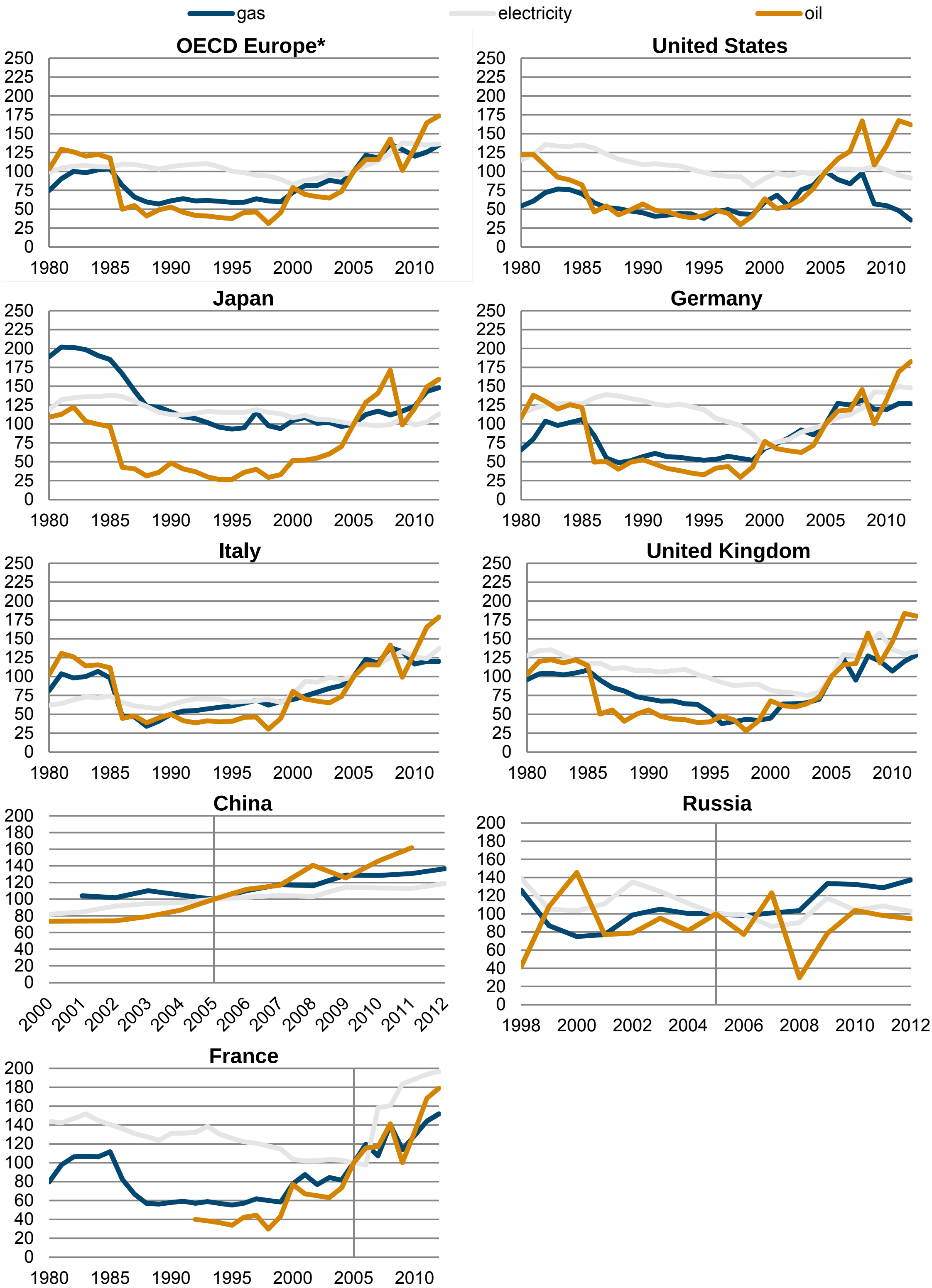
The observed cross-country differences with respect to the magnitude of this pass-through partly reflect the differences in the market structure and the pricing mechanism, e.g. in the extent of the price link between oil and gas and in the degree of price regulation at various stages of the value chain. Besides, electricity prices are affected by differences in the generation mix and the different support schemes with respect to renewables. Changes in the magnitude of the pass-through from oil to end-user gas and electricity prices over time partly reflect the shifts in the above-mentioned factors, and also technological developments. For instance, the expansion of global LNG production and shale gas production in the United States have contributed towards progressive globalisation of regionally fragmented gas markets and the increasing de-coupling between oil and gas prices in a number of regions. Similarly, the electricity price trends also reflect the increasing role of renewables in electricity generation.

Figure 2.1 / Real crude oil import price, 1980-2012



Notes: Deflated with PPI. IEA Europe is OECD Europe without Estonia, Iceland and Slovenia.
*Russia: end-user price for industry.
Source: IEA and national statistics.

Figure 2.2 / Oil, gas and electricity prices by country/region, 1980-2012, real index, 2005 = 100



Notes: Deflated with PPI. Oil price is crude oil import price, except for Russia where it is the industry end-user price. Gas and electricity prices are end-user prices for industry.
* Oil price for IEA Europe (OECD Europe without Estonia, Iceland and Slovenia).
Source: own calculations based on IEA and national statistics data.

BOX 2.1 / GAS AND ELECTRICITY PRICE DATA: SOURCES AND DEFINITIONS

The bulk of the price data for natural gas and electricity used in the present study has been derived from two sources: the International Energy Agency (IEA) and Eurostat.

The IEA provides annual and quarterly gas and electricity price data for most OECD countries, including the majority of (though not all) EU countries, for the time period since 1978. The data we use for our analysis are end-user prices charged to industry. The final (end-user) price consists of upstream/generation costs, transportation and distribution costs and margins, and taxes such as the excise tax or the renewable surcharge. Note that gas and electricity end-user prices for households and so-called 'commercial' users (e.g. schools and hospitals) are usually very different from prices for industry. In Europe, they are typically much higher, although this is not the case e.g. in Russia, China or Japan because of the cross-subsidisation of residential energy users by industry.

Gas and electricity supply contracts for industrial end-users are typically rather complex. For instance, the gas and electricity price varies greatly depending on the volume consumed: the larger the energy consumption, the less the price, reflecting the lower marginal costs of energy supplies to large users. In addition, contract and tariff conditions typically depend on the continuity of supply, load factors and the diurnal pattern of use, and may include a fixed charge ('network') component irrespective of the volume consumed. Given this complexity, the IEA derives a representative energy price by calculating the average unit value of energy consumed. The latter is either obtained from utilities as average revenue per unit delivered, or from industry as average expenditure per unit purchased. In this sense, the gas and electricity price data provided by the IEA are representative for the industrial sector of a particular country. Note that they reflect prices for industry as a whole rather than for individual industries, the price data for which are generally unavailable.

Eurostat provides half-yearly data on gas and electricity prices, and is a welcome addition to the IEA data in several important ways. First, it provides price data for the remaining EU countries which are not OECD members, essentially some of the former communist countries of Central and Eastern Europe. Many of them exhibited energy price dynamics which was very different from that in the 'old' EU, mostly because of the under-pricing of energy in these formerly planned economies and the correspondingly strong price hikes during the transition period. Second, Eurostat provides data on the individual components of electricity price: energy and supply, network costs, and taxes and levies, as well as the share of renewables and the degree of monopolisation in electricity generation. Unlike the IEA, Eurostat price data are differentiated by consumption volume: it provides price data for 7 consumption bands in the case of electricity and 6 consumption bands in the case of natural gas, making it more difficult to calculate a 'representative' average price. (Prior to 2007, the classification of consumption bands was even more disaggregated). Another disadvantage of Eurostat data is the methodological break in 2007.[7]

In all cases, the reference energy price underlying our analysis is net of the value-added tax (VAT). The reason is that in the EU, the VAT imposed on production inputs – including electricity and gas used in

7 Since the second half of 2007, the price data are half-year averages, whereas prior to that they corresponded to prices on 1 January and 1 July, respectively. Besides, prior to 2007 price data were provided by standard reference consumers whereas since 2007, they are classified by standard consumption bands. Finally, prior to 2007 data were largely based on tariff price data whereas since 2007 they correspond to actual prices.

the production process – is refundable (usually in the form of a tax credit); therefore, its size should not affect the behaviour of firms. However, other taxes sometimes imposed on gas and electricity – such as the excise tax – are not refundable and are therefore relevant for our analysis. Both the IEA and Eurostat generally provide data on the tax component of end-user electricity and gas prices. In the United States, there is no uniform tax on gas and electricity, although individual states and municipalities may impose their own taxes. The latter are not reflected in the IEA statistics, making price comparisons between the US and other countries somewhat more problematic. Generally however local taxes on gas and electricity in the US are rather low.

Finally, cross-country energy price comparisons involve market exchange rates rather than purchasing power parities (PPPs), since it is exchange rates which are relevant for the production costs and the external competitiveness of firms and industries.

2.2 NATURAL GAS PRICES

2.2.1 GAS PRICES IN CONTINENTAL EUROPE

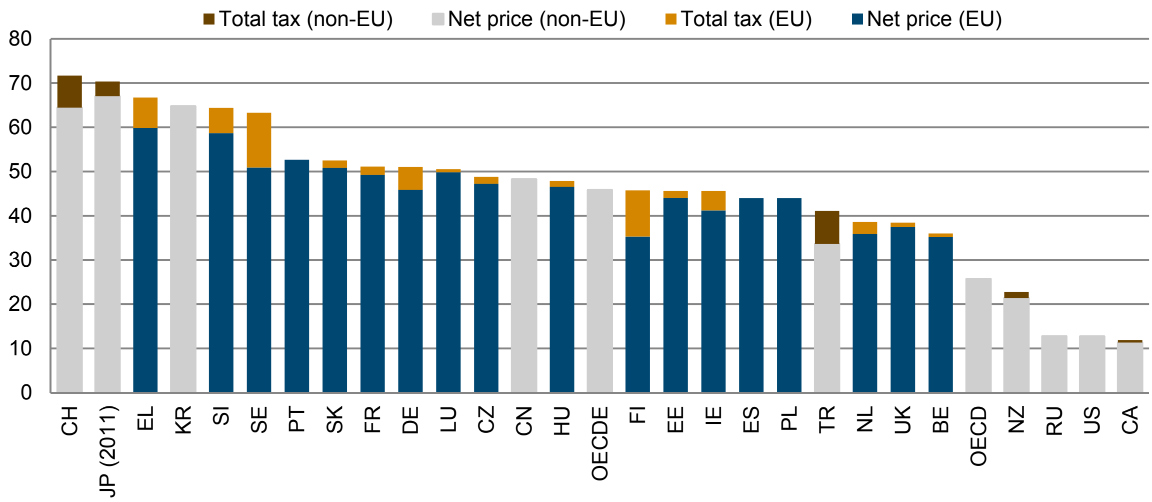
In continental Europe, the dynamics of upstream gas prices has been – at least until recently – broadly following the oil price dynamics. This is hardly surprising given that both regions are heavily dependent on gas imports and import contracts typically link the gas price to that of oil. In the EU, domestic gas production which is largely confined to the North Sea basin (including the territorial waters of the UK, Netherlands and Denmark) has recently been declining, thus making the continent increasingly dependent on gas imports. Historically, the bulk of imported natural gas came from three major external suppliers: Russia (Soviet Union), Norway and Algeria, largely via pipelines. At present, imported gas accounts for around half of EU gas consumption, with half of those imports coming from Russia. Obviously, Central and East European EU member countries are more dependent on the Russian gas supplies for geographic reasons, whereas Algeria features as an important gas supplier for Southern European countries such as Italy.

The bulk of gas imports to continental Europe are carried out within the framework of long-term contracts which typically stipulate supply volumes for years in advance and contain a formula linking the gas price to the price of oil/oil products, whereby the gas price is typically adjusted on a quarterly basis and follows the oil price with a several-months lag.[8] This means that swings in the global oil prices – including the continuous increase during the pre-crisis years, a sharp decline in 2008-2009 and a subsequent rebound in the years thereafter – have translated into changes in gas import prices in Europe with only a short delay. At the same time, the pass-through to end-user prices for industry has been generally more limited and cushioned by other (less volatile) end-price components such as transportation and distribution costs and margins, which are typically heavily regulated. In particular, regulated gas transportation costs, which are usually relatively stable, account for a significant share of the final price. As a result, although gas prices paid by the final consumers often increased as much as upstream prices in absolute terms, the increase in percentage terms has been generally much smaller (Morgan and Emoto, 2007).

[8] Such contracts also usually contain the so-called ‘take-or-pay’ clause, meaning that the gas buyer is obliged to buy a fixed share (e.g. 80%) of the stipulated volume or otherwise faces fines.

In addition, excise taxes on gas which are levied in many EU countries have in some cases provided an extra cushion to end-user prices. The size of the excise tax on gas for industry varies across EU Member States by a wide margin, with the highest rates observed in Scandinavian countries such as Finland and Sweden (Figure 2.3). In most EU countries, however, excise taxes on gas are rather low and account for less than 10% of the final price, while some countries such as Spain, Portugal and Poland do not impose excise tax on gas at all. Since excise taxes are typically specified in volume rather than value terms, an increase in the pre-tax price led to an under-proportional increase in the final price – unless the excise tax rate itself was adjusted upwards accordingly. For instance, in France where the excise tax on gas dates back to 1986, its hikes over the past ten years have been generally lagging behind the increase in the pre-tax price. On the other hand, in Germany where the excise tax on gas was imposed in 1989 the tax hikes have been more in line with the pre-tax price dynamics.

Figure 2.3 / End-user gas price for industry and its components in 2012, by country, in USD/MWh

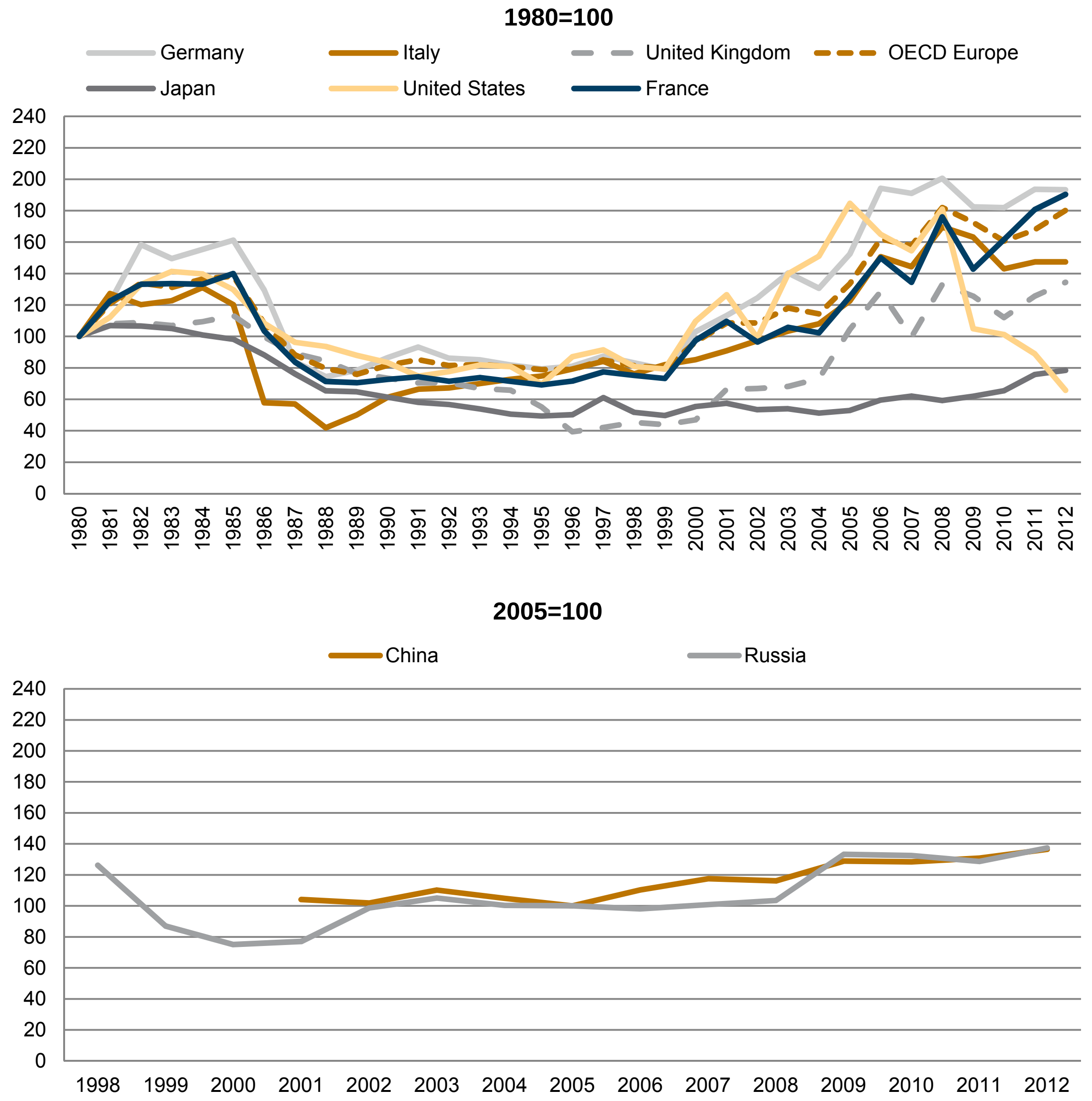


Source: IEA, national statistics.

Starting from 2009, the gas prices in continental Europe have somewhat de-coupled from the oil prices and initially declined (Figure 2.4). This has been the combined effect of weak gas demand in Europe and the shale gas ‘revolution’ in the Unites States, as a result of which the US have become almost self-sufficient in terms of gas supply. As a result, LNG shipments from third countries (such as Qatar), which previously targeted the US market, have been re-directed to markets elsewhere, notably in Europe and the Asian-Pacific area. In Europe, the share of LNG in overall gas supplies over the past few years has been constantly on the rise and reached around 20%. The spot prices paid for LNG have been generally much lower than for natural gas shipped through pipelines, putting pressure on traditional gas suppliers such as Russia and Norway, and contributing to the overall downward gas price trend in Europe. This pressure has resulted in numerous re-negotiations of long-term gas supply contracts in favour of buyers, although in Eastern Europe the scope for re-negotiations has been constrained by the more limited access to LNG and fewer possibilities for gas supply diversification. Apart from lower gas prices, usually obtained by including a spot price component into the long-term contract, the concessions achieved in the wake of recent contract re-negotiations have often involved more flexible supply terms such as the relaxation of the ‘take-or-pay’ principle, and, in a number of cases, retroactive compensations (such as those to Germany by Russia's Gazprom). As a result, according to the International Gas Union (2013), the share of European gas imported under old oil-indexation contracts dropped to around 60% by 2012, with the remainder offset by gas-to-gas competition.

However, more recently the gas price decline has come to a halt and has even reversed in a number of countries (Figure 2.4), as the share of LNG in European markets started falling again due to its diversion towards more lucrative markets in the Asian-Pacific basin.

Figure 2.4 / Real gas end-user price for industry



Notes: Deflated with PPI.
Source: own calculations based on IEA data.

2.2.2 GAS PRICES IN THE UNITED STATES

The pricing mechanism for natural gas in the United States and in the UK is very different from the one in continental Europe. Here, the link between oil and gas prices is generally less pronounced. To the extent that it existed historically, it reflected first of all the substitution possibilities between oil and gas rather than contractual price links. Upstream gas prices in the US are largely determined by the interplay of supply and demand in the wholesale gas market, with the gas supply coming partly from local production and partly from imports – both by pipeline from Canada and in the form of LNG. This pricing mechanism means that upstream gas prices in these two countries are not only largely decoupled from oil prices but also much more volatile than, for instance, in continental Europe (see e.g. Corbeau, 2010; Biermann, 2008).[9] Gas prices in the US are determined at several gas trading hubs which are usually located on interstate gas pipelines, notably in Henry Hub. There is also intense competition in the segments further down the value chain (gas transportation and distribution), meaning that all in all, gas prices in the US are determined by the market forces. On top of that, in the United States there is a strong link between wholesale and end-user gas prices. This is partly due to the low taxation: unlike in European countries (including the UK), there is no federal excise tax on gas in the United States.[10]

The deregulation of gas prices in the US started with the adoption, in 1978, of the Natural Gas Policy Act which liberalised the upstream gas prices. In the next step, the regulation of gas transportation tariffs was abolished in 1985, along with the permission of the so-called ‘third party access’ (i.e. access by companies other than the pipeline owner) to gas pipelines. By 1993, all remaining price ceilings had been removed, and since then there has been little regulatory change. Liberalisation and open access to pipelines have led to the creation of a competitive wholesale gas market in the US as well as to the emergence of numerous gas marketers – intermediary companies between gas suppliers, on the one hand, and gas distributors and large gas consumers, on the other.

The first deregulation steps and the two ‘oil price shocks’ (in the early and late 1970s respectively) resulted in US gas prices rising sharply initially: between 1970 and 1984, they jumped some 15 times. However, they fell thereafter, as implemented energy efficiency measures and slow economic growth depressed gas prices once again. Over time, the progressive liberalisation of gas marketing and wholesale gas prices attracted many new companies and created intense competition among both gas producers and marketing firms, exerting downward pressure on gas prices (Figure 2.4). Despite that, between 2000 and 2006, the end-user gas prices for industry were rising rather fast, and faster than the oil prices. Partly, this was due to supply constraints following the 2005 hurricane and a surge in gas demand, as several new gas-fired power stations came on-stream. This increase in gas prices also had a major impact on the US export performance at the time. According to Riker’s (2012) estimations, the surge in gas and electricity prices in the US during that period suppressed the country’s manufacturing exports by about USD 11.5 billion per year.

However, in 2006 gas prices in the US started declining relative to oil prices, and since 2009 have also been falling rapidly in absolute terms thanks to the rapid increase in shale gas supplies. As can be seen

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9 This price volatility has a high-frequency nature (monthly and even daily) and therefore cannot be seen from Figure 2.2 which is based on annual data.

10 However, some US states impose taxes on oil and gas production (often called ‘severance’ or ‘conservation’ taxes), which are sometimes paid by the gas purchaser. As of 2012, there were 31 states in the United States which levied such taxes (National Conference of State Legislatures, 2012).

from Figure 2.4, the resulting drop in real (PPI-adjusted) gas prices in the US has been dramatic and unmirrored in other countries and regions (see e.g. Kefferpütz, 2010). The 'shale gas revolution' in the US represented the combined effect of two revolutionary technological developments: horizontal drilling and the use of 'fracking' (i.e. pumping a mixture of water and chemicals) to release natural gas from shale rock formations (see e.g. Kefferpütz 2010). The increased gas supplies in the US have also been helped by the existing export restrictions: in order to export natural gas, producers need to obtain an export licence from the regulatory authorities. Largely under the pressure from the manufacturing lobby, which is interested in keeping domestic gas prices low, the licensing of gas exports from the United States has proceeded very sluggishly so far. However, the export restrictions are likely to be relaxed somewhat in the near-term, not least reflecting concerns over the current domestic price level being too low to encourage further investments into shale gas exploration and production. As a result of increased exports, the International Energy Agency (2013) projects that domestic gas prices in the United States will rise somewhat in the near-term from the current very low levels. Still, a sizeable gas price gap, e.g. with respect to Europe and Japan, will persist nevertheless, providing important comparative advantages to energy-intensive branches and possibly inducing a wave of re-industrialisation in the United States.

2.2.3 GAS PRICES IN JAPAN

In Japan, gas prices are closely tied to the prices of LNG, since the country imports virtually all of its gas and nearly all of it comes in the form of LNG. Japan was the first country which started importing LNG from Alaska in 1969, and is the world's biggest LNG importer. Similarly to how gas prices are linked to the long-term supply contracts in continental Europe, LNG prices in the Asia-Pacific basin, of which Japan is part, are linked to the prices of oil. However, this linkage has the form of an 'S-curve' which stipulates the upper and the lower boundary of the contract gas price irrespective of the oil price. Thus, the 'S-curve' mechanism provides certain hedging against large swings in the oil price and implies that LNG prices in the Asia-Pacific basin only follow the oil prices to some extent.

Partly because of these 'in-built' price caps, the increase in gas prices in Japan during the pre-crisis years was much less pronounced that in other countries and regions covered by the present study (Figure 2.4). However, and in sharp contrast to developments in the United States and even in Europe, import gas prices in Japan nearly doubled during the post-crisis years: from around USD 9/MBtu to USD 16/MBtu at the end of 2011. This reflects a combination of both demand and supply factors in and around Japan. On the demand side, demand for natural gas in Japan picked up after the coal-fired power generation capacities had been largely destroyed in areas hit by the 2007 earthquake. Besides, the country's government has been encouraging the replacement of coal in electricity generation by the more environmentally-friendly gas. More recently, the demand for natural gas in Japan has also been boosted by the suspension of all nuclear power generation following the 2011 Fukushima disaster. On the supply side, the tightening of LNG supply in the Asia-Pacific region has also played a role.

Apart from the recent increases in the import price, the very high level of end-user gas prices for industry in Japan (Figure 2.3) is also explained by the domestic pricing policies. The domestic gas market structure is oligopolistic: four vertically-integrated companies combined control 75% of the gas market in Japan, and the retail market is characterised by the prevalence of regional gas monopolies. Historically, their pricing power has been counterweighed by heavy government intervention into the price-setting mechanism, although over the past two decades a number of liberalisation reforms have been implemented.[11] However, there is no gas tariff differentiation between industrial and residential users in Japan. Given that the marginal costs of gas supplies to small residential users are higher than to large industrial plants, this implies cross-subsidisation of households by industry, which is reflected in the high level of gas prices paid by the latter. There is also a non-refundable 5% value-added tax on gas in Japan, although the excise tax was abolished back in 1989.

2.2.4 GAS PRICES IN CHINA

Unlike in Europe, the United States or Japan, domestic gas tariffs in China have been historically set with little regard to international energy price developments. The country's gas market is characterised by an oligopolistic structure in both the upstream and midstream segments of the value chain. Three big gas companies account for all domestic gas production in China, dominate pipeline transport and storage, and enjoy preferential access to LNG facilities, although since 2006 they no longer have exclusive rights to gas imports and exports (in practice, however, a 'third party access' to facilities is needed). At the same time, gas distribution in China is operated not by the 'big three', but by local governments, while major industrial users often purchase natural gas directly from producers (Yuying et al., 2013).

Unlike e.g. coal whose price regulation was abandoned in 2007, gas prices in China continue to be regulated on a 'cost-plus' basis.[12] Upstream prices and transportation tariffs are set by the central government and end-user gas prices by provincial authorities. Thanks to a rapid increase in domestic production, China was self-sufficient for gas up until 2006, and the 'cost-plus' formula held well to ensure gas prices remained sufficiently low to be an attractive alternative to coal – the government's stated goal. Gas prices rose only modestly during that time period – see Figure 2.4 (Morgan and Emoto, 2007). However since 2006, China has become a net gas importer, with more expensive imported gas putting the traditional 'cost-plus' formula under increasing pressure. Currently, imports – largely in the form of LNG – already account for around one-quarter of Chinese gas consumption. As a result, the average pace of the increase in upstream gas prices in China accelerated from 8.6% in 2001-2006 to 10.4% in 2007-2012, translating into an acceleration of the increase in end-user prices for industry from 4% to 5.2% respectively, although the impact of higher upstream prices on end-user prices was mitigated by tariff regulation in other segments of the value chain (HSBC 2013).[13]

At present, gas prices for industrial users in China are generally high, particularly by the standards of emerging economies, and are comparable to European gas prices (Figure 2.3), although there is a very substantial regional variation (Table 2.1). The high price level for industry partly reflects the still existing cross-subsidisation between industrial and residential users – the latter generally pay much less than industry. Another issue is gas availability in China: the over-consumption of gas by households, thanks to its under-pricing, sometimes results in shortages of gas supplies to other users such as industry and power generators (OECD/IEA, 2012).

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[11] This applies first of all to large gas consumers (>100 thousand cm of gas per year) who are allowed to choose gas supplier and negotiate price directly.

[12] This 'cost-plus' formula implied that retail gas prices in China corresponded to the costs of domestic gas production plus the transportation and distribution tariffs regulated by the government.

[13] The following example may illustrate the gap that exists between cheap domestic and more expensive imported gas in China. In Shanghai, the city gate gas price (i.e. the upstream price plus transportation tariff) at the end of 2011 ranged from USD 8/MBtu for domestic gas to USD 13 for Turkmen pipeline gas to USD 17-18 for LNG (Yuying et al., 2013).

Table 2.1 / End-user gas prices in selected Chinese cities in March 2013, in USD per MBtu

City	Industry	Residential
Beijing	12.98	10.42
Tianjin	12.79	10.05
Shanghai	15.03	11.42
Nanjing	13.48	10.05
Ningbo	17.59	12.79
Shi Jiazhuang	13.48	10.97
Tai Yuan	12.57	9.60
Chongqing	10.24	7.86

Source: Magazine of China Energy Price Association, March 2013.

In 2011, the government started a reform aimed at moving away from the current 'cost-plus' approach and gradually liberalising gas prices in the country, not least in order to create incentives for unconventional gas production.[14] The progressive liberalisation of gas prices in China is conceived as one of the nine measures to promote economic reforms. HSBC (2013) estimates that gas prices for end-users in China will increase by around 30% over the next 3-5 years, assuming the LNG import price remains flat.

2.2.5 GAS PRICES IN RUSSIA

In Russia, domestic gas prices have been historically low and have remained so both for industrial and household users (see Figure 2.3). In the case of households, cheap energy is an important social policy tool, while the low energy prices paid by industry help offset the negative impact of poor energy efficiency on industrial competitiveness, particularly in energy-intensive branches (which are prominent in Russia). This low level of domestic gas tariffs reflects, to a large extent, cross-subsidisation of domestic customers by Russia's state-owned gas monopolist, Gazprom, at the expense of export shipments (largely to Europe, which is Gazprom's main export market and where prices are the highest). Thus, similarly to China, the gas market in Russia continues to be heavily regulated, and no major liberalisation – which would involve e.g. a restructuring of Gazprom into several competing units – is currently in sight. Apart from Gazprom, there are a number of other gas producers in Russia (such as the oil companies and Novatek), but they still have limited access to Gazprom's pipeline network.

However, since 2006, Russia launched a programme of gradual domestic tariff adjustment to the so-called 'netback-parity' levels, which implies that domestic gas prices should ultimately equal export prices minus transportation costs and export-related taxes. Apart from the stated objective of encouraging energy-saving behaviour and investments into energy-efficient technologies, this programme is to be seen as part of the country's WTO-accession commitments. In particular, it was part of the bilateral Russia-EU WTO deal, as the EU viewed the low level of gas tariffs for industry in Russia as a competition-distorting factor. The initial goal of reaching the netback-parity levels by 2011 has been delayed, however, first due to the global crisis and more recently (in 2013) by the government decision to freeze the tariffs of the so-called natural monopolies in order to curb the high inflation and stimulate investments in the face of the stagnating economy. All in all, the real gas price for domestic industrial

[14] In line with the pilot reform project launched in the provinces of Guangdong and Guangxi, city-gate gas prices are now linked 60% to fuel oil and 40% to liquefied petroleum gas (LPG) prices – competing fuels for industry and residential sector, respectively. In a first stage, prices will be changed annually before moving to quarterly changes, while in the longer term, prices will be formed through market competition, with the government supervising only pipeline transportation tariffs and gas distribution fees (Yuying et al., 2013).

users has increased only moderately over the past years (Figure 2.4): the only big jump, which occurred in 2008-2009, reflected the plunging producer prices rather than the nominal gas tariff adjustments.

2.2.6 SUMMARY CONCLUSIONS: GAS PRICES IN INTERNATIONAL COMPARISON

As can be seen from Figure 2.3, end-user gas prices for industry vary across countries by a very wide margin. This is a reflection of the regional fragmentation of wholesale gas markets and the differences in wholesale gas pricing formulas, on the one hand, and the varying degree of end-user price regulation on the other.

Wherever wholesale gas prices are (still) linked to oil prices, such as in Japan, they tend to be higher than e.g. in continental Europe where the imports of LNG have put the traditional oil-indexing under increasing pressure. Conversely, in the United States and Canada where price formation in the wholesale gas markets is largely independent of the oil markets, prices tend to be much lower. In the US, wholesale gas prices have plunged over the past few years first of all thanks to the recent shale gas 'revolution' and, given the high degree of pass-through to end-user prices, have resulted in much lower prices for industry. As a result, gas prices for industry in the US stand currently at around one-quarter of the OECD-Europe average. At the same time, Figure 2.3 also illustrates that the differences in taxation levels explain only a minor part of the cross-country gas price differences. Even in Scandinavian countries where the excise taxes on gas tend to be the highest, removing them completely would only reduce the existing gap, e.g. to the US levels, insignificantly.

Elsewhere, the cross-country differences in end-user gas prices can be largely attributed to the varying degrees of price regulation. For instance, in Russia gas prices for industry are as low as in the US, but are explained by totally different factors, namely the heavy end-user price regulation and the effective cross-subsidisation of domestic customers by Russia's gas monopolist Gazprom at the expense of foreign shipments. In contrast, industrial gas prices in China have grown markedly as a result of the recent deregulation efforts, although the country's increased dependence on imports of expensive LNG has played a role as well. Gas prices for industry in China vary strongly by region, reflecting the differences in the pricing policies of regional authorities, but on average they are already broadly in line with the European level. Finally, gas prices for industry in Japan are currently among the highest in the world not only because of the high upstream prices (not least because the gas demand surged over the past few years after the shutdown of nuclear power generation capacities following the Fukushima disaster), but also because there is a de facto cross-subsidisation of households by industry.

2.3 ELECTRICITY PRICES

This section looks at the developments in industrial electricity prices in detail. The first part presents a comparison of electricity prices and their evolution between the European Union (EU) and its major competitors: the United States, Japan, Russia and China. In the second part, differences across the EU Members States are elaborated upon. In the third part, selected drivers of electricity prices are investigated.

Electricity prices depend on a range of factors. The design and organisation of the power market plays an important role for price formation and sets the framework (liberalised or regulated markets). Overall, the main factors are demand and supply (electricity generation mix). Furthermore, electricity prices are heavily influenced by various policy targets, for example combating climate change, environmental concerns or social considerations, which may result in various forms of cross-subsidisation.

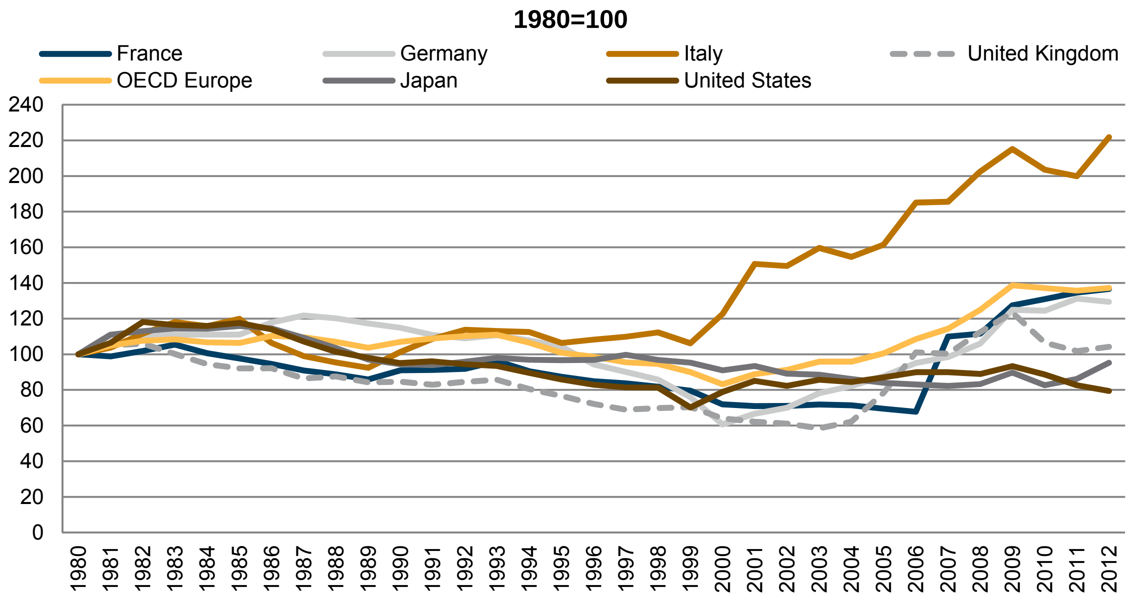
The analysis of electricity prices depends on data availability and quality. Analysis in this section concentrates on electricity end-user prices for **industrial consumers (excluding VAT)** only and does not feature household prices. To illustrate the long-run trends, we use data from the International Energy Agency (IEA), whereas to analyse the differences within the European Union, we use data from Eurostat.

2.3.1 ELECTRICITY PRICES IN INTERNATIONAL COMPARISON

Long-run electricity price developments

Figure 2.5 illustrates the long-run electricity prices developments in the European Union (OECDE representing the EU-average[15]), as well as four large EU member countries, the United States and Japan (in real terms, PPI deflated). Trends in industrial end-user prices for electricity in the EU, US and Japan were largely similar between the mid-1980s and the beginning of the 2000s, showing an overall declining trend. Figure 2.5, however, also reveals variations across the regions. While in the US, electricity prices saw a steady decline over this entire period, EU electricity prices started to decrease only ten years later. In Japan, electricity prices fell in the second half of the 1980s and then largely remained flat.

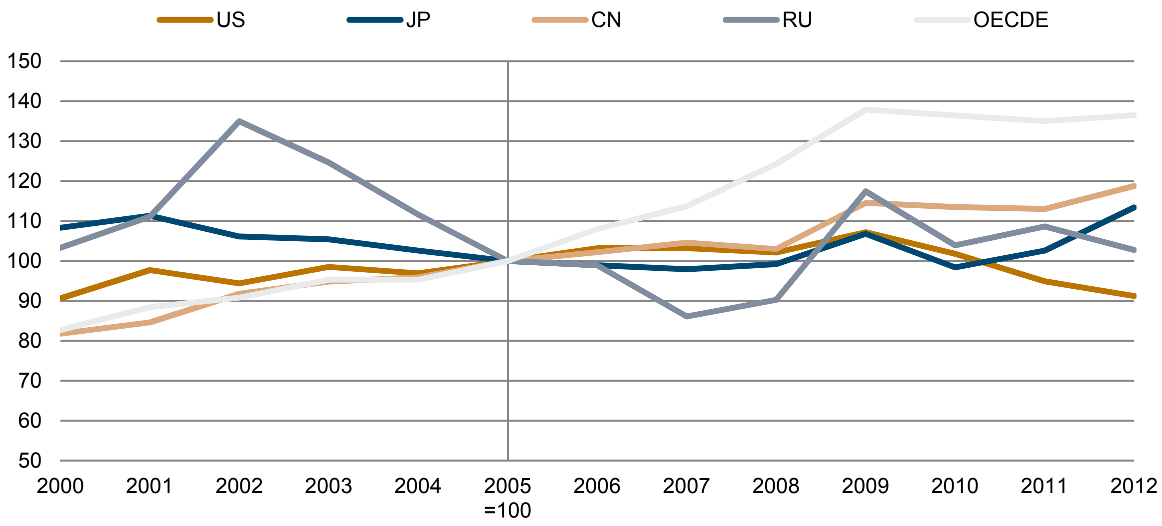
Figure 2.5 / Real electricity end-user price for industry



Note: Deflated with PPI.
Source: IEA.

[15] OECD Europe includes: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom. Prior to 1995 the Czech Republic, Estonia, Hungary, Poland, the Slovak Republic and Slovenia are excluded.

Figure 2.6 / Real end-user electricity prices in industry, 2005=100



Source: IEA and national statistics (CN, RU).

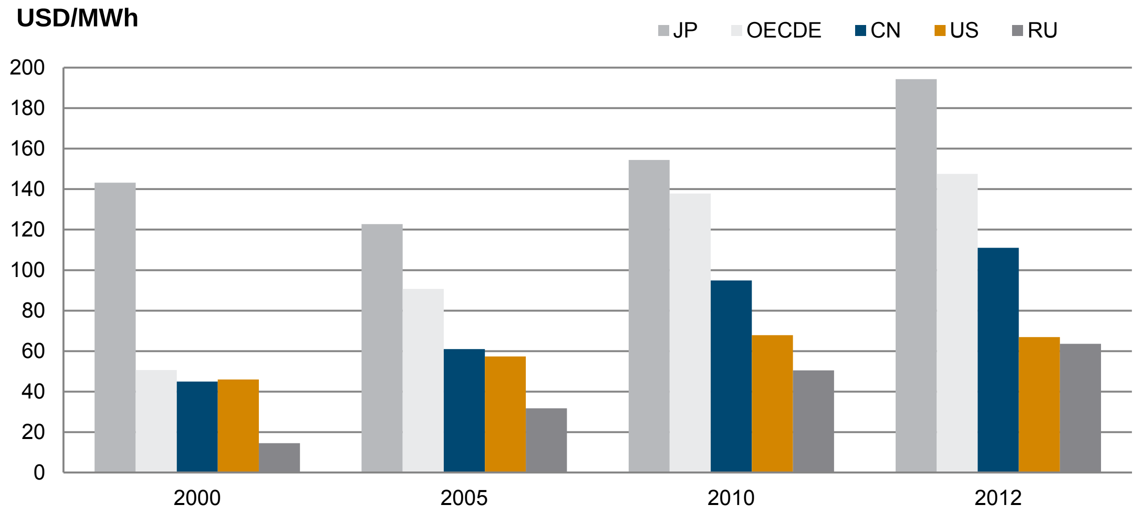
In 2000, industrial electricity prices started to rise in the EU and the US, while they continued to fall in Japan. The price rise was substantial in the EU, with prices in 2012 being 40% above the 1980 level. Only the crisis stopped the steep price increase. Differences among the EU member countries widened considerably during this decade. In the US, prices rose modestly and started to fall in 2010 as a result of the shale gas boom. In 2012 they were 20% below the 1980 level. In Japan, the decline in prices was first halted in 2009 and then in 2011. In 2012, Japanese electricity prices were nearly as high as in 1980.

Figure 2.6 adds China and Russia to the comparison of industrial electricity prices across world regions, presenting price developments during the period between 2000 and 2012 (again in real terms, deflated by PPIs). Chinese electricity prices saw a continuous rise during this time period similar to the EU, although less steep. Russian electricity prices show a comparatively high volatility, with prices declining from 2003 until 2007 and then largely rising afterwards.

Industrial electricity price levels since 2000

In 2000, industrial electricity prices (in nominal terms) varied considerably across the world regions (see Figure 2.7). They were the highest in Japan while roughly similar in the EU, China and US where they stood at about one-third of the Japanese level. Russian electricity prices were the lowest – again only one-quarter of the then EU-China-US price. Price differences widened substantially during the next twelve years. In 2012, Japanese electricity prices were still the highest (about USD 200 per MWh) and Russian ones still the lowest (USD 64 per MWh). However, the gap between the European and Chinese prices on the one hand, and the US price on the other, widened dramatically. In 2012, European electricity prices stood at USD 147 per MWh – one-quarter below the Japanese prices. However, they were higher than in China (by about 30%) and double the US and Russian levels. In addition, Figure 2.8 depicts the broad range of electricity prices across EU Member States (see below for a detailed discussion) and selected non-EU countries.

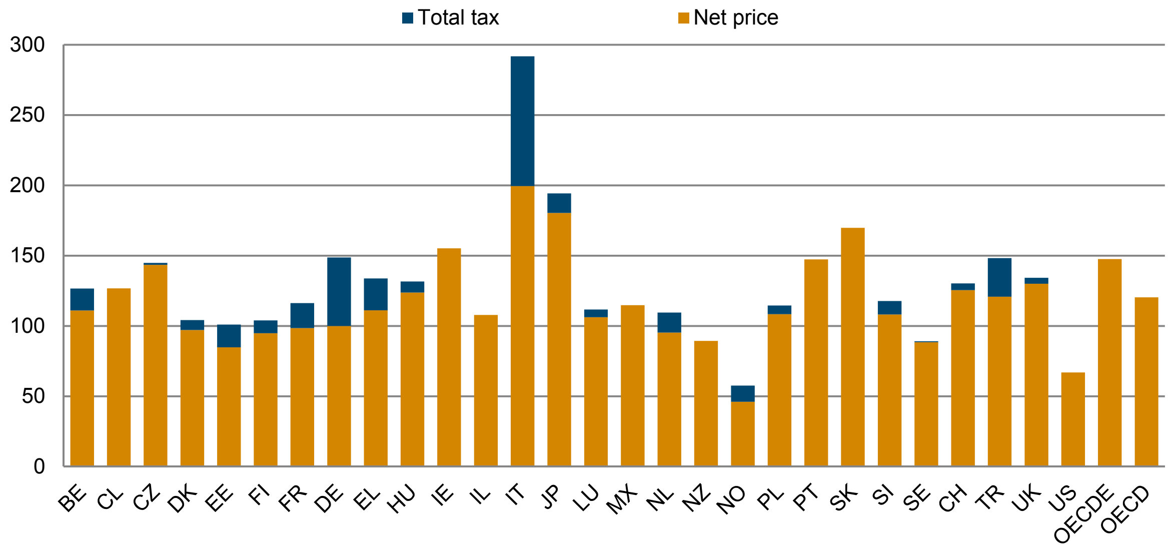
Figure 2.7 / Nominal end-user electricity prices in industry



Source: IEA and national statistics (CN, RU).

In its New Policies Scenario, the most recent World Energy Outlook of the International Energy Agency (IEA, 2013) projects that the gap in industrial electricity prices between the US on the one hand and the EU and China on the other will continue to widen modestly between 2012 and 2035. Electricity prices in the EU are projected to increase by 24% and become the highest among the major industrialised countries by 2035. They are forecast to be twice as high as prices in the US. Chinese industrial prices are projected to rise too, by almost 20%, thus remaining below the EU level. Industrial prices in Japan are said to decrease, as some of its nuclear power plants come back online and generation from renewable sources increases. Japanese prices will thus reach similar levels to those in the EU.

Figure 2.8 / Nominal end-user electricity prices in industry, various countries; in 2012, USD/MWh

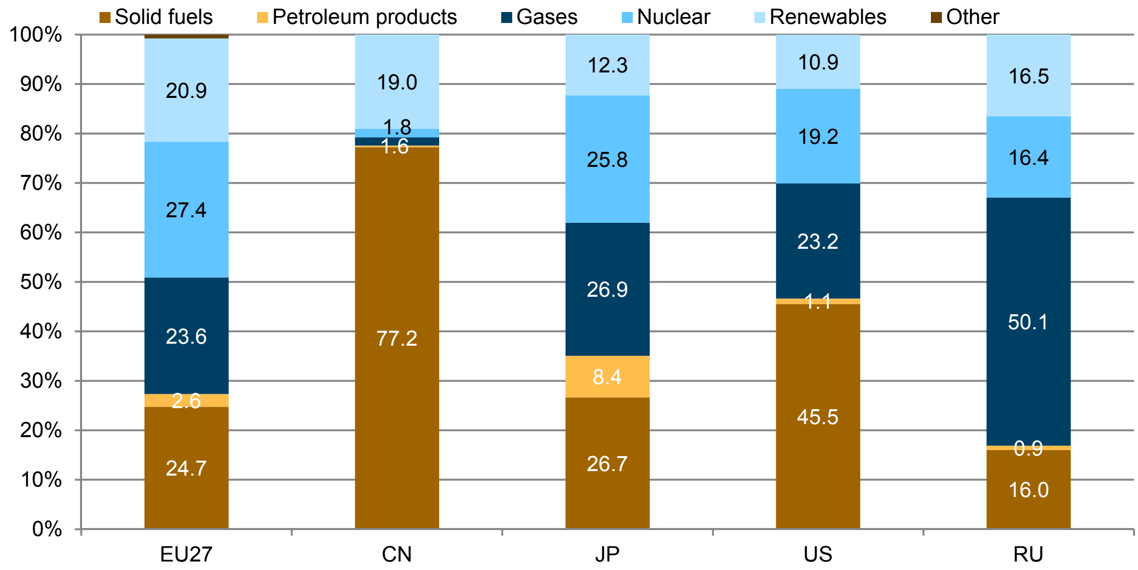


Source: IEA.

Figure 2.9 shows the electricity generation mix for the selected regions of the world. *In the EU-27,* the electricity generation mix in 2010 was rather diversified (however masking large differences across the Member States, see later on): generation from nuclear power accounted for the largest share with 27%, followed by solid fuels (25%), natural gas (24%) and renewables (21%). The currently high gas prices in the EU combined with the low coal prices and low CO_2 prices have, however, favoured coal-fired power generation and thus led to a switch from gas to coal generation (IEA, 2013).

In *China*, electricity prices are regulated. In 2010, coal was the main source of power generation, responsible for 77% of China's electricity generation, followed by renewables with 19%. Generation from petroleum products, gas and nuclear fuel was very small, with shares of below 2% each.

Figure 2.9 / Electricity generation mix, 2010, world regions



Source: European Commission Energy-Country Factsheets 2012, IEA.

In *Japan*, electricity generation in 2010 was quite diversified: electricity was generated from solid fuels (27%), gas (27%) and nuclear power (26%). The share of renewables stood at 12%. However, the accident in Fukushima Daiichi in 2011 led to the shutdown of 50 nuclear reactors and thus a sharp reduction of electricity generation from this source, although fourteen reactors should be restarted in late 2013/early 2014. In the meantime, electricity demand is increasingly being met by fossil-fuelled power plants depending on high-cost imports (IEA, 2013).

In the *United States*, solid fuels made up most of the electricity generation mix (45%) in 2010. Another important power source was gas (23%), followed by nuclear power (19%). Renewables accounted for 11% of electricity produced. However, the recent shale gas boom has led to plunging gas prices in the US and thus to a switch from coal to gas in power generation – contrary to developments in the EU (IEA, 2013).

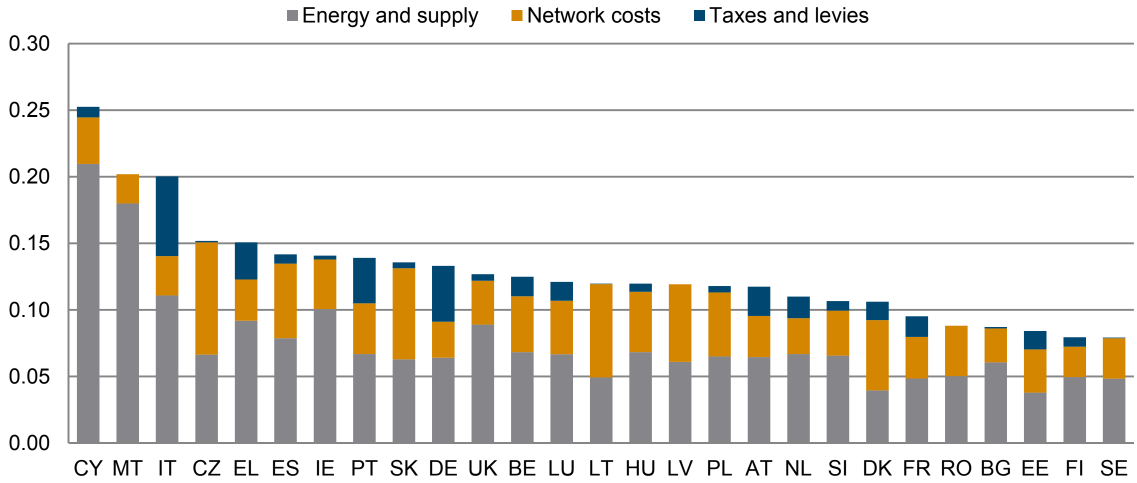
In *Russia*, the power generation mix was dominated by gas (50%), while electricity production from solid fuels, nuclear and renewables each accounted for 16%.

2.3.2 ELECTRICITY PRICES IN THE EUROPEAN UNION

This section looks at electricity prices for industrial consumers across European Member States using the Eurostat data. As there is no single price for electricity, Eurostat collects electricity prices for a total of seven different types of users according to annual electricity consumption (consumption bands IA-IF). In Eurostat publications, the standard industrial consumer refers to the medium standard industrial consumption band with an annual consumption of electricity between 500 and 2000 MWh (IC). We opted to calculate a weighted average electricity price based on the electricity consumption data from WIOD (year 2007/2008) weighted by the number of enterprises from Eurostat.

Figure 2.10 depicts this weighted average electricity price in 2012 for the countries of the European Union. As can be seen, electricity prices vary considerably, with the highest prices being observed in Cyprus, Malta and Italy. On the other hand, prices are the lowest in Sweden, Finland, Estonia, Bulgaria and Romania. Thus, prices in Cyprus were three times higher than those in Sweden. For the other countries, prices ranged between EUR 0.095 (France) and 0.152 per kWh (Czech Republic).[16]

Figure 2.10 / Weighted average electricity price for industrial consumers; in 2012, EUR/kWh

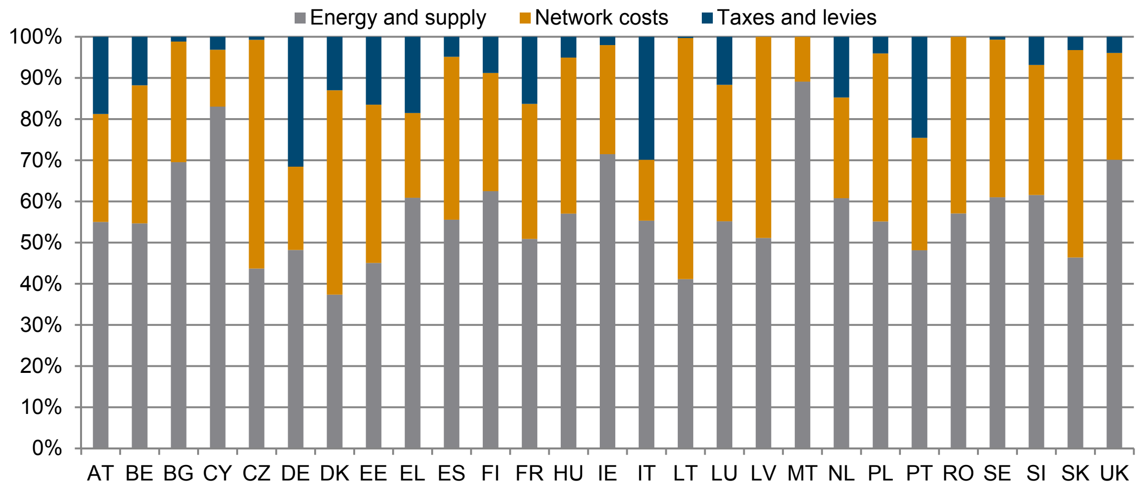


Source: Eurostat, WIOD and wiiw calculations.

A change in the Eurostat methodology from 2007 onwards allows looking at the components of the industrial end-user electricity price: energy & supply, network costs and taxes & levies. As can be seen from Figure 2.11, energy & supply prices are the most important component in many countries, though not in all. In a range of countries, the share of energy & supply is below 50% (DE-48%, PT, SK, EE, CZ, LT, DK-37%). Network costs make up almost 60% of the total price in Lithuania and the Czech Republic, and about 50% in Slovakia, Denmark and Latvia. At the other end, the lowest shares of network costs are registered in Malta, Cyprus and Italy with about 10%, followed by Germany and Greece with about 20%. Taxies and levies, which are set nationally, are the highest in Germany and Italy, accounting for 32% and 30% of the total price respectively. In contrast, no taxes and levies for industrial electricity consumers are charged in Lithuania, Malta, Latvia and Romania.

[16] These prices are higher than the prices of the standard industrial consumer in Eurostat. This is reasonable as the weight of the lower consumption band with higher prices in our calculated average price is larger, thus resulting in overall higher prices.

Figure 2.11 / Components of industrial electricity prices, 2012



Source: Eurostat, WIOD and wiiw calculations.

Table 2.2 / Electricity price developments in the EU countries, 2008-2012, cumulative % change

	Energy and supply	Network costs	Taxes and levies	Total price
Austria	-8.4	28.7	48.1	8.4
Belgium	-13.2	33.0	9.4	4.2
Bulgaria	16.2	42.8	100.0	23.8
Cyprus [1]	38.7	0.9	1.3	30.0
Czech Republic	-14.6	39.5	-8.3	8.3
Denmark	-40.7	81.7	3.0	-2.5
Estonia	32.3	5.0	174.5	30.9
Finland	3.9	24.2	169.2	16.1
Germany	-10.4	3.4	204.2	17.2
Greece [2]	20.9	-7.3	157.4	26.2
Hungary	-17.8	-7.9	158.3	-11.1
Ireland [2]	11.5	-5.1	540.0	8.0
Italy	1.7	18.4	143.0	26.6
Latvia	12.7	60.8	0.0	32.0
Lithuania [1]	6.5	15.4	-91.3	7.3
Luxembourg [3]	2.0	2.3	-2.3	1.9
Malta	15.3	0.0	0.0	13.4
Netherlands	-15.3	32.2	18.4	-1.7
Poland	29.9	-1.2	-15.8	12.9
Portugal	17.5	46.7	30.3	27.6
Romania	-15.6	-17.1	0.0	-16.3
Slovakia	-18.9	22.6	528.6	2.0
Slovenia	-19.7	-6.4	102.9	-12.0
Spain	-2.6	85.8	24.6	23.9
Sweden	-11.7	34.0	20.0	3.8
UK	9.5	42.5	17.8	17.1

Notes: Consumption band IB: 20 MWh < Consumption < 500 MWh.
However, for Belgium, Finland, Germany and Ireland the most common band was band IC (500 MWh < Consumption < 2 000 MWh).
1) 2010-2010.- 2) 2009-2012.- 3) 2007-2011.
Source: Eurostat.

One has to keep in mind that these prices are weighted average prices. Large energy-intensive industries may in fact benefit from long-term supply contracts or self-generation, resulting in lower costs. A recent study dealt with costs in the aluminium industry (Renda et al., 2013), an industry where electricity costs account for about one-third of total production costs. It shows that electricity prices paid by aluminium smelters differ considerably: the highest cost smelter paid for electricity more than five times what the lowest cost smelter paid. While the former had to buy electricity in the market, the latter profited from long-term contracts and was thus shielded from the effects of EU and national energy policies (see Renda et al., 2013, p. 158). However, long-term contracts may come into conflict with EU Competition Law.

When looking at price trends over the period 2008-2012 (in nominal terms), we now employ Eurostat data for the consumption band which applies to the largest number of firms. With the exception of four countries, (see Table 2.2), this is the IB consumption band (20 MWh < Consumption < 500 MWh). Overall, between 2008 and 2012, industrial electricity prices increased in all but 5 EU Member States: they only dropped in Romania, Slovenia, Hungary, Denmark and the Netherlands. Price increases were the lowest in Slovakia and Sweden with 2% and 4% respectively, reached about 17% in Germany, and were the largest in Latvia and Estonia with 30% each. Table 2.2 also indicates the sources for these increases. Overall, increases in network costs and taxes and levies were large, while energy & supply costs decreased in some countries. As the example of Germany shows, energy & supply costs fell by 10%, but network costs increased by 3% and taxes and levies by 204%. However, as a harmonised reporting methodology for the breakdown of electricity prices into energy and supply, network costs and taxes and levies is generally missing, cross-country comparisons have to be made with caution.

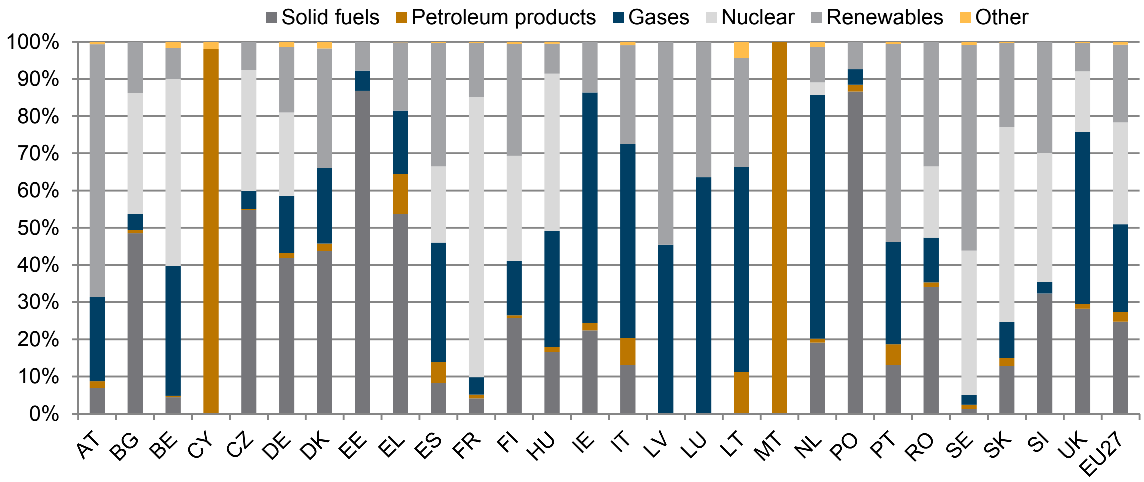
2.3.3 DRIVERS OF ELECTRICITY PRICES IN THE EUROPEAN UNION

Electricity prices are influenced by a wide range of factors. As discussed above, network costs as well as tariffs and levies have a significant impact on prices. This section reviews some major drivers of electricity prices, including the electricity generation mix and certain EU policies.

Electricity generation mix

As has been shown above, the electricity generation mix in the EU-27 was rather diversified in 2010: about one-quarter came from solid fuels (25%), followed by gas (24%), nuclear power (27%) and renewables (21%). However, this average figure masks large differences among the EU member countries (see Figure 2.12). In some countries, electricity generation was in fact dominated by one fuel: e.g. petroleum products in Cyprus and Malta (100%), solid fuels in Estonia and Poland (about 86%) or nuclear power in France (75%). The electricity mix was more diversified in only a few countries. Those countries included Germany, Denmark, Spain, Finland, Hungary, Romania and Slovenia.

Figure 2.12 / Electricity generation mix in the EU Member States, 2010



Source: European Commission Energy-Country Factsheets 2012.

BOX 2.2 / ELECTRICITY PRICES AND THE MERIT-ORDER IN LIBERALISED MARKETS

'In standard wholesale electricity market design, marginal pricing determines the spot-market price of electricity. Generators offer capacity into the market at a price sufficient to recover their short-term running costs (including fuel and carbon prices). Capacity is dispatched starting with the lowest-price offer, moving up to more expensive options until demand is met. Under normal conditions, the offer price of the last unit of generation dispatched (the 'marginal' unit of generation) sets the market price for electricity, which is paid to all generation dispatched irrespective of their individual offers (thus when the spot-market price is higher than a generator's offer price, the generator receives extra revenues, called 'infra-marginal rents'). In many markets, gas-fired generation generally sets this spot-market clearing price.' (IEA, 2011)

The **merit-order curve (supply curve)** now depicts the feed-in ranking of electricity generation by its short-run marginal costs. It goes from the least to the most expensive unit. The merit-order for Germany shows the following ranking (without renewables, see Von Roon and Huck, 2010): the lowest marginal costs are recorded by nuclear energy generation, followed by generation from brown coal, black coal, gas, and finally from oil. Renewables, i.e. wind and solar power, have negligible variable costs (no-fuel costs).

Renewables, feed-in tariffs and merit-order effect

The EU Climate and Energy Package enacted in 2009 set a target to raise the share of EU energy consumption produced from renewable energy sources (RES) to 20% by the year 2020. Each Member State has its own national target, reflecting its starting point and potential, which it tries to achieve by national mechanisms. As certain renewable energy technologies are not generally cost-competitive, economic support may thus be justified (Brown and Müller, 2012; Philibert, 2012). One of these support mechanisms is the so called 'feed-in tariff scheme' (see, for example, Frondel et al., 2010; Kubat and Kennedy, 2011).

Feed-in tariff schemes guarantee special rates for renewable electricity provided to the grid and are long-term contracts (e.g. 20 years in Germany). They are usually paid by electricity consumers and linked to their consumption and, depending on EU country, enter either the ‘network costs’ or the ‘taxes and levies’ component of the electricity price.[17] In order to assess the impact of feed-in tariff schemes on the electricity price, one has to look at two effects. On the one hand, the merit-order effect lowers the wholesale price of electricity (see Philibert, 2012). That is, when large shares of renewables are introduced with low marginal costs, fossil-fuel plants are not needed to meet the demand. These plants no longer set the electricity price and are pushed out of the market (especially gas-fired generation plants). The price drops to the lower costs of renewable generators. On the other hand, RES-support costs are added to the electricity price, thus mostly compensating for the price decrease from the merit-order effect for the end-user. The net effect depends on who actually bears the costs of RES support.

As the example of Germany shows, there are significant differences with respect to who pays these additional costs. In Germany, the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz EEG) is the most important instrument for promoting renewable energy. There are many exemptions from the EEG-levy included in this act. For instance, energy-intensive industries pay sharply reduced rates, while self-generation is exempted (Folkers-Landau, 2013). Thus, for these companies the merit-order effect may be larger than the RES additional costs, resulting in decreasing electricity prices (see Sensfuß, 2011; Kubat and Kennedy, 2011; Renda, 2013).

The EU Emissions Trading Scheme and the crisis

The EU Emissions Trading Scheme (EU ETS) is a ‘cap-and-trade’ system launched in 2005. Its main goal is to reduce the emission of greenhouse gases. It has developed in three phases so far (trading periods 2005-2007, 2008-2012 and 2013-2020). The EU Climate and Energy Package adopted in 2009 set the target of a 20% reduction of greenhouse gas emissions from the 1990 levels by 2020 and led to a revision of the EU ETS, which has been applicable since 2013. Emission allowances are the ‘currency’ of the EU ETS. The prices of these emission allowances are, however, currently very low. This is due to the huge excess supply of emission allowances built up during the former trading periods and to the crisis which led to lower emissions and thus less demand for emission allowances (see Folkers-Landau, 2013).

Overall, fossil fuel generation plants (coal, gas, oil) need a carbon emission allowance for each unit of emitted CO_2, which increases their variable costs. Coal-fired generation plants have a higher carbon emission per unit of output than gas-fired generation plants (almost double), thus carbon emission allowances have a stronger impact on the former (see Reinaud, 2005). Emission allowances thus alter the operating costs in the power generation sector. As short-run marginal costs increase, (see Box 2 describing the mechanism for electricity prices), the spot market follows this trend. Furthermore, the merit-order curve might change as well when coal-fired generation becomes more expensive than gas-fired generation. How far such a revision in the merit-order occurs depends, however, on the range of prices involved (gas prices, coal prices and CO_2 prices, see Reinaud, 2005 for a discussion).

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[17] There is no single EU guideline with respect to where the ‘renewables’ surcharge should be captured; this varies from country to country. For instance, in Denmark it enters the ‘network costs’ component, whereas in Austria and the UK it is captured under ‘taxes and levies’.

The ETS thus implies increased indirect (through higher electricity prices) and direct costs to energy intensive sectors and thus the danger of carbon leakage. Carbon leakage is the risk of businesses transferring production to other countries which have laxer constraints on greenhouse gas emissions. This could lead to an overall increase in their global emissions. The EU Commission set up a list of sectors and sub-sectors which are deemed to be exposed to a significant risk of carbon leakage, including e.g. producers of aluminium, copper, fertilisers, steel, paper, cotton, chemicals and some plastics. In 2012, the Commission adopted rules on the national support for industrial electricity costs in the context of the EU Emissions Trading Scheme. Under these rules, certain aid is allowed to compensate for EU ETS allowance costs passed on to electricity prices in those sectors included in the list. These subsidies are thus considered compatible with the internal market rules (see European Commission, 2012a).

Liberalisation and regulation

The liberalisation of EU electricity and gas markets started in the second half of the 1990s and evolved over time with the First (adopted in 1996), Second (2003) and Third Internal Energy Market packages (2009) forming the legislative framework. The EU Second Energy Market package entailed the unbundling of former vertically integrated utilities in order to separate infrastructure and service provision, the non-discriminatory access to networks for all energy producers, the establishment of a regulator and gradual market opening. The electricity markets for all non-household customers were opened on 1 July 2004 (for households on 1 July 2007), allowing businesses to choose their supplier. The Third Internal Energy market package further amended the existing legislation and established the Agency for Cooperation of Energy Regulators.

The main aim of energy market liberalisation was to introduce competition to those parts of the industry where it is possible (generation, supply). However, in some EU Member States market concentration in these areas is still high. Furthermore, there are still regulated end-user electricity prices for industry in about one-third of EU Member States (see European Commission, 2012b).

2.3.4 SUMMARY CONCLUSIONS

On the one hand, the recent shale gas boom in the United States has led to lower gas prices and thus lower electricity prices in recent years. On the other hand, electricity prices in the European Union have seen a substantial increase during the last decade, leading to a widening gap with respect to US industrial electricity prices. European electricity prices are currently twice as high as those in the US with a further widening of this gap projected.

There are also substantial differences across EU Member States regarding the level of industrial electricity prices. Between 2008 and 2012, the increase in electricity end-user prices in the EU was largely due to network costs and taxes and levies, while energy & supply costs even decreased in a number of countries. EU policies in the field of renewable energy and the European Emissions Trading Scheme do play an important role for electricity prices although there are certain exemptions or compensation measures for energy-intensive industries. However, in some cases, national energy policies may contradict EU Competition Rules and are thus a highly sensitive and topical issue.

2.4 POTENTIAL IMPLICATIONS FOR INDUSTRIAL COMPETITIVENESS

The observed cross-country differences in energy prices – as long as they are not matched by corresponding gaps in energy intensity levels – may have important repercussions on both the production costs and industrial competitiveness. For instance, cheap energy in the United States, particularly when it comes to natural gas, more than compensates for the relatively high energy intensity of its manufacturing[18] (which is only about 20% higher than in the EU – see Table 1.7 in Task 1) and potentially represents an important competitive advantage for US producers, particularly in energy-intensive branches.

With respect to the other major EU competitors, energy cost competitiveness is likely to be less of an issue. In Russia, cheap energy is compensated for by the very high energy intensity of production, whereas in both China and Japan energy prices are at least as high as in the EU, and are coupled with the much higher energy intensity of manufacturing[19] in China's case. At the same time, the potential energy cost disadvantages to Chinese industrial producers are likely to be counteracted by other cost factors such as the cheap labour.

[18] Excluding NACE Rev. 1 23 (coke, refined petroleum and nuclear fuel).

[19] Excluding NACE Rev. 1 23 (coke, refined petroleum and nuclear fuel).

Task 3: Measuring the impact of energy prices on energy intensity

In this chapter, we aim at econometrically estimating how the energy intensities of individual industries have responded to energy price shocks, using the price and energy consumption data for a panel of 30 countries over a time period between 1995 and 2009. Measuring the price elasticity of energy intensity should allow us to answer the question as to whether the energy efficiency improvements have been sufficient to offset the impact of increased energy prices. Besides, it may provide some guidance on the issue to what extent energy prices (which can be affected by policy-makers e.g. via changes in taxation) can be used as a tool to induce the desired improvements in energy efficiency.[20]

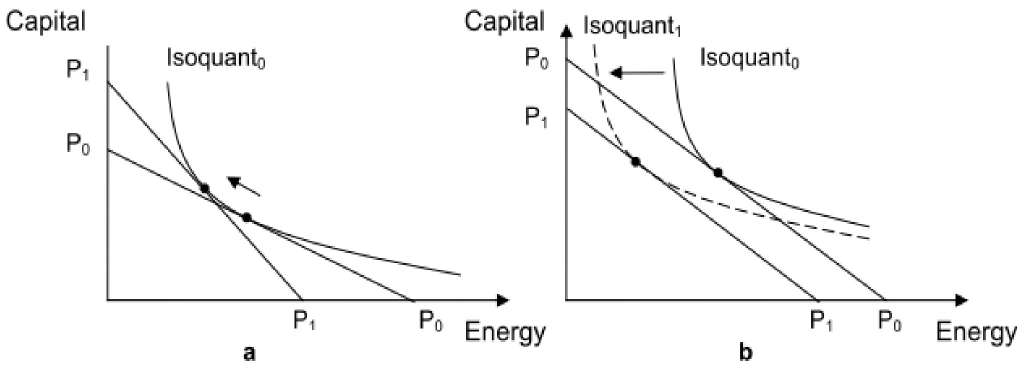
3.1 THEORETICAL CONSIDERATIONS

The responsiveness of energy intensity to changes in the energy price essentially depends on the willingness of the particular industry to invest in new energy-efficient equipment. Such a decision essentially trades off higher initial capital costs against lower future energy operating costs. In a simple model (Figure 3.1a), an increase in the price of energy relative to capital (a shift from P0 to P1) will induce a partial substitution of energy by capital in producing the same quantity of output (Isoquant0), thus resulting in a new equilibrium. However, in real life a decision on whether to invest in new energy-saving equipment depends on many factors (a good overview is provided by Gillingham, Newell and Palmer 2009). For instance, the role of expectations is crucial. If the energy price is expected to stay at a new (higher) level over a protracted period of time, the willingness to invest in new capital will be clearly greater than when the energy price shock is deemed as temporary. Conversely, the expectations of persistently lower energy prices may not lead to capital disinvestment, implying that there may be asymmetric effects on energy intensity with respect to the direction of energy price changes. Further, expectations with respect to other factors, such as changes in operating costs related to energy use (e.g. pollution charges) or the lifetime of the equipment, are also relevant. Clearly, the decision-time horizon plays a role as well.

Investment into energy-efficient technologies will only be undertaken if the discounted present value of future gains from reduced energy consumption outweighs the costs of capital investment. This implies that the more expensive energy-efficient capital is, the less likely it is that a firm will be interested in investing in it. In this context, access to external funds (e.g. bank loans) which may be required to finance such an investment may also play a role. Other factors constraining energy-efficient investments may include information asymmetries, e.g. with respect to the energy-efficiency properties of investment goods, resulting in sub-optimal levels of energy-efficiency investments and the so-called ‘energy efficiency gap’. Clearly, energy-saving investments in response to energy price shocks are likely to be greater in energy-intensive sectors (such as pulp and paper, chemicals, glass, cement or basic metals), than in industries which consume little energy in the first place.

20 It has to be borne in mind that for data reasons, our estimations cover the ‘pre-crisis’ period. In the ‘post-crisis’ period (i.e. starting from 2009), the more difficult access to capital, which is typically required to finance energy-saving investments, may result in price elasticities of energy intensity being lower than those obtained in the present study.

Figure 3.1 / Energy efficiency-improving substitution (a) versus energy-saving technological change (b)



Source: Gillingham, Newell and Palmer (2009).

In the context of an energy efficiency debate, energy and capital may be thus regarded as substitutes: a lower capital stock requires more energy consumption per unit of produced output, and vice versa. However, more generally, capital investment decisions also depend on many other factors which may have nothing to do with energy efficiency considerations. For instance, rising wages may also induce firms to become more capital-intensive, which is indeed what has happened historically in the process of economic development. The latter incentive for firms to invest is potentially more powerful than energy price shocks, given that labour costs typically account for a much higher share of total costs.[21] In this way, capital investments may actually raise the energy intensity, so that energy and capital behave as complements rather than substitutes. Besides, technological developments may also play a role. For instance, technological change in Figure 3.1b allows using less capital and less energy at the same time when producing the same volume of output (Isoquant$_0$ shifts to Isoquant$_1$). Also here, capital and energy behave as complements rather than substitutes, while the energy intensity goes down.

Econometric studies which addressed the issue of whether energy and capital are substitutes or complement each other have come up with very different results. Overall, time-series estimations typically found that energy and capital tend to be substitutes, whereas cross-country estimations more often than not provided evidence of complementarity between the two (Dahl 1993).[22] Intuitively, this makes sense. In a time-series context, a country/industry/firm usually does not undergo major structural shifts in its production structure – which could bring about an increase in both capital and energy consumption – even over relatively long periods of time. Therefore, energy price shocks faced by such a country/industry/firm are likely to give rise to energy-saving investments, implying that energy and capital tend to behave as substitutes. In a cross-section context, on the other hand, countries which are at very

21 In OECD countries, energy typically accounts for some 4-5% of overall costs on average, going up to 7-8% for energy-intensive industries aggregated at NACE Rev. 1 2-digit level. At a more disaggregated level however the share may be much higher. For instance, Riker (2012) calculated the share of energy costs *for the US industries* at the 6-digit NAICS level and found that for paperboard mills they reach 17%, for glass containers 18%, for nitrogenous fertilisers 21%, and for industrial gas and cement production as much as 29% of total costs. According to the European Commission's (2014b) estimates, the shares of energy costs in total production costs of some industrial products *in Europe* are even higher, reaching e.g. 35-40% for aluminium, 40% for lime, and between 40 and 80% for some chemical products such as ammonia, ethylene, and chlorine.

22 There is however no universal acceptance of this. For instance, the literature review provided by Krishnapillai and Thompson (2012) mentions studies which provide evidence of substitutability between energy and capital in the cross-section – rather than time-series – context.

different development levels typically have also very different relative capital and labour endowments. Poor countries tend to have lower capital stocks (and vice versa), which is primarily explained by the cheapness of labour in these countries rather than cheapness of energy. Besides, countries which are at similar development levels may have very different production structures: some may specialise in energy-intensive industries whereas others may not. The former will tend to use both a lot of capital and energy at the same time, whereas the latter will not. Thus, comparing the energy intensities of these countries at a given point in time may tell us a lot about their industrial structure, but little about the impact of energy prices on energy intensity. The same problem clearly applies even more so in the case of cross-section comparisons between individual industries or firms.

3.2 EMPIRICAL METHODOLOGY

The above considerations suggest that to properly capture the link between energy prices and energy intensity, time-series estimations should provide a more appropriate framework than cross-section estimation techniques. At the same time, the annual frequency of observations and the relatively short time period covered by the WIOD data (between 1995 and 2009) make it impossible to run separate time-series regressions for each country and prompt the use of a panel-data approach instead. In the panel-data context,[23] the above theoretical considerations imply that an appropriate approach is to analyse the 'within-variation' of the energy intensity over time by using the country fixed effects. A fixed-effects panel-data regression does not compare energy intensities across countries, but instead captures the country-specific effects – such as the development level or the country's economic structure – in the country dummies, or 'fixed effects'. Besides, fixed-effects specification will allow us to avoid the usual problems related to comparisons of the industrial value-added across countries, such as the choice of an appropriate conversion factor (exchange rates, PPPs, etc.)

Given that for the bulk of industries, natural gas and electricity are the two most important energy types, we run separate regressions for gas and electricity for each of the 14 manufacturing industries presented in Table 3.1, i.e. 28 regressions in total. For our purposes, we define energy intensity as consumption of energy product (gas or electricity) by a given industry divided by the value-added of this industry measured at constant 1995 prices. This provides us with an indicator measuring the use of energy per unit of physical output for each industry. To calculate the energy intensity, we use value-added rather than gross output as the denominator, since the numerator only captures energy consumed in the production process of this particular industry (without energy used to produce intermediate inputs). Data on both energy consumption and industrial value-added are taken from the WIOD database.[24]

On the right-hand side, all explanatory variables are included with at least a one-year lag due to the potential endogeneity problems.[25] The main explanatory variable we are looking at is the price of energy product (lagged by one year) whose intensity we aim to explain. If energy price has the expected negative

[23] Our panel consists of thirty countries, including 21 EU Member States (i.e. EU-28 without Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta and Romania) and 9 non-EU countries (Australia, Canada, China, Japan, Mexico, Russia, South Korea, Turkey and the United States).

[24] The WIOD energy accounts are based on the "gross energy use" concept. For more details on that, see Box 3.1.

[25] These endogeneity problems could be understood as follows. Not only can energy price have an impact on energy intensity, but also vice versa. For instance, a decline in energy intensity results in lower demand for this energy type, which may translate into lower energy price (which in turn may mitigate the scope of energy-efficiency efforts, known as the 'rebound' effect).

effect on energy intensity, the coefficient on the energy price which measures the own-price elasticity of energy intensity (our model is specified in logs) should be statistically significant and negative. The price data we use in our regressions are taken from the IEA: they are country-specific, but do not allow us to differentiate between prices paid by individual industries.[26] Specifically, the price variable we use is the relative energy price, i.e. the nominal price of energy product (gas or electricity) deflated with the industry-specific output deflator. The intuition behind using the relative – rather than the nominal – energy price is as follows. If the industry is able to pass over the increased energy costs further on to its customers via a corresponding increase in its sale price (i.e. the relative energy price stays the same), it will be unlikely to face any pressures to implement energy-saving measures. Such a situation is possible, for instance, when the industry is facing little competitive pressure, e.g. is highly monopolised or protected from external competition, or else when the energy price shock is uniform and affects not only the given industry, but its foreign competitors as well. The data on industry-specific output deflators used for the calculation of the relative energy price are taken from the WIOD database.

Table 3.1 / Manufacturing industries underlying panel-data regressions

NACE Rev.1	Description
15t16	Food, Beverages and Tobacco
17t18	Textiles and Textile Products
19	Leather, Leather and Footwear
20	Wood and Products of Wood and Cork
21t22	Pulp, Paper, Paper , Printing and Publishing
23	Coke, Refined Petroleum and Nuclear Fuel
24	Chemicals and Chemical Products
25	Rubber and Plastics
26	Other Non-Metallic Mineral
27t28	Basic Metals and Fabricated Metal
29	Machinery, Nec
30t33	Electrical and Optical Equipment
34t35	Transport Equipment
36t37	Manufacturing, Nec; Recycling

Another variable included into our estimating regression is capital stock per employee (also available from the WIOD database),[27] which should capture the impact of a changing capital stock per se on energy intensity. As argued above, fixed capital investments are not necessarily motivated by energy efficiency considerations, but may still have an impact on energy intensity (Kim and Heo, 2013, with the discussion going back to Berndt and Wood, 1975). As an alternative to capital stock per employee, we also try GDP per capita which may be expected to have a similar effect on the energy intensity. Finally, we also include a time-trend in order to account for the global (price) shocks and/or exogenous technical progress which may also have an impact on the energy-intensity.

[26] In reality, the prices of energy inputs paid by different industries may be different e.g. because of the different consumption patterns (industries with the prevalence of small enterprises using relatively little energy pay a higher price than e.g. large steel mills) or because energy products may be taxed differently across industries. For instance, in the EU, electricity consumed in energy-intensive industries such as metals and chemicals is exempted from the usual ‘renewable’ surcharge paid by other industries and households. The price data underlying our estimations do not allow us to take account of such industry-specific differences in the energy prices.

[27] The capital stock data in WIOD build on the database collected within the framework of the EU KLEMS project (for more details, see www.euklems.net). The EU KLEMS database provides time-series on capital stock by industry for a limited set of OECD countries for the time-period 1995-2007. For 2008-2009 and for the remaining countries for the entire period of 1995-2009, the capital stock data have been constructed on the basis of the perpetual inventory method, using the time-series on real investments and the industry-specific depreciation rates ranging, depending on the industry, between 4 and 10%. For methodological details, see Timmer et al. (2012).

BOX 3.1 / GROSS ENERGY USE CONCEPT UNDERLYING THE WIOD DATA

When it comes to measuring the amount of energy consumed, Eurostat typically refers to *gross inland energy consumption*, sometimes abbreviated as *gross inland consumption*, which is the total energy demand of a country or region. It represents the quantity of energy necessary to satisfy inland consumption of the geographical-entity under consideration.

Gross inland energy consumption covers:

- consumption by the energy sector itself;
- distribution and transformation losses;
- final energy consumption by end-users; and,
- 'statistical differences' (not already captured in the figures on primary energy consumption and final energy consumption).

The difference between *gross inland energy consumption* and *gross energy consumption* is that the latter also includes the transformation output, i.e. electricity or heat produced from other energy sources. Therefore, gross energy consumption is a product-specific consumption and does not reflect the demand for primary energy.

According to Timmer et al. (2012), 'WIOD energy accounts are based on the *gross energy use* concept which means that one has some double counting regarding the total energy metabolism of an economy (e.g. records of crude oil as input to refineries and refined products as input to all sectors, or natural gas as input to power sector and electricity consumption by all sectors, etc.). However, this gross energy concept is fully consistent with the input records in the use tables and all the information on the country energy mix is kept, which makes the environmental accounts with such concept more suitable for modelling applications (e.g. fuel substitution).'

Thus, the gross energy use concept underlying the WIOD energy accounts corresponds to the definition of gross energy consumption, i.e. it should also include self-production of energy.

Thus, our baseline estimating equation looks as follows:

$$\ln\left(\frac{\text{Energy Use(e)}_{it}}{\text{VA}_{it}}\right) = \alpha_1 \ln(\text{RP}^{e}_{it-1}) + \alpha_2 \ln(\text{K}_{it-1}) + \gamma_c + \text{time\_trend} \quad + \varepsilon_{iet}, \tag{5}$$

where

i is industry (according to NACE Rev. 1 classification at the 2-digit level);

e is energy product (gas resp. electricity);

t is year;

VA is industrial value-added in national currency at constant 1995 prices (taken from WIOD);

RP^{e}_{it-1} is the relative energy price (nominal price in national currency/MJoule taken from IEA, deflated with the industry output deflator taken from WIOD);

K_{it-1} is the capital stock per employee of industry *i* in previous year *t-1* (at constant 1995 prices) taken from WIOD;

γ_c is the country fixed effect; and,

ε_{iet} is the error term.

This specification using energy prices lagged by one year allows us to derive the own-price elasticity of energy intensity in the short run. However, because of the long lifetimes of existing capital equipment and other factors, the implementation of energy-saving measures and investment into energy-efficient technologies typically occur with a time lag (Gillingham et al., 2009; Berndt and Wood, 1975 and 1979). To capture this long-run effect on the energy intensity, we also try another specification where the only difference to (5) is that instead of the (relative) energy price lagged by one year we use its moving average over the past five years. For instance, energy intensity in 2009 is regressed on the average energy price for the time-period 2004-2008, and so on.

3.3 ESTIMATION RESULTS AND INTERPRETATION

Tables 3.2-3.5 report the results of our estimations for 14 manufacturing industries for electricity and natural gas. The obtained coefficients on the constant and the country dummies (fixed effects) are not reported for space reasons, but can be made available upon request. The coefficients on the country dummies are in many cases highly significant, suggesting the importance of country-specific conditions such as the economic structure or the development level in explaining the observed variation in energy intensity.[28] Also, the coefficient on the time-trend is also often significant and usually negative, suggesting a secular decline in the energy intensity over time *on top* of other explanatory variables. This may be due to capital stock becoming more energy-efficient over time for reasons other than energy prices, e.g. reflecting the emergence of new generations of technologies being used. In the majority of industries, the R-squared of our regressions is reasonably high (generally at least 0.7 and often exceeding 0.9), implying that the variations of just two variables – price and capital stock, coupled with the time-trend and the country fixed effects – explain the bulk of the variation in the dependent variable (energy intensity).

The estimation results for electricity intensity (Table 3.2) are generally in line with our expectations. For 8 industries, the own-price elasticity coefficient has been found to be statistically significant (at 10% significance level) and has the ‘right’ (negative) sign already in the short run, ranging between -0.2 (in pulp and paper, and ‘other non-metallic mineral products’ which include inter alia glass and cement) and -0.7 (in electrical and optical equipment). Thus, depending on the industry, a 1% increase in the relative electricity price brings about a 0.2 to 0.7% reduction in the electricity intensity of production in the short

28 However, there appears to be no clear-cut pattern in the size and significance of the country dummy coefficients by country.

run (one year). Only for one industry (rubber and plastics) does the own-price elasticity coefficient turn out to be significantly positive.

Table 3.2 / Estimation results for electricity intensity in the short run, by industry

VARIABLES	15t16	17t18	19	20	21t22	23	24	25	26	27t28	29	30t33	34t35	36t37
Electricity_price	-0.445***	-0.011	-0.498***	-0.452***	-0.215***	-0.072	0.051	0.233*	-0.216***	-0.322***	-0.240*	-0.702***	0.029	-0.128
	(-8.489)	(-0.151)	(-4.295)	(-3.086)	(-4.156)	(-0.481)	(0.717)	(1.740)	(-3.587)	(-6.540)	(-1.935)	(-8.355)	(0.266)	(-0.958)
Capital_stock	-0.524***	-0.006	-0.241***	0.214	0.042	0.204	0.026	-0.640***	-0.220***	0.085	-0.176	-0.528***	-0.759***	-0.330**
	(-6.500)	(-0.070)	(-3.020)	(1.403)	(0.632)	(0.991)	(0.245)	(-3.318)	(-2.704)	(0.903)	(-1.408)	(-3.524)	(-6.980)	(-2.507)
trend	0.026***	-0.021***	0.005	-0.003	-0.001	0.027*	-0.027***	-0.008	-0.003	-0.009***	-0.023***	0.005	0.002	0.002
	(7.990)	(-3.821)	(0.610)	(-0.356)	(-0.349)	(1.806)	(-4.661)	(-0.896)	(-0.828)	(-3.165)	(-3.128)	(0.470)	(0.332)	(0.190)
Country dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	382	382	368	382	382	338	382	382	382	382	382	382	382	382
R-squared	0.905	0.883	0.746	0.841	0.966	0.678	0.932	0.814	0.888	0.965	0.828	0.847	0.717	0.821

Source: Own calculations.

Table 3.2 also demonstrates that for 7 industries, the capital stock per employee exerts a significant negative effect on the electricity intensity, with the elasticities ranging between -0.2 and -0.8. This supports the proposition that electricity and capital tend to behave as substitutes rather than complements. However, as discussed above, it should be borne in mind that capital investments are undertaken not only for energy-efficiency reasons. Since we have *both* the electricity price and the capital stock variables in our regression, which are for a number of industries both significant at the same time, our results can be interpreted in the following way. The coefficient on the capital stock per employee captures the effect that the capital investment – undertaken for whatever reason – has on the electricity intensity. Then, the coefficient on the energy price should capture the effect of the latter variable on electricity intensity via channels other than capital stock accumulation. In other words, the electricity price tends to have an impact on the electricity intensity even with the capital stock unchanged. This effect may reflect, for instance, the changing *composition* of the capital stock: while the total stock may remain the same, the share of energy-efficient equipment in total stock may rise as a result of energy-saving investments undertaken in response to energy price shocks, so that the energy intensity goes down as a result.[29]

The inclusion of GDP per capita instead of capital stock per employee did not bring about any noteworthy changes in our estimation results, so that the estimation results of this specification are not reported (but are available upon request). However, the coefficient on the time-trend in this specification generally becomes less significant, suggesting that the dynamics in GDP per capita may capture some of the secular trends previously captured by the time-trend variable.[30]

In the long run (Table 3.3), the absolute value of the own-price elasticity of electricity intensity tends to get somewhat larger than in the short run, albeit with some exceptions (notably wood products where the own-price elasticity coefficient actually turns insignificant). This result is again well in line with our expectations and confirms the proposition that energy-efficiency improvements in response to energy price shocks tend to take place only with a time-lag.

[29] This interpretation is consistent with Kim and Heo (2013) who differentiate between capital that increases electricity demand and capital that does not, thus pointing to the importance of the capital stock structure for explaining the electricity intensity.

[30] One of such secular trends may be e.g. the behavioural changes leading to energy savings.

Table 3.3 / Estimation results for electricity intensity in the long run, by industry*

VARIABLES	15t16	17t18	19	20	21t22	23	24	25	26	27t28	29	30t33	34t35	36t37
Electricity_price	-0.622***	0.211	-0.737**	0.057	-0.442***	-0.177	0.076	0.402	-0.345***	-0.395***	-0.360**	-0.620**	0.468**	-0.201
	(-4.473)	(0.789)	(-2.251)	(0.150)	(-3.285)	(-0.734)	(0.608)	(1.308)	(-2.962)	(-3.024)	(-2.358)	(-2.448)	(2.138)	(-0.916)
Capital_stock	-0.342*	0.233*	-0.206	0.335	0.132	0.228	0.136	-0.735	-0.106	0.254	-0.169	-0.503**	-1.408*	-0.135
	(-1.852)	(1.665)	(-1.053)	(1.535)	(1.036)	(0.970)	(0.872)	(-1.523)	(-0.860)	(1.248)	(-0.971)	(-2.299)	(-1.962)	(-0.510)
trend	0.021***	-0.055***	-0.021	-0.031*	-0.004	-0.018	-0.040***	-0.029*	-0.006	-0.010*	-0.024*	0.002	-0.006	-0.019
	(2.824)	(-3.099)	(-1.057)	(-1.809)	(-0.493)	(-0.774)	(-3.658)	(-1.764)	(-0.877)	(-1.671)	(-1.803)	(0.159)	(-0.317)	(-1.052)
Country dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	263	263	253	263	263	230	263	263	263	263	263	263	263	263
R-squared	0.922	0.909	0.758	0.852	0.979	0.797	0.959	0.866	0.921	0.971	0.912	0.929	0.736	0.867

* With Newey-West standard errors adjusted for autocorrelation.
Source: Own calculations.

For the natural gas intensity, the obtained estimation results (Table 3.4) are also generally 'intuitive'. For 6 industries, the own-price elasticity of gas intensity has been found to be negative and significant (at 10% significance level), ranging from about -0.2 for textiles and metals to around -0.5 for coke and refined petroleum and 'other non-metallic mineral products' including inter alia glass and cement. The latter finding does not come as a surprise given that both industries are highly gas-intensive; therefore, in these two industries gas price shocks are expected to induce more gas-saving efforts than elsewhere. Thus, depending on the industry, a 1% increase in the relative price of natural gas brings about a 0.2 to 0.5% reduction in the gas intensity of production in the short run. Only for the leather industry does the own-price elasticity of gas intensity turn out to be positive.

Table 3.4 / Estimation results for natural gas intensity in the short run, by industry

VARIABLES	15t16	17t18	19	20	21t22	23	24	25	26	27t28	29	30t33	34t35	36t37
Gas_price	0.092	-0.201*	0.256*	0.306	-0.044	-0.526***	-0.305***	0.010	-0.529***	-0.237***	-0.087	-0.112	0.156	-0.447**
	(1.022)	(-1.702)	(1.937)	(1.558)	(-0.357)	(-3.778)	(-3.135)	(0.059)	(-5.737)	(-3.204)	(-0.793)	(-1.087)	(1.037)	(-2.352)
Capital_stock	0.108	0.086	0.324***	-0.687**	0.326*	0.602***	0.073	-0.849**	0.307*	-0.030	-0.294**	0.292	-0.549***	-0.378
	(0.607)	(0.459)	(2.871)	(-2.529)	(1.679)	(3.230)	(0.465)	(-2.568)	(1.939)	(-0.156)	(-2.091)	(1.234)	(-2.993)	(-1.636)
trend	0.006	0.014	-0.033**	-0.026	-0.012	0.036***	-0.000	-0.017	0.018**	0.007	-0.006	-0.048***	-0.047***	0.049**
	(0.713)	(1.067)	(-2.329)	(-1.369)	(-0.835)	(2.865)	(-0.019)	(-0.951)	(2.098)	(1.031)	(-0.546)	(-2.950)	(-3.136)	(2.386)
Country dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	349	349	309	335	349	254	348	335	349	349	345	345	341	337
R-squared	0.904	0.865	0.851	0.747	0.868	0.930	0.936	0.853	0.922	0.935	0.907	0.841	0.779	0.871

Source: Own calculations.

Interestingly, unlike in the case of electricity intensity, the coefficients on the capital stock per employee are generally less clear-cut. In a number of cases (e.g. in leather industry, pulp and paper, other non-metallic mineral products, and most notably coke and refined petroleum), they turn out to be significantly *positive*, suggesting that unlike in the case of electricity, capital investment per se does not go hand in hand with less gas consumption, but rather with higher gas consumption. Thus, at least for these four industries, gas and capital cannot be credibly seen as substitutes but rather complement each other. Of course, this finding should not come as a surprise since – as mentioned above – capital investment can be undertaken for any number of reasons other than energy-saving efforts. In addition, the WIOD data on the consumption of natural gas by industry, which underlie our econometric estimations, do not allow us to differentiate between gas used for energy purposes and that used as a feedstock. This explains, for instance, why in the coke and refined petroleum industry, where natural gas is used primarily as feedstock rather than as an energy source, the positive relationship between the capital stock per employee and the gas intensity of production is the highest (elasticity of +0.6).

In the long run (Table 3.5), the own-price elasticities of gas intensity become generally larger in absolute terms, in some cases significantly, such as in chemicals (where it goes up from -0.3 in the short run to nearly -0.5 in the long run). However, the own-price coefficients become generally less significant: as a result, the statistically significant (at 10% level) negative relationship between gas prices and gas intensity holds in the long run only for three industries: chemicals, other non-metallic mineral products, and basic metals – which are all particularly gas-intensive.[31]

Table 3.5 / Estimation results for natural gas intensity in the long run, by industry*

VARIABLES	15t16	17t18	19	20	21t22	23	24	25	26	27t28	29	30t33	34t35	36t37
Gas_price	-0.186	0.101	0.926***	-0.826	-0.340	-0.705	-0.482*	0.225	-0.587**	-0.284*	-0.143	-0.066	0.063	-0.043
	(-1.086)	(0.409)	(2.939)	(-1.606)	(-1.544)	(-1.484)	(-1.777)	(0.750)	(-2.169)	(-1.709)	(-0.675)	(-0.320)	(0.334)	(-0.119)
Capital_stock	-0.218	-0.119	0.303	0.205	0.202	-0.162	-0.277	-1.239**	0.071	-0.082	-0.197	-0.353	-0.723**	0.153
	(-1.150)	(-0.527)	(1.449)	(0.513)	(0.774)	(-0.441)	(-0.968)	(-2.339)	(0.209)	(-0.213)	(-0.787)	(-0.947)	(-1.973)	(0.455)
trend	0.021	-0.034**	-0.097***	0.053	0.007	0.062*	0.028	-0.013	0.018	0.012	-0.012	-0.023	-0.044	-0.017
	(1.556)	(-2.016)	(-3.599)	(1.263)	(0.326)	(1.903)	(1.048)	(-0.380)	(0.964)	(0.766)	(-0.736)	(-1.034)	(-1.614)	(-0.349)
Country dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	235	235	200	215	235	167	234	221	235	235	231	231	219	221
R-squared	0.957	0.915	0.904	0.830	0.916	0.937	0.954	0.899	0.952	0.953	0.929	0.928	0.918	0.922

* With Newey-West standard errors adjusted for autocorrelation.
Source: Own calculations.

[31] In many cases, the reason for the statistically insignificant own-price coefficients is the large Newey-West standard errors, whose computation was necessary to get rid of the autocorrelation when using the five-year moving averages of the gas price variable. Using conventional standard errors instead would result in a total of seven industries exhibiting a negative long-run relationship between gas prices and gas-intensity of production.

BOX 3.2 / ALTERNATIVE ECONOMETRIC SPECIFICATIONS OF THE RELATIONSHIP BETWEEN ENERGY PRICES AND ENERGY INTENSITY

To check the robustness of our estimation results, we also tried alternative specifications of our estimating equation. One alternative specification includes the prices of alternative energy inputs (natural gas in the regression for electricity-intensity and electricity in the regression for gas intensity respectively) and the so-called 'outsourcing component'. The intuition behind this is as follows.

First, along with the price of the energy product in question, the prices of other energy products may matter as well, reflecting potential substitution effects. For instance, the increase in the price of gas relative to electricity may induce the substitution of gas by electricity in the production process, and vice versa. Including the prices of alternative energy products into our estimation regression should allow us to measure such potential substitution effects, with the size of the coefficient (expected to be positive) measuring the cross-price elasticity of energy intensity with respect to alternative energy products. Clearly, the possibility of such substitution depends on the particular production technology and is expected to vary greatly from industry to industry.[32]

Second, as already discussed in detail in Chapter 1, the observed reduction in energy intensity in response to energy price shocks may not necessarily result from technological improvements. Instead, it may reflect the outsourcing of energy-intensive parts of the value chain to other countries, where energy may have become relatively cheaper. In this case, the value-added of a given industry goes down, but its energy consumption goes down even more (given that it is the energy-intensive processes which are being outsourced), so that its energy intensity declines as a result. Such an 'improvement' in energy intensity has nothing to do with investments into energy-saving technologies, but represents a pure 'structural' effect. Conversely, an industry may 'in-source' certain energy-intensive activities from other countries if domestic energy prices have become cheaper relative to those abroad, resulting in domestic energy intensity going up.

To capture the latter effect, we include an interaction term into our regression which represents the sum (across countries) of the bilateral relative energy price gaps weighted with the share of intermediate imports from and exports to a certain country in total intermediate imports and exports. The latter share can be understood as a measure of 'openness' with respect to another country, which shows how well interlinked the industry is in production chains with this other country, giving some indication of how easily the energy-intensive task can be outsourced.[33] A negative and significant coefficient on this interaction term can be interpreted as an indication of the presence of such a structural outsourcing effect, which is expected to increase with the size of the energy price gap between countries and with the degree of the industry's openness.[34]

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32 Coal is another relatively important energy input in the majority of industries, making coal prices another potential candidate to be included to capture possible substitution effects. However, the IEA provides data on coal prices for only a limited number of countries, making it difficult to include them into our regressions.

33 For instance, off-shoring or in-shoring could be easier for well-interlinked industries than for domestically-oriented ones.

34 Halicioglu (2009) used a similar measure of trade openness while estimating the CO_2 emissions function. Our approach is also in line with the findings of Gerlagh and Mathys (2011), who show that 'energy intensive sectors have higher economic activity and export from energy abundant countries. The trade and location effects increase with a sector's exposure to international trade.'

Taking into account the prices of alternative energy type and the 'outsourcing component', our original estimating equation (5) can be upgraded to:

$$\ln\left(\frac{\text{Energy Use}(e)_{it}}{\text{VA}_{it}}\right) = \alpha_1 \ln\left(RP^{ele}_{it-1}\right) + \alpha_2 \ln\left(RP^{gas}_{it-1}\right) + \alpha_3 \ln(K_{it-1}) +$$

$$+\alpha_4 \sum_d \frac{P^e_{cit-1} - P^e_{dit-1}}{P^e_{cit-1}} \times \frac{IIM_{cdit-1} + IEX_{cdit-1}}{TIIM_{cit-1} + TIEX_{cit-1}} + \gamma_c + time\_trend \quad + \varepsilon_{iet}, \qquad (6)$$

with

$\sum_d \frac{P^e_{cit-1} - P^e_{dit-1}}{P^e_{cit-1}} \times \frac{IIM_{cdit-1} + IEX_{cdit-1}}{TIIM_{cit-1} + TIEX_{cit-1}}$ being the interaction term capturing the 'structural' ('outsourcing') effect, where

c is reporter country;

d is partner country;

P^e_{dit-1} is the nominal price of the analysed energy input in country d;

IIM_{cdit-1} is intermediate inputs of industry i in country c from country d;

IEX_{cdit-1} is intermediate exports of industry i from country c to country d;

$TIIM_{cit-1}$ is total intermediate inputs of industry i in country c (both foreign and domestic); and,

$TIEX_{cit-1}$ is total production of intermediate inputs by industry i in country c (both exported and sold domestically).

The estimation results of this specification are presented in Tables A1 (for electricity) and A4 (for gas) of the Appendix. In the case of electricity, the obtained coefficients on the 'outsourcing component' were found to be insignificant and very low in absolute magnitude for nearly all industries. Therefore, the estimation results presented in Table A1 omit them.

Generally, cross-prices and the 'outsourcing component' (in the case of gas) add very little in explaining the observed variation in the dependent variable (energy intensity): in both regressions, the R-squared increases only marginally. The evidence on cross-price elasticities is mixed. For electricity (Table A1), the cross-price elasticities with respect to gas prices are indeed positive and significant for four industries, suggesting that there might be some shift away from gas towards electricity in response to gas price shocks (although in the long run – see Table A3 – the coefficients on cross-price elasticities become more mixed). On the contrary, in the case of natural gas (Table A4), the obtained estimates of cross-price elasticity with respect to electricity prices are totally 'counter-intuitive' and in all cases negative. The bottom line is that while electricity tends to behave as a substitute for gas, the reverse is not true – or at least is not supported by empirical evidence.[35] Another finding is that the 'outsourcing'

35 We also tried oil prices as yet another variable which might capture substitution effects between alternative fuel types, but the obtained coefficients were generally insignificant and are not reported.

component does play a role for the gas intensity of four industries: pulp and paper, rubber and plastics, other non-metallic mineral products, and machinery. For these four industries, the obtained coefficients on the variable *outsourcing_comp* in Table A4 are negative and significant. The higher the cross-border price gap and the extent of international inter-linkages of these four industries, the more likely they will outsource their gas-intensive production processes to cheaper locations. Interestingly, in the long run (Table A6), the ‘outsourcing’ effect is also observed in the case of four industries; however, there are only two industries – pulp and paper, and rubber and plastics – for which it holds both in the short run and in the long run.

Finally, we also tried a specification without the country fixed effects (i.e. pooled across countries), with the industrial value-added underlying our energy intensity calculations converted at constant exchange rates of 1995. The pooled specification not only takes account of the ‘within’ variation for each individual country over time, but also of the ‘between’ variation across countries. The results of these pooled estimations for electricity and gas are presented in Tables A2 and A5 respectively. As can be seen from these tables, the estimated own-price elasticities of energy intensity tend to be much higher than those in fixed-effects estimations´. However, one has to bear reservations in mind with respect to the pooled regressions highlighted in Section 3.1 – namely, that these (high) own-price elasticities may not capture what we want to capture (technological improvements with respect to energy price shocks), but other factors such as the structural differences between countries, the different development levels, etc. Importantly, the R-squared of pooled regressions is generally rather low, especially for gas, suggesting the crucial importance of including the country fixed effects into the estimating regression.

3.4 SUMMARY

All in all, our econometric results confirm the responsiveness of industrial energy intensity to energy price shocks, particularly for electricity, with the long-run elasticities being generally higher in absolute value than those in the short run (see Table 3.6). These elasticities are generally in line, or somewhat higher than those obtained in earlier econometric studies (Dahl, 1993; Bohi and Zimmerman, 1984). Another interesting finding is that capital investments tend to reduce the electricity intensity even when they are undertaken for reasons other than electricity price shocks, but this does not hold true in the case of gas intensity where rather the opposite is observed. Capital investments tend to increase – rather than reduce – the gas intensity of production. Also, while electricity tends to substitute natural gas if the latter becomes more expensive, the reverse is not confirmed empirically: on the contrary, the cross-price elasticities of gas intensity with respect to electricity prices are negative. Finally, while we found virtually no evidence of outsourcing to cheaper locations in response to electricity price shocks – the achieved improvements in electricity intensity are primarily due to technological rather than structural reasons – in the case of natural gas, such ‘outsourcing’ effects appear to be present at least in some industries, particularly in the short run. Needless to say, the obtained results are highly industry-specific.

Our findings also suggest that gas and electricity may not be efficient tools to address the issue of energy cost competitiveness. Although the obtained own-price elasticities of energy intensity are generally negative and not negligible, even in the long run (at least taking five years as a measure of the ‘long run’) their magnitude is smaller than one. This implies that energy efficiency improvements in response to energy price shocks are not strong enough to offset the adverse impact of rising energy prices, so that the energy-related expenditures go up as a result. Indeed, this is what has largely happened over the past two decades: as demonstrated in Chapter 1, notwithstanding the energy efficiency improvements, the energy-related expenditures – and energy cost shares – have indeed gone up in the major industrial countries analysed in this report.

Chapter 4 investigates the link between energy prices, energy efficiency and industrial competitiveness in more detail.

Table 3.6 / Own-price elasticities of electricity and natural gas intensity, by industry

Manufacturing industries, according to NACE Rev. 1		Electricity		Natural gas	
		short-run	long-run	short-run	long-run
Food, Beverages and Tobacco	15t16	-0.445***	-0.622***	0.092	-0.186
Textiles and Textile Products	17t18	-0.011	0.211	-0.201*	0.101
Leather, Leather and Footwear	19	-0.498***	-0.737**	0.256*	0.926***
Wood and Products of Wood and Cork	20	-0.452***	0.057	0.306	-0.826
Pulp, Paper, Printing and Publishing	21t22	-0.215***	-0.442***	-0.044	-0.340
Coke, Refined Petroleum and Nuclear Fuel	23	-0.072	-0.177	-0.526***	-0.705
Chemicals and Chemical Products	24	0.051	0.076	-0.305***	-0.482*
Rubber and Plastics	25	0.233*	0.402	0.010	0.225
Other Non-Metallic Mineral	26	-0.216***	-0.345***	-0.529***	-0.587**
Basic Metals and Fabricated Metal	27t28	-0.322***	-0.395***	-0.237***	-0.284*
Machinery, Nec	29	-0.240*	-0.360**	-0.087	-0.143
Electrical and Optical Equipment	30t33	-0.702***	-0.620**	-0.112	-0.066
Transport Equipment	34t35	0.029	0.468**	0.156	0.063
Manufacturing, Nec; Recycling	36t37	-0.128	-0.201	-0.447**	-0.043

Source: Own calculations.

Task 4: Energy intensity, energy cost shares, and industrial competitiveness

Chapter 3 investigated the responsiveness of industrial energy intensity to energy price shocks. The conclusion was that while industries have tended to reduce their energy intensity in response to higher energy prices, particularly in the long run, the elasticity of response has been generally less than one. This implies that, by and large, higher energy prices have not been fully offset by energy efficiency improvements, resulting in higher energy costs. This chapter aims to answer the question of how these developments have affected the competitiveness of manufacturing industries. Did export competitiveness suffer as a result of insufficient improvements in energy efficiency and/or higher energy costs?

4.1 THEORETICAL CONSIDERATIONS AND PREVIOUS FINDINGS

As demonstrated in Chapter 1, energy cost shares in manufacturing industries – though generally on the rise over the past two decades – are typically quite low. On average, they stand at some 2-3% of gross output, and labour-related expenses are a much more important cost factor for industries. However, on a more disaggregated basis, energy may account for up to 40-80% of production costs for some particularly energy-intensive sectors such as aluminium and chemicals (see e.g. European Commission, 2014b). For these industries, changes in energy intensity or energy costs can be expected to have a considerable impact on their export competitiveness. But even for less energy-intensive industries, any increase of energy cost shares may still affect export competitiveness to some extent. For instance, in highly competitive sectors, if profits are not high enough to offset even an incremental increase in energy costs, export competitiveness may suffer as a result.

In line with the so-called ‘Porter hypothesis’, environmental and energy regulations can induce energy efficiency and encourage innovations that help improve commercial competitiveness in the medium and long run (Porter and van der Linde, 1995). However, in order to lower their energy intensity, companies often need to undertake investments into new technologies, which can have medium-run payback periods, thus making firms less competitive in the short run. Loss of competitiveness is particularly likely when domestic emission mitigation policies are unilateral: according to the ‘pollution haven hypothesis’, domestic manufacturers may lose market share to foreign competitors and/or relocate production activity to unregulated economies (Joseph and Pizer, 2011). In principle, government support policies can be used to mitigate the deterioration in industrial competitiveness. However, such measures risk subverting the incentives for companies to restructure, resulting in expenditures that show little long-term promise for stimulating the economy or protecting the environment (Frondel et al., 2010). A similar effect could be expected at the industry level where it can be further reinforced by within-industry reallocations, with most energy-intensive firms potentially driven out of the market.

The findings of previous studies analysing the nexus between energy intensity/energy cost shares and competitiveness have been mixed. Some early studies, which focused mostly on the impact of government regulations in the US, found a negative effect of regulations aimed at fostering eco-innovations including the adoption of energy-efficient technologies, on industrial competitiveness (see, for instance Christiansen and Haveman, 1981; Gollop and Roberts, 1983; Greenstone, 2002). Part of these studies was later disputed by Jaffe et al. (1995), and similarly inconsistent results were found for individual industries. For instance, while the competitiveness of the US pulp and paper industry suffered from environmental regulations (Gray and Shadbegian, 2003), the opposite was found for the oil refining industry (Berman and Bui, 2001).

Riker (2012) focused on the performance of three-digit manufacturing industries and selected energy-intensive six-digit manufacturing industries in the US between 2002 and 2006. His findings suggest that energy price increases had a clear detrimental effect on export competitiveness, resulting in total export losses of an estimated USD 11.5 billion per year. The impact of higher energy prices on the export competitiveness varied greatly by industry, depending on the energy cost share and the price elasticity of the industry's products in export markets. Using a very different approach, Eichhammer and Walz (2011) analysed the competitiveness gap between developed countries on the one hand, and developing and emerging economies on the other. Their conclusion was that at least part of the gap was explained by the much lower energy efficiency in the latter group of countries, which is itself a manifestation of their lower absorptive capacity for energy-efficient technologies.

Focusing on the EU, Rennings and Rexhäuser (2011) analysed the competitiveness effects of implementing energy-saving technologies on European industry, using data from the Community Innovation Survey (CIS) which reports information for more than 76 thousand firms from eighteen EU countries for the time period between 2006 and 2008. Their results suggest that energy-saving process innovation had only minor effects on the growth rate of firms' turnover. At the same time, the European Competitiveness Report 2012 (European Commission, 2012c) found that, by and large, European manufacturing industries have been able to improve their competitiveness by offering new, more energy-efficient products such as consumer durables and capital goods. The latter represented an alternative (to energy cost pressures), and previously under-researched, 'transmission channel' of higher energy prices on industrial competitiveness. The report concluded that 'overall, there seems to be evidence that product innovators introducing energy-saving products on the market enjoy higher sales generated by product innovation compared to conventional product innovators. This, of course, may also reflect an important competitive advantage'.

The Council of the European Union (2014) analysed the competitiveness aspects of energy prices and regulatory costs for selected energy-intensive industries in the EU. Its findings were mixed: while the burden of high energy prices and regulatory costs put some aluminium plants at risk of closure (11 plants out of 26 which were open in 2003 have already closed), other plants – particularly those with long-term energy contracts or self-generating energy – were among the most competitive in the world. With regard to the steel industry, it found that while 'in normal times regulatory costs are not the main driver of the cost competitive gap, in times of crisis a reduction in regulatory costs can certainly alleviate the pain.' This conclusion is supported by an earlier report on the cumulative cost impact for the steel industry (CEPS, 2013) which found that energy-related regulatory costs, such as ETS and the costs of renewables support, become crucial at the margin. While during the boom years, they accounted for around 7% of the steel industry's EBITDA, this ratio jumped to above 100% in the crisis year of 2009. On the other hand, Okereke and McDaniels (2012) found that competitiveness losses of the European steel industry resulting from higher energy costs were largely exaggerated.

The contribution of the present study is to attempt to quantify the link between energy intensity/energy cost shares and competitiveness for a wide range of countries and industries based on the time series available from a single dataset (WIOD), which ensures internal consistency and comparability of data.

4.2 EMPIRICAL METHODOLOGY

To measure the impact of changes in energy intensity and energy cost shares on industrial competitiveness, a panel-data model for the period 1995-2007 was set up, using total (intra- and extra-EU) exports as a dependent variable. Methodologically, the model is estimated in first differences with country-industry fixed effects, in order to account for the unobserved country/industry heterogeneity, thus explaining the export dynamics of each industry in each country over time. Apart from the main variables of interest (i.e. energy intensity and energy cost shares), the model includes a range of control variables which are customarily used to explain the export performance of a country or industry, such as labour productivity, the shares of high-skilled and medium-skilled labour, capital intensity, wages, and the size of the economy.

All in all, our econometric model looks as follows:

$$\dot{Comp}_{ijt} = \alpha_0 + \alpha_1 \dot{lnEnergyint}_{ijt} + \alpha_2 \dot{lnLPVAppp95}_{ijt} + \alpha_3 \dot{HSKL}_{ijt} + \alpha_4 \dot{MSKL}_{ijt} + \alpha_5 \dot{lnK}_{ijt} + \alpha_6 \dot{lnWagePe}_{ijt} + \alpha_7 \dot{lnGDPppp}_{jt} + \gamma_{ij} + \varepsilon_{ijt} \qquad (7).$$

$Comp_{ijt}$ is the measure of export competitiveness of industry *i* (according to NACE Rev. 1 classification at the 2-digit level) in country *j* in year *t.* In the baseline specification, the measure of competitiveness is $lnExp_{ijt}$, the logged value of exports (in million US dollars) of industry *i* in country *j* in year *t*. In alternative specifications which are tried in order to check the robustness of results, the value of exports is replaced with the revealed comparative advantage (RCA) indices. One RCA index, RCA_{ijt}, is based on gross exports and is defined as the share of sector *i* in the exports of country *j* in relation to the country's *j* share in the world trade. Another RCA index, $RCA\_VA_{ijt,}$ is calculated in a similar way as $RCA_{ijt,}$ but is based on *value-added exports*, i.e. gross exports net of imported intermediate inputs.[36]

$lnEnergyint_{ijt}$ is the log of energy intensity, defined as the consumption of energy in GJ by industry *i* in country *j* in year *t*, divided by the industry's value-added at constant 1995 prices. Instead of, and in addition to energy intensity, we also use $Costshare\_k_{ijt}$ as the cost shares (in % of gross output) for the following *k* different types of energy inputs:

CPA 10 - coal,

CPA 11 - crude oil and natural gas,

CPA 23 - coke, refined petroleum and nuclear fuels,

CPA 40 - electrical energy, gas, steam, and hot water.

[36] In the specifications with RCA and RCA (value-added) as dependent variables, GDP as an explanatory variable has been omitted, since the size of the economy should not affect the *relative* measures of competitiveness such as RCAs.

In the baseline specification, $lnLPVAppp95_{ijt}$ denotes the log of labour productivity measured as gross output at constant 1995 PPPs per employee. In alternative econometric specifications, labour productivity is also calculated using value-added instead of gross output.

$HSKL_{ijt}$ is the share of high-skilled employees, and $MSKL_{ijt}$ is the share of medium-skilled employees in total employment, with the share of low-skilled employees as a reference group. [37]

lnK_{ijt} is the log of capital intensity, i.e. capital stock at constant 1995 prices per employee, of industry *i* in country *j* in year *t*.

$lnWagePe_{ijt}$ denotes the log of wages (at continuous PPPs) per employee.

$lnGDPppp95_{jt}$ is the log of GDP of country *j* at constant 1995 PPPs, included in order to capture the size of the economy.

γ_{ij} is the country-industry fixed effect accounting for the unobserved heterogeneity in the dynamics of the respective competitiveness indicator across countries/sectors over time, and

ε_{ijt} is the error term.

The model is run on a sample of 21 EU countries[38] and thirteen NACE 2-digit manufacturing sectors available from the WIOD database.[39] Unlike in Chapter 3, the chosen time-span underlying the baseline estimation is 1995-2007. In the baseline regression, data for 2008 and 2009 were excluded since the global economic and financial crisis may have impacted very differently across sectors, thus making the results difficult to interpret.[40] The crisis-related sharp drops in exports and GDP were largely driven by financial factors which are outside the scope of our model.

Since the dependent variable $lnExp_{ijt}$ has been found to have a unit root, the model is estimated in first differences (t-t_{-1}), which is indicated by the $\dot{}$ sign in equation (7). To ensure the comparability of results, this also applies to alternative econometric specifications. Wherever variables are taken in logs, their first difference corresponds to their growth rate. In this context, an obtained coefficient is to be interpreted as a percentage change of the dependent variable (e.g. exports) in response to a 1% increase in the exogenous variable (e.g. energy intensity or labour productivity). Variables which are expressed as shares (in %), such as the energy cost shares, are not in logs: their first differences indicate a change in percentage points (p.p.) against the previous year. In this case, an obtained coefficient measures the relative change of the dependent variable (e.g. exports) in response to a 1 p.p. rise in the energy cost share.

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37 In WIOD, skills are defined on the basis of educational attainment: high-skilled labour refers to tertiary education, medium-skilled labour to upper-secondary or post-secondary non-tertiary education, and low-skilled labour to basic education.

38 This corresponds to EU-28 without Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta, and Romania.

39 Coke, refined petroleum, and nuclear fuel industry (NACE 23) was excluded from the model, since it uses energy inputs as crude oil primarily as a feedstock rather than as an energy source. As already demonstrated in Chapter 1, its inclusion may result in distorted estimation results.

40 Reassuringly, the main results are similar for the full sample – see Table A.10 of the Appendix.

4.3 ESTIMATION RESULTS AND INTERPRETATION

The results of our estimations are presented in Table 4.1. Columns 1-3 show the results for the total sample of industries. As can be seen, energy intensity is negatively related to exports (column 1), and similar results are obtained when energy intensity is replaced by the total energy cost share (column 2). In column 3, the energy cost share is split into its main components. In this specification, only the cost share of electricity, gas, steam and hot water (CPA 40) has the expected significant negative relationship with exports, but the coefficient on energy intensity becomes insignificant.[41] These results suggest that a rise in the cost share component CPA 40 by 1 percentage point (p.p.) is statistically associated with a 1.6% decline of exports. The fact that only the cost component CPA 40 is significant is not surprising given that, as demonstrated in Chapter 1, it accounted for more than 60% in the EU27 total energy costs in 2011. It should be noted however that, although statistically significant, the elasticity of exports with respect to the cost share CPA 40 is very low, considering that an increase in the electricity cost share by 1 p.p. of gross output is in fact very large given its initial low level.

Table 4.1 / Energy intensity, energy cost shares, and industrial competitiveness: empirical findings

	Total industries[1)]			Energy-intensive industries[2)]		
Dependent variable: exports	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Energy intensity	-0.024*		-0.018	-0.067		-0.055
	(-1.80)		(-1.33)	(-1.63)		(-1.30)
Energy cost share		-0.008*			-0.002	
		(-1.75)			(-0.36)	
Cost share of coal			0.018			0.020
			(0.74)			(0.72)
Cost share of oil and gas			0.003			0.010
			(0.27)			(0.87)
Cost share of coke, ref. Petroleum			0.001			0.012
			(0.12)			(1.09)
Cost share of electricity, etc.			-0.016***			-0.017**
			(-2.63)			(-1.99)
Labour productivity (GO based)	0.329***	0.335***	0.329***	0.418***	0.444***	0.395***
	(10.56)	(10.81)	(10.54)	(4.55)	(4.89)	(4.24)
Share of high-skilled labour	0.726***	0.725***	0.717***	0.962	0.960	0.894
	(2.89)	(2.89)	(2.86)	(1.64)	(1.63)	(1.52)
Share of medium-skilled labour	-0.376*	-0.398*	-0.365*	-0.757	-0.729	-0.674
	(-1.81)	(-1.91)	(-1.75)	(-1.58)	(-1.51)	(-1.40)
Capital intensity	-0.283***	-0.282***	-0.279***	-0.443***	-0.439***	-0.405***
	(-6.90)	(-6.87)	(-6.80)	(-3.78)	(-3.73)	(-3.42)
Wage per employee	0.066	0.064	0.061	0.010	-0.003	-0.013
	(1.45)	(1.42)	(1.35)	(0.10)	(-0.03)	(-0.12)
GDP	-0.011	0.025	-0.011	0.261	0.318	0.196
	(-0.06)	(0.14)	(-0.06)	(0.66)	(0.81)	(0.49)
Constant	0.070***	0.070***	0.071***	0.066***	0.066***	0.068***
	(10.46)	(10.41)	(10.44)	(4.55)	(4.52)	(4.66)
Observations	3,094	3,094	3,094	720	720	720
R-squared	0.06	0.06	0.06	0.06	0.059	0.08
Number of i	259	259	259	60	60	60

Notes: 1) Excluding NACE 23 – Coke, refined petroleum and nuclear fuel. 2) The sub-sample of energy-intensive sectors includes NACE 24 – Chemicals and chemical products, NACE 26 – Other non-metallic minerals, and NACE 27to28 – Basic metals and fabricated metals.
Source: own calculations.

[41] The coefficients on other cost shares included separately are found to be insignificant, whereas the coefficient on energy intensity remains significantly negative (see Table A.11 of the Appendix).

Overall, these findings suggest that, despite energy costs being relatively small compared to other cost components, their growth has had some negative impact on export competitiveness. Besides, a comparison of the results across specifications of the model suggests that, in terms of international competitiveness, energy cost shares have mattered more than energy efficiency: the coefficient of energy intensity loses significance when cost shares are added into the regression. This can be explained by the fact that energy cost shares are determined by both energy prices and energy intensity. Manufacturing firms across the globe may have access to the same energy-saving technologies, so that investments in energy efficiency did not sufficiently alter the relative position of different countries. On the other hand, the substantial differences in energy prices seem to have impacted the competitiveness of European manufacturing (especially energy-intensive) industries.[42]

At the same time, our results demonstrate that energy-related costs are not the main determinant of export competitiveness and are overshadowed by other more important factors. For instance, there is consistent evidence of a positive productivity-competitiveness nexus across all the model specifications: labour productivity (gross output-based) is positively associated with export competitiveness.[43] Wages are found to be positively, though not significantly, associated with exports. Intuitively, this makes sense: labour productivity gains need to be larger than wage increases in order to result in lower unit labour costs and improved competitiveness. Human capital matters for export competitiveness too: an increase in the high-skilled labour share is associated with higher exports.

Relatively more counter-intuitive is the coefficient of capital intensity, which is found to be negatively associated with exports. This counter-intuitive result cannot be explained by the historically superior export performance of industries such as electronics and transport vehicles, which are not capital-intensive. The sub-sample of energy-intensive industries, which are generally also more capital-intensive, yields similar results (columns 4-6 of Table 4.1): the negative coefficient of capital intensity is found to be even larger in absolute terms. The negative coefficient of capital intensity can be rather explained by the simultaneous presence in the regression of two other variables connected to capital intensity: labour productivity, which is measured as output per employed person, and the share of high-skilled labour which is a proxy for human capital and relates to capital intensity via a capital-skill complementarity. This could point towards a certain degree of (multi-)collinearity amongst these variables.

For this reason, two robustness checks were tried. First, the regressions were run excluding labour productivity (Table A.7 of the Appendix). In this case the coefficient on energy intensity becomes larger in absolute terms and more significant, while the results for cost shares stay the same. The coefficient of capital intensity becomes lower in absolute terms, but remains significantly negative. A possible explanation for this could be that industries which climb up the value chain tend to produce less capital-intensive goods or offshore capital-intensive production processes elsewhere.[44] An indication for the latter aspect is that when replacing exports with RCA as the competitiveness indicator, capital intensity

[42] The correlation between the measure of energy intensity and that of CPA 40 cost share is relatively low (0.19) that is reassuring in terms of the effects of potential collinearity.

[43] Alternatively, we tried labour productivity based on value-added as a robustness check (see Table A.9 of the Appendix) and found qualitatively similar results.

[44] This is consistent with the so-called ‘Feenstra-Hanson maquiladoras’ effect: off-shoring of production stages, which are on average capital-intensive in country A, to country B, where this production process has capital intensity below the country B’s average, would imply an increase of exports from country B whereas exports from country A would decline (Feenstra and Hanson, 1995).

is negatively related when measured in value-added terms, but insignificant when measured in gross trade. In these cases the coefficients concerning energy intensity become significantly negative.

Second, the regressions were run excluding capital intensity (Table A.8 of the Appendix). In this case, the coefficients on labour productivity become smaller. The effects of energy intensity lose significance, while the coefficients on the cost share again remain unaffected. It should also be noted that the coefficients on capital intensity (in absolute terms) are lower than or close to those for labour productivity. This can be interpreted as a positive effect of total factor productivity.

Table 4.2 / Regression results of alternative specification: RCA as dependent variable

	Total industries[1]			Energy intensive industries[2]		
Dependent variable: revealed comparative advantage (RCA)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Energy intensity	-0.018		-0.013	-0.035		-0.029
	(-1.53)		(-1.01)	(-1.09)		(-0.89)
Energy cost share		-0.005			0.003	
		(-1.31)			(0.66)	
Cost share of coal			0.004			0.033**
			(0.55)			(2.15)
Cost share of oil and gas			0.009			0.013
			(0.99)			(1.40)
Cost share of coke, ref. Petroleum			-0.004			0.007
			(-0.44)			(0.81)
Cost share of electricity, etc.			-0.014**			-0.008
			(-2.50)			(-1.23)
Labour productivity (GO-based)	0.260***	0.267***	0.259***	0.269***	0.280***	0.250***
	(9.27)	(9.56)	(9.19)	(3.96)	(4.18)	(3.63)
Share of high-skilled labour	-0.001	0.000	-0.005	-0.033	-0.031	-0.095
	(-0.00)	(-0.00)	(-0.02)	(-0.07)	(-0.07)	(-0.21)
Share of medium-skilled labour	0.338*	0.326*	0.356*	0.733*	0.769**	0.801**
	(1.75)	(1.69)	(1.84)	(1.96)	(2.06)	(2.14)
Capital intensity	-0.153***	-0.153***	-0.150***	-0.192**	-0.188**	-0.169*
	(-4.25)	(-4.26)	(-4.16)	(-2.21)	(-2.16)	(-1.93)
Wage per employee	-0.002	-0.003	-0.003	-0.058	-0.061	-0.068
	(-0.05)	(-0.07)	(-0.08)	(-0.74)	(-0.77)	(-0.86)
Constant	-0.009***	-0.009***	-0.009***	-0.015**	-0.015**	-0.015**
	(-2.88)	(-2.73)	(-2.88)	(-2.58)	(-2.53)	(-2.54)
Observations	3,250	3,250	3,250	756	756	756
R-squared	0.034	0.034	0.037	0.034	0.033	0.048
Number of i	272	272	272	63	63	63

1) Without NACE 23 coke, refined petroleum and nuclear fuel.
2) The sub-sample of energy-intensive sectors includes NACE 24 chemicals and chemical products, NACE 26 other non-metallic minerals, and NACE 27to28 basic metals and fabricated metals.
Source: own calculations.

The results were tested against other robustness checks. For example, when labour productivity is recalculated based on value-added (rather than gross output), the coefficient on energy intensity becomes insignificant, whereas the cost share of CPA 40 remains significantly negative (Table A.9 of the Appendix). This finding also holds for the total sample of industries when competitiveness is measured by RCA rather than exports (Table 4.2). In fact, many of the results hold irrespective of which measure of competitiveness – exports or RCA – is chosen as the dependent variable. Interestingly, when RCA is measured in value-added terms, the coefficient on energy intensity becomes more negative and more often significant, which might imply that industries which upgrade along value chains become less energy-intensive (Table 4.3). Another difference is that when competitiveness is measured using RCAs rather than exports, the coefficient on the share of high-skilled labour is no longer significant, whereas the coefficient on the share of medium-skilled labour becomes positive when RCA is calculated in gross trade terms.[45] Finally, when including the crisis period, i.e. using the period 1995-2009, the main results concerning energy intensity and the cost share of CPA 40 still hold, with the coefficients of energy intensity being negative but insignificant, whereas the other cost share components become positive and significant in some cases (Table A.10 of the Appendix). This might be the result of the differentiated impact of the crisis across industries, and possibly also reflect some substitution across energy sources, particularly coal.

Table 4.3 / Regression results of alternative specification: RCA (value-added based) as dependent variable

	Total industries[1)]			Energy intensive industries[2)]		
Dependent variable: revealed comparative advantage based on value-added (RCA_VA)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Energy intensity	-0.044***		-0.039***	-0.086***		-0.081**
	(-3.66)		(-3.20)	(-2.64)		(-2.44)
Energy cost share		-0.006			-0.001	
		(-1.54)			(-0.20)	
Cost share of coal			0.002			0.017
			(0.20)			(1.05)
Cost share of oil and gas			0.005			0.004
			(0.51)			(0.45)
Cost share of coke, ref. Petroleum			0.003			0.007
			(0.42)			(0.84)
Cost share of electricity, etc.			-0.013**			-0.008
			(-2.35)			(-1.14)
Labour productivity (GO-based)	0.175***	0.189***	0.174***	0.242***	0.278***	0.231***
	(6.36)	(6.89)	(6.30)	(3.48)	(4.04)	(3.26)
Share of high-skilled labour	-0.225	-0.214	-0.235	0.154	0.160	0.096
	(-0.98)	(-0.93)	(-1.03)	(0.33)	(0.34)	(0.21)
Share of medium-skilled labour	0.220	0.207	0.236	0.448	0.492	0.484
	(1.16)	(1.09)	(1.24)	(1.17)	(1.28)	(1.26)
Capital intensity	-0.122***	-0.122***	-0.119***	-0.190**	-0.185**	-0.174*
	(-3.45)	(-3.43)	(-3.36)	(-2.13)	(-2.06)	(-1.93)
Wage per employee	0.050	0.050	0.047	0.011	-0.002	-0.001
	(1.25)	(1.23)	(1.17)	(0.14)	(-0.02)	(-0.01)
Constant	-0.008**	-0.007**	-0.008***	-0.015**	-0.014**	-0.015**
	(-2.57)	(-2.27)	(-2.58)	(-2.48)	(-2.22)	(-2.43)
Observations	3,250	3,250	3,250	756	756	756
R-squared	0.025	0.022	0.027	0.038	0.029	0.044
Number of i	272	272	272	63	63	63

1) Without NACE 23 coke, refined petroleum and nuclear fuel.
2) The sub-sample of energy-intensive sectors includes NACE 24 chemicals and chemical products, NACE 26 other non-metallic minerals, and NACE 27to28 basic metals and fabricated metals.
Source: own calculations.

45 These results however do not hold for the subset of energy-intensive industries, where robustness checks yield more mixed results.

Finally, columns 4-6 of Table 4.1 present the regression results of the baseline specification for the sub-sample of energy-intensive sectors: chemicals and chemical products (NACE Rev. 1 24), other non-metallic minerals (NACE Rev. 1 26), and basic and fabricated metals (NACE Rev. 1 27to28). Generally, the obtained results are similar to the ones for the overall sample. For instance, the results point again towards a negative effect of a higher share of the cost component CPA 40, and the magnitude of the effect is similar. Also, there is evidence of a positive labour productivity-competitiveness nexus and of a negative capital intensity-competitiveness nexus. Intuitively, we would expect that for energy-intensive industries, energy intensity and energy cost shares should have more of an adverse effect on competitiveness than for other sectors. However, our findings do not suggest evidence of that: in all specifications in columns 4-6 of Table 4.1, the coefficients on energy intensity are negative but insignificant. This counterintuitive finding might be caused by the limited variation in this small subset of the sample.[46]

One important difference from the results for the sample of total industries is that in the case of energy-intensive industries, competitiveness is *not* positively related to the share of high-skilled labour. The coefficient on the share of high-skilled labour is no longer significant, while the negative coefficient on the share of medium-skilled workers loses significance as well. Intuitively, this makes sense: energy-intensive industries are generally not overly reliant on high-skilled labour to begin with.

4.4 SUMMARY

This chapter analysed how changes in energy intensity and energy cost shares affected the export competitiveness of EU manufacturing industries. To this end, a panel-data model with country-industry fixed effects was set up, assessing the impact of different factors on the export competitiveness.

Overall, although the analysis provides evidence that export competitiveness of manufacturing industries – as measured by export growth – is related to energy intensity, its significance is generally overshadowed by other factors such as labour productivity and human capital. This conclusion also largely holds for energy-intensive industries. A comparison of the results across different model specifications suggests that energy cost shares matter more for international competitiveness than energy efficiency, particularly when it comes to the cost share of electricity, gas, steam and hot water (CPA 40). The last result is robust to all the specifications tried for this study. This suggests that industries that faced increases in the cost share of CPA 40 tended to experience a loss in competitiveness. However, at the level of aggregation allowed by the WIOD dataset, the observed negative impact is relatively small in magnitude. An increase in the cost share of CPA 40 by 1 percentage point of gross output is associated with deterioration in export competitiveness to the tune of 2%.

The fact that energy cost shares are found to matter more for competitiveness than energy efficiency can be explained by the fact that the former are determined by both energy prices and energy intensity. Manufacturing industries across the globe may have access to the same energy-saving technologies, so that investments in energy efficiency did not sufficiently alter the relative position of different countries.

46 It has to be borne in mind however that these results are for energy-intensive industries as a whole. As mentioned above and demonstrated in detail e.g. in European Commission (2014b), there is a wide variation in energy intensity and energy cost shares across *individual* energy-intensive industries, for some of which the negative relationship between energy intensity and competitiveness is likely to be significant.

On the other hand, the substantial differences in energy prices documented in Chapter 2 seem to have impacted the competitiveness of European manufacturing industries. This is consistent with the findings of Chapter 3, which showed that despite the significant achievements of European manufacturing industries, the improvements in energy intensity were not large enough to compensate for the competitiveness gap generated by the energy price increase.

As such, these findings are in line with those of the European Commission (2014a). However, they are based on a relatively simple model specification and should be interpreted with some caution, since they are based on the developments prior to the ‘shale gas revolution’ in the US. It is possible that the increased energy price gap between the US and other countries may be impacting export competitiveness more strongly than what is suggested by the estimates of this study, but these effects cannot be captured with our data finishing in 2009. Moreover, due to data limitations, all findings are based on the NACE 2-digit level of aggregation. At a more disaggregated level, energy intensity and energy cost shares may potentially have a much greater impact on export competitiveness, especially for energy-intensive industries (see e.g. European Commission, 2014b).

Conclusions

The findings of this study suggest that energy is a factor that does affect industrial competitiveness, even if it generally accounts for a rather low share of overall production costs, at least at a high level of aggregation. Chapter 1 demonstrates that in advanced economies such as the EU, the United States and Japan, energy accounts for only about 5% of production costs (measured in gross output terms). In manufacturing, if we exclude coke, petroleum and nuclear fuel, the share of energy costs is even lower – only around 3%. But the aggregate figures mask wide divergence across individual manufacturing industries: in some of them, such as aluminium, selected chemical products, glass or cement production, the share of energy costs goes up to 30-40% of total production costs and even higher. Chapter 1 also provides evidence of a general decline of energy intensity levels in the major economies over the past two decades. It has been driven primarily by technological improvement, although a structural shift away from energy-intensive sectors has also contributed in Central and Eastern Europe. This decline has been accompanied by a broad convergence of energy intensity levels, with the most energy-intensive economies (such as those in the EU-12) recording the greatest improvements.

Nevertheless, despite these favourable energy intensity trends, the energy cost shares have been generally on the rise, a reflection of the generally increased energy prices. Chapter 2 highlights the wide variation in energy price trends across countries and trends. It demonstrates that although the oil prices picked up strongly over the past two decades, the pass-through to gas and especially electricity prices was generally less pronounced. However, the gas and electricity prices in the EU rose strongly relative to some of the main competitors, largely on account of the network costs component.

The econometric estimations in Chapter 3 shed further light on the factors driving the above-mentioned secular rise in the energy cost shares. Essentially, the phenomenon reflects the relatively inelastic response of industries to energy price ‘shocks’ with energy-saving measures and the implementation of energy-efficient technologies. While there has been a sizeable reduction in energy intensity in response to higher energy prices in a number of industries, particularly in the case of electricity and in the long run, the elasticity of this reduction has been in most cases less than one. This implies that the improvements in energy efficiency have not been sufficient to fully offset the energy price increase. This finding also brings into question the effectiveness of energy price hikes as a tool aimed at inducing the desired energy intensity improvements. At the same time, there is some evidence that European industries have performed better than their main competitors in reducing their energy intensity.

Finally, Chapter 4 econometrically demonstrates that although energy intensity has some impact on export competitiveness, its magnitude is not very large, at least at the NACE 2-digit aggregation level. The negative impact of energy cost shares on competitiveness is generally stronger, particularly in the case of electricity, gas, steam and hot water (CPA 40) which is the biggest energy source for European industries. The increase in the cost share of CPA 40 had a significant negative impact on export competitiveness in the period 1995-2009. Also, the large within-sector heterogeneity suggests that the impact may be stronger for some specific energy-intensive industries.

All in all, while energy efficiency improvements have helped European manufacturing industries to compete in international markets, there is some evidence that the uneven development of energy prices had detrimental effects on export competitiveness. These conclusions largely confirm the findings of the European Competitiveness Report 2012 and are also in line with the recent findings of the European Commission (2014a, 2014b)[47] – despite the different variables in focus (energy intensity/energy cost shares vs. energy prices) and the differences in methodologies applied (econometric estimations vs. a forward-looking modelling approach). Moreover, it is important to bear in mind that, because of data availability, the conclusions in this study are based on the time-period until 2009, i.e. before the start of the 'shale gas revolution'. The asymmetric energy price shock that resulted from it can potentially have stronger effects on industrial competitiveness which are not captured by this study.

47 European Commission (2014b) has found that 'a strong *asymmetric* rise of electricity and gas prices in the EU has adverse effects on the economy ... The energy-intensive industries are particularly suffering from loss of competitiveness ...'.

Appendix

Table A.1 / Estimation results for electricity intensity in the short run, including gas price, by industry

VARIABLES	15t16	17t18	19	20	21t22	23	24	25	26	27t28	29	30t33	34t35	36t37
Electricity_price	-0.462***	-0.129	-0.786***	-0.416**	-0.297***	0.006	0.221**	0.426**	-0.358***	-0.393***	-0.614***	-0.702***	-0.015	0.076
	(-6.574)	(-1.430)	(-5.241)	(-2.094)	(-4.463)	(0.021)	(2.504)	(2.389)	(-5.028)	(-6.302)	(-3.900)	(-5.148)	(-0.102)	(0.404)
Gas_price	0.016	0.130**	0.367***	-0.110	0.079	-0.132	-0.263***	-0.103	0.135**	0.045	0.393***	0.018	0.122	-0.239
	(0.306)	(1.975)	(2.893)	(-0.688)	(1.493)	(-0.469)	(-3.276)	(-0.714)	(2.482)	(0.920)	(3.351)	(0.162)	(1.050)	(-1.517)
Capital_stock	-0.560***	-0.027	-0.187**	0.232	0.071	0.197	0.012	-0.876***	-0.288***	0.138	-0.230*	-0.470***	-0.819***	-0.495***
	(-6.630)	(-0.295)	(-2.233)	(1.352)	(1.010)	(0.929)	(0.115)	(-3.937)	(-3.571)	(1.343)	(-1.825)	(-3.090)	(-7.193)	(-3.366)
trend	0.024***	-0.029***	-0.018	0.002	-0.008	0.048**	-0.011	-0.004	-0.008*	-0.010***	-0.038***	0.002	-0.006	0.017
	(5.876)	(-4.721)	(-1.647)	(0.173)	(-1.512)	(2.394)	(-1.550)	(-0.376)	(-1.813)	(-2.763)	(-4.044)	(0.231)	(-0.590)	(1.319)
Country dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	349	349	335	349	349	305	349	349	349	349	349	349	349	349
R-squared	0.912	0.891	0.755	0.842	0.963	0.698	0.930	0.810	0.899	0.962	0.841	0.857	0.722	0.809

Table A.2 / Estimation results for electricity intensity in the short run, without country dummies, by industry

VARIABLES	15t16	17t18	19	20	21t22	23	24	25	26	27t28	29	30t33	34t35	36t37
Electricity_price	-0.656***	-0.436***	-0.860***	-0.311**	-0.992***	-0.312**	-0.549***	0.306**	-0.142***	-0.942***	-0.251***	-0.611***	-0.122*	-0.193
	(-10.339)	(-6.258)	(-11.339)	(-2.393)	(-10.416)	(-2.123)	(-6.191)	(2.362)	(-3.059)	(-11.496)	(-2.860)	(-7.986)	(-1.897)	(-1.469)
Capital_stock	-0.130***	-0.181***	-0.096***	-0.346***	0.009	-0.029	-0.445***	-0.458***	-0.420***	-0.200***	-0.573***	-0.413***	-0.461***	-0.269***
	(-4.115)	(-7.076)	(-3.522)	(-6.237)	(0.205)	(-0.465)	(-9.051)	(-7.471)	(-17.805)	(-4.239)	(-13.377)	(-10.123)	(-13.136)	(-5.438)
trend	0.020***	0.006	0.011	0.014	0.031***	0.020	0.009	-0.019	0.006	0.014*	-0.003	-0.002	-0.002	0.001
	(3.526)	(0.873)	(1.390)	(0.930)	(3.173)	(1.081)	(0.937)	(-1.521)	(1.304)	(1.654)	(-0.292)	(-0.212)	(-0.341)	(0.103)
Observations	382	382	368	382	382	338	382	382	382	382	382	382	382	382
R-squared	0.388	0.312	0.355	0.136	0.247	0.035	0.406	0.136	0.584	0.369	0.464	0.480	0.397	0.104

Table A.3 / Estimation results for electricity intensity in the long run, including gas price, by industry*

VARIABLES	15t16	17t18	19	20	21t22	23	24	25	26	27t28	29	30t33	34t35	36t37
Electricity_price	-0.697***	-0.027	-1.698***	-0.230	-0.577***	0.151	0.079	0.995***	-0.493**	-0.428**	-0.534***	-0.256	0.246	0.491
	(-3.751)	(-0.097)	(-4.826)	(-0.684)	(-3.393)	(0.340)	(0.493)	(2.617)	(-2.403)	(-2.305)	(-3.090)	(-0.897)	(0.911)	(1.393)
Gas_price	0.039	0.369***	1.292***	0.410	0.166	-0.285	-0.024	-0.644**	0.255	0.053	0.233*	-0.273	0.449	-0.826**
	(0.299)	(3.069)	(4.651)	(1.652)	(1.539)	(-0.778)	(-0.160)	(-2.556)	(1.040)	(0.337)	(1.679)	(-1.407)	(1.376)	(-2.284)
Capital_stock	-0.287	0.098	-0.064	0.221	0.176	0.129	0.067	-1.174**	-0.103	0.137	-0.256*	-0.454*	-1.683**	-0.379
	(-1.523)	(0.627)	(-0.342)	(0.899)	(1.308)	(0.605)	(0.401)	(-2.342)	(-0.747)	(0.601)	(-1.813)	(-1.865)	(-2.125)	(-1.505)
trend	0.014	-0.073***	-0.095***	-0.050*	-0.015	0.023	-0.033**	0.010	-0.019	-0.008	-0.029**	0.011	-0.030	0.030
	(1.546)	(-3.308)	(-2.922)	(-1.929)	(-1.455)	(0.812)	(-2.175)	(0.485)	(-1.099)	(-0.717)	(-2.156)	(0.571)	(-1.312)	(1.187)
Country dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	235	235	225	235	235	202	235	235	235	235	235	235	235	235
R-squared	0.933	0.917	0.801	0.854	0.978	0.823	0.962	0.866	0.924	0.967	0.917	0.934	0.754	0.862

* With Newey-West standard errors adjusted for autocorrelation.

Table A.4 / Estimation results for natural gas intensity in the short run, including electricity price and 'outsourcing' component, by industry

VARIABLES	15t16	17t18	19	20	21t22	23	24	25	26	27t28	29	30t33	34t35	36t37
Gas_price	0.104	-0.085	0.520***	0.353	0.344**	-0.536*	-0.006	0.732***	-0.330**	-0.107	0.439***	0.241	0.653**	0.245
	(0.758)	(-0.528)	(3.035)	(1.214)	(2.132)	(-1.854)	(-0.046)	(2.616)	(-2.346)	(-1.128)	(3.076)	(1.116)	(2.529)	(0.740)
Electricity_price	-0.704***	-0.495**	-0.648***	-0.256	-0.641***	-0.033	-0.608***	-0.930***	-0.176	-0.243**	-0.706***	-0.667***	-0.752***	-1.012***
	(-5.040)	(-2.510)	(-3.385)	(-0.804)	(-3.456)	(-0.105)	(-4.475)	(-3.371)	(-1.227)	(-2.099)	(-4.150)	(-2.922)	(-3.128)	(-3.398)
Capital_stock	0.089	-0.050	0.307***	-0.668**	0.271	0.621***	0.025	-0.862**	0.320**	-0.043	-0.264*	0.317	-0.474**	-0.347
	(0.536)	(-0.259)	(2.773)	(-2.428)	(1.415)	(3.210)	(0.164)	(-2.576)	(2.025)	(-0.224)	(-1.931)	(1.336)	(-2.591)	(-1.358)
Outsourcing_comp	1.396***	0.251	0.195	0.277	-0.321*	0.612	0.048	-0.849**	-0.538*	-0.056	-0.611***	0.286	-0.312	-0.530
	(4.190)	(1.459)	(1.347)	(0.650)	(-1.878)	(1.337)	(0.340)	(-2.032)	(-1.657)	(-0.738)	(-3.867)	(1.023)	(-0.926)	(-0.859)
trend	0.021**	0.027*	-0.035**	-0.023	-0.016	0.031	-0.003	-0.038*	0.010	0.004	-0.019*	-0.044***	-0.062***	0.031
	(2.194)	(1.938)	(-2.477)	(-1.144)	(-1.156)	(1.551)	(-0.244)	(-1.930)	(0.980)	(0.550)	(-1.795)	(-2.632)	(-3.285)	(1.417)
Country dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	349	349	309	335	349	254	348	335	349	349	345	345	341	337
R-squared	0.917	0.870	0.858	0.748	0.874	0.931	0.941	0.859	0.923	0.936	0.915	0.848	0.786	0.875

Table A.5 / Estimation results for natural gas intensity in the short run, without country dummies, by industry

VARIABLES	15t16	17t18	19	20	21t22	23	24	25	26	27t28	29	30t33	34t35	36t37
Gas_price	-0.993***	-0.834***	-0.839***	-0.706***	-1.071***	-1.157***	-1.489***	-0.114	-0.949***	-1.148***	-0.751***	-0.691***	-0.440***	-0.217
	(-7.827)	(-6.433)	(-7.108)	(-5.226)	(-9.214)	(-5.304)	(-15.445)	(-0.599)	(-7.910)	(-12.270)	(-5.845)	(-6.735)	(-3.611)	(-1.036)
Capital_stock	0.340***	0.350***	0.161***	-0.207***	0.556***	-0.403***	-0.318***	-0.283**	-0.116	-0.074	-0.227***	-0.364***	0.009	-0.099
	(4.216)	(5.701)	(3.029)	(-2.740)	(7.852)	(-3.374)	(-4.878)	(-2.531)	(-1.501)	(-1.093)	(-2.827)	(-5.309)	(0.105)	(-0.966)
trend	0.044***	0.034*	0.043***	0.001	0.046***	0.037	0.081***	-0.058**	0.050***	0.041***	0.011	0.010	-0.033*	-0.015
	(2.782)	(1.953)	(2.621)	(0.034)	(2.818)	(1.148)	(6.148)	(-2.261)	(3.276)	(3.258)	(0.640)	(0.540)	(-1.868)	(-0.483)
Observations	349	349	309	335	349	254	348	335	349	349	345	345	341	337
R-squared	0.152	0.129	0.143	0.146	0.243	0.230	0.572	0.054	0.241	0.359	0.203	0.323	0.087	0.013

Table A.6 / Estimation results for natural gas intensity in the long run, including electricity price and 'outsourcing component', by industry*

VARIABLES	15t16	17t18	19	20	21t22	23	24	25	26	27t28	29	30t33	34t35	36t37
Electricity_price	-0.001	0.309	1.295***	-0.867	0.120	-0.456	-0.497	1.515***	-0.423	-0.290	0.078	-0.375	0.962*	0.968
	(-0.002)	(0.941)	(3.589)	(-0.905)	(0.373)	(-0.597)	(-1.163)	(2.715)	(-1.396)	(-1.590)	(0.231)	(-0.703)	(1.816)	(1.313)
Gas_price	-0.712***	-0.524	-0.597	0.440	-0.845*	-0.266	-0.119	-1.148*	-0.396	0.139	-0.625*	0.115	-1.048***	-1.393*
	(-2.795)	(-1.042)	(-1.477)	(0.571)	(-1.748)	(-0.437)	(-0.283)	(-1.752)	(-1.400)	(0.410)	(-1.730)	(0.192)	(-2.642)	(-1.860)
Capital_stock	-0.163	-0.287	0.263	0.148	0.152	-0.139	-0.273	-1.110**	0.121	-0.042	-0.136	-0.325	-0.682*	0.217
	(-0.893)	(-1.051)	(1.120)	(0.393)	(0.547)	(-0.320)	(-0.989)	(-2.146)	(0.356)	(-0.101)	(-0.517)	(-0.860)	(-1.717)	(0.703)
Outsourcing_comp	0.454	-0.025	-0.178	-0.313	-0.338*	-1.400**	0.252	-2.021***	-0.114	-0.133*	0.007	0.809	-0.818	-0.909
	(0.810)	(-0.092)	(-0.675)	(-0.313)	(-1.747)	(-2.112)	(0.930)	(-2.917)	(-0.159)	(-1.764)	(0.012)	(1.044)	(-1.144)	(-0.816)
trend	0.022	-0.025	-0.105***	0.043	0.001	0.057	0.031	-0.076**	0.015	0.011	-0.011	-0.002	-0.079	-0.049
	(1.479)	(-1.203)	(-3.659)	(0.797)	(0.064)	(1.035)	(1.039)	(-2.155)	(0.639)	(0.600)	(-0.460)	(-0.054)	(-1.629)	(-0.938)
Country dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	235	235	200	215	235	167	234	221	235	235	231	231	219	221
R-squared	0.961	0.916	0.907	0.831	0.920	0.938	0.954	0.904	0.953	0.954	0.931	0.930	0.924	0.925

* With Newey-West standard errors adjusted for autocorrelation.

Table A.7 / Energy intensity, energy cost shares, and industrial competitiveness: alternative specification without labour productivity

	Total industries[1]			Energy intensive industries[2]		
Dependent variable: exports	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Energy intensity	-0.038***		-0.033**	-0.099**		-0.082*
	(-2.89)		(-2.41)	(-2.38)		(-1.95)
Energy cost share		-0.008*			-0.001	
		(-1.73)			(-0.08)	
Cost share of coal			0.016			0.014
			(0.65)			(0.49)
Cost share of oil and gas			0.007			0.018
			(0.69)			(1.56)
Cost share of coke, ref. Petroleum			0.002			0.014
			(0.20)			(1.30)
Cost share of electricity, etc.			-0.016**			-0.016*
			(-2.57)			(-1.95)
Share of high-skilled labour	0.836***	0.844***	0.832***	0.885	0.872	0.833
	(3.27)	(3.30)	(3.26)	(1.49)	(1.46)	(1.40)
Share of medium-skilled labour	-0.458**	-0.483**	-0.437**	-0.834*	-0.782	-0.710
	(-2.17)	(-2.28)	(-2.06)	(-1.71)	(-1.60)	(-1.46)
Capital intensity	-0.152***	-0.146***	-0.149***	-0.225**	-0.196*	-0.193*
	(-3.82)	(-3.66)	(-3.73)	(-2.07)	(-1.80)	(-1.77)
Wage per employee	0.213***	0.215***	0.208***	0.162	0.157	0.129
	(4.85)	(4.90)	(4.73)	(1.63)	(1.57)	(1.30)
GDP	0.225	0.287	0.225	0.613	0.725*	0.519
	(1.25)	(1.60)	(1.24)	(1.57)	(1.86)	(1.31)
Constant	0.066***	0.065***	0.066***	0.059***	0.058***	0.061***
	(9.59)	(9.45)	(9.55)	(4.02)	(3.91)	(4.14)
Observations	3,094	3,094	3,094	720	720	720
R-squared	0.023	0.021	0.026	0.033	0.025	0.049
Number of i	259	259	259	60	60	60

1) Without NACE 23 coke, refined petroleum and nuclear fuel.
2) The sub-sample of energy-intensive sectors includes NACE 24 chemicals and chemical products, NACE 26 other non-metallic minerals, and NACE 27to28 basic metals and fabricated metals.
Source: own calculations.

Table A.8 / Energy intensity, energy cost shares, and industrial competitiveness: alternative specification without capital intensity

	Total industries[1]			Energy intensive industries[2]		
Dependent variable: exports	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Energy intensity	-0.021	-0.017	-0.015	-0.062	-0.063	-0.049
	(-1.58)	(-1.28)	(-1.11)	(-1.49)	(-1.48)	(-1.14)
Energy cost share		-0.006			0.001	
		(-1.36)			(0.08)	
Cost share of coal			0.024			0.024
			(0.96)			(0.84)
Cost share of oil and gas			0.004			0.016
			(0.42)			(1.32)
Cost share of coke, ref. Petroleum			0.001			0.012
			(0.14)			(1.14)
Cost share of electricity, etc.			-0.017***			-0.018**
			(-2.74)			(-2.11)
Labour productivity (GO-based)	0.265***	0.265***	0.265***	0.275***	0.275***	0.261***
	(8.83)	(8.85)	(8.83)	(3.25)	(3.24)	(3.07)
Share of high-skilled labour	0.758***	0.753***	0.749***	0.896	0.895	0.839
	(3.00)	(2.98)	(2.96)	(1.51)	(1.51)	(1.42)
Share of medium-skilled labour	-0.432**	-0.450**	-0.416**	-0.705	-0.703	-0.602
	(-2.07)	(-2.15)	(-1.98)	(-1.46)	(-1.45)	(-1.24)
Wage per employee	-0.057	-0.058	-0.061	-0.128	-0.128	-0.137
	(-1.37)	(-1.38)	(-1.45)	(-1.31)	(-1.31)	(-1.40)
GDP	0.215	0.224	0.213	0.602	0.601	0.506
	(1.22)	(1.27)	(1.20)	(1.56)	(1.55)	(1.30)
Constant	0.060***	0.060***	0.060***	0.053***	0.053***	0.056***
	(9.09)	(9.10)	(9.09)	(3.72)	(3.71)	(3.91)
Observations	3,094	3,094	3,094	720	720	720
R-squared	0.044	0.045	0.047	0.042	0.042	0.058
Number of i	259	259	259	60	60	60

1) Without NACE 23 coke, refined petroleum and nuclear fuel.
2) The sub-sample of energy-intensive sectors includes NACE 24 chemicals and chemical products, NACE 26 other non-metallic minerals, and NACE 27to28 basic metals and fabricated metals.
Source: own calculations.

Table A.9 / Energy intensity, energy cost shares, and industrial competitiveness: alternative specification with labour productivity based on value-added

	Total industries[1)]			Energy intensive industries[2)]		
Dependent variable: exports	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Energy intensity	-0.014		-0.008	-0.050		-0.039
	(-1.00)		(-0.57)	(-1.13)		(-0.86)
Energy cost share		-0.007			0.001	
		(-1.55)			(0.23)	
Cost share of coal			0.013			0.011
			(0.51)			(0.39)
Cost share of oil and gas			0.005			0.016
			(0.51)			(1.39)
Cost share of coke, ref. Petroleum			0.001			0.016
			(0.15)			(1.49)
Cost share of electricity, etc.			-0.016***			-0.015*
			(-2.66)			(-1.79)
Labour productivity (VA-based)	0.170***	0.181***	0.170***	0.257***	0.300***	0.242***
	(4.90)	(5.55)	(4.90)	(2.76)	(3.48)	(2.60)
Share of high-skilled labour	0.820***	0.817***	0.814***	0.849	0.836	0.791
	(3.22)	(3.21)	(3.20)	(1.43)	(1.41)	(1.34)
Share of medium-skilled labour	-0.433**	-0.452**	-0.417**	-0.826*	-0.792	-0.710
	(-2.06)	(-2.14)	(-1.97)	(-1.71)	(-1.63)	(-1.46)
Capital intensity	-0.221***	-0.224***	-0.218***	-0.339***	-0.345***	-0.304***
	(-5.25)	(-5.32)	(-5.17)	(-2.93)	(-2.98)	(-2.61)
Wage per employee	0.132***	0.127***	0.127***	0.049	0.028	0.025
	(2.82)	(2.74)	(2.72)	(0.46)	(0.27)	(0.23)
GDP	0.165	0.185	0.165	0.456	0.473	0.356
	(0.92)	(1.04)	(0.92)	(1.16)	(1.20)	(0.89)
Constant	0.067***	0.067***	0.067***	0.064***	0.064***	0.066***
	(9.87)	(9.86)	(9.83)	(4.35)	(4.37)	(4.47)
Observations	3,094	3,094	3,094	720	720	720
R-squared	0.031	0.032	0.034	0.044	0.043	0.059
Number of i	259	259	259	60	60	60

1) Without NACE 23 coke, refined petroleum and nuclear fuel.
2) The sub-sample of energy-intensive sectors includes NACE 24 chemicals and chemical products, NACE 26 other non-metallic minerals, and NACE 27to28 basic metals and fabricated metals.
Source: own calculations.

Table A.10 / Energy intensity, energy cost shares, and industrial competitiveness: baseline specification on the sample 1995-2009

	Total industries[1]			Energy intensive industries[2]		
Dependent variable: exports	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Energy intensity	-0.020		-0.009	-0.031		-0.019
	(-1.51)		(-0.68)	(-0.76)		(-0.47)
Energy cost share		-0.013***			-0.001	
		(-3.11)			(-0.14)	
Cost share of coal			0.047*			0.047*
			(1.94)			(1.70)
Cost share of oil and gas			0.000			0.017
			(-0.05)			(1.41)
Cost share of coke, ref. Petroleum			-0.011			0.004
			(-1.36)			(0.44)
Cost share of electricity, etc.			-0.023***			-0.017**
			(-3.86)			(-2.05)
Labour productivity (GO-based)	0.344***	0.349***	0.344***	0.474***	0.484***	0.448***
	(11.40)	(11.64)	(11.39)	(5.51)	(5.68)	(5.17)
Share of high-skilled labour	0.435*	0.431*	0.422*	0.670	0.671	0.591
	(1.87)	(1.86)	(1.82)	(1.26)	(1.26)	(1.11)
Share of medium-skilled labour	-0.461**	-0.498**	-0.466**	-0.724	-0.715	-0.634
	(-2.25)	(-2.43)	(-2.27)	(-1.54)	(-1.52)	(-1.35)
Capital intensity	-0.254***	-0.260***	-0.253***	-0.419***	-0.424***	-0.378***
	(-6.78)	(-6.94)	(-6.76)	(-4.08)	(-4.12)	(-3.65)
Wage per employee	0.023	0.026	0.020	-0.051	-0.051	-0.071
	(0.54)	(0.59)	(0.46)	(-0.53)	(-0.54)	(-0.75)
GDP	1.242***	1.247***	1.228***	1.345***	1.354***	1.321***
	(10.91)	(10.98)	(10.75)	(5.02)	(5.06)	(4.88)
Constant	0.028***	0.029***	0.030***	0.030***	0.031***	0.031***
	(5.92)	(6.10)	(6.19)	(2.82)	(2.87)	(2.91)
Observations	3,261	3,261	3,261	759	759	759
R-squared	0.127	0.129	0.133	0.159	0.159	0.172
Number of i	259	259	259	60	60	60

1) Without NACE 23 coke, refined petroleum and nuclear fuel.
2) The sub-sample of energy-intensive sectors includes NACE 24 chemicals and chemical products, NACE 26 other non-metallic minerals, and NACE 27to28 basic metals and fabricated metals.
Source: own calculations.

Table A.11 / Energy intensity, energy cost shares, and industrial competitiveness: alternative specification with cost shares of individual energy products

	Total industries[1)]				Energy intensive industries[2)]			
Dependent variable: exports	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Energy intensity	-0.024*	-0.024*	-0.024*	-0.017	-0.069*	-0.065	-0.072*	-0.050
	(-1.82)	(-1.81)	(-1.83)	(-1.31)	(-1.66)	(-1.56)	(-1.74)	(-1.18)
Cost share of coal	0.014				0.022			
	(0.59)				(0.78)			
Cost share of oil and gas		0.006				0.015		
		(0.66)				(1.30)		
Cost share of coke, ref. Petroleum			0.003				0.015	
			(0.37)				(1.41)	
Cost share of electricity, etc.				-0.016***				-0.019**
				(-2.68)				(-2.37)
Labour productivity (GO-based)	0.330***	0.329***	0.329***	0.329***	0.421***	0.397***	0.410***	0.410***
	(10.57)	(10.53)	(10.56)	(10.56)	(4.58)	(4.27)	(4.46)	(4.47)
Share of high-skilled labour	0.723***	0.733***	0.723***	0.718***	0.950	0.991*	0.902	0.927
	(2.88)	(2.92)	(2.88)	(2.87)	(1.62)	(1.69)	(1.53)	(1.58)
Share of medium-skilled labour	-0.375*	-0.363*	-0.373*	-0.373*	-0.747	-0.693	-0.735	-0.742
	(-1.81)	(-1.74)	(-1.80)	(-1.80)	(-1.56)	(-1.44)	(-1.53)	(-1.55)
Capital intensity	-0.282***	-0.282***	-0.283***	-0.281***	-0.440***	-0.421***	-0.439***	-0.424***
	(-6.87)	(-6.87)	(-6.89)	(-6.84)	(-3.75)	(-3.55)	(-3.74)	(-3.61)
Wage per employee	0.065	0.066	0.065	0.062	0.004	0.013	0.007	-0.010
	(1.43)	(1.46)	(1.44)	(1.38)	(0.04)	(0.13)	(0.07)	(-0.09)
GDP	-0.010	-0.007	-0.018	-0.011	0.266	0.293	0.170	0.237
	(-0.06)	(-0.04)	(-0.10)	(-0.06)	(0.68)	(0.74)	(0.43)	(0.61)
Constant	0.070***	0.070***	0.071***	0.071***	0.066***	0.065***	0.069***	0.068***
	(10.47)	(10.39)	(10.46)	(10.49)	(4.55)	(4.43)	(4.68)	(4.67)
Observations	3,094	3,094	3,094	3,094	720	720	720	720
R-squared	0.06	0.06	0.06	0.063	0.064	0.065	0.066	0.071
Number of i	259	259	259	259	60	60	60	60

1) Without NACE 23 coke, refined petroleum and nuclear fuel.
2) The sub-sample of energy-intensive sectors includes NACE 24 chemicals and chemical products, NACE 26 other non-metallic minerals, and NACE 27to28 basic metals and fabricated metals.
Source: own calculations.

References

Ajanovic, A., Dahl, C., and Schipper, L., (2012), 'Modelling transport (energy) demand and policies — An introduction', Energy Policy 41, pp. iii-xiv

Ang, B.W., (2004), 'Decomposition for Policymaking in Europe: Which is the Preferred Method?', Energy Policy, 32, pp. 1131-1139.

Berman E. And Bui L.T.M. (2001), Environmental regulation and productivity: evidence from oil refineries, The Review of Economics and Statistics 83(3), pp. 498-510.

Berndt, E.R., and Wood, D.O., (1975), 'Technology, prices, and the derived demand for energy', The Review of Economics and Statistics, 57(3), pp. 259–268.

Berndt, E.R., and Wood, D.O., (1979), 'Engineering and econometric interpretations of energy-capital complementarity', The American Economic Review Nr. 69(3), pp. 342-354

Biermann, A., (2008), 'Energy Prices and Taxes in the United States', Energy Prices & Taxes, 1st Quarter.

Bohi, D., and Zimmerman, M., (1984), 'An update on econometric studies of energy demand behaviour', Annual Review of Energy, 9, pp. 105-54.

CEPS (2013), Assessment of cumulative cost impact for the steel industry, Final Report, 10 June, Brussels.

Chai, J., Guo, J., Wang, S., and Lai, K.K., (2009), 'Why does energy intensity fluctuate in China?', Energy Policy 37, pp. 5717-5731

Charemza, W.W., and Deadman, D.F., (1997), 'New direction in econometric practice, general to specific modelling, co-integration and vector autoregression', Edward Elgar Publishing, Ltd., Hants, England.

Christiansen, G.B. and Haveman R.H. (1981), The contribution of environmental regulation to the slowdown in productivity growth, Journal of Environmental Economics and Management 8(4), pp. 381-390.

Constantini, V., and Mazzanti, M., (2011), 'On the green and innovative side of trade competitiveness? The impact of environmental policies and innovation on EU exports', Research Policy, Vol. 41, Issue 1, pp. 132-153

Corbeau, A.-S., (2010), 'The evolution of gas prices', Energy Prices & Taxes, 1st Quarter.

Council of European Union (2014), The case of energy-intensive industries, presentation by the Working Party on the Competitiveness and Growth, 5 March.

Dahl, C., (1993), 'A survey of energy demand elasticities in support of the development of the NEMS', MPRA Paper No. 13962, October.

Dahl, C., and Sterner, T., (1991), 'Analysing gasoline demand elasticities—a survey', Energy Economics 13, pp. 203-210.

Directive 2012/27/EU of the European Parliament and Council of 25 October 2012 on energy efficiency.

Eichhammer, W., and Walz, R., (2011), 'Industrial energy efficiency and competitiveness', UNIDO Working Paper, No 5, Vienna.

European Commission (2007), 'Analysis of the economic impact of energy product prices on competitiveness of the energy and manufacturing sectors in the EU: comparison between EU and US'. DG Transport and Energy. Brussels, Belgium.

European Commission (2012a), Guidelines on certain State Aid measures in the context of the greenhouse gas emission allowance trading scheme post-2012, SWD(2012 130 final, SWD(2012), 131 final.

European Commission (2012b), 'Energy Markets in the European Union in 2011', DG Energy, Luxembourg, http://ec.europa.eu/energy/gas_electricity/doc/20121217_energy_market_2011_lr_en.pdf

European Commission (2012c), European Competitiveness Report 2012, 'Reaping the Benefits of Globalization', http://ec.europa.eu/enterprise/policies/industrial-competitiveness/competitiveness-analysis/european- competitiveness-report/index_en.htm

European Commission (2013a), 'Member States' Energy Dependence: An Indicator-Based Assessment', European Economy Occasional Papers 145, April.

European Commission (2013b), Green Paper on 'A 2030 framework for climate and energy policies', http://ec.europa.eu/energy/green_paper_2030_en.htm

European Commission (2013c), 'Market Functioning in Network Industries – Electronic Communications, Energy and Transport', European Economy Occasional Papers 129, February.

European Commission (2014a), 'Energy economic developments in Europe', DG Economic and Financial Affairs, European Economy Series No. 1, http://ec.europa.eu/economy_finance/publications/european_economy/2014/pdf/ee1_en.pdf

European Commission (2014b), Energy prices and costs report, SWD (2014) 20 final, 22 January, Brussels, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014SC0020&from=EN

European Competitiveness Report 2012, http://ec.europa.eu/enterprise/policies/industrial-competitiveness/competitiveness-analysis/european-competitiveness-report/index_en.htm

Feenstra, R. and Hanson G. (1995), Foreign direct investment and relative wages: evidence from Mexico's maquiladoras, NBER Working Paper No. 5122, May.

Folkerts-Landau, D., (2013), Energiewende 2.0 – don't risk competitiveness, Deutsche Bank Research, 26, November 2013.

Frondel, M., Ritter, N., Schmidt, C.M., and Vance. C., (2010), 'Economic impacts from the promotion of renewable energy technologies: The German experience', Energy Policy (38), pp. 4048-4056.

Gerlagh, R., and Mathys, N.A., (2011), 'Energy Abundance, Trade and Industry Location', Fondazione Eni Enrico Mattei, Nota di Lavoro, 03.2011.

Gillingham, K., Newell, R.G., and Palmer, K., (2009), 'Energy efficiency economics and policy', Annual Review of Resource Economics, 1, pp. 597-619.

Gollop, F.M. and Roberts M.J. (1983), Environmental regulations and productivity growth: the case of fossil-fueled electric power generation, Journal of Political Economy 91(4), pp. 654-674.

Gray W.B. and Shadbegian R.J. (2003), Plant vintage, technology, and environmental regulation, Journal of Environmental Economics and Management 46(3), pp. 384-402.

Greenstone M. (2002), The impacts of environmental regulations on industrial activity: evidence from the 1970 and 1977 clean air act amendments and the census manufacturers, Journal of Political Economy 110(6), pp. 1175-1218.

Halicioglu, F., (2009), 'An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey', Energy Policy, 37(3).

Hang, L., and Tu, M., (2007), 'The impacts of energy prices on energy intensity: Evidence from China'. Energy Policy, Vol. 35, Issue 5, pp. 2978-2988.

Hossain, S., (2011), 'Panel estimation for CO2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries', Energy Policy, 39(11), pp. 6991–6999.

HSBC (2013), 'China oil and gas: gas pricing reform – upstream and midstream to benefit', 8 May, http://www.research.hsbc.com

International Gas Union (2013), Wholesale gas price survey – 2013 edition, A global review of price formation mechanisms 2005-2012, Fornebu, Norway.

IEA (2010), 'The Importance of Demand-Side Efficiency Improvements in the Electricity Sector', Energy Prices & Taxes, 1st Quarter.

IEA (2011), Climate and Electricity Annual: Data and Analyses, OECD/IEA, Paris.

IEA (2013), World Energy Outlook 2013, Paris.

Jaffe A.B. et al. (1995), Environmental regulation and the competitiveness of US manufacturing: what does the evidence tell us?, Journal of Economic Literature 33(1), pp. 132-163.

Joseph, A., and Pizer, W., (2011), 'The Competitiveness Impacts of Climate Change Mitigation Policies', HKS Faculty Research Working Paper Series RWP11-047, John F. Kennedy School of Government, Harvard University.

Kefferpütz, R., (2010), 'Shale Fever: Replicating the US gas revolution in the EU?', CEPS Policy Brief, No. 210/June

Kim, J., and Heo, E., (2013), 'Asymmetric substitutability between energy and capital: Evidence from the manufacturing sectors in 10 OECD countries', Energy Economics, 40, pp. 81–89.

Krishnapillai, S., and Thompson, H., (2012), 'Cross section translog production and elasticity of substitution in US manufacturing industry', International Journal of Energy Economics and Policy, Vol. 2, No. 2, pp. 50-54.

Kubat, J., and Kennedy, A., (2011), 'Feed-in tariffs in selected EU countries', IEA Energy Prices & Taxes, 1st Quarter.

Ma, H., Oxley, L., and Gibson, J., (2009), 'Substitution possibilities and determinants of energy intensity for China', Energy Policy, Vol. 37, Issue 5, pp. 1793-1804.

Ma, H., Oxley, L., and Gibson, J., (2010), 'China's energy economy: A survey of the literature', Economic Systems, Volume 34, Issue 2, pp. 105-132

Mendiluce, M., Perez-Arriaga, I., and Ocana, C., (2010), 'Comparison of the evolution of energy intensity in Spain and in the EU15. Why is Spain different?', Energy Policy 38, pp. 639-645.

Morgan, T., and Emoto, H., (2007), 'The impact of higher energy prices on demand', International Energy Agency, Energy Prices & Taxes, 1st Quarter.

Mulder, P., and de Groot, H.L.F., (2012), 'Structural change and convergence of energy intensity across OECD countries, 1970–2005', Energy Economics, Volume 34, Issue 6, pp. 1910–1921.

Mulder, P., and de Groot, H.L.F., (2013), 'Dutch sectoral energy intensity developments in international perspective, 1987–2005', Energy Policy, Vol. 52, pp. 501-512

Narayan, P.K., and Wong, P., (2009), 'A panel data analysis of the determinants of oil consumption: The case of Australia', Applied Energy 86, pp. 2771–2775.

National Conference of State Legislatures (2012), 'Oil and gas severance taxes: states work to alleviate fiscal pressures amid the natural gas boom', http://www.ncsl.org/research/energy/oil-and-gas-severance-taxes.aspx

OECD/IEA (2012), Gas pricing and regulation: China's challenges and IEA experience.

Okereke C. and McDaniels D. (2012), To what extent are EU steel companies susceptible to competitive loss due to climate policy ? Energy Policy 46, pp. 203-215.

Philibert, C., (2012), 'Solar Energy Perspectives: Policies', Energy Prices & Taxes, 2nd Quarter.

Pindyck, R.S., and Rubinfeld, D.L., (1991), Econometric Models & Economic Forecasts, McGraw-Hill, New York.

Porter, M., and van der Linde, C., (1995), 'Toward a New Conception of the Environment-Competitiveness Relationship', Journal of Economic Perspectives, Vol. 9, No. 4, pp. 97–118

Reinaud, J., (2005), 'Impact of Carbon Emission Trading on Electricity Generation Costs', Energy Prices & Taxes, 2nd Quarter.

Renda, A., (project co-ordinator) (2013), Four Assessment of Cumulative Cost Impact for the Steel and the Aluminium Industry – Final Report Aluminium, Centre for European Policy Studies, Economisti Associati.

Rennings, K. und Rexhäuser S. (2011), Long-Term Impacts of Environmental Policy and Eco-Innovative Activities of Firms, International Journal of Technology Policy and Management, Special Issue Vol. 11, Nos. 3/4, pp.274–290.

Riker, D., (2012), 'Energy Costs and Export Performance', US Department of Commerce, Manufacturing and Services Economics Brief No. 7, April.

Seale, J.L., and Solano, A.A., (2012), 'The changing demand for energy in rich and poor countries over 25 years'. Energy Economics, Volume 34, Issue 6, pp. 1834-1844

Sensfuß, F., (2011), Analysen zum Merit-Order Effekt erneuerbarer Energien, Frauenhofer ISI, Karlsruhe, Februar.

Stern, D., (2012a), 'Interfuel substitution: a meta-analysis', Journal of Economic Surveys Vol. 26, No. 2, pp. 307-331.

Stern, D., (2012b), 'Modeling international trends in energy efficiency', Energy Economics, Volume 34, Issue 6, pp. 2200-2208.

Swift, T.K., and Moore, M.G., (2013), 'Shale Gas Brightens Outlook for U.S. Chemicals', www.aiche.org/cep

Timmer, M., (ed.) (2012), The World Input-Output database (WIOD): Contents, Sources and Methods, available at http://www.wiod.org/publications/source_docs/WIOD_sources.pdf

Von Roon, S., and Huck, M., (2010), Merit Order des Kraftwerkparks, Forschungsstelle für Energiewirtschaft e.V.

Waldron, M., and Heymi, B., (2013), 'Investment in Renewable Energy', Energy Prices & Taxes, 3rd Quarter.

Wettestad, J., (2008), 'EU Energy-intensive Industries and Emissions Trading. Losers becoming Winners?', CANES Working Paper, FNI Report 10/2008.

Yang, M., Yang, F., and Chen, X., (2011), 'Effects of substituting energy with capital on China's aggregated energy and environmental efficiency', Energy Policy 39, pp. 6065-6072

Yuying, L. et al., (2013), 'A comparison of natural gas pricing mechanisms of the end-user markets in USA, Japan, Australia and China', China-Australia Natural Gas Technology Partnership Fund, 2013 Leadership Imperative, August 6.

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