FONDAZIONE ENI ENRICO MATTEI

NOTA DI LAVORO

64.2010

The Linkages between Energy Efficiency and Security of Energy Supply in Europe

By **Andrea Bigano,** Fondazione Eni Enrico Mattei, Milan, Italy

Ramon Arigoni Ortiz, Basque Centre for Climate Change, Bilbao, Spain

Anil Markandya, Basque Centre for Climate Change, Bilbao, Spain

Emanuela Menichetti, Observatoire Méditerranéen de l'Energie, Nanterre, France

Roberta Pierfederici, Fondazione Eni Enrico Mattei, Milan, Italy

INSTITUTIONS AND MARKETS Series
Editor: Fausto Panunzi

The Linkages between Energy Efficiency and Security of Energy Supply in Europe

By Andrea Bigano, Fondazione Eni Enrico Mattei, Milan, Italy
Ramon Arigoni Ortiz, Basque Centre for Climate Change, Bilbao, Spain
Anil Markandya, Basque Centre for Climate Change, Bilbao, Spain
Emanuela Menichetti, Observatoire Méditerranéen de l'Energie, Nanterre, France
Roberta Pierfederici, Fondazione Eni Enrico Mattei, Milan, Italy

Summary
It can be argued that one way to reduce the dependence from external energy sources, is simply to reduce the demand for energy. Energy savings may thus be considered a policy priority when concerns for energy security are particularly strong. Drawing on an original econometric approach, we check whether policies and measures that affect indicators of energy efficiency performance have an analogous effect on security of supply indicators, both at the whole economy level and within the main sectors of energy use in the EU 15 countries and Norway. Our analyses show that the indicators studied are affected by a number of policies and measures; however very few of them seem able to tackle effectively and simultaneously, energy efficiency, carbon efficiency and energy security. The main lesson to be drawn from this analysis is therefore that there is a number of energy efficiency policies in the EU that do work, but there is no silver bullet able to successfully address different policy objectives. Taking a more general perspective, what seems to work is the policy mix rather than this or that policy in insulation.

Keywords: Energy Efficiency, Energy Security, Policy Effectiveness, Europe

JEL Classification: Q40, Q48, Q58, C33

Address for correspondence:

Andrea Bigano
Fondazione Eni Enrico Mattei
Corso Magenta 63
20123 Milan
Italy
E-mail: andrea.bigano@feem.it

The linkages between energy efficiency and security of energy supply in Europe.

Andrea Bigano[a], Ramon Arigoni Ortiz[b], Anil Markandya[b], Emanuela Menichetti[c], and Roberta Pierfederici[a]

a Fondazione Eni Enrico Mattei, Milan, Italy
b Basque Centre for Climate Change, Bilbao, Spain
c Observatoire Méditerranéen de l'Energie, Nanterre, France

Abstract

It can be argued that one way to reduce the dependence from external energy sources, is simply to reduce the demand for energy. Energy savings may thus be considered a policy priority when concerns for energy security are particularly strong.
Drawing on an original econometric approach, we check whether policies and measures that affect indicators of energy efficiency performance have an analogous effect on security of supply indicators, both at the whole economy level and within the main sectors of energy use in the EU 15 countries and Norway.
Our analyses show that the indicators studied are affected by a number of policies and measures; however very few of them seem able to tackle effectively and simultaneously, energy efficiency, carbon efficiency and energy security. The main lesson to be drawn from this analysis is therefore that there is a number of energy efficiency policies in the EU that do work, but there is no silver bullet able to successfully address different policy objectives. Taking a more general perspective, what seem to work is the policy mix rather this or that policy in insulation.

JEL classification codes: Q40, Q48, Q58, C33

1. Introduction

In recent decades, increasing demand for energy, fluctuating oil prices, uncertain energy supplies and global warming made the EU-citizens to realize that secure and safe supplies of energy can no longer be taken for granted. It becomes obvious that improved energy efficiency can play a critical role in addressing energy security, environmental and economic objectives.

Security of energy supply has been widely debated, mostly in relation to the upstream (security of supply for specific geographical region or single country). However, it can be argued that one way to reduce the dependence from external energy sources, or the exposure to energy prices volatility and increase, is simply to reduce the demand for energy. Energy savings may thus be considered a policy priority when concerns for energy security are particularly strong. Thus, in order to fully understand how energy security affects the European society and how demand-side policies can be geared a detailed knowledge of energy intensities in the Europe member countries' sectors and of their potential for efficiency improvement is potentially very important.

This paper collects the main results of the analyses of energy efficiency in an energy security perspective, carried out within an European 7th Framework Programme project[1], looking in detail into energy use by sector in Europe.

To this purpose an original econometric approach is applied to EU-15 countries and Norway. Drawing on Arigoni Ortiz et al. (2009) and Confindustria (2008), which focused solely on energy and carbon efficiency indicators, we check whether policies and measures that affect indicators of energy efficiency performance have an analogous effect on security of supply indicators, both at the whole economy level and within the main sectors of energy use. We apply this approach to the most up-to date data and on energy policies and measures and energy indicators available at the time of writing.

The analyses have shown that the indicators studied are affected by a number of policies and measures (P&Ms); however very few P&Ms seem able to tackle effectively and simultaneously, energy efficiency, carbon efficiency and energy security.

The main lesson to be drawn from this analysis is that there is a number of energy efficiency policies in the EU that do work, but there is no silver bullet able to successfully address different policy objectives. Taking a more general perspective, what seem to work is the policy mix rather this or that policy in insulation.

The rest of the paper is organized as follows. Section 2 gives a general overview of energy consumption in Europe in the last 3 decades and describes in more detail the indicators studied. Section 3 looks at the energy reduction potential and European and at the European policy framework for the promotion of energy efficiency and at national policies in the various sectors of energy use. Section 4 explains the methodology applied in our panel analyses, Section 5 describes the dataset and Section 6 discusses the results. Section 7 concludes. Annex I lists and explains the variables used in the econometric analyses.

2. Main Energy Efficiency Indicators for the EU

This Section provides an international comparison of energy efficiency indicators. Energy efficiency is evaluated by macro and specific indicators defined at the level of the economy as a whole, of a sector, of an end-use. Three indicators are considered to compare energy efficiency performances and to monitor energy efficiency trends. In fact, due to the peculiarities of the sectors considered, it is not possible to use the same indicators of energy efficiency for all the subsectors. In particular

- Energy Intensities index (E.I.): it is the ratio between energy consumption and a macro-economic variable, measured in monetary units; it makes sense only for sectors yielding output measurable in value terms. Thus it is used for the analyses of the industrial, service and agricultural sectors;

[1] Project No 213744, 7th Framework Program. The financial support of the DG Research of the European Commission is gratefully acknowledged. The authors are grateful to Claudia Checchi and Stefan Hirschberg for their comments and suggestions. All errors are ours.

- Energy Efficiency index (E.E.): it accounts for a synthesis of energy efficiency trends, assessed using unit consumption measures, that relate energy consumption to a physical indicator of activity; It is used mainly for the residential sector, whose contribution to the welfare of the economy cannot be measured in terms of value added;
- Carbon Intensity (C.I.): it is the ratio between emissions, generally expressed in terms of CO_2, and a macro-economic variable measured in monetary units. In this case, similar considerations apply: when value data for the output of the sector under scrutiny are available, one can compute the carbon intensity (that is, the ratio of CO_2 emissions and value added); otherwise, physical indicators such as emissions per capita must be used.

The indicators can also be used to help monitoring the success of key policies that attempt to influence energy consumption and energy efficiency.
To frame our discussion in its appropriate context, let us look briefly to the general situation of energy consumption in Europe.

2.1 Energy Consumption in the EU

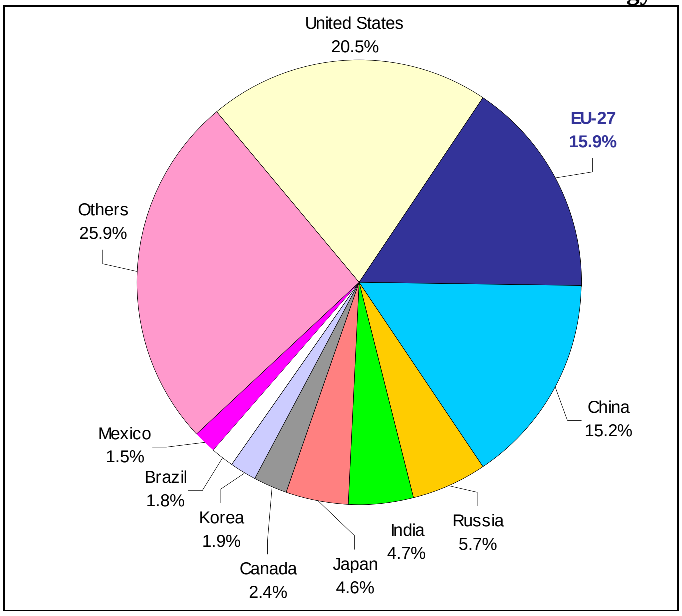
Despite being the largest economy worldwide in terms of GDP, the growth in energy consumption of Europe is rather limited. Europe contributes to 16 percent of total world energy consumption, which is as much as China, and less than the amount consumed by USA (Figure 1).
The primary and final energy consumption increased at approximately the same rate between 1990 and 2004 (1% per year on average) in the EU-15 and amounted to around respectively 1000 Mtoe and 1500 Mtoe (source: ODYSSEE). However, the period 1993-2000 was characterized by faster growth in energy consumption (1.5% per year) driven by a steady and rapid expansion of the economy (2.7% per year for the GDP and 2.3% per year for industry). Since 2000, there has been a slowdown in economic activity, which has resulted in a lower progression of energy use. Electricity demand underwent a more rapid progression of around 2% per year on average.

In 2007, the final energy consumption of the European Union (EU-27) reached 1196 Mtoe. The industrial sector accounted for 25% of final energy consumption and the residential sector for 25%, the remainder was shared among services transport, and agriculture. The share of renewable energies in the total final energy consumption was 9% (source: Enerdata).

Indexing the level of energy consumption in 1990, the European consumption decreased right after, and from 1996 it smoothly increased at a rate of ten percent in 15 years, which is sensibly lower than the one shown by the other world economies (Figure 2).
As to the relative contribution on European energy consumption from EU-15 countries (Figure 3), energy consumption has increased for the EU as a whole, while the consumption share of each country has remained rather stable. The highest portion of energy consumption is ascribable to Germany, followed by France, United Kingdom and Italy. While France, Italy and Spain experienced the highest increase in energy consumption from 1980 to 2006.
Disaggregating demand by energy fuels, European consumption is mainly composed by oil, gas and electricity (Figure 4), and their shares are equal respectively to 42, 25 and 20 percent. Solid fuels, in spite of being historically an important source of energy, at the present they contribute only marginally to the total energy mix. Renewable energy sources and industrial waste own a limited share of total consumption and their contribution remained invariant during the last 15 years.
In terms of categories of final users, the service, agricultural and household sectors taken together (this aggregate is labelled “other sectors” in Figure 5) contribute the largest share of total final energy consumption, then followed by industry and finally by transport. Over the 15 year period, the demand in the industry sector has slightly decreased, while an opposite trend characterizes the transport sector.
Moving to electricity generation, solid fuels remain a significant energy source, contributing to 28 percent of total generation, although their use has diminished a little over time. The largest source is represented by nuclear, making more than 30 percent of total production. A sustained

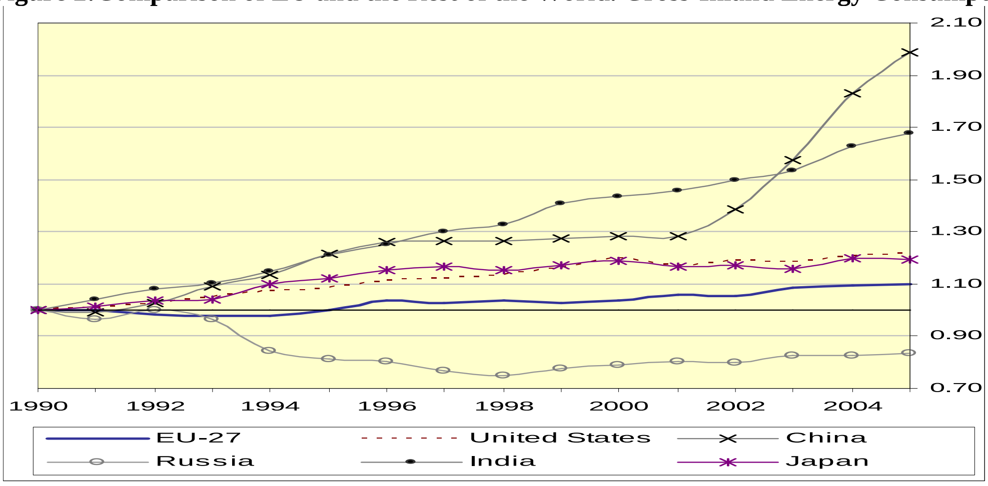
upward thrust is displayed by gas, which at present guarantees 21 percent of total production. Renewables own a relevant share (14 percent in 2005).

Figure 1: Comparison of EU and the Rest of the World. Gross-Inland Energy Consumption. 2005



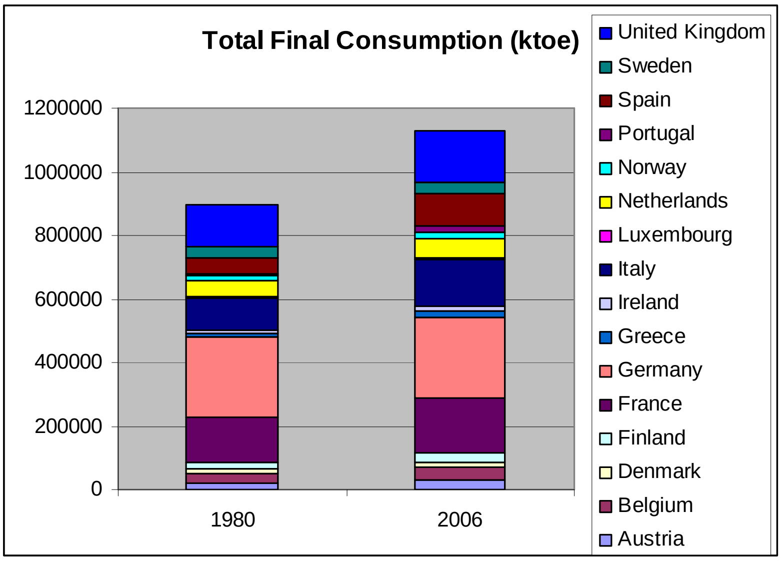
Notes: 1990=1. China, including Hong Kong. Source: Eurostat.

Figure 2:Comparison of EU and the Rest of the World. Gross-Inland Energy Consumption



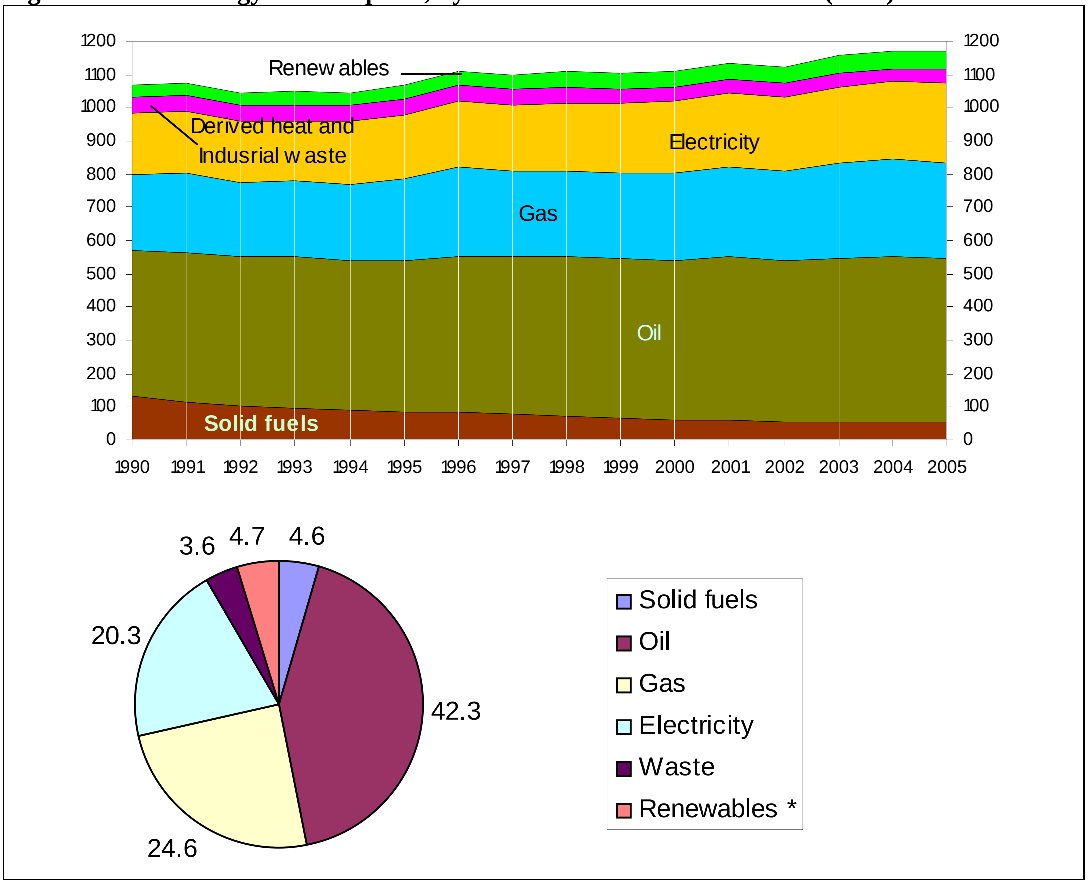
Notes: 1990=1. Source: Eurostat data.

Figure 3: Final Energy Consumption, by Country: EU-15 + Norway. Comparison between 1980 and 2006 levels, ktoe.



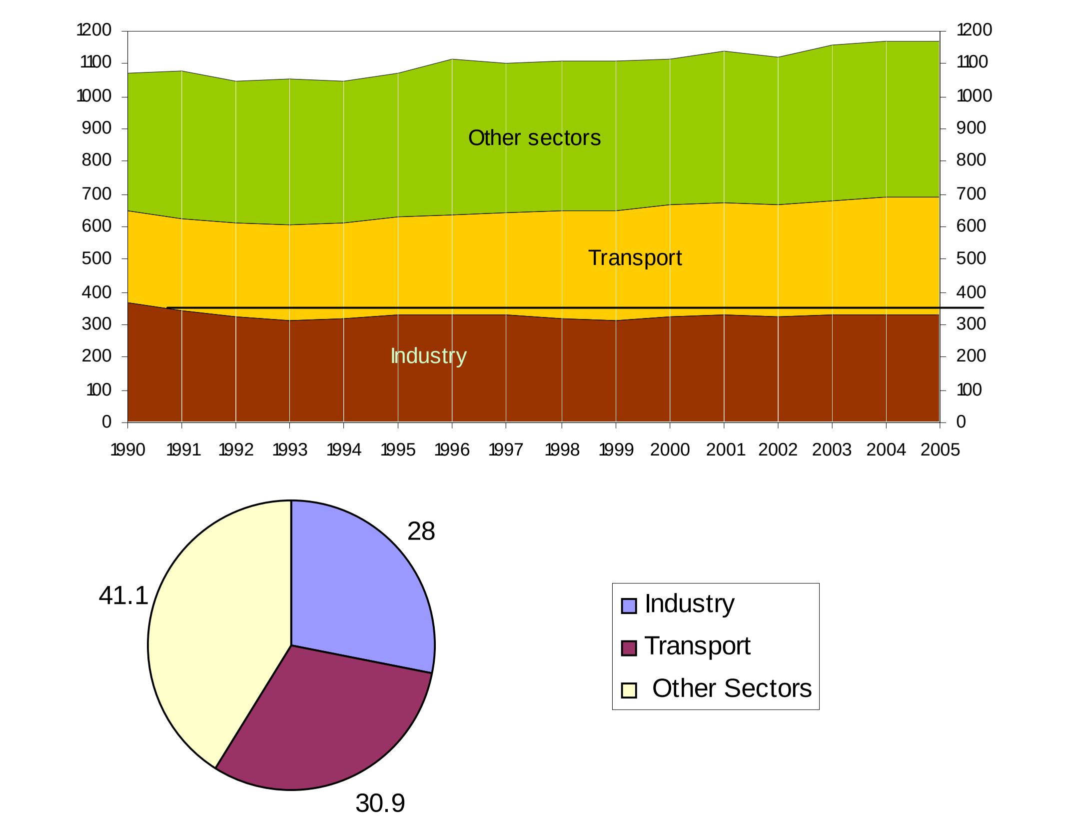
Source: Author s' computation on data from IEA.

Figure 4: Final Energy Consumption, by Fuel: EU-27. Mtoe and Shares (2005)



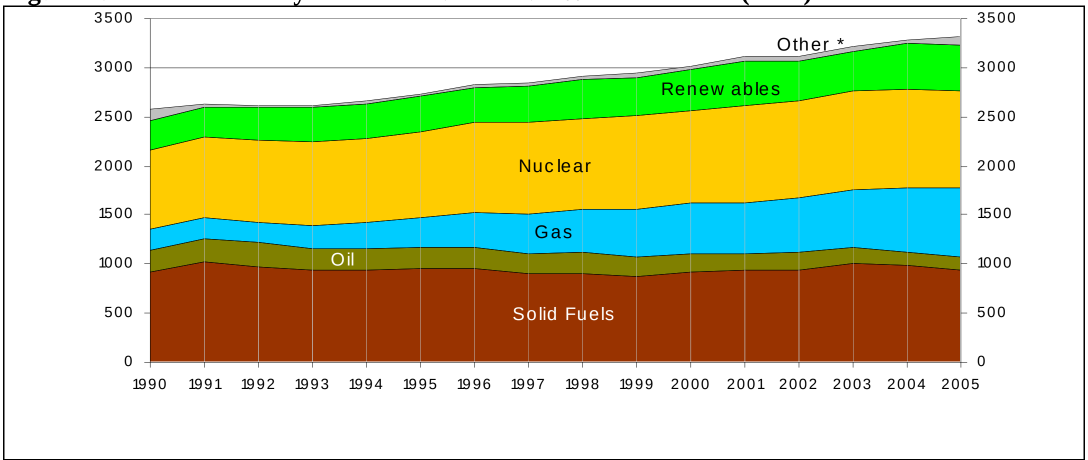
Note: * Renewables not including Electricity. Source: Eurostat.

Figure 5: Final Energy Consumption, by Sector. EU-27 and shares (2005)



Source: Eurostat.

Figure 6: Gross Electricity Generation. EU-27. TWh and Shares (2005)

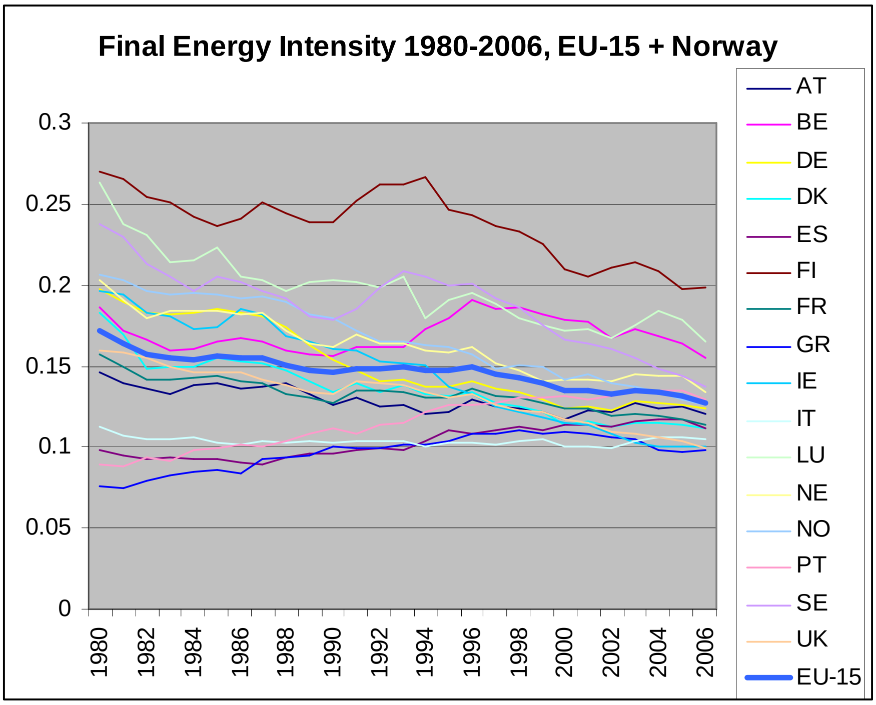


2.2 Energy Intensity in the EU

This Section provides a descriptive international comparison of energy intensity indicators. Figure 7 reports data on energy intensity[2] for 16 European countries. Because of data availability, we have decided to focus on the EU-15 countries and on Norway, i.e. the countries where those data are available since 1980. The countries that have recently joined the European Union have not been included in the analysis. In fact, for these countries time series are available only since 1990. In addition, because of their geographical and economic proximity, data for the EU-15 nations are more easily comparable.

[2] Estimated as energy use per unit of output.

Figure 7: Final Energy Intensity in European Countries + Norway, 1980-2006, ktoe/00$ppp.



Source: Author's computation on data from IEA, EUROSTAT, OECD.

Energy Intensity is an **economic** indicator of energy used in the production activity of a country. The index is defined as the ratio between energy consumption and an indicator of activity measured in monetary units (e.g. GVA). This indicator can be used whenever energy efficiency is assessed at a high level of aggregation (i.e. at the level of the whole economy or at a sector level), since in this case it is not possible to characterise economic activity with technical or physical indicators. High (low) E.I. indicates a high (low) price or cost of converting energy into GVA. The classical E.I. index is calculated by dividing energy consumption by GVA, on a sector basis.

In this study the final and sectoral energy consumption have been obtained from the IEA balance sheet (ktoe). The sectoral values added result from a combination of data from EUROSTAT national accounts and OECD database.

Figure 7 shows the pattern of final energy intensity of the overall economy in the EU-15 plus Norway from 1980 to 2006. Looking at the average of European countries, the index exhibits a smoothly decrease over the entire period under scrutiny. The largest improvements are displayed by Luxembourg and Finland, the latter registering a sharp decrease in the E.I. index, which changes over from 0.27 ktoe/00$ppp in 1980 to 0.19 in 2006. By contrast, the Portuguese E.I. index shows a stable upward trend, interrupted by a drop starting from 2005. In Spain after a period of decrease, the index starts to grow up from the '90s. On the other hand, Italy exhibits a four-phase pattern. In the first one it can be notice a stable decrease in the E.I. index until the mid-'80s. From this period the index remains nearly constant up to 2002, when it starts to rise. In the latest phase, starting in 2005 the index drops again.

Table 1 depicts the evolution of energy intensity of the industry sector for the sixteen countries under scrutiny: in 2005 the countries with the lowest levels of energy intensity were Ireland, Denmark and Greece. Energy policy decisions taken by the respective authorities (as well as the structure of their productive sectors) have allowed these countries to reach good results in terms of energy intensity achievements.

3-year Average Centered on 1985			3-year Average Centered on 1995			3-year Average Centered on 2005	
IT	0.113		IE	0.110		IE	0.063
ES	0.120		DK	0.113		DK	0.088
UK	0.121		IT	0.120		GR	0.108
DK	0.122		UK	0.123		UK	0.117
GR	0.125		GR	0.125		IT	0.126
AT	0.136		AT	0.130		NO	0.131
PT	0.150		ES	0.137		AT	0.139
FR	0.163		DE	0.137		DE	0.139
DE	0.165		FR	0.167		ES	0.142
IE	0.173		PT	0.184		FR	0.154
BE	0.209		NO	0.195		PT	0.201
NE	0.227		NE	0.215		SE	0.210
NO	0.240		BE	0.278		NE	0.234
SE	0.252		SE	0.285		LU	0.240
FI	0.330		LU	0.315		BE	0.297
LU	0.391		FI	0.370		FI	0.318
Average	0.190			0.188			0.169
Median	0.164			0.152			0.140
Minimum	0.113			0.110			0.063
Maximum	0.391			0.370			0.318

Source: Authors' computation on data from IEA, EUROSTAT, OECD.
Note: arrows shows movements between quartiles over time.

Table 1: Energy Intensity in Industry Sector: EU-15+ Norway, 1980-2006, ktoe/00$ppp.

Table 1 highlights that, between 1995 and 2005, apart from Portugal and Spain, energy intensity has improved significantly in countries like Norway, Luxembourg, Ireland, Denmark and Greece. The best performance is achieved by Ireland, which climbed up from the tenth position in 1985 to the top of the ranking in 1995 and 2005. Some countries, such as Ireland, Denmark and Norway, have improved their position both in absolute and in relative terms during the period considered. Others, like France, in spite of the improvement of the E.I. index, have lost their position with respect to the top performers.
In addition, Table 1 illustrates also a general trend regarding the energy intensity of European countries. The average value steadily decreases, losing almost the 12 percent of the 1985 value. Even the median value displays a significant downward trend, switching most of countries closer to the minimum value.
Finally, the difference between the minimum value and the maximum value decreases as well (0.255 in 2005 with respect to 0.278 at the begin of the period). This information provides additional evidence on how energy intensity has improved (and converged) among the considered countries. Similar patterns of convergence towards lower levels of energy intensity across the countries under scrutiny characterise the evolution of this indicator in the transport sector and in the "other sectors". We omit the details for economy of space (tables are available from the authors upon request).

2.3. Energy efficiency in the residential sector

The energy intensity index cannot capture the efficiency of the residential sector, since household activities does not generate value added directly. For this sector, one needs to resort to indexes unrelated to economic values, such as the energy efficiency index. In contrast with energy intensity indicators, in fact, the energy efficiency index is based on measures of unit consumption, that is, on physical/technological measures.

Hence, it follows that the influence of economic structural changes, as well as the impact of other factors which are not directly associated to a strict definition of energy efficiency, are not considered in the construction of the indicators.
The classical energy efficiency (E.E.) index ranges between 0 and 100. A decrease in the index is to be interpreted as an improvement in energy efficiency.
The E.E. index is calculated by weighting the changes in unit consumptions (UC), according to the consumption's share of the sector they refer to. UC are defined at a more disaggregated level by relating energy consumption to an indicator of activity measured in physical terms. UC are expressed in different units, depending on the sub-sector or end-use, in order to provide the best proxy of energy efficiency. The final E.E. index is a pure number (that is, it is not expressed in terms of any unit of measure).
UC for the households sector are not of course pure numbers, but are expressed in physical units: toe per dwelling or per m^2 for heating, toe per dwelling or per capita for water heating and cooking and kWh per dwelling or per appliance for electrical appliances as televisions, fridge, freezers, washing machines, dish washers.
Two alternative but equivalent methods can be used in order to calculate E.E. indices:
The E.E. index is calculated as a weighted average of unit consumption indices by sub-sectors. Its interpretation is easier, as the value obtained is directly linked to the variation of E.E. within each sub-sector. The idea is to calculate the variation of the weighted index of UC between a base year and year *t*, as follows:

$$\mathrm{I_t}/\mathrm{I_0} = \left(\sum_i EC_{i,t} * \left(UC_{i,t} / UC_{i,0} \right) \right) \qquad (1)$$

where UC_i indicates the unit consumption index of a sub-sector *i* and EC_i is the share of sub-sector *i* on total consumption. The E.E. index is then calculated by taking the data starting point as base year.

Table 2 shows the percentage change in the energy efficiency index in the EU-15 and Norway between 1980-2004 by considering separately the sub-samples 1980-1992 and 1993-2004. That is, it shows whether in the residential sector significant changes have occurred.
The resulting ranking of these countries does not necessarily single out the most or least "virtuous" countries in terms of energy efficiency: the table displays the countries that have been able to benefit from their potential of energy efficiency improvement, irrespective of their original level of energy efficiency in the base year.
The most significant improvements in the energy efficiency of the household sector have been achieved in Portugal and Norway (data were available on for a sub set of EU countries thus making impossible an assessment of the evolution of this indicator across the EU-15 countries and Norway). In Portugal, the increases in energy efficiency in the two sub-samples have been 12.9 and 42.4 percentage points, respectively. In Norway, improvements have been more impressive. Although in Norway, during the 1980-1992 period, energy efficiency has decreased by 15.8 percent, this country was able to raise energy efficiency standards. Consequently, during the 1992-2004 period, energy efficiency has increased by approximately, 11.7 percent.
This reversal in the general trend has been argued to be due to the policies introduced by these countries in order to boost energy savings and energy conservation. The lesson that can be drawn from the experience of these countries, is that the implementation of these policies is feasible, not only in countries with high indexes of economic and social development like Norway, but also in countries that have to do efforts in order to reduce the gap they have with respect to the rest of Europe (such as Portugal).
Table 2 illustrates how large is the potential for improvement for the energy efficiency of the household sector for the less performing countries such as Italy, where the improvement in energy efficiency achieved by this sector has been equal only to 25 percent of the median change, and, approximately, a tenth of the improvement that more efficient countries (namely, Portugal and Denmark) have registered over the same period.

HOUSEHOLD (% change in EE Index over period)						
1980 - 2004			1980 - 1992		1992 - 2004	
PT	-49.8%		-31.7%	DK	PT	-42.4%
DK	-43.4%		-18.0%	SE	DK	-17.2%
SE	-28.5%		-12.9%	PT	AT	-16.3%
AT	-24.9%		-10.3%	AT	SE	-12.8%
FR	-17.1%		-10.0%	FR	NO	-11.7%
FI	-16.1%	Median	-7.9%	FI	FI	-8.9%
DE	-10.5%		-6.9%	UK	DE	-8.5%
UK	-8.7%		-2.2%	DE	FR	-7.9%
IT	-4.2%		0.5%	IT	IT	-4.7%
NO	2.2%		15.8%	NO	UK	-1.9%
ES	142.7%		40.5%	ES	ES	72.7%
BE	n / a		n / a	BE	BE	n / a
EL	n / a		n / a	EL	EL	n / a
IE	n / a		n / a	IE	IE	n / a
LU	n / a		n / a	LU	LU	n / a
NL	n / a		n / a	NL	NL	n / a
Average =	-5.3%		-3.9%			-5.4%
Median =	-16.1%		-7.9%			-8.9%
St. Dev =	0.516		0.188			0.280
Minimum =	-49.8%		-31.7%			-42.4%
Maximum =	142.7%		40.5%			72.7%

Notes: Countries are ordered according to their energy efficiency performance in descending order. Arrows show significant movements between quartiles over time. Source: Authors' calculations on Odyssee (ENERDATA) data.

Table 2: Percentage Change of Energy Efficiency in the EU-15 Countries and Norway, 1980-2004. Household sector.

2.4. Energy Efficiency in the Transport Sector

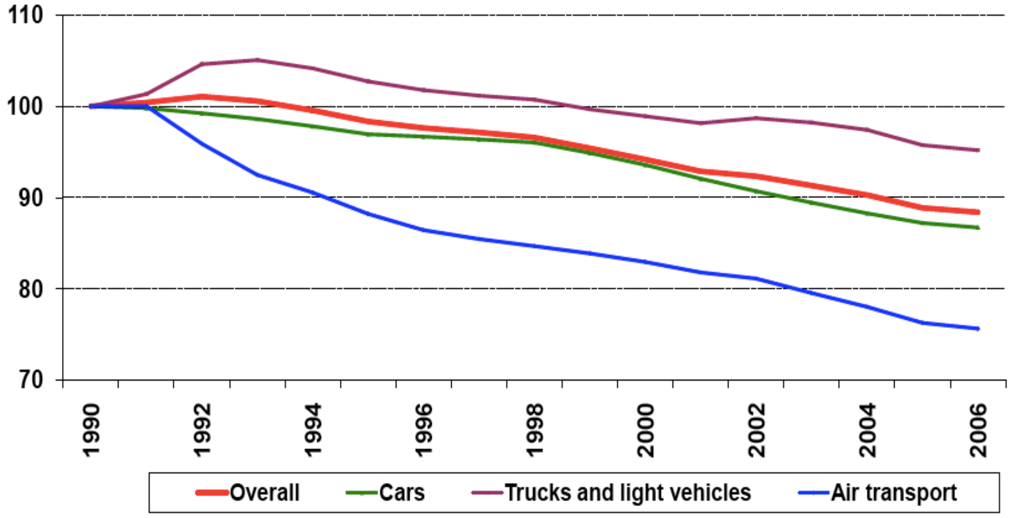
Table 3 shows the percentage change of energy efficiency for the transport sector. Over the whole sample (1980-2004), the countries that reported the best performances have been Ireland and Greece. Across sub-samples the most significant improvements have been achieved by the Belgian transport sector. While during the period 1980-1992, in Belgium, energy efficiency has decreased by 75.4 percent, in the period 1992-2004, energy efficiency has increased by 49.4 percent. Over the whole sample, the improvements in energy efficiency have been equal to 11.2 percent. On a smaller scale, France, Sweden and Norway have reported similar changes. In transport, the progression is modest but regular: 9 % efficiency improvement.

By contrast, performances in the energy transport sector have worsened in Spain. If, on the one hand, improvements have been very significant in the first sub-samples with an increase in energy efficiency equal to 35.4 percent, in the second sub-sample, efficiency has decreased by 6.7 percent.

In Italy, the performance of the transport sector has been remarkable. From 1980 to 2004, energy efficiency has increased approximately by 13.4 percentage points, or the median change and twenty times higher than the increase in the efficiency of the industrial sector. However, even in this case, a potential for further improvements would be possible if appropriate policy measures and technological changes concerning the transport sector as a whole were implemented.

Disaggregating the E.E. index by transport modes, it can be noticed that a regular improvement of the energy efficiency of transport (12%) takes place in the EU over the period 1990-2006. The lower progress can be blamed on the road transport of goods, while the best performance in the index takes place in the air transport (Figure 8).

Figure 8: Energy efficiency index for transport EU-27 (ODEX).



Source: ODYSSEE.
Note: Technical ODEX index calculated on 7 modes: cars (litres/km), trucks & light vehicles(toeper tkm), air (toe per passenger); rail ,water (toe/ tkm or pkm); motorcycles, buses (toe/vehicle).

As cars are the most important energy user in passenger transport, it is interesting to look at more detailed indicators for this mode. In this case, since that the passenger transport sector is not able to generate value added, the energy intensity of passenger road transport is calculated as liters of gasoline equivalent per 100 vehicle-km. Figure 9 reveals wide variations in the levels and trends amongst countries. The results reflect a number of unrelated factors such as vehicle technologies and the effect of driving conditions.

The average fuel intensities of cars decreased in all of EU-15 countries between 1990 and 2005, due to a combination of several factors. The 1990s were characterized by the widespread diffusion of vehicles equipped with electronic control systems for fuel management and by stronger consumer demand for more efficient cars — a reaction to high fuel prices. Since the early 2000s, intensities declined further in Europe as a result of increased sales of direct-injection diesel cars.

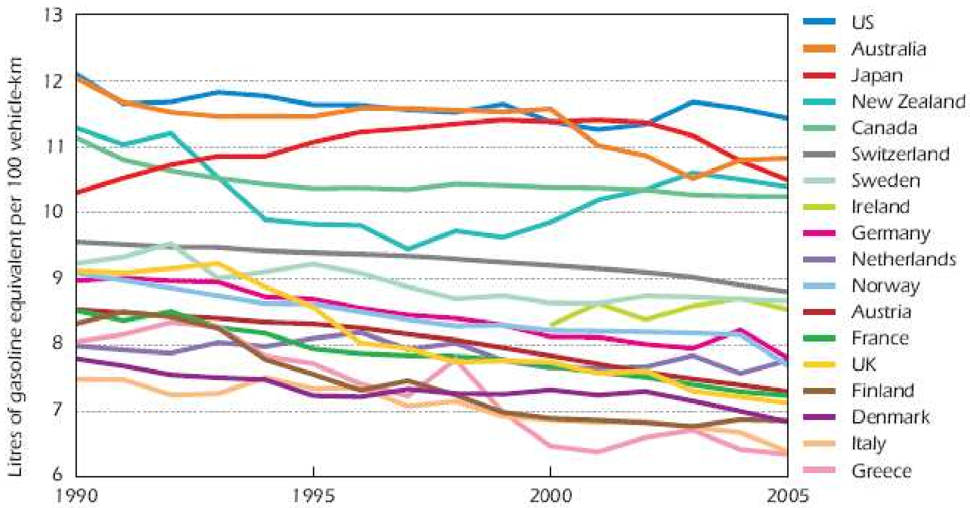
The increasing weight of vehicles has been another factor offsetting improvements in the underlying efficiency of new car engine technologies. Over the last 15 years, the average size and weight of the stock of cars increased as larger and heavier vehicles, such as SUVs, became more popular. This trend, combined with additional safety features also increasing weight, has tended to raise the energy consumption of cars. In European countries, the number of cars with an engine capacity greater than two liters has more than doubled since 1990.

TRANSPORT (% change in EE Index over period)					
1980 - 2004		1980 - 1992		1992 - 2004	
IE	-45.0%	-35.4%	ES	BE	-49.4%
EL	-43.7%	-25.8%	IE	IE	-26.0%
AT	-33.2%	-24.1%	EL	EL	-25.9%
ES	-31.1%	-21.7%	AT	NO	-21.4%
NO	-27.4%	-13.8%	IT	PT	-14.8%
PT	-24.4%	-12.2%	DE	AT	-14.7%
DE	-23.1%	-11.3%	PT	DE	-12.4%
DK	-16.9% **Median**	-10.9%	DK	FR	-12.0%
IT	-13.4%	-7.6%	NO	SE	-11.2%
SE	-12.8%	-3.4%	NL	FI	-7.4%
FR	-12.0%	-2.8%	LU	DK	-6.8%
BE	-11.2%	-1.9%	UK	NL	-4.7%
NL	-7.9%	-1.8%	SE	UK	-3.4%
FI	-7.5%	-0.2%	FI	IT	0.5%
UK	-5.2%	0.0%	FR	ES	6.7%
LU	123.5%	75.4%	BE	LU	129.9%
Average =	-12.0%	-6.1%			-4.6%
Median =	**-15.2%**	-9.2%			-11.6%
St. Dev =	0.382	0.241			0.381
Minimum =	-45.0%	-35.4%			-49.4%
Maximum =	123.5%	75.4%			129.9%

Notes: Countries are ordered according to their energy intensity. Arrows show significant movements between quartiles over time. Source: Authors' calculations on Odyssee (ENERDATA) data.

Table 3: Percentage Change of Energy Efficiency in the EU-15 Countries and Norway, 1980-2004. Transport Sector

Figure 9: Average Fuel Intensity of the Car Stock, IEA-18, 1990-2005.

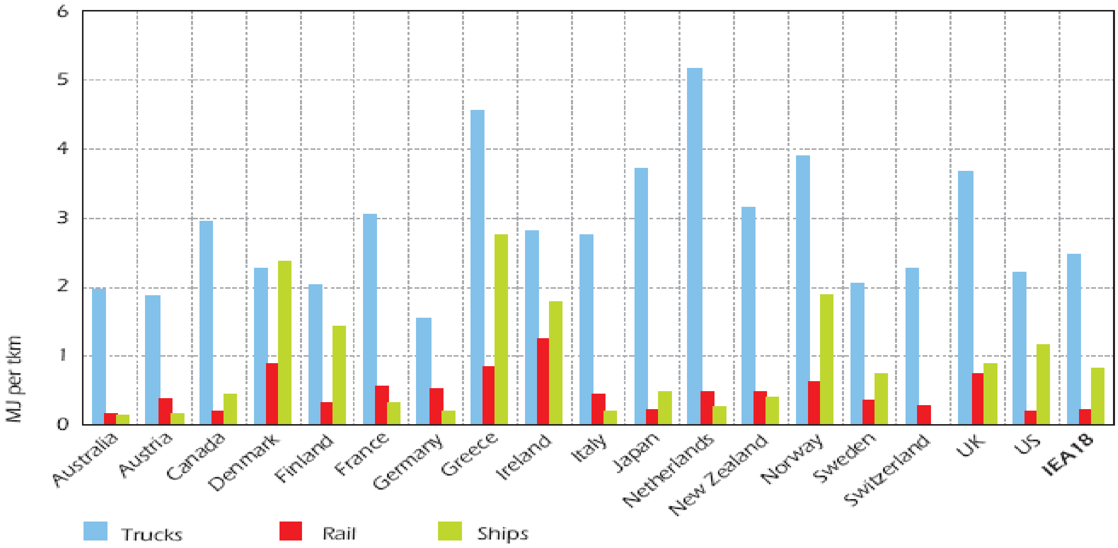


Source: IEA.

For the EU-15, the energy intensities of trucks, ships and rail vary significantly, with trucks being the most intensive (Figure 23). In Netherlands trucks use 17 times more energy than rail to move one ton of goods a distance of one kilometer, while in other countries like Denmark, Finland and Ireland the difference in energy use among transport modes is less wide. The large range for the energy intensity of truck freight can partly be explained by the type of goods moved, the size and geography of the country, the average load factors and the split between urban delivery trucks and long-haul trucks, which are much larger and less energy intensive.

Looking at the trends, trucking activity - measured in ton-kilometers - increased in all EU countries and trucking was the fastest growing freight mode in most of them. The highest increase in trucking was seen in Ireland, driven by the very rapid expansion of the Irish economy. GDP in Ireland increased at an average annual rate of 6.5% between 1990 and 2005. Trucking also increased substantially in large countries with low population densities such as Norway. Rail and shipping activity increased in many countries.

Figure 10: Freight Transport Energy Use per Ton-Kilometer by Mode, IEA-18, 2005.



Source: IEA.

The difference in the energy intensity among modes has some important implications for trends in freight energy consumption. First, because of its much higher energy intensity, growth in road freight haulage will have a more significant impact on energy use than growth in freight transport by rail or ships. Second, intensity reductions in trucking will result in higher energy savings than intensity reductions in rail and ships or than modal switching between these two modes.

2.5. Carbon Intensity

Carbon Intensity is an indicator akin to energy intensity, and measures the degree of carbonisation of an economy or of a given productive sector. At the aggregated level, Carbon Intensity is computed as the ratio of CO_2 emission equivalents generated (in terms of Mton of CO_2) to the indicator of economic activity, GVA. The same sectoral disaggregation as in the case of energy intensity can be performed. Moreover, note that Carbon Intensity can be interpreted as the product of energy intensity and the carbon content of the energy consumed, or

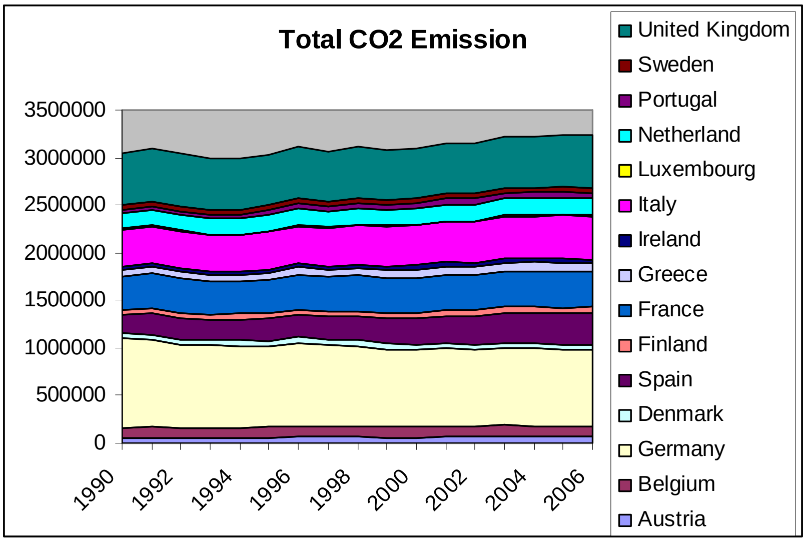
$$\mathrm{I.CO_2} = \frac{CO_2}{GVA} * \frac{E}{\mathrm{E}} = \frac{E}{GVA} * \frac{CO_2}{E} = E.I * \frac{CO_2}{E}. \qquad (2)$$

The *Carbon Content* of consumed energy measures the quantity of CO_2 (or, in its more general format, CO_2 equivalents[3]), per unit of energy consumed. It can happen that energy intensity increases while carbon intensity decreases, for instance in presence of a massive switch from oil to natural gas; the latter being “cleaner” and allowing a decrease in CO_2 equivalents emitted while leaving unchanged the quantity energy consumed. The Carbon Content can thus be regarded as a technological parameter which takes into account changes in the fuel mix of country or of a sector.

[3] CO_2 emission equivalents are computed on the basis of the global warming potential of each greenhouse gas, i.e. the contribution to global warming of each gas relative to CO_2 (CO_2= 1, CH_4=21, N_2O=310)...

Available information on CO_2 emissions starts from 1990, hence carbon intensity indexes cover a period lower than energy intensity and energy security indexes. Figure 11 displays the trend of carbon intensity index in EU countries over the period 1990-2006, covering CO_2 emissions from all sectors, including emissions from energy sector.
In Europe, total CO_2 emissions registered a slight increase from 1990, with a growth rate of 5.8 percent between 1990 and 2006. In 2006 Germany contributed the most to total CO_2 emissions in Europe, followed by United Kingdom, Italy and France. The shares of CO_2 emissions by country remain rather stable during the period considered. Germany and United Kingdom are the only EU countries which show a decrease of emissions during the period under scrutiny, by 14 % and 1 % respectively, while the largest increase is registered in Spain.

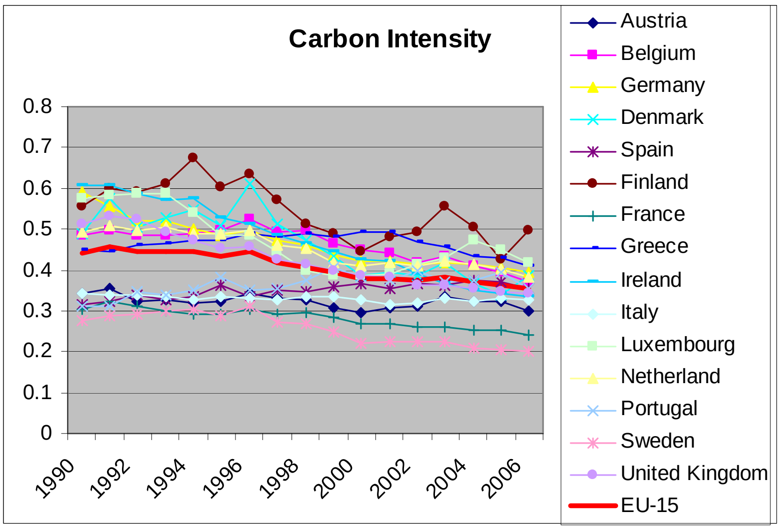
Figure 11: Total CO_2 Emission in European countries , 1990-2006.



Source: Authors' computation on data from ENERDATA.

Figure 12 shows the trend of carbon intensity in European countries between 1990 and 2006. Looking at the average of EU-15 countries, carbon intensity decreased from 1990 to 2006 of about 20 percent, although in Spain and Portugal the index increased. The best performances are attained by Ireland and Germany, which show a variation of about -45 and -33 percent respectively between 1990 and 2006.

Figure 12: Total Carbon Intensity in European Countries , 1990-2006, kt CO_2/00$ppp.



Source: Authors' computation on data from ENERDATA, EUROSTAT, OECD.

2.6. Energy Security

In the scientific literature, different approaches for studying energy security can be identified. Some studies focus on a country's *current* diversification of energy sources or import sources as a measure of energy security, for instance Neff (1997); Jansen et al (2004). Others studies look at the future development of oil supply and imports using bottom-up energy systems models, e.g. Constantini et al (2007); Turton and Barreto (2006).

A number of researchers have tried to develop a set of security indicators (IEA, 2001; Kendell, 1998; von Hirschhausen and Neumann, 2003). These measures can be further grouped into two categories: dependence and vulnerability, represented both in physical and economic terms.

Dependence is a measure of how much the domestic economy relies on sources of energy that are not under its control. Physical measures of dependence include: (a) imports of energy as a percent of total imports, (b) oil imports as a percent of total oil consumption, (c) gas imports as a percent of total gas consumption. Economic measures of dependence are oil and gas consumption in physical units per US$ of real GDP.

Vulnerability is a measure of the likelihood of domestic disruption in case some external energy source is reduced or cut off. Physical measures of vulnerability include (a) the amount of imported oil used in transportation relative to total energy used in transportation, (b) amounts of imported oil and gas fired electricity generation relative to total electricity generation, (c) degree of supply concentration and (d) the Shannon-Weiner diversity index[4].

A non-exhaustive but fairly extensive list of indicators can be found in Table 4. Subject to data availability these indicators were tested in the panel analyses illustrated in Sections 4 to 6. Those that yielded the best results in terms of responsiveness to energy policies were oil intensity, gas intensity, the ratio of gas imports to gas consumption and the ratio of net imports of energy to total primary energy supply.

	Vulnerability	**Dependence**
Physical Dimension	Imported oil used in transportation (Mtoe)/Total energy used in transportation (Mtoe)	Imports of energy/Total primary energy supply
	Imported Oil and Gas–fired electricity generation (gWh)/Total electricity consumed (gWh)	Country's oil gross and net imports/Total oil consumption
	Per capita oil consumption (Ktoe)	Country's gas gross and net imports/Total gas consumption
	Degree of supply concentration for oil and gas	
	Shannon-Weiner Index for supply	
	Per capita gas consumption (Ktoe)	
Economic Dimension	Value of oil (or gas) imports/Value of total exports	Oil consumption (Toe) per $ of real GDP
		Gas consumption (Toe) per $ of real GDP

Table 4 Energy Security indicators

Oil intensity is given by consumption (Ktoe) per dollar of real GDP (we choose to measure it in PPP, constant 2000 international Millions of US$)[5]. The bulk of oil products is used in transportation (light and middle distillates); currently the most important alternative fuels - LPG and natural gas - hold minuscule shares.

All EU countries have improved the energy ratio since 1975 with growth in GDP outstripping that of oil consumption. Most likely this is due to energy switching toward others fuels,(mainly gas), and to an increase in the efficiency in the transport sector.

Figure 13 shows a progressive convergence of the index among the European countries.

[4] The Shannon-Weiner index can be used to evaluate how the diversity of a given market is changing over time. The minimum value the Shannon-Weiner index can take is zero, which occurs when imports come from a single country. In this case, there would be no diversity of supply. The index places weight on the contributions of smallest participants in various fuel markets as they provide the options for future fuel switching. Unfortunately this indicator did not yield significant results in our panel regressions.

[5] Gas and Oil consumption in Ktoe (Thousand Tons of oil equivalent) provided by Enerdata. GDP data provided by WDI 2008.

All countries have seen an increase in gas intensity since 1975 to 2005 with the exception of the Netherlands. Ireland and Denmark registered a remarkable upward trend, while Austria and Belgium have seen the smallest increase in percentage terms. In Italy the value of the indicator almost tripled over the period considered. Figure 14 illustrates the performance of this indicator for gas over the period 1960-2005.Differences between countries reflect many factors including climatic and industrial structure characteristics. The residential sector is the largest consuming sector of natural gas, followed by the industrial, electricity and commercial ones. The use of gas in power generation is growing rapidly and for this reason in the early 90s, before the use of gas for electricity generation, gas demand was more seasonal and the daily average demand was only around half the winter maximum.

Figure 13 Oil Consumption (ktoe) per MUS$6 of real GDP

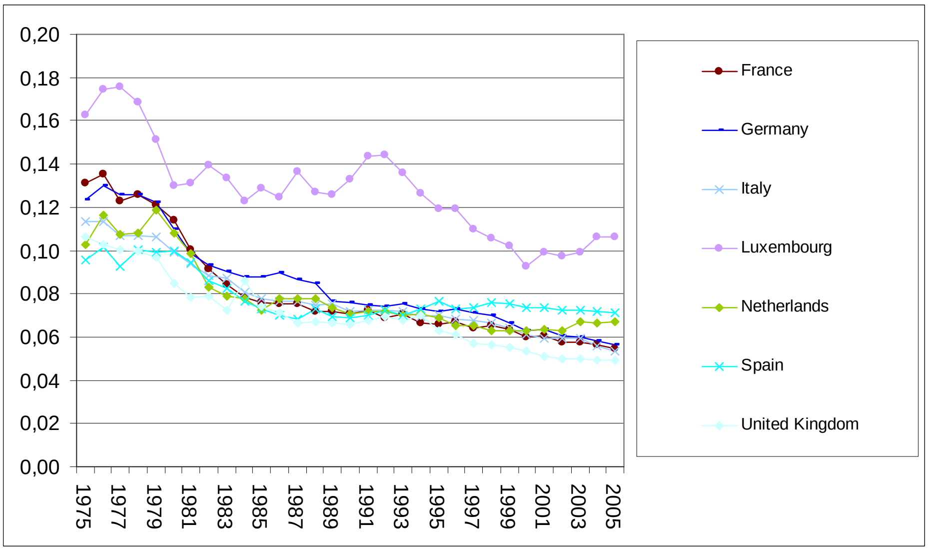
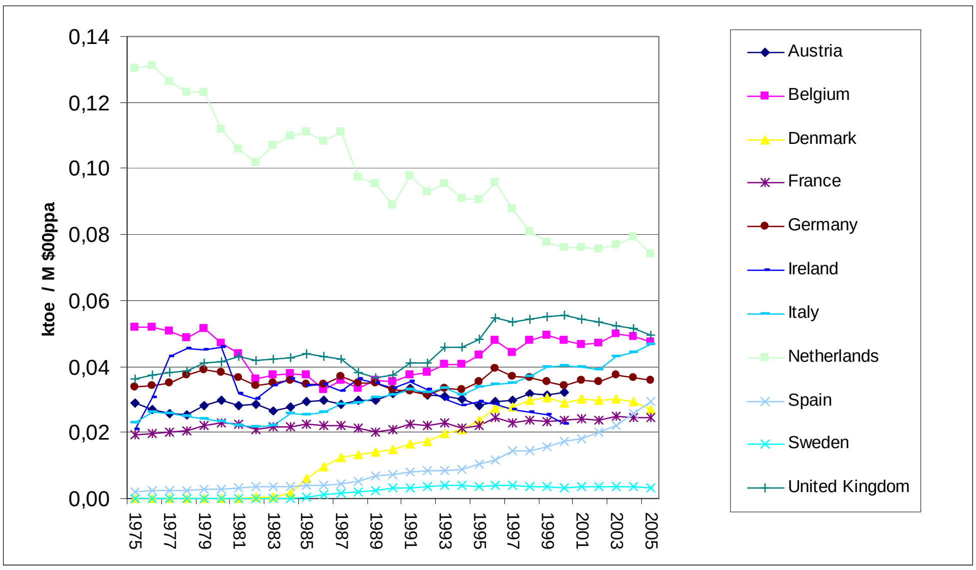


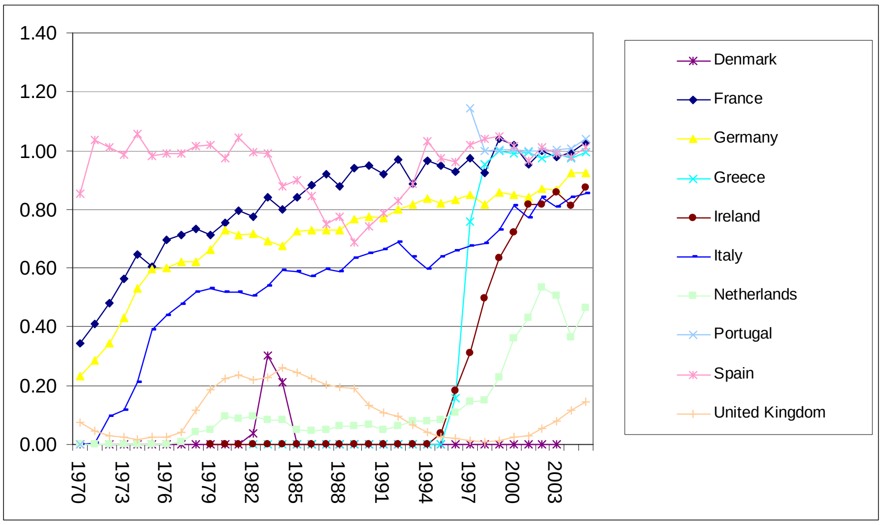
Figure 15 shows the ratio of gross natural gas imports to natural gas consumption. Greece registered the most noticeable upward trend over the period considered. In Italy, the indicator exhibited a steady increase during the period under consideration. United Kingdom (0.14)[7] was the country with the lowest ratio in 2004, while Portugal registered the highest index. Notice that Ireland, Greece and Portugal are rather new to the gas market, introduced only recently.

Figure 14 Gas primary consumption (Ktoe) per MUS$ of real GDP



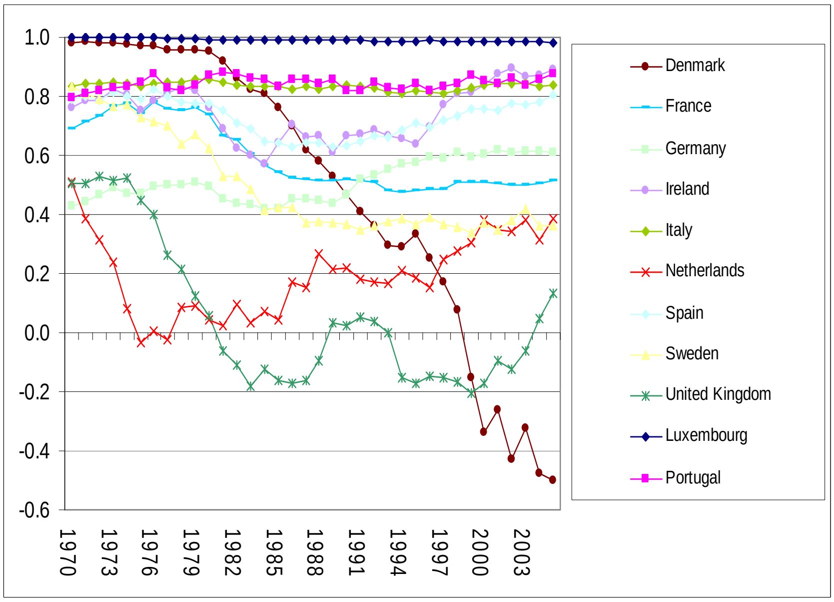
[6] Million U.S. dollars.
[7] 2004 data not available for Denmark, that registered in 2003 an indicator equal to zero.

Figure 15 Gross imports of gas over total primary gas consumption, by selected countries



The last indicator is not the most appropriate index to measure the dependence on imported energy. A more appropriate indicator can be calculated using net imports of energy. In fact according to Skinner (1995) "*with total [gross] imports in the numerator rather than net imports, not only is the computed dependence higher due to the quantity of exports, but also comparisons in dependence over a number of years can be substantially distorted due to changes in export patterns*". In order to have an indicator with an upper bound equal to 1 (that indicates the maximum level of dependence) we include in the denominator the TPES, stock variations and marine bunkers[8]. Luxembourg[9] (0,99), Ireland (0,89), Portugal (0,86) and Italy (0,84) registered the highest dependence ratio in energy imports in 2004. By contrast Norway, a net exporter of energy, registered the lowest ratio (-7,6) followed far by Denmark (-0,48) and UK (0,05). In the period 1980-1990 all the EU-15 countries and Norway registered a downward trend in the energy dependence indicators (bar Luxembourg and Netherlands). In the period 1970-2004 Germany registered the largest increase in this indicator (+41%).

Figure 16 Ratio of net imports to TPES in selected EU countries



---

[8] TPES is defined by IEA as the sum of: Indigenous production + imports – exports – international marine bunkers +/- stock changes.

[9] Obviously for Luxembourg the TPES has been calculated not considering marine bunkers as this land locked country has none .

3. Energy saving potentials and energy policies in the EU.

3.1. Key recent energy policies of the European Union

Several European Directives to improve energy efficiency have been implemented during the last years. Milestone policies are listed in Table 5 below. Until 2006, most initiatives target specific modes or sectors of energy use in Europe, setting the general framework in which national policies of Member States should then develop in accordance of the subsidiarity principle. However what was lacking was a general and comprehensive strategy in the energy field in Europe, which was increasingly felt as a necessity in view of the increasing complexity of the situation in the field of energy.

1992	*2000*	*2002*	*2005*	*2006*	*2008*
European Directive on labeling of the energy consumption's household appliances	*Action Plan for Energy Efficiency 2000-2006*	*European Directive on building's efficiency*	*Eco-Design Directive concerning all new products outside of the transport sector*	*European Action Plan for Energy Efficiency (2007-2013)*	*Climate Action and Renewable Energy Package*

Table 5 Key energy savings policies in the EU. ***Source: ADEME***

The Green Paper "Energy", adopted by the EC in March 2006, lays the basis for a European Energy Policy; this document highlights that the development of a common policy is a long-run project whose ultimate purpose is to balance three core objectives: sustainable development, competitiveness and security of supply.

As a foundation for this process the European Commission (EC) proposes establishing a Strategic EU Energy Review to be presented to the Council and Parliament on a regular basis, covering all the energy policy issues. Through the Strategic EU Energy Review, the EC aims at covering all aspects of energy policy, analyzing all the advantages and drawbacks of different energy mixes. Although a country's energy mix is and will remain a question of subsidiarity, its decisions have consequences for other countries and the EU as a whole, both in terms of pollution and energy security. All in all this should eventually lead to the definition of a EU's overall energy mix to ensure security of supply and sustainability, whilst respecting the right of Member States to make their own energy choices.

A more sustainable, efficient and diverse energy mix is identified as the third priority area. The Strategic EU Energy Review is identified as the tool for defining common strategies for what concerns the choice of an environmental sustainable energy mix that could improve the security of supply, while allowing Member States to be independent on these issues.

The fourth action area is strictly related to the third one and addresses the challenges of global warming. An Action Plan on energy efficiency and a new Road Map for renewable energy sources should be adopted by the EC to select the measures necessary for the EU to save 20 percent of the energy that it would otherwise consume by 2020.

Environmental concerns are somehow addressed also in the fifth action area that aims at developing and deploying new energy technologies in order to secure energy supply and improving sustainability and competitiveness. The EC proposes to establish a strategic energy technology plan in order to develop promising energy technologies and to make them marketable. At the end of the day, what emerges from the Green Paper is that the three policy objectives, competitiveness, security of supply and sustainability, are closely interlinked and complementary. In January 2007 the European Commission presented an Energy and Climate Change Package including a Strategic Energy Review. This package was finally agreed upon in December 2008. In March 2007 the EU Summit of Head of States agreed upon an action plan, including among others:

- A target to save 20% of the EU's total primary energy consumption by 2020;
- A binding target to raise the EU's share of renewable to 20% by 2020;
- An obligation of 10% biofuels in the transport fuel mix by 2020 for each EU member;
- An European Strategic Energy Technology Plan for low carbon technologies.

Most European countries are showing significant commitment in the implementation of energy efficiency measures. For example, Italy submitted the action plan to achieve an energy savings of 9% in 2016 (directive 2006/32/EC). The plan shows the current and future actions sectors with an expected energy savings of 35.7 Twh per year in 2010 and 126.3 Terawatt hour (Twh) per year in 2016. From 2008 a fund of 40 million euro per year is established to promote renewable sources and energy efficiency.

The Green Paper on Energy Efficiency (European Commission, 2005), points out that the EU could effectively save at least 20 percent of its present energy consumption. In order to support a better integration of energy efficiency measures into national legislation the European Commission has proposed several directives which have been adopted and are now in force. These concern broad areas where there is significant potential for energy savings, such as:

- End-use Efficiency & Energy Services;
- Energy Efficiency in Buildings;
- Eco-design of Energy-Using Products;
- Energy Labelling of Domestic Appliances;
- Combined Heat and Power (Cogeneration).

Directive 2006/32/EC sets an indicative energy saving target of 9 percent on total energy use, over a period of 9 years, to be reached by means of energy services and other energy efficiency improvement measures. Member States submitted their first National Energy Efficiency Action Plan (NEEAP) to the Commission in June 2007. In their NEEAPs, Member States show how they intend to reach the 9 percent indicative energy savings target by 2016.

Among the main EU legislation for buildings are the Boiler Directive (92/42/EEC), the Construction Products Directive (89/106/EEC) and the buildings provisions in the SAVE Directive (93/76/EEC). The Directive on the energy performance of buildings (EBPD 2002/91/EC), enforced since January 2003 builds on those measures with the aim to improve further the energy performance of public, commercial and private buildings in all Member States. In order to support the implementation of the Directive the European Commission established the EPBD Buildings Platform which provides information services for practitioners and consultants, experts in energy agencies, interest groups and national policy makers in the European Member States[10].

The European Union has highlighted the existence of a potential energy saving of over 20 percent by 2020, which can be met removing wastes and inefficiencies. Realizing this potential will bring to some 390 Mtoe of energy savings, along with large energy and environmental benefits. On the basis of the policies and measures contained in the Green Paper on Energy Efficiency: “Doing More with Less”, an Action Plan has been presented in October 2006, by the European Commission. The Plan is built on the existing EU energy efficiency legislation and its objective is to provide a framework, which helps achieving the 20 percent saving potentials. This framework is constituted by a list of cost-effective measures, by priority actions to be either immediately initiated or executed gradually along the Plan’s six years period. The NEEAPs will integrate well with the objectives of the Action Plan, as far as the latter represent the instruments for monitoring, reviewing and updating the plan.

The Commission has published an impact assessment report for the Action Plan for Energy Efficiency, which allow to quantify the effects of the action proposed (Tipping et al., 2006). The estimates however contain a certain degree of uncertainty, as far as a wide range of topics, at all

---

[10] The existing implemented Directives for ECO-design of energy-using products are related to ballasts for fluorescent lighting (2000/55/EC), household electric refrigerators and freezers (96/57/EC), hot-water boilers fired with liquid or gaseous fuels (92/42/EEC). These Directives have been amended in July 2005 by the article 21 of the Directive 2005/32/EC. The latter define conditions and criteria for setting requirements regarding environmentally relevant product characteristics (such as energy consumption). In principle, the Directive applies to all energy using products (except vehicles for transport) and covers all energy sources. For energy demand in households relevant Directives are the energy labelling for electric refrigerators (2003/66/EC), electric ovens (2002/40/EC), air-conditioners (2002/31/EC), dishwashers (1999/9/EC) and household lamps (98/11/EC). Others Directives are related to household dishwashers (97/17/EC) washing machines (96/89/EC), household combined washer-driers (96/60/EC) household electric tumble driers (95/13/EC), household washing machines (95/12/EC), household electric refrigerators, freezers and their combinations (94/2/EC), household appliances (92/75/EEC).

levels of policy and decision makers, is involved. After evaluating a large set of possible instruments, some priority actions have been selected on the ground of their impact on energy savings. By far the most promising measure seems to be the extension of white certificate schemes[11], after evaluation of present national schemes, to all EU-countries coupled with energy efficiency obligations on energy suppliers (80Mtoe of potential savings), followed by maximum CO_2 emission standards for different type of cars coupled with more stringent agreements with car and truck producers after 2008-2009 (28Mtoe of potential savings) and end-user price increase to discourage fuel use (20Mtoe of potential savings). Taken together the eighteen policy options identify up to 353 Mtoe of potential primary energy savings over and above the current 'business as usual' projection without taking into account antagonistic or synergetic interactions (overlap) between the different policy options. Taking into account the separate policy options overlap the gross estimated aggregate energy savings potential estimate reduces by 26% to 262 Mtoe in year 2020.

3.2. The residential sector

Looking at the IEA studies on energy efficiency, in the residential sector (IEA 2006, 2008c), the average energy consumption per dwelling in the EU-15 reached in 2004 between 1.1 and 2.3 toe per year, with an European average of 1.7 toe per year. This average energy consumption in 2004 was slight below its 1990 level. The changes in the average energy consumption per household result from a mix of different factors that have countervailing influence:

- Energy efficiency improvements generated by more efficient new buildings and appliances and by most energy substitutions tend to lower energy consumption
- Larger dwellings, more appliances, increased heating are driving energy demand upwards (rebound effect).

Large appliances experienced the biggest energy efficiency improvements: 20% since 1990 (1.5% per year). In most countries, energy efficiency increased by around 1% per year, which corresponds to the target of the European Energy Efficiency Directive.

As mentioned above, the EU has set up a legal framework for energy efficiency. Most EU countries have responded to, and transposed into their national legislation, energy efficiency-related Directives. This activity included preparing the National Energy Efficiency Action Plans – under the Energy Services Directive (2006), transposing and recasting the Energy Performance of Buildings Directive (2002) and extending the energy efficiency and labeling requirements for energy-using products and electrical appliances through transposing the Eco-Design and labeling Directives (1992, updated in 2008). The following examples present some case of implementation of measures to promote energy efficiency in the residential sector.
In Italy, in the recent past, the administration has made a number of amendments to energy efficiency policy. The country started a White Certificates Scheme in January 2005, and this scheme was then amended by an Inter-ministerial Decree, its duration extended from 2009 to 2014. The 2008-2011 Economic and Financial Programming Document of the Italian Government provides for the pursuit and extension of fiscal measures to encourage energy efficiency of buildings and energy use equipment. Also, articles 351 and 352 of Budget Law 2007 included funding of 15 million € for 2007-2009 to underwrite a provision allowing a tax deduction worth 55% of the total amount of 2007 expenditures for the implementation of projects to enhance the energy efficiency of buildings.

Other European countries have set up similar policies. In the United Kingdom, the Energy Efficiency Commitment (2002-2005) programme required that all electricity and gas suppliers with 15,000 or more domestic customers must achieve a combined energy saving of 62 TWh by 2005 by assisting their customers to take energy-efficiency measures in their homes: suppliers must achieve at least half of their energy savings in households on income-related benefits and tax credits. In France, the aggregate energy intensity decreased by around 1.1% from 1990-

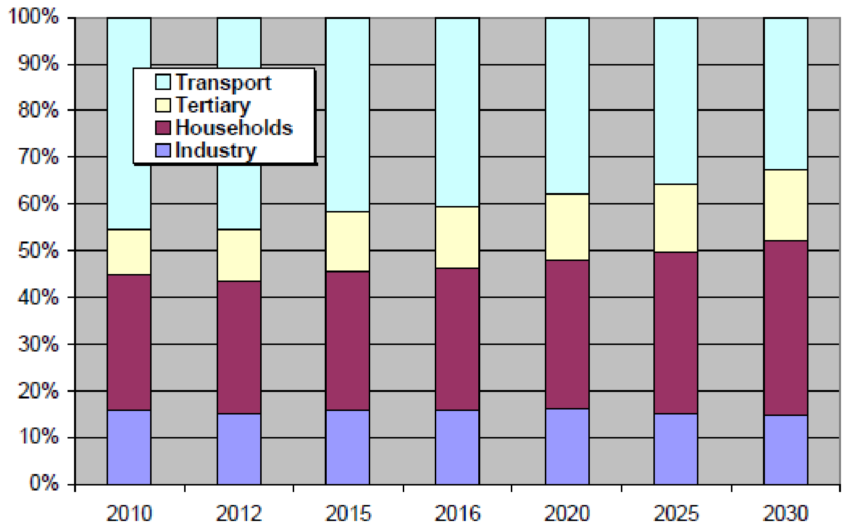
[11] White certificates are issued by national energy authorities and certify energy efficiency improvements by eligible economic agents.. They are tradable in order to minimise the overall costs of reaching a given overall national energy efficiency target.

2005. This decrease was made up of a 0.6% decline due to improved energy efficiency and a 0.5% decline due to changes in economic activity and structure. France has also developed innovative financing products for the residential sector since 2007, when in partnership with banks low-interest loans for residential energy conservation projects were offered, financed through a special tax-free savings account.

Electrical Appliances

According to the study of the European Commission (European Commission, 2009a) on energy savings potentials, electrical appliances in the residential sector have the largest potential at the short term (2010) for improving its energy efficiency.

Figure 17: Sectoral contributions to the Energy savings potentials over time in relative terms.



(Source: European Commission, 2009a)

Few measures concern the use of electricity in buildings, although the consumption of electricity for households appliances is steadily increasing. Electricity consumption in buildings grows at an average rate of 1.5% per year according to the ODYSSEE database. Electrical and electronic appliances represent 14% of household's final energy consumption and 62% of their electricity consumption in 2007. Several European directives have been adopted during the 1990's in order to lay down minimal standards concerning energy efficiency. After their implementation, the share of energy consumption of large household appliances[12] in the total electricity consumption of this sector decreased (54% in 1990, 45% in 2006). For example, refrigerators in the United Kingdom have decreased their energy consumption by 21% between 1995 and 2000. During the same period, freezers in the United Kingdom have decreased by about 25% their average electricity consumption. In general, large appliances display the best improvements in terms of energy efficiency in the residential sector in Europe. The share of the small household appliances consumption in the residential sector's total electricity consumption has on the contrary increased (38% of the specific total electricity consumption in 2006, and 27% in 1990). Although the energy efficiency of large household appliances improved on average by 20% between 1990 and 2004, in the same period, the average consumption per household decreased of only 2% because the household appliances penetration rate grew up, thus counterbalancing the best part of improvements in technical efficiency (a clear example of the *rebound effect*). For instance, the technical improvements concerning computer and TV-set screens did not lead to energy savings because of their steadily growing sizes. Televisions have undergone a rapid transformation in recent years as flat-screen technology replaces bulkier traditional screens. Spurred on by falling retail prices, consumers continue to purchase televisions with larger screens for primary use, while often keeping existing televisions. Consequently, the number of televisions is growing in most countries. Televisions are also

12 Large household appliances include: refrigerators and freezers, washing machines, dishwashers, hoods, microwave ovens, cooking appliances such as hobs, ovens, air conditioners

switched on for longer periods of time, although they may not be watched. Increased use of games consoles and program-recording devices have tended to extend viewing hours. These developments are leading to increases in energy use of approximately 5% per year, which cause the global energy consumption of televisions to nearly triple by 2030 if current trends continue.

Over the last 18 years, the Energy Labeling Directive (92/75/EEC) has proven a very effective policy instrument, leading to a significant improvement of the energy efficiency of the household appliances in the EU. The “A-G” label displayed on appliances such as washing machines, dishwashers, refrigerators or ovens has provided consumers information at the point of sales about energy consumption and hence the running costs of the product, thus steering the demand towards the best-performers. The European Commission aims to extend the scope of the Directive to energy-using products used in the industrial and commercial sectors and to other energy-related products which have an impact on energy consumption during use. If fully implemented, the proposal is expected to result in energy savings corresponding to 27 Mtoe annually by 2020 or translates into the annual abatement of 80 Mt of CO_2 emissions (based on savings from commercial heating and refrigeration appliances and windows alone). The Eco-design directive aims to integrate environmental standards as soon as possible during the design and the conception of the product, as well as applying a life-cycle approach in the designing stage of the product. The Commission has adopted in December 2008 the eco-design regulation to reduce standby energy consumption of all household and office products. This regulation aims to cut the standby electricity consumption by almost 75% by 2020. The standby consumption of new products has to be less than 1-2 W as of 2010 and less than 0.5-1 W in 2013. The aim is to reduce by 2020 73% of the electricity consumption in “off mode” for those appliances within the EU. Currently, the electricity consumption of appliances when they are in “off mode” is around 50 TWh per year, which is more than 10% of the French total electricity consumption. The European Commission aims to reduce the energy consumption of electrical household appliances and of office products. In Europe, minimum efficiency standards for several types of appliances and products will be introduced in the next few years. These standards will be set by EU regulations that are to be based on the Eco-Design Directive (2005/32/EC). At this stage, the EU Commission has plans for proposing such standards for 19 product groups.

Lighting

Globally incandescent lamps are estimated to have accounted for 970 TWh of the worldwide final electricity consumption in 2005 (IEA, 2006). In the hypothetical case that all these lamps were to be replaced by compact fluorescent lamps, cumulatively this would reduce global net lighting costs by USD 1.3 trillion from 2008 to 2030, and avoid 6.4 $GtCO_2$ emissions at negative abatement cost. In Europe, lighting is by far the major end-use category in tertiary sector consumption, responsible for about 175 TWh or 26% of total electricity consumption in the tertiary sector (source: European Commission). Within the household’s consumption, in 2004, the share of lighting energy consumption reached 14% (source: ODYSSEE).

The European Commission’s draft regulation “implementing Directive 2005/32/EC with regard to eco-design requirements for non-directional household lamps” aims at progressively phasing out incandescent bulbs between 2009 and 2012. It is estimated that the EU will save around 40 TWh and 15 Mt CO_2 per year.

Following its commitment under the European Union Energy Services Directive, Germany’s 2007 National Energy Efficiency Action Plan aims to achieve 9% energy efficiency improvement between 2007 and 2016, incorporating a target of 933 PJ, with an interim target of 510 PJ for 2010. In the area of lighting, Germany, like other EU countries, has an established comparative energy label for household lamps and plans to develop new standards for office, residential and outdoor lighting products under the EU Eco-Design Directive. By 2011, the United Kingdom aims to go beyond the European Directive in setting up minimal standards for energy efficiency concerning 21 products especially in the lighting sector.

3.3. The industrial sector

The International Energy Agency (IEA, 2008) reports that industry accounts worldwide for nearly one third of total global primary energy supply[13] and 36% of CO_2 emissions. Total final energy use by industry was 113 EJ in 2004[14]. Rough estimates suggest that 15% of total energy demand in industry is for feedstock, 20% for process energy at temperatures above 400°C, 15% for motor drive systems, 15% for steam at 100-400°C, 15% for low-temperature heat and 20% for other uses, such as lighting and transport.

In Europe (EU-15, in 2004), the industrial sector consumed around 27% of the energy used by final consumers (279 Mtoe)[15], of which 97% was consumed by the manufacturing industry. Industry is the sector with the slowest progression in energy consumption (comparing to residential and transport sectors); as a result, its share in final energy consumption has been falling between 1990 and 2004 (minus 3 points). In a few countries (Greece, the United Kingdom, Ireland, Germany, Luxembourg, Portugal, Belgium), the drop in the importance of the sector has been quite substantial (minus 5 points on average). Over the same period, energy efficiency improved by 12% in manufacturing industry.

IEA analysis shows that substantial opportunities to improve industrial energy efficiency remain within the European countries. For example, it recommends to establish standards for industrial electric motors, or to examine the barriers to the optimization of energy efficiency in motor-driven systems. This analysis shows that there is a significant potential for energy savings through enhanced energy efficiency policies for motors. The IEA estimates that if all countries adopted best practice minimum energy performance standards for industrial electric motors, between 240 and 475 TWh of electricity demand could be saved by 2030.

After the oil price shock during the 70's, energy efficiency in the industrial sector improved noticeably during the last three decades.

EU energy efficiency legislation is recent, although legislation has existed for a longer period in certain member states. The steps which industry has taken have largely been voluntary and usually driven by cost, but are also in conjunction with EU initiatives.

EU could save at least 20% of its present energy consumption in a cost-effective manner (European Commission, 2005). The EU has announced an EEAP (Energy Efficiency Action Plan) to save up to 20% of energy throughout the Union (about 39 Mtoe) and 27% of energy in manufacturing industries by 2020. The hope is to reduce direct costs in the EU by 100 billion € annually by 2020 and save around 780 million tones of CO_2 per year.

Besides the EU-ETS scheme, that became a flagship measure of the European policy concerning reduction of greenhouse gas emission and improvement of energy efficiency in the industry, there are few regulatory measures on energy efficiency in the European industrial sector. In Italy, industries consuming over 10 Mtoe per year must designate an energy administrator. In Portugal, Romania, Bulgaria, Lithuania, the most important energy consumers have to lead a compulsory energy audit.

Some countries give priority to tax tools, as Germany, Estonia, Italy, the Netherlands, Sweden and the United Kingdom which set up environmental taxes proportional to electricity and fossil fuels consumption and gas emissions.

Direct subsidies are also implemented, particularly to finance innovative projects which introduce new efficient technologies on the market.

Energy management (EM) programs address the way an industrial plant is managed to exploit cost-effective energy savings opportunities. Global adoption of EM measures could produce industrial energy demand savings of 3-7%. Large energy savings can also be made from light industry that consumes 30% of industrial energy use by increasing EM programs in this sector. Many countries are also continuing, or expanding, their promotion of energy management in industry. These policies commonly include the provision of energy management tools, training, energy manager certification and quality assurance. Nevertheless, there is some concern about the level of energy management support in some European countries.

---

[13] 11,213 Gtoe in 2004

[14] 1 Mtoe = 41 868 EJ

[15] In the EU-25, the industrial energy use was 319 Mtoe or about 28% of the annual EU final energy use, and 30% of primary energy demand.

3.4. The transport sector

In the Green Paper on energy efficiency (European Commission, 2005), the Commission estimates that the EU could reduce energy consumption by 20% by 2020, and it claims that the first sector with a high energy saving potential is transport, representing a third of the EU's total consumption. The dominance of road transport and its high level petrol dependence are accompanied by congestion and pollution problems which add to energy waste. To face these issues, the Commission proposes tax schemes favouring clean and economical vehicles and the use of public transport and car pooling. The Commission is also in favour of financing research and development of alternative fuels. Finally, it calls for better road and air traffic management on a continental scale to limit congestion and pollution, particularly by using the applications of the GALILEO Programme[16].

In the Action Plan for Energy Efficiency (European Commission, 2006), the Commission estimated that the energy saving potential in the transport sector is around 26% reduction in energy consumption. The Commission plans to set a binding target to reduce polluting car emissions to achieve the threshold of 120g of CO_2/km by 2012. It also intends to address the issue of car components, such as air conditioning and tyres, in particular by issuing a European standard for rolling resistance and by promoting tyre pressure monitoring. The Action Plan includes an initiative to extend the greenhouse gas emissions trading scheme to the air transport sector, to improve air traffic control (SESAR), to implement the third rail package, and to connect ships to the electricity network when in harbour.

Since the 2001 White Paper, which was revised in 2006, this policy area has been oriented towards harmoniously and simultaneously developing the different modes of transport, in particular with co-modality, which is a way of making use of each means of transport (ground, waterborne or airborne) to its best effect.

In what follows, we focus on the road transport given its overwhelming relevance for energy consumption.

<u>"Euro" Emission Standards</u>

According to a recent study on European transport policies (European Commission, 2009b), the EU "has developed vehicle emission standards with the aim of lowering the negative environmental and health impacts from motorized transport. The standards are defined in a series of Directives, which date back to the 1970s, staging the progressive introduction of increasingly stringent requirements. The setting of standards has had an impact on the evolution of the vehicle fleet composition over the years. This led to a considerable change in the size and type of emissions of air pollutants from motorized transport, which have substantially decreased over time".

A regulation of 2007[17] introduces new common requirements for emissions from motor vehicles and their specific replacement parts (Euro 5 and Euro 6 standards). The Euro standards set limits on vehicles' emissions of carbon monoxide (CO), hydrocarbons (HC), oxides of nitrogen (NO_x) and particulate matter (PM). As soon as the Euro 5 and Euro 6 standards enter into force, Member States must refuse the approval, registration, sale and introduction of vehicles that do not comply with these emission limits.

The Euro 5 standard came into force on September 2009. Its main effect should be to reduce the emissions of particulate matter from diesel cars from 25 mg/km to 5 mg/km.

Euro 6 is scheduled to come into force on 2014 and will mainly reduce the emissions of NO_x from diesel cars further, from 180 mg/km to 80 mg/km.

<u>Pricing and Taxation</u>

A common EU environmental framework for road vehicles registration and annual circulation taxation is still under discussion. At national level there are some examples of transport charges.

---

[16] The purpose of the Galileo programme is to establish the first worldwide satellite radionavigation and positioning infrastructure specifically for civil purposes.

[17] Regulation (EC) No 715/2007 of the European Parliament and of the Council of 20 June 2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information.

In Germany, Italy and Spain, light vehicles' registration tax varies according to their emissions. In Spain, the government has also introduced financial incentives to replace old vehicles with new ones with better CO_2 performances.

It should be also noted that some European cities, namely London, Stockholm and Milan, have introduced urban charging schemes and distance related charging schemes on motorways (e.g. HGVs charging scheme in Germany).

However, few measures have yet been taken to internalize costs of CO_2 emissions, rail and road noise and congestion. With the exception of Milan, urban road charges have focused on congestion, though some exemptions were allowed for electric or hybrid vehicles.

The EU legislation sets minimum annual taxes for heavy goods vehicles (above 12 tonnes) and establishes that taxes have to vary according to the number and composition of axles; yet national authorities can set taxes structure as well as the procedures for levying and collecting them. However, several Member States already apply charges differentiated on proxies for environmental impact (e.g. engine size and type).

Reduction of CO_2 Emissions from Cars

According to the Review of Common Transport Policy, "in 1998 and 1999 the European Commission entered a voluntary agreement with the European, Japanese and Korean car industry to reach average emissions of CO_2 from new cars of 140g/km by 2012. In 2007 the Commission concluded that, although there had been a reduction in average emissions (from 186g/km in 1995 to 161g/km in 2004), the target was unlikely to be met, and made a legislative proposal to ensure that, along with other technological improvements and an increased use of biofuels, the target of 120g/km would be met by 2012.

The legislation was discussed and approved on December 2008. It sets that the fleet average to be achieved by all cars registered in the EU is 130 grams per kilometer (g/km), with an additional 10g/km to be achieved from other sources, including CO_2 restrictions for vans, the use of biofuels, cleaner fuels, more efficient air conditioning systems, and the use of tyres with lower rolling resistance. A so-called limit value curve implies that heavier cars are allowed higher emissions than lighter cars while preserving the overall fleet average. In 2012, 65% of each manufacturer's newly registered cars must comply on average with the limit value curve set by the legislation. This will rise to 75% in 2013, 80% in 2014, and 100% from 2015 onwards. If the average CO_2 emissions of a manufacturer's fleet exceed its limit value in any year from 2012, the manufacturer has to pay an excess emissions premium for each car registered. This premium amounts to €5 for the first excess g/km, €15 for the second g/km, €25 for the third g/km, and €95 for each subsequent g/km. From 2019, even the first excess g/km will cost €95.

A target of 95g/km is specified for the year 2020. The implementation of this target, including the excess emissions premium, will have to be defined in a review to be completed no later than the beginning of 2013".

In order to reduce carbon dioxide emissions from new cars and vans sold in the European Union, in 1999 the European Commission proposed to label new vehicles according to their fuel economy[18] [Directive 1999/94/EC], with the aim to ensure well informed consumption choices. Currently the Directive is under revision [COM(2007) 19] and the adoption of the proposal to revise CO_2/cars labelling Directive is foreseen towards the end of 2009.

4. Panel Analysis: Methodology

This section describes the techniques applied in this study to identify and characterise the energy intensity, carbon efficiency, carbon intensity and energy security determinants by means of panel econometric analyses, focusing on the following factors suggested by the literature:

- Structural changes in the economy: GDP, sectoral GDP shares changes, R&D expenditure;
- Policies: national and supranational energy policies (e.g. EU directives, presence of national carbon/energy taxes, etc.)

[18] The fuel economy is the distance traveled by a vehicle per unit of fuel used.

- Measures: fiscal, education/information initiatives, legislation (mandatory standards or labelling), cooperative measures, cross-cutting measures
- Energy: energy prices, energy balance sheet.

The goal is hence to assess the economic variables which could have a significant effect in improving the energy intensity, energy efficiency, energy security and carbon intensity and to identify the policies and measures (P&M) implemented in European countries which have been effective for the same purpose. A further goal is to compare the significant drivers resulting from regressions, in order to understand whether there are some factors which affect both energy intensity and energy security and if improvements in carbon intensity match with lower energy intensity.
In order to achieve these goals, we have chosen to apply econometric models which exploit the panel data format. The panel data analysis, indeed, allows us to combine cross-sectional data and time series data, obtaining a gain in the efficiency of estimates, thanks to the availability of a large amount of information.

The estimates are obtained by regressing the energy intensity index (EI), the energy efficiency index (EE), the energy security index (ES) and the carbon intensity index (CI) - or CO_2 emissions pro capita in the case of the household sector, on a set of explicative variables X (such as energy prices, GDP, R&D expenditure, etc.) and policy variables PM. The EI, CI and the ES indexes have been calculated both at a aggregate level and at a sub-sector level, focusing on three main productivity sectors, namely Industry, Other and Transport sectors. For the ES and CI a more detailed disaggregation is been carried out, splitting the Other sectors into Agriculture plus Tertiary sector and Residential sector. The EE index model has been estimated for the Residential and the Transport sectors.
The analysis therefore includes 18 general panel models, with alternative specifications for energy security[19], focusing on the EU15 countries and Norway between the period 1980-2006[20].
The econometric models have the following functional form:

$$EI_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMK_{it} + u_{it} \qquad (3)$$

$$EE_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMN_{it} + u_{it} \qquad (4)$$

$$ES_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMN_{it} + u_{it} \qquad (5)$$

$$CI_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMN_{it} + u_{it} \qquad (6)$$

$$CC_{it} = \alpha_i + \lambda X_{it} + \beta_1 PM1_{it} + \ldots + \beta_K PMN_{it} + u_{it} \qquad (7)$$

Where *EI* is the Energy Intensity index, *EE* is the Energy Efficiency index, *ES* is the Energy Security index, *CI* is the Carbon Intensity index, and CC are the carbon emissions per capita. The matrix X_{it} includes the explanatory variables related to economic structural changes, society and energy market. The variables PM_J, j=1,…,K, represent instead the policies included in the regression, which are dummy variables equal to 1 if the policy is in force in the *i-th* country and *t-th* year.
The double pointer (i,t) shows the panel structure of the dataset. In particular the index i=1,…,N represents the country, while the index t=1,…,T refers to time. The parameters λ e β_j, j=1,…,K, are constant across countries and over time, while the parameters α_i change only with the country. The parameters α_I are known as fixed effects and capture the individual heterogeneity which characterize panel data models.
The individual heterogeneity is unknown, systematic and correlated with regressors. To solve this issue we have chosen a fixed-effect model, where the individual heterogeneity is modeled by means of *country-specific* constants. Such models differ from random-effects models, where instead the individual heterogeneity is a random variable μ_I, included in the disturbance term, $\alpha_i = \alpha$ e $u_{it} = \mu_i + e_{it}$.

[19] Given the vast range of possible energy security indicators, we have tested a few alternative options.
[20] For the EE indexes the analysis focuses on the period 1980-2004.

The random-effect model implies the use of a random sample of individuals. We used instead a dataset where the selection of countries under scrutiny are not random, this makes the fixed-effects models more useful for our purpose than the random-effects models.
Models (3) – (7) are special cases of Seemingly Unrelated Regression equation systems (SUR), where the coefficients λ e β_j, vary across individuals. In a model where coefficients are indexed with i=1,…,N, the excess of parameterization implies issues in degrees of freedom and less efficient estimates of coefficients. Considering the high number of policies used in the regression, the fixed-effects model is preferable to a SUR system.
We have tested also one-year and two-year lags for all the P&M variables, and one-year lags for the main economic variables. The approach followed consisted in testing models which cover all macro-variables and policies, as well as their lags, cutting out variables with non statistically significant coefficients. This process has been iterated until a set of significant explicative variables has been obtained.
Data concern observations on 16 countries (N=16) for 27 periods (T=27), related to 69 variables overall, which 57 are dependent or explicative variables (X_{it}; PM_{it}) and 18 are endogenous variables (Y_{it}). The set of independent variables includes energy intensity, energy efficiency and energy security indexes calculated for each country as a whole and for the three macro-sectors, as well as the carbon intensity index calculated only for the entire economy.
We have created therefore 18 panel models, one for each indicator/sector and we have proceeded by regressing each endogenous variable on the set of explicative variables in order to find statistically significant regressors.

5. Panel Analysis: Data

For the estimates of the energy indexes and the economic variables we have combined a set of different data sources. The Energy Intensity index has been calculated by using the IEA[21] database for energy final consumption data and EUROSTAT[22] and OECD[23] databases for the estimates of sectoral value added. Energy Security indexes are been obtained employing data extracted from ENERDATA[24] and IEA. Data for the Carbon Intensity index have been extracted from the ENERDATA[25] and EUROSTAT/OECD databases, while per capita CO_2 emissions for the residential sector are been computed by combining data from WDI[26] and ENERDATA.
The EI index is defined as the ratio between energy consumption and an indicator of activity measured in monetary units (e.g. GVA). Energy consumption can be classified as primary and final. By primary energy consumption it is meant the energy of combustible fuels and natural sources (oil, coal, etc.) whose transformation generates the energy used for final consumption. In this study we consider final energy consumption to calculate the EI index. The IEA energy balances provide information on primary and final energy consumption by country, energy product and sector. Regarding the indicator of economic activity, used both in the energy intensity and in the carbon intensity indexes, we have chosen the GVA in US dollars at constant prices, calculated at PPPs using the 2000 as base year, which allows us to make a more careful international comparison. The indexes have therefore the GVA, rather than the GDP, as denominator since that taxes and subsides, included in the GDP, are not relevant for our purposes. EUROSTAT database includes the monetary values of all goods and services produced by a given country. These values represent the GDP at an aggregate level and the value added produced in each sectors, at a sectoral level. We have chosen the EUROSTAT database because it allows the disaggregation of GVA in 32 subsectors. The indexes are calculated by sectors, aggregating production activity for three macro-sectors, namely industry,

---

[21] IEA World Energy Statistics and Balances - Extended Balances Vol 2008 release 01.
[22] EUROSTAT - National Accounts by 6 and 31 branches - aggregates at current prices.
[23] OECD.Stat - *Gross domestic product (output approach) US $, constant prices, constant PPPs, OECD base year (2000), millions.*
[24] Enerdata – World Energy database, 2007.
[25] Enerdata – EmissionStat, 2007.
[26] World Development Indicators, The World Bank, 2008.

other and transport, where the sector *other* includes public and private services, as well as agriculture and residential. We have chosen to focus the analysis on EU-15 +Norway for the period 1980-2006.
The Energy Efficiency indexes[27] have been computed by combining data extracted from IEA and MURE-Odyssee databases. IEA energy balances provide data on final and sectoral energy consumptions (Mtoe), while Odyssee (MURE) database includes the data on unit consumption, (physical/technological data).
The economic time series are obtained from different sources, mainly World Development Indicators (WDI), EUROSTAT[28] and IEA[29]. Energy prices data have been extracted from IEA databases, R&D expenditures have been obtained from EUROSTAT, while the WDI has provided information on the remaining macro-variables.
Policies and measures data are taken from the MURE[30] database. MURE (*Mesures d'Utilisation Rationnelle de l'Energie*) provides information on energy efficiency policies and measures that have been carried out in the Member States of the European Union. The database collects the energy efficiency measures relevant to the four main energy demand sectors, namely household, transport, industry and tertiary and on general energy efficiency programs and on general cross-cutting measures. Dummies variables have been created by subcategory of policy, that is, the dummy variable is equal to 1 if any kind of policy included in the same subcategory is implemented in the country under scrutiny during the period considered. Annex I provides a glossary of data with a description of economic variables and policy dummies.

6. Panel Analysis: Results

In this Section we illustrate the result of the panel analyses. Our aim is to check whether the implementation of energy efficiency policies has had an effect in EU (EU15+Norway) countries on indicators of energy efficiency, carbon efficiency and security of supply.
In particular we are interested in checking whether some policies had a sort of "double dividend" by having a positive effect on more than one of these indicators. Besides policy dummies, we also look at the effect of the macro drivers (GDP, prices, R&D, etc.). We first look at the effect of sector specific policies, and then we look at joint effect of policies on the European economy as a whole.[31]

6.1 Panel analyses of energy polices in the EU for the residential sector and for the "other sectors"

In this sub-section we analyse the European residential sector and the consumption sectors usually grouped under the "other sectors" label in energy statistics, that is the tertiary sector and agriculture. As explained before, to assess energy efficiency we need to resort to different indicators according to whether the sector under scrutiny contributes to the officially recorded production of value added or not. Thus we look at energy intensity for the "other sectors" and to a physical indicator of energy efficiency for the residential sector. For the same reasons it will not be possible to assess the carbon intensity of the residential sector, but we look at (per capita) emissions. The regressions' results are reported in Table 6.

The residential Sector

The energy efficiency in the household sector appears to be improved by the application of a number of policies, both sector- and non sector- specific. In particular, mandatory standards for buildings and regulation for heating systems and hot water systems have proven effective, along with cooperative measures and cross cutting policies with sector-specific characteristics. Cross

[27] See Annex II for the methodology used to compute the EE indexes.
[28] Eurostat - Statistics on research and development - R&D expenditure at national and regional level.
[29] IEA - Energy Prices and Taxes – Vol. 2009 release 02.
[30] http://www.isisrome.com/mure/
[31] All coefficients displayed in Tables 7, 8 and 9 are significant at least a 95% confidence level (most variables are significant at least at 99%).

cutting policies such as the implementation of fiscal measures and general programs to improve energy efficiency or promote renewable energy sources also had a positive effect.

				Dependent variables							
				energy intensity/efficiency		**energy security**			**carbon intensity/emissions**		
			Unit	eioth	eehouody	Esoth	esagter	eshou	cioth	ciagter	co2hou
Coefficients		Energy Price	US$/unit	-	-1.46	-0.01	-0.01	-	-0.001	-	-0.01
		GDPppp	US$	-0.03	40.26	0.60	0.44	-11.68	-0.033	-0.06	0.38
		R&Dppp	US$	0.01	-	-	-	14.47	-	0.03	-0.20
		Share Industry	%	-	-	-	-	-	-	-	-
		Energy Production	ktoe	-	-	-	-	-	-	-	-
	Household Policy Variables	Hh01		-	-7.22	-	-	-	-	-	-
		Hh02		-	-12.03	-	-	-	-	-	-
		Hh03		-	-	-	-	-	-	-	-0.159
		Hh04		-0.007	-	-	-	-	-0.0254	-	-
		Hh05		-	-	-	-	-	-	-	-0.049
		Hh06		-0.010	-	-	-	-	-	-	-0.11
		Hh07		-0.007	-	-0.1729	-	-	-	-	-
		Hh08		-	-	-	-	-	-0.008	-	-
		Hh11		-0.006	-19.28	-	-	-	-	-	-
		Hh12		-0.008	-14.64	-0.08	-	-5.2255	-0.008	-	-0.072
	Tertiary Policy Variables	Te02		-	-	-0.09	-	-	-	-	-
		Te06		-	-	-0.18	-	-	-	-	-
		Te07		-	-	-	-	-	-	-0.007	-
		Te08		-	-	-0.17	-0.156	-	-	-	-
		Te09		-	-	-	-	-	-0.015	-	-
		Te10		-	-	-	-	-	-	-0.005	-
	Cross-Cutting Policy Variables	Cc01		-	-16.712	-	-	-3.95	-0.0136	-	-
		Cc03		-	-16.513	-	-	-	-	-	-
		Cc04		-	-	-	-0.113	-	-	-	-0.097
		Cc07		-0.0081	-	-	-	-	-0.009	-	-0.074
R-square				0.67	0.46	0.47	0.37	0.3	0.76	0.55	0.46

Notes: *eioth* = energy intensity index other sectors (residential+tertiary+agriculture); *eehouody* = energy efficiency index - residential sector (Odyssee), 1980-2004; *esoth* = energy security index - other sectors (proxy:Gas import/gas consumption); *esagter*= energy security index - agriculture+tertiary (proxy:Gas import/gas consumption); *eshou1*=energy security index - residential sector (proxy:Total GAS consumption/GDP); *cioth*: carbon intensity index - other sectors (residential+tertiary+agriculture); *ciagter*: carbon intensity index - agriculture+tertiary

Table 6. Econometric Results of the Energy Intensity, Energy Security and Carbon Intensity Indicators for the residential and the Other sectors

As to the macro variables, electricity price has a beneficial effect on this indicator, confirming that the share of household energy use which is not related to transport, mainly has to do with electrical appliances and lighting. On the other hand, increasing per capita income appears to be bad news for energy efficiency. This is probably linked to the well known high income elasticity of the demand of electrical appliances. To anticipate, that the same variable has a beneficial effect on aggregate energy intensity. There the efficiency gains due to shifts in the

productive structure towards a less energy intensive setting, typical of richer economies may have prevailed and counterbalanced this detrimental one, specific of the household sector.
Carbon emissions. Energy prices and GDP per capita have an analogous effect as on energy efficiency: price increases improve the performance of this indicator and higher income worsens it. R&D expenditures have a small beneficial effect.
Residential policies improve this indicator, but with the exception of cross-cutting with sector-specific characteristics, they are different from those influencing the energy efficiency indicator: building regulations, legislative/informative measures, and grants or subsidies to promote energy efficiency. Again, some cross cutting policies are effective, in particular those related to financial measures.
If we look at the effect on **energy security** of policies aimed at energy efficiency in the residential sector and general cross cutting measures only, the results are quite disappointing.
Note that for al consumption sectors, we consider the aggregate value for these indicators, but we regress them on sector-specific policy variables. The idea behind this strategy is that we want to look at the effect of policies designed for the various consumption sectors, or cross cutting policies affecting the sector under scrutiny, on energy security indicators that are likely to be relevant for this sector. We do not compute a sector specific energy security indicator, because its meaningfulness would be questionable.

Relying only on this family of policies has little or no effect on most energy security indicators. Only a couple of gas-related indicators of energy security appear to respond positively to these policies. In particular, the ratio of gas consumption and GDP turns out to decrease in presence of general support to energy efficiency and renewable energy sources, climate policies, and those cross cutting policies that have a more specific focus on households. Increasing income per capita appear to promote diversification of fuel use, while R&D's effect is detrimental in this case. Energy prices do not appear to be playing a significant role.
Note that these results are not directly comparable with those for the "other sector" below because the indicator chosen as energy security proxy is different. The other energy security indicator displaying some responsiveness to this family of policies is in fact the same proxy as for the "other sectors" (the ratio of gas imports to gas consumption); however in this case we obtained less significant results. In particular, in this case only grants and subsidies to promote energy efficiency in the residential sector had a significant beneficial impact. Macro variables behave as they do in the analogous regressions for the "other sectors" policies described below: increasing energy prices improve this indicator and increasing per capita GDP worsens it.

The "other sectors"
"Other Sectors" is a general aggregate used in energy balances that includes the residential sector, the tertiary sector and agriculture. It is not always easy to disentangle these three components.
Energy intensity is in this case measurable, since two out of three of its components do produce value added. It is however an upward biased measure, because there is nothing in the denominator related to the household sector. Nevertheless, this measure of energy efficiency seems to be sensitive to policies targeted at the residential sector: mandatory standards for electrical appliances, grants, subsidies or soft loans to encourage energy efficiency at home, along with cooperative measures and cross cutting policies with sector-specific characteristics have proven effective. Notice that these are not exactly the same set of household policies and measures that have a beneficial effect on the energy efficiency indicator, although some overlapping is present; this may be a side effect of the bias just highlighted.
Measures aimed at the tertiary sector does not seem to influence this indicator, while general cross cutting policies have positive effects (again not the same policies as in the energy efficiency case).
Also the behaviour of macro variables is rather different: this time increasing energy prices have no effect on this indicator, while GDP per capita slightly improves it and R&D worsens it.
As to **carbon intensity indicators**, there is a noticeable difference between these aggregates and the pure per capita emissions for households. In fact, for the more general aggregate, (i.e. carbon intensity in the "other sectors"), mandatory standards for electrical appliances, tax exemption and tax reduction, as well as cross cutting measures with sector specific

characteristics are effective. Of the tertiary sector policies, cooperative measures only are effective. General cross-cutting measures, in particular those aimed at improving energy efficiency or mitigating climate change or policies schemes to support renewable energy are also beneficial. Again increasing energy prices improve this indicator, this time, also GDP per capita improves this indicator. This is understandable as carbon intensity by construction gets lower as GDP increases[32].

To assess the weight of the "other" sectors' policies on **energy security**, we look at both the joint effect of the policies aimed at the three sub-sectors together and the effect of these policies separately. More specifically we consider the effect of policies aimed at energy efficiency in the "other sectors" to see if these policies have an effect on the ratio of gas imports to total gas consumption. In terms of macro variables, in this case energy prices appear to improve this indicator, while GDP per capita worsens it.

In terms of policy variables, we found that loans to the household sectors and cross-cutting measures with a residential focus do improve this indicator. Note that the same policy variables had a beneficial impact on the energy intensity of this aggregate, and in the case of loans, on aggregate energy intensity. Also a number of policies aimed at the tertiary sector improve this dimension of energy security: soft loans for energy efficiency, renewable energy and CHP, regulations for building equipment and policy promoting information and education in energy efficiency. These policies, however had no effect on energy efficiency or energy intensity for this aggregate. No general cross cutting policy displays any effect. The effect of tertiary policy variables is not robust to the specification of the model: if we test only the policies aimed at the tertiary sector, and cross cutting policies, we find that only policies promoting information and training in energy efficiency issues and cross-cutting financial measures have a significant effect.

6.2. The transport sector

The main results for the transport sector are collected in Table 7 below.

The energy intensity of the transport sector is beneficially influenced both by sector-specific and cross-cutting measures. Sector-specific measures include support fiscal instruments encouraging the adoption of more efficient vehicles such as tax exemptions, tax reductions or accelerated depreciation of obsolete vehicles and the measures to improve transport infrastructures. Cross-cutting policies include those promoting the introduction of marked based instruments. In terms of macro drivers, increases in the price of diesel improve this indicator, not unexpectedly. R&D seem to have a similar effect. Per capita income, on the other hand, has a detrimental effect.

If we look at **energy efficiency improvements** in pure physical terms, the fit of the regression improves considerably, thus highlighting the bias induced in the case of energy intensity by implicitly comparing the consumption of a whole sector to the value added generated only by a fraction of it. The general picture is not so different however: both sector-specific policies and cross-cutting policies are effective, although not quite the same policies. The exception are the support fiscal instruments noted above, which are effective also in this perspective. Social planning measures (e.g. those aimed at improving the efficiency of transport networks) also work in this direction. As to cross-cutting measures, fiscal and financial measures appear to be effective. In terms of macro variables, only R&D expenditures have an effect akin to the one displayed for energy intensity.

As to **carbon intensity**, the sector appear to be particularly sensitive to include support fiscal instruments encouraging the adoption of more efficient vehicles such as tax exemptions, tax reductions or accelerated depreciation of obsolete vehicles. Among cross cutting policies, market based instruments appear to be effective. In terms of macro variables, increasing incomes improves this indicator, something that at first glance is at odds with what noted for

[32] We also checked the different impact of policies for the sub-sectors on carbon intensity by disentangling the impact on the carbon intensity of the value generating sub-sectors (tertiary and agriculture) of policies aimed at the tertiary sector from those aimed at the household sector. We found again sector-specific measures that work: fiscal support measures such tax exemptions or reductions for energy efficiency improving inputs and cross cutting measures with a focus on the tertiary or agricultural sectors. GDP per capita displays the same beneficial effect noted for the "other sector" aggregate while R&D quite surprisingly worsens this indicator.

energy intensity. On one hand in fact richer economies consume more energy for their transport needs. On the other hand, they seem to use cleaner means of transport. Thus there appears to be an increasing diversification in transportation options as income per capita increases, while the higher availability of economic means leads nevertheless to a higher demand for energy. R&D worsens this indicator.

Finally, in terms of the sector's contribution to **energy security,** results are in general quite disappointing; the best fit is obtained in the case of the ratio of oil consumption to GDP[33]. Even in this case however, only-cross cutting measures (those with sector specific characteristics and those aimed at improving general public knowledge about energy efficiency) appear to be effective. In terms of macro variables, only income per capita have a (beneficial) effect on this indicator: the same argument about diversification of transport means in richer economies noted for carbon intensity may hold here as well.

6.3. Panel analyses of energy polices in the EU for the industrial sector

The energy intensity in the industrial sector is affected by a number of policies. General cross-cutting policies about energy efficiency have a beneficial effect in this case, as the policies targeted at the industrial sector, in particular measures supporting information, education and training and cooperative measures are effective.

In this case, no energy price seem to have a significant impact: probably on one hand sunk costs related to investment constrain the possibility of fuel switching in the short term in response to price swings; on the other hand firm can put in place hedging strategies to sterilise, at least partially, the effect of energy price variations on their balances. GDP reduces energy intensity, as does the share of industry on value added. R&D expenditures tend to worsen this indicator; this somewhat puzzling effect is briefly discussed below for the case of the overall energy intensity.

As to **carbon intensity**, the industrial sector appear to be particularly sensitive to sector specific cooperative measures and again cross cutting policies, in particular those related to marked based instruments. As to macro drivers, energy prices, the share of industry and GDP per capita both have a beneficial effect, while energy production has no significant effect.

To assess the sector's **energy security**, we have chosen to look at two indicators: oil intensity (oil consumption on GDP) and gas intensity (gas consumption on GDP).

The regression of the first indicator confirms that the higher the weight of industry in the economy, the less vulnerable the latter is to disturbances and threats coming from the oil market. The effects of other macro drivers are the same as those described for the economy as a whole, (bar R&D, that displays no significant effect here). In terms of policies, this indicator appear to be influenced by cross cutting policies, both of general application and with sector specific characteristics.

The second indicator gives a slightly different picture: in this case also fiscal measures in the industry sector, along with the same cross-cutting measures with sector-specific characteristics, highlighted for the previous indicator, reduce vulnerability. However, general cross-cutting policies are no longer effective. With the exception of the share of the industrial sector in the economy, macro variables have a markedly different impact: both increasing electricity production and GDP pro capita leads to more vulnerability: this makes sense, because natural gas has had an increasing share in gross electricity generation, and gas is a superior good compared to oil and coal for household heating purposes.

6.4. Panel analyses of energy polices in the EU for the whole economy

As shown in Table 7, **the energy intensity** at the aggregate level is affected by a number of policies. It is interesting to note that besides general cross cutting policies about energy efficiency, promotion of renewable energy sources or climate change mitigation, (particularly if using marked based instruments), also sector-specific policies have a beneficial effect on overall energy intensity. In the residential sector, mandatory standards for electrical appliances and the deployment of grants, subsidies or soft loans have proven particularly effective. Measures

[33] Regressing our dependent variables on alternative energy security indicators (oil import/oil consumption and oil consumption in transport / total energy consumption in transport) have led to way less significant results.

supporting information, education and training in the industrial sector and tax exemptions in the tertiary sector also seem to improve overall energy intensity.
As expected, increasing the residential electricity price induces a small but significant reduction in overall energy intensity. An analogous effect, both in terms of sign and in terms of magnitude, has the share of industry on value added. GDP reduces energy intensity, hinting that richer economies, at least in Europe, tend to use their energy more efficiently, while a somewhat puzzling, perverse but significant effect have R&D expenditures. Note however that the R&D variable does not capture R&D in the energy sector, but overall R&D. It is thus not implausible that these expenditures steer the overall economy towards a slightly more energy intensive configuration.
A similar picture characterises **carbon intensity**. Household electricity prices and GDP have roughly the same effect as on energy intensity, both in terms of sign and in terms of order of magnitude. R&D expenditures and industry's share in value added have no significant effect, while energy production slightly worsens this indicator (although the significance of this variable is weak).
A number of sector-specific policies improve this indicator: legislative or informative measures for the industry sector, mandatory standards for household electrical appliances, cooperative measures in the household and tertiary sectors, and cross cutting policies.
As to **energy security**, after testing various candidates we have chosen to focus on two indicators for aggregate energy security (total energy imports/TPES and oil consumption/GDP).
The first aggregate indicator displays a relatively low sensitivity to energy efficiency policies. In fact, only cross-cutting measures (legislative and cooperative) and, curiously, information initiatives in the tertiary sector have a significant beneficial effect, reducing the imports of energy as expected, energy production reduces import dependence, while it is less clear why a similar effect is produced by increasing R&D expenditures. Higher GDP and higher household energy prices stimulate imports, not unexpectedly.
If instead, vulnerability is assessed by looking at how important is oil in the economy, EU-15 countries have some more tools at their disposal to reduce it: general cross cutting measures, soft loans for the adoption of renewable energy sources and efficiency improvements in the transport and tertiary sectors, grant subsidies and again informative measures in the tertiary sector. Increases in electricity and industrial production, which are not very oil intensive in western Europe, tend to reduce the weight oil has on the economy and hence the vulnerability of the latter. Also, there is a significant positive relationship between higher level of GDP per capita and higher energy security of the overall economy, as oil gets increasing substituted with other energy sources.
The impact of GDP on energy system vulnerability therefore seems to be twofold, depending on the indicator we use to measure the aggregate energy security. On the one hand, indeed, an increase in GDP reduces the dependence on oil improving the security of energy supply, while on the other hand it increases imports, strengthening the dependence on foreign energy suppliers. Looking at the regression coefficient values, however, the effect of decreasing the consumption of oil in favour of a less vulnerable energy mix seems to be more significant.

6.5. Discussion

In general, the fit of the econometric models analysed in this study is reasonable, (R-square ranging from 0.3 to 0.76), however it is on average lower for sectoral regressions than for those focusing on the overall economy.
A number of policies have a beneficial influence across EU countries on specific policy target indicators. There is however very little overlapping among policies in terms of their effectiveness on both energy efficiency indicators and energy security indicators. This seem to confirm the traditional economic policy wisdom dating back to Jan Tinbergen (1952, 1956) that multiple policy objectives require multiple instruments. However, there is an exception to this general rule in our case: general cross cutting policies appear to have beneficial effects on both aggregate energy intensity, carbon intensity and energy security.

Table 7. Econometric Results For the industrial and transport sectors and the whole economy.

			Dependent variables											
		Unit	**Energy intensity**			**Energy efficiency**	**Energy security**					**Carbon intensity**		
			eifin	**eiind**	**eitra**	**eetraody**	**esfin***	**esfin2**	**esind1**	**estra**	**esind2**	**Cifin**	**citra**	**ciind**
Coefficients **Macro Drivers**	Energy Price	US$/unit	-0.001	-	-0.046		0.0047	-	-		-	-0.002		-0.003
	GDPppp	US$	-0.020	-0.096	0.176		0.333	-22.41	-20.43	-26.60	3.447	-0.067	-0.346	-0.054
	R&Dppp	US$	0.0166	0.0515	-0.063	-7.798	-0.1	6.843	-		-	-	0.271	-
	Share Industry	%	-0.002	-0.006			-	-0.473	-0.388		-0.436	-	-	-0.007
	Energy Production	ktoe	-	-0.012			-0.178	-11.2	-12.64		10.049	0.0341	-	-
Industry Policy Variables	In03		-	-	-	-	-	-	-	-	-	-0.060	-	-
	In06		-	-	-	-	-	-	-	-	-8.294		-	-
	In08		-0.012	-0.013	-	-	-	-	-	-	-	-	-	-
	In09		-	-0.009	-	-	-	-	-	-	-	-	-	-0.026
	In10		-	-	-	-	-	-	-7.302	-	-4.693	-	-	-
Household Policy Variables	Hh04		-0.02	-	-	-	-	-	-	-	-	-0.0431	-	-
	Hh06		-0.011	-	-	-	-	-	-	-	-	-	-	-
	Hh07		-0.01	-	-	-	-	-	-	-	-	-	-	-
	Hh11		-	-	-	-	-	-	-	-	-	-0.030	-	-
	Hh12		-	-	-	-	-	-	-	-	-	-0.019	-	-
Transport Policy Variables	Tr06		-	-	-0.054	-9.515	-	-	-	-	-	-	-0.115	
	Tr09		-	-	-0.052		-	-	-	-	-	-	-	
	Tr10		-	-	-	-7.01	-		-	-			-	
	Tr11		-	-	-		-	-12.59	-	-13.407	-	-	-	-
Tertiary Policy Variables	Te05		-	-	-		-	-3.29	-	-	-	-	-	-
	Te06		-	-	-		-	-9.126	-	-	-	-	-	-
	Te07		-0.012	-	-		-	-	-	-	-	-	-	-
	Te08		-	-	-		-0.041	-3.878	-	-	-	-	-	-
	Te09		-	-	-		-	-	-	-	-	-0.0175	-	-
Cross-Cutting Policy Variables	Cc01		-0.006	-	-		-	-	-	-	-	-	-	-
	Cc02		-	-	-		-0.042	-	-	-	-	-	-	-
	Cc03		-	-	-	-5.39	-	-	-	-	-	-	-	
	Cc04		-	-	-	-4.71	-	-	-	-	-	-	-	
	Cc05		-	-	-	-	-0.0754	-	-	-7.243	-	-	-	-
	Cc06		-0.007	-	-0.041	-	-	-	-	-	-	-	-0.17	-0.034
	Cc07		-0.009	-0.014	-0.023	-	-	-5.379	-6.453	-	-	-0.0196	-	-0.03
R^2			0.72	0.45	0.25	0.52	0.64	0.71	0.67	0.63	0.44	0.67	0.33	0.54

Notes: All reported coefficients are statistically significant. Negative numbers indicate an improvement in energy security or reduction in energy intensity and carbon intensity and vice-versa.
esfin1 = Total import/TPES; *esfin2* = Total oil consumption/GDP; *esind1* = Total oil consumption/GDP; *esind2* = Total gas consumption/GDP; eitra =energy intensity index transport sectors ; *eetraody* = energy efficiency index - transport sector (Odyssee), 1980-2004; *estra* = energy security index - transport sectors (proxy:Oil consumption/GDP); *eitra* = carbon intensity index - transport sectors.

Between energy intensity and carbon intensity the overlaps are more widespread, and also some sector specific policies improve the performance of both indicators. This is hardly surprising, given the high correlation between the two indicators, and holds in particular for the household sector, but also cooperative measures in the industry sector affect both carbon and energy intensity at the aggregate level. It is quite striking that energy efficiency policies aimed at the residential, tertiary and agricultural sector have very little effectiveness in improving energy security. Cross cutting policies, which are very relevant in terms of multi-dimensional effectiveness in the aggregate case play a less relevant role in the residential, tertiary and agricultural sectors: only general programmes related to energy efficiency, climate change mitigation and renewable energy have this double beneficial effect, and only in terms of the ratio of gas consumption and GDP and household energy efficiency.

For the transport sector, our analysis has shown that while there are quite a number of cross cutting policies and of policies aimed at the transport sector that improve energy efficiency, energy intensity and carbon efficiency, only cross cutting policies (both with and without sector-specific characteristics) have a significant impact on oil security, the only facet of energy security that, according to our descriptive analysis, is relevant for this sector. The indication here seems to be that while energy efficiency can be significantly improved in this sector by well designed policies, the sector is still too tightly bound to oil products for any of these policy to result in significant change in its oil security. This result is underpinned also by the fact that our analysis did not find any significant overlapping between security and other indicators. One significant overlapping among energy efficiency, carbon intensity and energy intensity was singled out, as while carbon intensity and energy intensity overlap twice. In terms of goodness of fit, the results for the transport sector are mixed, with R-square ranging from 0.25 and 0.63, reaching its highest value in the energy security regression. On average R-square is below the values observed in the general case and in all other sectors.

7. Conclusions

In this study we have explored the relationships between energy efficiency and energy security, both for the economy in general and for the industrial sector in particular in the EU 15 and Norway.

To this purpose we have provided a descriptive analysis of a few energy efficiency indicators and of the energy potentials in the industrial sector. The most original contribution of this study, however, is the development and the application of an econometric approach to a dataset of policies and measures in the EU that applies panel analysis methods to test the effect of such policies on energy efficiency, carbon efficiency and energy security.

The descriptive analyses of Sections 2 and 3 have highlighted a fairly convergent trend in the EU 15 towards a more efficient configuration of energy use, both at the aggregate level and in the industry sector, albeit with varying results in terms of performance and speed across countries and sectors.

Our survey of energy efficiency policies in the EU has shown that there is indeed a significant commitment both at the EU level and at the national level, to devise and implement policies and measures to promote energy efficiency.

For the residential sector, varying results in terms of performance and speed across countries are noticeable, but they are difficult to assess in terms of pure energy efficiency due to the intrinsic cross-country incomparability of the index, that by construction mainly allows to track energy efficiency progress of a given country across time, but cannot tell us within any given pair of countries, which one has ever been more efficient than the other.

In the transport sector there is more homogeneity across Europe due to the overwhelming preponderance of road transport, both for passenger and freight traffic, and the fact that road transport is the mode that has improved the least over the period considered in this study.

Surely there has been since the 90’s a growing policy activity in this area in the EU. While it has surely led to a number of success stories in terms of unit efficiency (take for instance the energy efficiency labeling for electrical appliances or the mandatory standards for lighting), their ultimate effectiveness has been limited by a significant presence of the rebound effect in the residential sector. The Green Paper Energy explicitly recognize the great potential for energy efficiency gains in the transport sector, and indeed it appears clear that there is still a lot to do, particular in terms of rethinking the pecking order of the transport mode in Europe, still severely unbalanced towards road transport.

What has been perhaps lacking is an effective coordination among member states inspired by a shared strategy in the field of energy policy. This is a quantum leap whose urgency is clearly felt, and the recent developments in the EU energy policy appear as serious if not completely successful attempts to build it.
The current situation is thus the result of a complex evolution towards not fully achieved but increasing coordination between energy efficiency policies among member states, in which EU directives have played a major role as catalysts and harmonizing devices, but in which some significant heterogeneity is still present. It is thus interesting to draw on this diversity across countries to look at the effectiveness of energy efficiency policies in different national contexts and in terms of different indicators. A panel analysis is the ideal tool to explore this issue as it exploits a large amount of heterogeneous information by combining cross-sectional data and time series data, to obtain a gain in the efficiency of estimates.

Our panel analyses covers energy efficiency indicators, carbon efficiency indicators and energy security indicators. It turns out that quite a number of policies had a beneficial impact on energy efficiency and carbon efficiency, measured respectively as energy intensity and carbon intensity, at the aggregate level. However only one category of these policies (general cross-cutting policies), have proven also useful to improve the performance of aggregate energy security indicators. Restricting our focus to the industry sector, we notice that, again, sectoral energy efficiency and carbon efficiency have been improved significantly by a number of policies. However, none of these policies had an impact strong enough to improve also energy security, although there have been beneficial policies for energy security implemented in the industrial sector that had no significant effect on energy efficiency indicators.
Restricting our analysis to the residential sector, the tertiary sector and the agricultural sector, or the transport sector does not lead to sharper or more encouraging conclusions in terms of co-benefits on energy security of energy efficiency policies.

In fact it turns out that energy efficiency policies aimed at the specific sub-sectors sector have very little effectiveness in improving energy security. This is particularly true for the industry and the transport sector and this in general holds also for general cross cutting policies. The only exception relates to the policies aimed at the households: there is one significant overlapping between security and on energy intensity in the case of residential loans.
For the transport sector, while there are quite a number of policies aimed at the transport sector that improve energy efficiency, energy intensity and carbon efficiency, only cross cutting policies (both with and without sector-specific characteristics) have a significant impact on oil security. The indication here seems to be that while energy efficiency can be significantly improved in this sector by well designed policies, the sector is still too tightly bound to oil products for any of these policies to result in significant change in its oil security. This result is underpinned also by the fact that our analysis did not find any significant overlapping between security and other indicators.

The main lesson to be drawn from this analysis is that energy efficiency policies in the EU do work, but there is no silver bullet able to successfully address different policy objectives, unless it is a policy so general that naturally encompasses different sectors and modes of energy use. Thus only broadly defined cross cutting policies (and the residential loans mentioned above) seem to have this double effect. The other seemingly surprising lesson is that there are policies, designed to improve energy efficiency, that are more effective in terms of improving energy security than in terms of their original goal. This may have to do with our choice of energy security indicators: we may have focused on the consumption of fuels that are more sensitive to certain policies, but may have not enough weight to improve the efficiency of the overall or sectoral energy mix. This is the case for instance of cross cutting policies focused on the transport sector, that have a significant effect on discouraging the consumption of oil products and therefore improve the performance of the energy security indicator that measures the dependence of the economy from oil.

Taking a more general perspective, what seem to work is the policy mix rather this or that policy in insulation: the good news then are that currently in Western Europe a policy menu is in place that has produced significant improvements in energy efficiency, has reduced the amount of carbon emissions generated by the economic system, and has contributed to a more secure energy supply for Europe.

This study is based on the most up-to-date data we were able to recover, and employs state of the art techniques. However, the analysis performed here could in principle be extended and refined. In particular it would have been interesting to look to more countries, to use continuous, instead of binary, policy variables.

The main limitation has been data availability. In particular, policy indicators and energy efficiency indicators for new accession countries were not available or available for a decade or less of observations. For policy variables, the MURE database is mostly qualitative, and reports the presence and the category of the policies and measures implemented in a given country, but it does not provide systematically quantitative information about these policies (such as the funds earmarked for a given policy or the financial impact of a given tax). Future analyses can be pursued by investigating the country-specific P&Ms that contributed to energy efficiency improvements. We have looked at such P&Ms at the regional level (EU-15 plus Norway), but analyses of single countries can help to understand if selected policies are more effective in different countries than others.

Another limitation is that the policy database covers only efficiency- and carbon emissions-related policies, while the policy areas related to competitiveness and market liberalization are not captured. This is potentially a problem given that a more competitive market can in principle spur efficiency through more correct price signals. An indirect hint that the market reforms of the EU energy markets may have had a role also from the energy efficiency point of view, is the significant impact of prices on energy efficiency.

Finally, given the unavoidable lag in data collection, the effects of the recent economic crisis could not be incorporated into this analysis. The crisis has resulted in a noticeable decrease in energy consumption, thus temporarily reducing the case for policy support to energy efficiency and carbon emission reduction. On the other hand it as also has temporarily reduced the momentum of the investment process in new technologies, thus slowing down the penetration of efficiency improving technologies, particularly in the industrial sector and in new infrastructures. On the other hand the strong commitment of the EU to climate change mitigation confirmed at the 15th COP in Copenhagen, suggests that the positive consequences of the crisis will not result in a relaxation of these policies in the EU.

References

ADEME (2008), “L’efficacité énergétique dans l’Union Européenne: panorama des politiques et des bonnes pratiques”, Paris, France.

Constantini, V., Gracceva, F., Markandya, A. and Vicini, G. (2007): *Security of energy supply: Comparing scenarios from a European perspective*. *Energy Policy* 35:210-226

EUROPA Gateway to the European Union (2008), Synthèse du Plan d’action pour l’efficacité énergétique de l’Union Européenne (2007-2012)”, Brussels, Belgium.

European Commission (2005), Commission Green Paper, "Energy Efficiency - or Doing More With Less" [COM(2005) 265 final - not published in the Official Journal], 22 June 2005, Brussels.

European Commission (2006) “Green Paper “Energy”, COM(2006) 105 final. Brussels, Belgium.

European Commission (2008) Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources .COM(2008)19 final, Brussels

European Commission (2009a), "Study on the Energy Savings Potentials in the EU Member States, Candidate Countries and EEA Countries", Brussels, Belgium.

European Commission (2009b), Review of the Common Transport Policy, Final Report, Brussels, August 2009.

European Commission, Communication from the Commission - Action Plan for Energy Efficiency: Realising the Potential [COM(2006) 545 – Not published in the Official Journal], 19 October 2006, Brussels.

European Commission, Communication from the Commission – An EU Strategy for Biofuels, COM(2006) 34 final, 8/2/2006, Brussels.

European Commission, Regulation No 715/2007 of the European Parliament and of the Council on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information, 20 June 2007, Brussels.

European Environment Agency (EEA) (2008), Climate for a transport change. TERM 2007: indicators tracking transport and environment in the European Union, Report No 1/2008, Brussels.

European Parliament and Council, Directive 2003/30/EC on the Promotion of the use of biofuels or other renewable fuels for transport, 8/5/2003, Brussels.

European Parliament and Council, Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance), 23 April 2009, Brussels.

European Parliament and Council, Proposal for a Directive on labelling of tyres with respect to fuel efficiency and other essential parameters [COM(2008) 779 final – Not published in the Official Journal] , Brussels.

European Parliament and Council, Proposal of for a regulation of the setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles, 19 December 2007, Brussels.

EUROSTAT (2009), Panorama of Transport, EUROSTAT Statistical Books, Luxembourg.

Geller H., P. Harrington, A.Rosenfeld, S. Tanishima and F. Unander (2006) "Policies for Increasing energy Efficiency: thirty years of experience in OECD countries" *Energy Policy*, 34, p.556-573

Greening, L.A. and Green, D.L., (1998). "Energy use, technical efficiency, and rebound effect: review of the literature". Conference Proceedings, Vol I. In: , 21st Annual International Conference of IAEE, Quebec, Canada, pp. 321–330.

Jansen, J.C., W.G. van Arkel, M.G. Boots (2004): *Designing Indicators of Long-Term Energy Supply Security*, ECN-C--04007, ECN, Petten, The Netherlands.

Kendell, J.M., (1998): *Measures of Oil Import Dependence*. EIA-DOE.

IEA, (2001): *Toward a sustainable energy future*. OECD/IEA, Paris

IEA (2006), "Light's Labour's Lost – Policies for Energy Efficiency Lighting", Press Release, Paris, France.

IEA (2007), "Industry: Tracking industrial Energy Efficiency and CO_2 Emissions", Paris, France.

IEA (2008a), "Assessing measures of Energy Efficiency Performances and their Application in industry", Information Paper, in support of the G8 Plan of Action, Paris, France.

IEA (2008b), "Energy Efficiency Policy recommendations", Paris, France.

IEA (2008c), "Energy Efficiency Requirements in Building Codes, Energy Policies for New Buildings", Information Paper, in support of the G8 Plan of Action, Paris, France.

IEA (2009), "Progress with implementing energy efficiency policies in the G8, Paris", France.

ISIS (2008), "MURE II Project. Best Available Technologies in Housing. Italian case study", Rome, Italy.

Markandya, A., Pedroso-Galinato, S. and Streimikiene, D., (2006). "Energy intensity in transition economies: Is there convergence towards the EU average?" Energy Economics 28, 121-145.

Neff, T.L. (1997): *Improving energy security in pacific Asia: diversification and risk reduction for fossil and nuclear fuels*. PARES (Pacific Asia Regional Energy Security Project)

Odyssee (2007), Evaluation of Energy Efficiency in the EU-15, indicators and policies, ADEME/IEEA, Paris, France.

OECD/IEA (2007), Energy Use in the New Millenium, Paris, France.

OECD/IEA (2008), Medium-term Oil Market Report, Paris, France.

OECD/IEA (2008), Review of International Policies for Vehicle Fuel Efficiency, Paris, France.

OECD/IEA (2008), Worldwide Trends in Energy Use and Efficiency, Key Insights from IEA Indicator Analysis, Paris, France.

OECD/IEA (2009), Towards a More Energy Efficient Future, applying indicators to enhance energy policy, Paris, France.

Schipper, L., Meyers, S., Howarth, R., (1993), "Energy intensities in OECD countries: an historical analysis". International Journal of Global Energy Issues 5(2/3/4), 76}89.

Skinner, W. C. (1995) Measuring Dependence on Imported Oil, Energy Information Administration/Monthly Energy Review August 1995.

Tinbergen, J. (1952), "On the Theory of Economic Policy, Amsterdam, North-Holland.

Tinbergen, J. (1956), "Economic Policy: Principles and Design, Amsterdam", North-Holland.

Tipping, P., Antonelli R., Boonekamp, P., Donkelaar Kroon M., Longstaff T. McLeod K., Srinivasan G., Tigchelaar C. (2006) "Impact Assessment on the Future Action Plan for Energy Efficiency" (CLWP: 2006/TREN/032), ECN, The Netherlands (http://www.ecn.nl/docs/library/report/2006/e06041.pdf)

Trégouët, R. (2008), "L'efficacité énergétique: un enjeu économique et écologique majeur pour la France et l'Europe", www.enerzine.com.

Turton, H. and Barreto, L. (2006): *Long-term security of energy supply and climate change*. Energy Policy, V. 34, 15, pp 2232-2250

von Hirschhausen, C., Neumann, A.(2003): *Security of 'Gas' Supply: Conceptual Issues, Contractual Arrangements, and the Current EU Situation*. Paper Presented at the INDES Workshop on Insuring against Disruptions of Energy Supply, Amsterdam, The Netherlands

World Energy Council (2008) "Energy Efficiency Policies around the World: Review and Evaluation" (2008), World Energy Council, London, United Kingdom

Annex I – Data Dictionary

Variable	Description
Country	EU15 countries + NO
Year	1980 – 2006
EIfin EIind EIoth EItra	Energy intensity index; Final (all sectors) Energy intensity index; Industry sector Energy intensity index; Other sectors Energy intensity index; Transport sectors
EEhouOdy	Energy efficiency index; Residential sector; 1980-2004, Odyssee data
EEtraOdy	Energy efficiency index; Transport sector; 1980-2004, Odyssee data.
ESfin1	Energy security index (Total Imports/TPES); Final (all sectors)
ESfin2	Energy security index (Total Oil Consumption/GDP); Final (all sectors)
ESind1	Energy security index (Total Oil Consumption/GDP); Industry sector
ESind2	Energy security index (Total Gas Consumption/GDP); Industry sector
ESoth	Energy security index (Gas Import/Gas Consumption); Other sectors
ESagter	Energy security index (Gas Import/Gas Consumption); Agriculture & Tertiary sectors
EShou	Energy security index (Total GAS Consumption/GDP); Residential sector
EStra	Energy security index; Transport sectors;
CIfin CIind CIoth CIagter Citra CO2hou PReleHH PReleIND PRdiesel ShINDwdi R&Dpps GDPppsCur EnProdWdi	Carbon intensity index; Final (all sectors) Carbon intensity index; Industry sector Carbon intensity index; Other sectors Carbon intensity index; Agriculture & Tertiary sectors Carbon intensity index; Transport sectors Per capita CO_2 emissions; Residential sector Price in US$ of electricity residential (incl. taxes); Total Price (US$/unit) Price in US$ of electricity industry (incl. taxes); Total Price (US$/unit) Price in US$ of diesel (incl. taxes); Total Price (US$/unit), Household Industry, value added (% of GDP) (NV.IND.TOTL.ZS) WDI Total intramural R&D expenditure (GERD). Millions of PPS (Purchasing Power Standard). All sectors. EUROSTAT GDP per capita, PPP (current international $) (NY.GDP.PCAP.PP.CD), WDI Energy production (kt of oil equivalent) (EG.EGY.PROD.KT.OE), WDI
PMhhT1 PMhhT2 PMhhT3 PMhhT4 PMhhT5 PMhhT6 PMhhT7 PMhhT8 PMhhT9 PMhhT10 PMhhT11 PMhhT12	P&Ms Household sector - Mandatory Standards for Buildings P&Ms Household sector - Regulation for Heating Systems and hot water systems P&Ms Household sector - Other Regulation in the Field of Buildings P&Ms Household sector - Mandatory Standards for Electrical Appliances P&Ms Household sector - Legislative/Informative P&Ms Household sector - Grants / Subsidies P&Ms Household sector - Loans/Others P&Ms Household sector - Tax Exemption / Reduction P&Ms Household sector – Tariffs P&Ms Household sector - Information/Education P&Ms Household sector - Co-operative Measures P&Ms Household sector - Cross-cutting with sector-specific characteristics
PMtrT1 PMtrT2 PMtrT3 PMtrT4 PMtrT5 PMtrT6 PMtrT7	P&Ms Transport sector - Mandatory Standards for Vehicles P&Ms Transport sector - Legislative/Informative P&Ms Transport sector - Grants / Subsidies P&Ms Transport sector – Tolls P&Ms Transport sector - Taxation (other than eco-tax) P&Ms Transport sector - Tax Exemption / Reduction / Accelerated Depreciation P&Ms Transport sector - Information/Education/Training

PMtrT8 PMtrT9 PMtrT10 PMtrT11	P&Ms Transport sector - Co-operative Measures P&Ms Transport sector – Infrastructure P&Ms Transport sector – Social Planning/Organisational P&Ms Transport sector - Cross-cutting with sector-specific characteristics
PMinT1 PMinT2 PMinT3 PMinT4 PMinT5 PMinT6 PMinT7 PMinT8 PMinT9 PMinT10	P&Ms Industry sector - Mandatory Demand Side Management P&Ms Industry sector - Other Mandatory Standards P&Ms Industry sector - Legislative/Informative P&Ms Industry sector - Grants / Subsidies P&Ms Industry sector - Soft Loans for Energy Efficiency, Renewable and CHP P&Ms Industry sector - Fiscal/Tariffs P&Ms Industry sector - New Market-based Instruments P&Ms Industry sector - Information/Education/Training P&Ms Industry sector - Co-operative Measures P&Ms Industry sector - Cross-cutting with sector-specific characteristics
PMteT1 PMteT2 PMteT3 PMteT4 PMteT5 PMteT6 PMteT7 PMteT8 PMteT9 PMteT10	P&Ms Tertiary sector - Mandatory Standards for Buildings P&Ms Tertiary sector - Regulation for Building Equipment P&Ms Tertiary sector - Other Regulation in the Field of Buildings P&Ms Tertiary sector - Legislative/Informative P&Ms Tertiary sector - Grants / Subsidies P&Ms Tertiary sector - Soft Loans for Energy Efficiency, Renewable and CHP P&Ms Tertiary sector - Tax Exemption / Reduction P&Ms Tertiary sector - Information/Education/Training P&Ms Tertiary sector - Co-operative Measures P&Ms Tertiary sector - Cross-cutting with sector-specific characteristics
PMccT1	P&Ms Cross-cutting - General Energy Efficiency / Climate Change / Renewable Programmes
PMccT2	P&Ms Cross-cutting - Legislative/Normative Measures
PMccT3	P&Ms Cross-cutting - Fiscal Measures/Tariffs
PMccT4	P&Ms Cross-cutting - Financial Measures
PMccT5	P&Ms Cross-cutting - Co-operative Measures
PMccT6	P&Ms Cross-cutting - Market-based Instruments
PMccT7	P&Ms Cross-cutting - Non-classified Measure Types

NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI

Fondazione Eni Enrico Mattei Working Paper Series

Our Note di Lavoro are available on the Internet at the following addresses:

http://www.feem.it/getpage.aspx?id=73&sez=Publications&padre=20&tab=1
http://papers.ssrn.com/sol3/JELJOUR_Results.cfm?form_name=journalbrowse&journal_id=266659
http://ideas.repec.org/s/fem/femwpa.html
http://www.econis.eu/LNG=EN/FAM?PPN=505954494
http://ageconsearch.umn.edu/handle/35978
http://www.bepress.com/feem/

NOTE DI LAVORO PUBLISHED IN 2010

GC	1.2010	Cristina Cattaneo: Migrants' International Transfers and Educational Expenditure: Empirical Evidence from Albania
SD	2.2010	Fabio Antoniou, Panos Hatzipanayotou and Phoebe Koundouri: Tradable Permits vs Ecological Dumping
SD	3.2010	Fabio Antoniou, Panos Hatzipanayotou and Phoebe Koundouri: Second Best Environmental Policies under Uncertainty
SD	4.2010	Carlo Carraro, Enrica De Cian and Lea Nicita: Modeling Biased Technical Change. Implications for Climate Policy
IM	5.2010	Luca Di Corato: Profit Sharing under the threat of Nationalization
SD	6.2010	Masako Ikefuji, Jun-ichi Itaya and Makoto Okamura: Optimal Emission Tax with Endogenous Location Choice of Duopolistic Firms
SD	7.2010	Michela Catenacci and Carlo Giupponi: Potentials and Limits of Bayesian Networks to Deal with Uncertainty in the Assessment of Climate Change Adaptation Policies
GC	8.2010	Paul Sarfo-Mensah and William Oduro: Changes in Beliefs and Perceptions about the Natural Environment in the Forest-Savanna Transitional Zone of Ghana: The Influence of Religion
IM	9.2010	Andrea Boitani, Marcella Nicolini and Carlo Scarpa: Do Competition and Ownership Matter? Evidence from Local Public Transport in Europe
SD	10.2010	Helen Ding and Paulo A.L.D. Nunes and Sonja Teelucksingh: European Forests and Carbon Sequestration Services : An Economic Assessment of Climate Change Impacts
GC	11.2010	Enrico Bertacchini, Walter Santagata and Giovanni Signorello: Loving Cultural Heritage Private Individual Giving and Prosocial Behavior
SD	12.2010	Antoine Dechezleprêtre, Matthieu Glachant and Yann Ménière: What Drives the International Transfer of Climate Change Mitigation Technologies? Empirical Evidence from Patent Data
SD	13.2010	Andrea Bastianin, Alice Favero and Emanuele Massetti: Investments and Financial Flows Induced by Climate Mitigation Policies
SD	14.2010	Reyer Gerlagh: Too Much Oil
IM	15.2010	Chiara Fumagalli and Massimo Motta: A Simple Theory of Predation
GC	16.2010	Rinaldo Brau, Adriana Di Liberto and Francesco Pigliaru: Tourism and Development: A Recent Phenomenon Built on Old (Institutional) Roots?
SD	17.2010	Lucia Vergano, Georg Umgiesser and Paulo A.L.D. Nunes: An Economic Assessment of the Impacts of the MOSE Barriers on Venice Port Activities
SD	18.2010	ZhongXiang Zhang: Climate Change Meets Trade in Promoting Green Growth: Potential Conflicts and Synergies
SD	19.2010	Elisa Lanzi and Ian Sue Wing: Capital Malleability and the Macroeconomic Costs of Climate Policy
IM	20.2010	Alberto Petrucci: Second-Best Optimal Taxation of Oil and Capital in a Small Open Economy
SD	21.2010	Enrica De Cian and Alice Favero: Fairness, Credibility and Effectiveness in the Copenhagen Accord: An Economic Assessment
SD	22.2010	Francesco Bosello: Adaptation, Mitigation and "Green" R&D to Combat Global Climate Change. Insights From an Empirical Integrated Assessment Exercise
IM	23.2010	Jean Tirole and Roland Bénabou: Individual and Corporate Social Responsibility
IM	24.2010	Cesare Dosi and Michele Moretto: Licences, "Use or Lose" Provisions and the Time of Investment
GC	25.2010	Andrés Rodríguez-Pose and Vassilis Tselios (lxxxvi): Returns to Migration, Education, and Externalities in the European Union
GC	26.2010	Klaus Desmet and Esteban Rossi-Hansberg (lxxxvi): Spatial Development
SD	27.2010	Massimiliano Mazzanti, Anna Montini and Francesco Nicolli: Waste Generation and Landfill Diversion Dynamics: Decentralised Management and Spatial Effects
SD	28.2010	Lucia Ceccato, Valentina Giannini and Carlo Gipponi: A Participatory Approach to Assess the Effectiveness of Responses to Cope with Flood Risk
SD	29.2010	Valentina Bosetti and David G. Victor: Politics and Economics of Second-Best Regulation of Greenhouse Gases: The Importance of Regulatory Credibility
IM	30.2010	Francesca Cornelli, Zbigniew Kominek and Alexander Ljungqvist: Monitoring Managers: Does it Matter?
GC	31.2010	Francesco D'Amuri and Juri Marcucci: "Google it!" Forecasting the US Unemployment Rate with a Google Job Search index
SD	32.2010	Francesco Bosello, Carlo Carraro and Enrica De Cian: Climate Policy and the Optimal Balance between Mitigation, Adaptation and Unavoided Damage

SD	33.2010	Enrica De Cian and Massimo Tavoni: The Role of International Carbon Offsets in a Second-best Climate Policy: A Numerical Evaluation
SD	34.2010	ZhongXiang Zhang: The U.S. Proposed Carbon Tariffs, WTO Scrutiny and China's Responses
IM	35.2010	Vincenzo Denicolò and Piercarlo Zanchettin: Leadership Cycles
SD	36.2010	Stéphanie Monjon and Philippe Quirion: How to Design a Border Adjustment for the European Union Emissions Trading System?
SD	37.2010	Meriem Hamdi-Cherif, Céline Guivarch and Philippe Quirion: Sectoral Targets for Developing Countries: Combining "Common but Differentiated Responsibilities" with "Meaningful participation"
IM	38.2010	G. Andrew Karolyi and Rose C. Liao: What is Different about Government-Controlled Acquirers in Cross-Border Acquisitions?
GC	39.2010	Kjetil Bjorvatn and Alireza Naghavi: Rent Seekers in Rentier States: When Greed Brings Peace
GC	40.2010	Andrea Mantovani and Alireza Naghavi: Parallel Imports and Innovation in an Emerging Economy
SD	41.2010	Luke Brander, Andrea Ghermandi, Onno Kuik, Anil Markandya, Paulo A.L.D. Nunes, Marije Schaafsma and Alfred Wagtendonk: Scaling up Ecosystem Services Values: Methodology, Applicability and a Case Study
SD	42.2010	Valentina Bosetti, Carlo Carraro, Romain Duval and Massimo Tavoni: What Should We Expect from Innovation? A Model-Based Assessment of the Environmental and Mitigation Cost Implications of Climate-Related R&D
SD	43.2010	Frank Vöhringer, Alain Haurie, Dabo Guan,Maryse Labriet, Richard Loulou, Valentina Bosetti, Pryadarshi R. Shukla and Philippe Thalmann: Reinforcing the EU Dialogue with Developing Countries on Climate Change Mitigation
GC	44.2010	Angelo Antoci, Pier Luigi Sacco and Mauro Sodini: Public Security vs. Private Self-Protection: Optimal Taxation and the Social Dynamics of Fear
IM	45.2010	Luca Enriques: European Takeover Law: The Case for a Neutral Approach
SD	46.2010	Maureen L. Cropper, Yi Jiang, Anna Alberini and Patrick Baur: Getting Cars Off the Road: The Cost-Effectiveness of an Episodic Pollution Control Program
IM	47.2010	Thomas Hellman and Enrico Perotti: The Circulation of Ideas in Firms and Markets
IM	48.2010	James Dow and Enrico Perotti: Resistance to Change
SD	49.2010	Jaromir Kovarik, Friederike Mengel and José Gabriel Romero: (Anti-) Coordination in Networks
SD	50.2010	Helen Ding, Silvia Silvestri, Aline Chiabai and Paulo A.L.D. Nunes: A Hybrid Approach to the Valuation of Climate Change Effects on Ecosystem Services: Evidence from the European Forests
GC	51.2010	Pauline Grosjean (lxxxvii): A History of Violence: Testing the 'Culture of Honor' in the US South
GC	52.2010	Paolo Buonanno and Matteo M. Galizzi (lxxxvii): Advocatus, et non latro? Testing the Supplier-Induced-Demand Hypothesis for Italian Courts of Justice
GC	53.2010	Gilat Levy and Ronny Razin (lxxxvii): Religious Organizations
GC	54.2010	Matteo Cervellati and Paolo Vanin (lxxxvii): "Thou shalt not covet ...": Prohibitions, Temptation and Moral Values
GC	55.2010	Sebastian Galiani, Martín A. Rossi and Ernesto Schargrodsky (lxxxvii): Conscription and Crime: Evidence from the Argentine Draft Lottery
GC	56.2010	Alberto Alesina, Yann Algan, Pierre Cahuc and Paola Giuliano (lxxxvii): Family Values and the Regulation of Labor
GC	57.2010	Raquel Fernández (lxxxvii): Women's Rights and Development
GC	58.2010	Tommaso Nannicini, Andrea Stella, Guido Tabellini, Ugo Troiano (lxxxvii): Social Capital and Political Accountability
GC	59.2010	Eleonora Patacchini and Yves Zenou (lxxxvii): Juvenile Delinquency and Conformism
GC	60.2010	Gani Aldashev, Imane Chaara, Jean-Philippe Platteau and Zaki Wahhaj (lxxxvii): Using the Law to Change the Custom
GC	61.2010	Jeffrey Butler, Paola Giuliano and Luigi Guiso (lxxxvii): The Right Amount of Trust
SD	62.2010	Valentina Bosetti, Carlo Carraio and Massimo Tavoni: Alternative Paths toward a Low Carbon World
SD	63.2010	Kelly C. de Bruin, Rob B. Dellink and Richard S.J. Tol: International Cooperation on Climate Change Adaptation from an Economic Perspective
IM	64.2010	Andrea Bigano, Ramon Arigoni Ortiz, Anil Markandya, Emanuela Menichetti and Roberta Pierfederici: The Linkages between Energy Efficiency and Security of Energy Supply in Europe

(lxxxvi) *This paper was presented at the Conference on "Urban and Regional Economics" organised by the Centre for Economic Policy Research (CEPR) and FEEM, held in Milan on 12-13 October 2009.*

(lxxxvii) *This paper was presented at the Conference on "Economics of Culture, Institutions and Crime" organised by SUS.DIV, FEEM, University of Padua and CEPR, held in Milan on January 20-22 2010.*