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Embedding the drivers of emission efficiency at regional level Analyses of NAMEA data

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Abstract

This paper provides new empirical evidence on regional–national disparities in environmental efficiency, based on analyses of NAMEA data referring to Italy and the Lazio region, where Rome is the main city. Shift-share analyses provide evidence on the drivers of environmental efficiency and on sector specificity. This confirms the usefulness of this method, in order to investigate structural and efficiency factors at the level of within country environmental efficiency performance. Our evidence shows that although the region around Rome has achieved higher environmental performance compared to Italy mainly thank to its being less industry based, some critical points in the energy sector and in some services should be taken into account in shaping the future development of the region. In addition, the use of regional NAMEA for econometric investigations of emission efficiency drivers at national level shows that though north south disparities favour northern and richer regions, in accordance with development oriented dynamics, environmental hot spots driven by specialization and efficiency related issues also appear in some northern industrial regions. Further, the role of public ad private R&D is of main relevance in enhancing emission on economic value ratios.
Environmental, industrial and sector-oriented policy making may derive valuable information from the evidence provided by our study, that highlights how analytical exploitation of NAMEA offers rich array of insights for regional policy making.

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1. Background and framework

This paper develops empirical analyses using data regarding the regional NAMEA (*National Accounting Matrix including Environmental Accounts*) of Italy. The NAMEA approach to identify environmental pressures across productive sectors originated in a series of studies carried out by Statistics Netherlands. NAMEA data are a matrix form statistical source, where economic (value added and employment) and environmental (emissions) indicators can be generated and shown at sector level. The first NAMEA was developed by the Dutch Central Bureau of Statistics under the supervision of Steven Keuning (De Boo et al., 1991). Haan and Keuning (1996) and Stauvermann (2007) among others, are examples of seminal papers containing long and comprehensive bibliographies of all past works. Furthermore, De Haan (2004) developed and propagated the NAMEA approach in detail and has applied the NAMEA for international comparisons. The Italian NAMEA, which dates back to 1990 (ISTAT, 2001) includes the following 10 air pollutants: carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), nitrogen oxides (NO_X), sulphur oxides (SO_X), ammonia (NH_3), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), particulate matter (PM_{10}) and lead (Pb). In the NAMEA tables environmental pressures (for Italian NAMEA air emissions and virgin material withdrawal) and economic data (output, value added,[1] final consumption expenditures and full-time equivalent job) are assigned to the economic branches of resident units or to the household consumption categories directly responsible for environmental and economic phenomena.[2] We focus here on macro sectors, obtained by aggregating the available productive branches at regional level to capture the main potential differences in environmental performance and associated drivers - manufacturing industries, non-manufacturing industries (other industrial sectors) and services.

Summing up, the main value of NAMEA for (applied) ecological economists is that it provides a coherent and robust merge of environmental, and economic (value added, production, employment) indicators monitored over time and across sectors. This allows quite robust inference on dynamics, correlation, even causation regarding performance / resource productivity indicators. For an overview of the methodological issues related to NAMEA, we refer the reader to Femia and Panfili (2005), Mazzanti and Montini (2010) and ISTAT (2007).

In referring to regional/national frameworks, the analysis is very significant since it allows the investigation to focus on structural and idiosyncratic features compared to national averages, providing useful insights for regional policy making on environmental, industrial and economic development dynamics, which is the keystone of economic development. It also enables economic policies to be differentiated by regions on the basis of the observed heterogeneity in economic-environmental relationships.

We are aware of some rare examples at international level of applied regional analyses of environmental-economic performances, and also a few national level studies, including the work carried out by the Wuppertal Institute on environmental input-output methodologies (Nansai et al., 2007; Suh, 2005; Huppes et al., 2005) based on NAMEA-like data, which are mainly focused on emissions.

Studies also exploit waste and materials (Nakamura and Kondo, 2002; 2009; Moll et al., 1999), and focus mainly on EU countries: Spanish works focusing on input output frameworks (Roca and Serrano, 2007a,b) while Italian analyses framed on environmental Kuznets curves background (Mazzanti and Zoboli, 2009; Marin and Mazzanti,

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[1] Output and value added are both in current prices and in Laspeyres-indexed prices.

[2] For an exhaustive overview of environmental accounting system see the so-called 'SEEA 2003' (UN et al., 2003).

2009a,b; Mazzanti et al., 2008[3]). We should highlight that although current NAMEA availability is somewhat irregular in terms of country and time periods, regional and national NAMEA are becoming increasingly available and being exploited[4] with the aim ultimately of generating a European Union (EU) NAMEA, covering at least the main EU countries. EUROSTAT aim is to release a EU27 NAMEA by 2011.

The paper is structured as follows. Section 2 discusses recent advances and applications of structural decompositions of energy and emissions trends in which, specifically, shift-share analysis can be inserted. Section 3 is devoted to presenting the shift-share empirical model and various empirical evidences. Section 4 presents econometric evidence on the drivers of emission efficiency. Section 5 concludes by providing some insights on policy making strategies that may be informed by this analysis.

2. Structural decomposition analyses, environmental accounts and regional NAMEA

Decomposition analysis is one of the most effective and widely applied tools for investigating the mechanism influencing energy consumption and emissions and their environmental side-effects. The basic rationale for structural decomposition analysis (SDA) is splitting an identity into its components; this represents a pragmatic alternative to econometric estimation especially for the kind of data required (not in the form of times series as in econometric estimations). The central idea of SDA is that changes in some variables are decomposed – usually in an additive way – in changes in its determinants. SDA has been applied to a wide range of topics (for a detailed survey see Rose and Casler, 1996 and Dietzenbacher and Stage, 2006), including the demand for energy (e.g. Jacobsen, 2000 and Kagawa and Inamura, 2004) and the emission of pollutants (e.g. Casler and Rose, 1998 and Wier, 1998).

Further, methods related to SDA are shift-share analysis (discussed more in depth in Section 3) and growth accounting. Several studies analyse and apply structural decomposition methodologies. Most related to EU countries, showing the extent to which NAMEA is a EU comparative advantage in environmental economics research (Huppes et al., 2005). We should only here recognise that there are several other methods (e.g., econometric ones) to analyse energy and emissions trends (see Greening et al., 2007 for a general overview).

Among examples of EU studies, Dietzenbacher and Los (1998, 2000) discuss methodological issues and present analyses on the Dutch economy (I-O tables) for 1986 and 1992. A case study of the Dutch economy in 1972 and 1986 (decomposition for value added growth) shows that the results obtained with the new decomposition method may differ from those obtained using the traditional approach. Jacobsen (2000) performs an I-O structural decomposition analysis for Denmark based on trade factors, for the period 1966-1992. Wier (1998) also explores the anatomy of Danish energy consumption and emissions of CO_2, SO_2 and NO_X. Changes in energy-related emissions between 1966 and 1988 (22-year period) were investigated using I-O SDA. De Haan (2001) confirms the prevalence of Nordic countries studies, The Netherlands *in primis* for obvious reasons, using I-O analysis, calculates that the main causes of reductions in pollution can be categorised as eco efficiency,

[3] Mazzanti and Montini (2010) collect Italian and EU works on the dynamics of economic and environmental performances including some NAMEA based investigations using decomposition and econometric tools.

[4] For an overview of recent developments in regional NAMEA (RAMEA) in Italy see the institutional site www.arpa.emr.it/ramea. Stauvermann (2007, p. 73) and Goralzcyck and Stauvermann (2008) present some comparative environmental performances from a RAMEA EU project.

changes in the production structure, changes in the demand structure, changes in demand volume. He finds that the scale effects are not compensated for by eco efficiency gains and negligible reductions result from the other two factors, which resulted in a net 20% increase in CO_2 emissions in the Netherlands in 1987-1998. This study confirms the complementarity and increased value in terms of the information to be derived from decomposition analysis compared to delinking studies that calculate the income-environment dynamic elasticity and the drivers of delinking using NAMEA data (Mazzanti et al., 2008, 2007).

Within the recent and rare studies exploiting NAMEA data with advances in regional studies frameworks, we should highlight the close-by study by Stauvermann (2007), who presents a Dutch pilot study based on a regional RAMEA. It is interesting to comment on and compare the set of ecological-economic indicators Stauvermann proposes, as an alternative, or perhaps better a first step embedded in a proper shift-share analysis, which, in this case, compares regional and national data. First, sector environmental impact indicators and environmental efficiencies are compared by means of normalising to the regional average, to highlight which sectors are more or less eco-efficient than the regional average. This analysis is first carried out on emissions-ecological factors and then incorporates economic-environmental indicators (emissions/value added ratio)[5] as in our paper. In all cases the comparison is merely between the regional average of the indicator and the sector specific values, or eventually regional eco-efficiency and national eco-efficiency per sector. Finally, a synthetic index can be compiled by relating the emissions share and the economic share of a sector, to the respective regional average shares. The use of such a relative indicator, which captures the extent to which the sector's contribution in terms of emissions is more or less proportional to its economic impact (if the emission shares is lower than the value added, the index is lower than unity), leads the analysis towards conceptual frameworks which have a strict connection with shift-share (this may be an embryonic component of it) and delinking/environmental efficiency oriented dynamic assessments.

The regionalisation of NAMEA is a new field that may offer good food for analyses and policy insights. Within this empirical framework, this paper aims at analyse which are the main drivers at regional level capable to promote positive environmental performances, and which are the foremost gaps at the sectoral level which reduce the capacity to obtain them. An environmental accounting approach such that of Italian regional NAMEA, in fact, allows considering both the regional and sectoral dimensions, as well as many different pollutants associated to several environmental themes such as climate change, local air pollution.

3. Shift-share analyses on regional NAMEA

3.1 The empirical framework

The first empirical objective of this paper is to measure the role of the regional productive structure in explaining the emissions efficiency gap between Lazio and Italy. Generally, shift-share analysis decomposes the source of change of the specified 'dependent variable' into regional specific components (the shift) and the portion that

[5] Interestingly, emissions/value added and emissions/employee ratios, both derivable from NAMEA, are used. For comparison, Mazzanti and Zoboli (2009) exploit the former indicator in order to assess the dynamic (1990-2001) correlation between environmental and economic productivities in Italy using NAMEA, while Mazzanti et al. (2008) use the latter per employee indicator, which is more in line with the Environmental Kuznets curve framework.

follows national growth trends (the share). This shift-share methodology emerged in the 1960s as a tool for analysing the indicators of regional productivity and employment (Dunn, 1960). It has been used only rarely for environmental economic analysis. The specific methodology used here was introduced by Esteban (2000, 1972). The decision to use shift-share analysis was to determine the effects and factors that synthetically explain the relative efficiency/inefficiency of the regional system compared to the (national) average. Our aim is to examine and test whether the gap between the region under consideration and the benchmark average depends on an overall higher/lower productivity differential for all sectors, and/or on a higher/lower regional specialization in sectors with higher/lower productivity.

In our analysis, the primary attention is on the 'intensity of emissions' (indicators of emissions per value added), at sector level, given that this variable provides insights into the efficiency of the productive sectors, which is very useful information for the formulation of actions to support environmental innovation at sector level.

More specifically, we develop an analysis of the relative environmental efficiency of the Lazio economic system with respect to the national average, referring to a vector of ten pollutants, which encompass GHG, regional pollutants and local pollutants, and to the economic sector included and specified by NAMEA.

Our starting point is the aggregate indicator of emissions intensity, represented by 'total emissions on value added', defined as E/VA for Italy - the benchmark, and as E_l/VA_l for Lazio. This indicator is decomposed as the sum of $(E^s/VA^s)*(VA^s/VA)$, where VA^s/VA is the share of sector value added on total value added, for all sectors *s*, with the value of *s* defined from 1 to j (j = 24 - the number of NACE sectors included in the regional NAMEA).

For clarity, we redefined the index of emissions intensity as X for the national average ($X=E/VA$), as X_l for Lazio ($X_l = E_l/VA_l$), and as X^s for each sector (for Lazio $X^s{}_l = E^s{}_l/VA^s{}_l$, for Italy $X^s = E^s/VA^s$). We then defined the share of sector value added as $P^s=VA^s/VA$ for Italy and $P^s{}_l=VA^s{}_l/VA_l$, for Lazio.

In other words:

$$X = \sum_s P^s X^s$$

$$X_l = \sum_s P^s{}_l X^s{}_l$$

On this basis we can easily identify three effects, as prescribed by the *shift-share decomposition* that represents one of the possible decompositive formulae[6]. These three effects explain the gaps in terms of aggregate emissions efficiency between Lazio and Italy.

The first effect ('structural' or *industry mix*) is given by:

[6] As underlined by an anonymous referee there is the problem of non-uniqueness in SDA. As recognized by Dietzenbacher and Los (1998 and 2000) and recently by Esteban (2006), a well-known problem of SDA is that the results often depend on the specific decomposition formula chosen, whereas numerous formulae are equivalent from a theoretical point of view. Esteban (2006) suggests the use of additional information of the variable of interest and applies a decomposition methodology using Generalized Maximum Entropy econometrics to select the decomposition formula that provides an "optimal" fit to additional empirical information.

$$m_l = \sum_s (P^s{}_l - P^s) X^s$$

m_l assumes a positive (negative) value if the region is 'specialised' ($P^s{}_l - P^s > 0$) in sectors associated with lower (higher) environmental efficiency, given that the gap in value added sector shares is multiplied by the value X of the national average ('as if' the region were characterised by average national efficiency). The factor m_l assumes lower values if the region is specialised in (on average) more efficient sectors.
The second factor, defined as the 'differential' or 'efficiency', is:

$$p_l = \sum_s P^s (X_l{}^s - X^s)$$

p_l assumes a positive (negative) value if the region is less (more) efficient in terms of emissions (the "*shift*" between regional and national efficiency), under the assumption that ('as if') value added sector shares were the same for the region, and for Italy ($P^s{}_l - P^s = 0$).

Finally, the effect of 'covariance' between these two equations, or the 'allocative component', is given by:

$$a_l = \sum_s (X_l^s - X^s)(P_l^s - P^s)$$

The a_l factor assumes a minimum value if the region is specialised in sectors where it presents the highest 'comparative advantage' (low intensity of emissions), then the covariance factor is between m_l and p_l.
Overall, this decomposition allows a measure of the underlying reasons for the differences in emissions intensity. It assesses with detail the source of regional (dis) advantage and eventually inform policy making (see Table 1).

Table 1 – Possible situation of regional environmental performances and policy actions

industry mix	*efficiency*	*Lines of actions*
+	+	Optimal situation: environmental policy functional to the economic system performance
-	-	Worst situation: necessity of strong joint actions on environmental policy and industrial policy sides
+	-	Development industrial policy aimed at enhancing the structural environmental performances jointly with competiveness
-	+	Environmental and innovation policy favoring more Energy and emission efficiency in the sectors which are more relevant in economic and environmental terms in the region

Note: + means the emission intensity is lower than the national average for the specific component of shift-share

3.2. Empirical evidence

First, we look at the evidence for the aggregate efficiency indicator (X_l-X). Table 2 shows the variable P_l for Lazio and P for Italy, which is the decomposition for value added by each productive branch. Table 3 shows the variables X_l (Lazio) and X (Italy), which refer to emissions on value added, by each pollutant. These four variables are the basis of the shift-share analysis following the approach described above. It is clear that Lazio emerges as being relatively more efficient for all the pollutants and emissions considered (Table 3)[7].

Table 2 – Value added by productive branches. Lazio and Italy – year 2000 *(shares)*

Productive branches (ATECO 2001)		Value added shares	
Title	NACE Code	Lazio (P_l^s)	Italy (P^s)
Agriculture, hunting and forestry	A	0.016	0.030
Fishing	B	0.000	0.001
Mining and quarrying	C	0.001	0.004
Manufacture of food products, beverages and tobacco	DA	0.011	0.020
Manufacture of textiles and textile products	DB	0.005	0.006
Manufacture of leather and leather products	DC	0.000	0.023
Manufacture of wood and wood products, Manufacture of rubber and plastic products, Manufacturing n.e.c.	DD-DH-DN	0.010	0.026
Manufacture of pulp, paper and paper products	DE	0.016	0.015
Manufacture of coke, refined petroleum products and nuclear fuel, Manufacture of chemicals, chemical products and man-made fibres	DF-DG	0.025	0.020
Manufacture of other non-metallic mineral products	DI	0.008	0.014
Manufacture of basic metals and fabricated metal	DJ	0.007	0.031
Manufacture of machinery and equipment n.e.c., Manufacture of electrical and optical equipment, Manufacture of transport equipment	DK-DL-DM	0.032	0.059
Electricity, gas and water supply	E	0.027	0.022
Construction	F	0.040	0.050
Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	G	0.121	0.138
Hotels and restaurants	H	0.029	0.035
Transport, storage and communication	I	0.114	0.078
Financial intermediation	J	0.091	0.066
Real estate, renting and business activities	K	0.197	0.181
Public administration and defence; compulsory social security	L	0.085	0.051
Education	M	0.046	0.044
Health and social work	N	0.046	0.044
Other community, social and personal service activities	O	0.054	0.036
Household related activities	P	0.016	0.008
Total		1.000	1.000

[7] It is worth noting the two caveats linked to NAMEA analysis. First, we deal with direct emissions; indirect emissions may be accounted for by LCA studies or input output studies aimed at calculating indirect emissions of sectors (for such a study on the EU using NAMEA as a source see Moll et al. (2006). Secondly, NAMEA attributes to energy production sector all the emissions. This means that manufacturing expresses only emission produced in its production processes, not linked to fuel consumption. This is the rationale of NAMEA. It may pose problems mainly when interpreting global emissions sector allocation.
Despite such limitations, the value added or NAMEA relies on its coherent economic-environmental integration of data series: no other official datasets provides a consistent merge of economic data (such as production, value added, and employment) and pollutant emissions, that allows various analyses around the links between economic and environmental indicators.

The sector decomposition also shows the extent to which the comparative advantage in efficiency is derived from services (G-P branches) and some manufacturing branches (DE, DF-DG, DJ, and DK-DL-DM). The latter sectors do not show unfavourable gaps for the region in all emission cases we consider.

Table 3 – Emission intensities. Lazio and Italy – Year 2000 *(emission tonnes per M€ of value added)*

NAMEA emissions/pollutants	Lazio (X_l)	Italy (X)
CH_4	1.148	1.769
CO	0.874	1.793
CO_2	221.860	381.072
N_2O	0.054	0.130
NH_3	0.179	0.435
NMVOC	0.470	0.750
NO_x	0.763	1.106
Pb	0.000211	0.000329
PM_{10}	0.069	0.165
SO_x	0.260	0.779

This empirical information is not sufficient, however, to identify the main structural drivers of the efficiency differential, or to provide major implications for policy. Therefore, we next analysed (Table 4) the factors and components (*m, p* and *a*) that contribute to explaining the (X_l-X) differential. We note that, in eight out of ten cases, including GHG and the main regional acid rain precursors and local pollutants, the primary finding from the shift-share analysis is that is the efficiency factor (p), which favours Lazio. Its relevance is associated to a weight that is often more than the 50% of the difference we observe between the region and Italy.

If we apply shift-share analysis separately on the aggregates of the manufacturing sectors (D), services (G-P) and 'other industrial sectors' (C,E,F) the regional comparative advantage is not affected.

The differences ($X_l - X$) are in fact favouring the region both across macro sectors and across pollutants. We can verify whether this higher efficiency is higher or lower in the three macro sectors with respect to the average benchmark related to the region-Italy comparison. In other words, the analysis by macro aggregates shows the extent to which they contribute to the average advantage of the region.

This comparative assessment, which was made by comparing the results in Tables 4 and 5 (the table showing the comparison is available upon request), indicates quite clearly that services, although still less intensive with respect to national averages, are the aggregate sector that is relatively *less efficient:* regional manufacturing favourable gaps to Italy are larger. This is to some extent a counterintuitive result since the region is heavily relying on services. Its environmental advantage should decrease if one took into account indirect emissions driven by services, including transport, energy efficiency of buildings and other[8]. Transport, energy efficiency of buildings, household activities' environmental performances are the causes of the absence of decoupling of the Italian economy that we may see when we compare evidence for industrial activities and total Italian emission dynamics (Mazzanti et al., 2008). Thus the picture on the regional performances may look well different if we include all emissions, not only 'production' directly related ones.

To provide some more insights on the Lazio advantage in emission efficiency, which may be partially explained by the lack of accounting of indirect emissions, we provide a closer look at environmental performances within the region, by providing a brief analysis on the recently published 2005 regional NAMEA data. A comparison to similar regions (as far as per capita income and the share of services are concerned) would in fact increase the regional policy content of results. Table 6 shows that Lazio is (one of) the most service intensive economy in Italy, with a high per capita value added, but generally low emission intensities if compared to other important and leading Italian regions (Figure 1). However a focus on PM_{10} presents a very high heterogeneity inside the region with high concentration of emissions in a few municipalities, Rome metropolitan area obviously included (Figure 2).

Thus, it can be said that the Lazio region's – where services play a stronger role comparatively to Italy - environmental comparative advantage is mainly driven by 'other industrial sectors' (extraction of materials, production and distribution of energy, construction). As before, we observe that the main driver explaining the

[8] The indirect effects are certainly important. As noted by Suh (2006) "what is often neglected is that services are deeply anchored to manufacturing outputs, and growth in services sector also lifts, by necessity, manufacturing outputs". A reduction of pollutant emissions in absolute terms, is not achieved automatically if the economy becomes more service oriented unless the services become independent of embedded pollutant emission intensive products.

differential is related to sectoral efficiency. We nevertheless note the heterogeneity across macro sectors: factor (*p*) – the efficiency factor - in six cases is the main driver (considering the absolute value) of manufacturing, while for services and other industries it is the main driver in nine and ten cases respectively.

Table 4 - *Shift-share* coefficients regarding the total economic system (all productive branches)

NAMEA emissions/pollutants	X_l	X	X_l - X	Difference %	*m*	*p*	*a*	*Primary factor*	*Primary factor (%)**
CH_4	1.148	1.769	-0.621	-35%	-0.136	-0.471	-0.0130	P	76%
CO	0.874	1.793	-0.919	-51%	-0.431	-0.770	0.283	P	52%
CO_2	221.860	381.072	-159.212	-42%	26.429	-159.253	-26.388	P	75%
N_2O	0.054	0.130	-0.076	-59%	-0.0272	-0.0428	-0.006	P	56%
NH_3	0.179	0.435	-0.256	-59%	-0.186	-0.1105	0.041	P	33%
NMVOC	0.470	0.750	-0.280	-37%	-0.162	0.0775	-0.194	A	45%
NO_x	0.763	1.106	-0.343	-31%	0.0298	-0.297	-0.075	P	74%
Pb	0.0002110	0.000329	-0.000118	-36%	-0.0002	-0.000040	0.0001	M	59%
PM_{10}	0.069	0.165	-0.097	-58%	-0.031	-0.0720	0.0072	P	65%
SO_x	0.260	0.779	-0.519	-67%	0.118	-0.529	-0.108	P	70%

Note: * share calculated on the sum of components in absolute values.
Legend:
X_l = (total emissions Lazio/total value added Lazio)
X = (total emissions Italy/total value added Italy)
m = sum by sectors s $((VA^s_l/VA_l)-(VA^s/VA))*(E^s/VA^s)$
p = sum by sectors s $(VA^s/VA)*((E^s_l/VA^s_l)-(E^s/VA^s))$
a = sum by sectors s $((VA^s_l/VA_l)-(VA^s/VA))*((E^s_l/VA^s_l)-(E^s/VA^s))$

Table 5 - *Shift-share* coefficients regarding the analyses for Manufacturing (D), other industrial sectors (C,E,F) and Services (G-P)

NAMEA emissions/pollutants	X_l	X	X_l-X	Difference %	*m*	*p*	*a*
Manufacturing							
CH_4	0.261	0.421	-0.160	-38%	0.154	-0.194	-0.120
CO	0.541	2.883	-2.343	-81%	-1.190	-2.2618	1.109
CO_2	426.282	469.605	-43.323	-9%	90.967	-104.519	-29.771
N_2O	0.027	0.163	-0.136	-83%	0.1788	-0.136	-0.178
NH_3	0.001	0.047	-0.0456	-97%	0.0567	-0.045	-0.056
NMVOC	1.836	1.974	-0.138	-7%	0.2039	0.621	-0.963
Nox	0.964	1.091	-0.128	-12%	0.089	-0.146	-0.070
Pb	0.001	0.001	-0.000003	-0.3%	-0.0005	-0.0001	0.0006
PM_{10}	0.146	0.273	-0.127	-47%	-0.039	-0.132	0.0447
SOx	0.691	0.852	-0.161	-19%	0.329	-0.346	-0.144
Non manufacturing (other industry)							
CH_4	2.850	3.739	-0.888	-24%	1.340	-1.645	-0.583
CO	0.747	1.664	-0.917	-55%	0.454	-0.996	-0.374
CO_2	1315.702	2529.417	-1213.714	-48%	930.408	-1556.852	-587.270
N_2O	0.057	0.102	-0.044	-44%	0.035	-0.057	-0.022
NH_3	0.002	0.003	-0.0009	-31%	0.00075	-0.00137	-0.00035
NMVOC	0.929	1.329	-0.400	-30%	0.110	-0.423	-0.087
NOx	1.693	2.764	-1.071	-39%	0.831	-1.385	-0.517
Pb	0.00009	0.00011	-0.00002	-22%	0.00003	-0.00004	-0.00001
PM_{10}	0.204	0.363	-0.159	-44%	0.094	-0.189	-0.063
SOx	2.009	6.576	-4.567	-69%	2.480	-5.115	-1.931
Services							
CH_4	0.651	0.706	-0.055	-8%	0.1999	-0.1978	-0.0566
CO	0.697	0.936	-0.239	-26%	0.0619	-0.2585	-0.0427
CO_2	97.181	112.641	-15.460	-14%	8.895	-23.946	-0.408
N_2O	0.010	0.013	-0.0035	-27%	0.0018	-0.0046	-0.0007
NH_3	0.008	0.011	-0.0033	-29%	0.0025	-0.0047	-0.0011
NMVOC	0.205	0.255	-0.0495	-19%	0.0065	-0.0395	-0.0165
NOx	0.575	0.784	-0.209	-27%	0.0732	-0.2616	-0.0209
Pb	0.000094	0.000117	-0.00002	-19%	0.000002	-0.000022	-0.000002
PM_{10}	0.024	0.067	-0.0427	-64%	0.0044	-0.0442	-0.0029
SOx	0.053	0.146	-0.0932	-64%	0.0326	-0.1021	-0.0237

Table 6 – Emission intensities. Lazio, Lombardy, Emilia Romagna, Campania and Italy – Year 2005 *(emission tonnes per M€ of value added)*

NAMEA emissions/pollutants	Lazio	Lombardy	Emilia-Romagna	Campania	Italy
CH_4	1.171	1.193	1.560	1.195	1.448
CO	0.415	0.384	0.524	0.760	0.990
CO_2	0.205	0.210	0.271	0.142	0.301
N_2O	0.037	0.068	0.143	0.066	0.096
NH_3	0.121	0.370	0.472	0.222	0.312
NMVOC	0.290	0.412	0.472	0.412	0.460
NO_x	0.528	0.465	0.612	0.704	0.714
Pb	0.139	0.231	0.137	0.065	0.211
PM_{10}	0.055	0.075	0.108	0.096	0.111
SO_x	0.101	0.100	0.227	0.078	0.316
Value added per labour unit (€)	62461.8	61704.7	54397.3	46641.3	53923.9
Per capita value added (€)	26061.1	28570.6	26559.4	13811.9	21747.1
Services' full-time equivalent job share (%)	79.8	60.1	60.3	71.7	65.1

Figure 1 - Emissions intensities by pollutant and region (index numbers, Italy = 100)

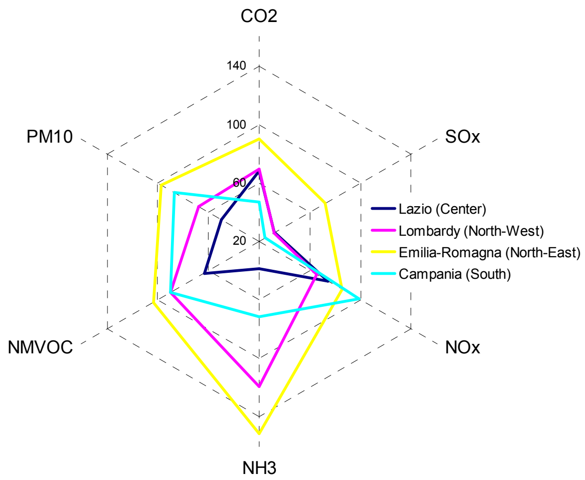
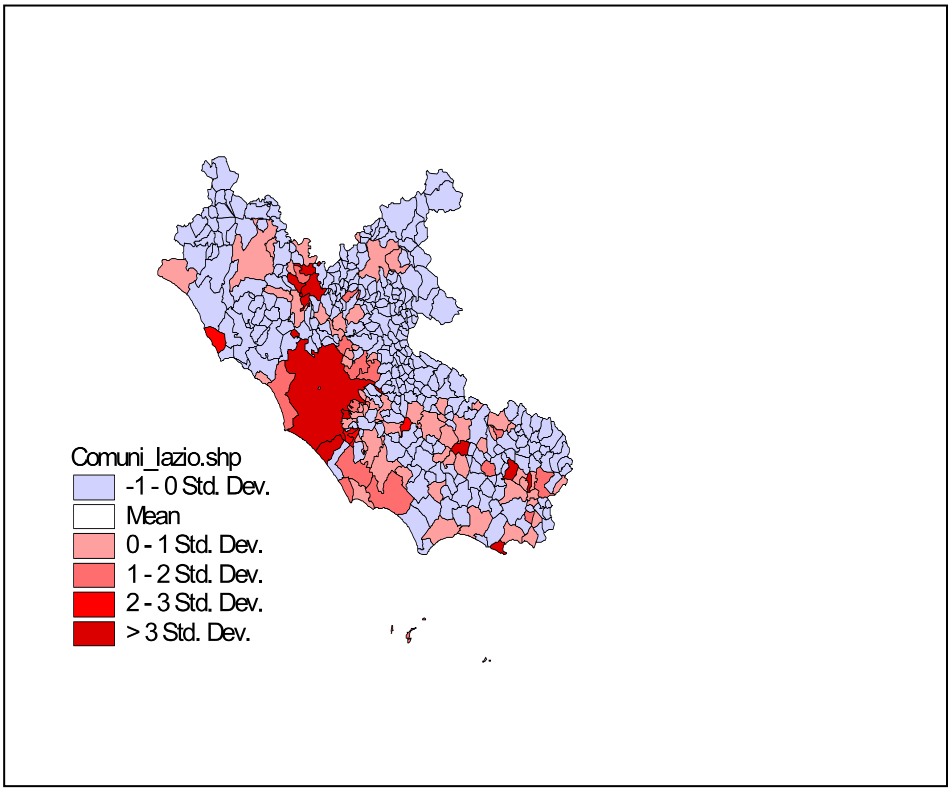


Figure 2 – Municipal PM_{10} emissions in the Lazio region (per kmq)



3.3 Regional weaknesses and policy issues

We provide further notes on results by specifically commenting on the role of energy intensity and the role of services at regional level.

First, if we consider sector composition, this does not favour Lazio for CO_2, SO_x e NO_x, the main environmental pollutants at supranational level. In other words, the situation regarding these three environmental externalities in the regional economic system is not structurally favourable. This may be due to the strong role and weight of regional production of electricity based on fossil fuel sources, which compensate for the low energy intensity. The region is highly dependent on oil (59%), with natural gas at only 21%. Renewable energy, including hydroelectric power, where Italy has a comparative advantage (two-thirds of total renewable energy in Italy comes from hydroelectric power stations, mainly located in the north), plays a very minor role[9]. This may point to a rather negative future scenario in terms of GHG emissions trends.

This unfavourable situation should be targeted by environmental policies aimed at integrating the region into the national efforts towards achieving the EU proposed policy targets of a 20% decrease in CO_2 by 2020 and a minimum 20% threshold for the renewable content of energy production. This is challenging for the region, given that innovation dynamics in services are on average low, and EU policy does not directly target services with environmental regulations that could be drivers of innovation. Also, the low performance in renewable

[9] It is worth noting that carbon dioxide and even oxides production involves a national flavour since they produce energy for the country as a whole: pollution sites are allocated through a process of national industrial policy, partially determined by regional 'preferences' and policies. It remains that regional policy may then influence, at least to some extent, the performances of such generation sites.

energy means that, on the one hand the region has strong incremental possibilities, but no specialisation, given the almost total absence of hydro and wind power generation sites. Some photovoltaic sites were recently established in the region. This could be an element of renewable based regional specialisation in the future. In addition, transport environmental performances must be improved by sustainable public mobility programmes and by addressing through economic instruments the congestion and pollution in Rome; together with win win solutions in housing energy efficiency such strategies can surely be highly effective and efficiency in decarbonise and strengthen the productivity of the regional economy.

Second, although Lazio is relatively more specialised than Italy on average in services, it seems that services are relatively 'less efficient' compared to the performances of other branches within the region, although they still benefit the region in comparison with Italy in terms of direct emissions. We note that the ranking of macro sectors for their contribution to regional environmental performance is as follows: (1) 'other industrial sectors' (C,E,F); (2) manufacturing; (3) services. Services do not present cases of emissions where their efficiency is higher than the average regional efficiency, compared to Italy. Within the region, and this is a somewhat counterintuitive result with respect to qualitative 'at first sight' assessment, environmental performances is not *primarily* driven by the structurally strong weight of services, and the dynamic evolution that produced an increasing share of the sectors that characterise Lazio more than Italy.

Complementary, descriptive evidence based on energy intensities could provide some explanation for these structural facts. Services intensity in 2003 was on a level with the average for Italy (18.6 tep/million€ GDP), as was electrical energy performance. The relevant services orientation of the region, and of Rome in particular, is on the one hand helpful in terms of environmental performance (productive specialisation effect), but on the other hand is partially balanced by a relatively 'high' (at least not lower than the average) energy intensity of the sector. In addition, the analysis shows that while the region is specialised in services, this specialisation occurs in those sub sectors with higher emission intensities. This reflects an important point, mostly for local (regional, municipality of Rome) policy actions: the high energy intensity of transport systems, which is related to the high ratio of cars/per head. Using ENEA (2006) data, as above, we note that the region in 2003 had an intensity of 50.7 tep/million€ GDP, one of the highest in Italy (33.4 for Lombardy). Environmental and transport policies should incorporate complementary actions to tackle the relative low performance of the transport sector and poor household behaviour towards transport, especially in the critical hot spot of Rome.

4. Emissions drivers: labor productivity, regional policy and innovation

As a final and complementary exercise to previous shift-share investigation, we present econometric evidence using the original and recently released (2009) Italian regional NAMEA, for the year 2005, that involves 20 regions and 24 productive sectors, thus allowing for a cross section analysis on 480 units. Within this empirical framework, we seek to analyse which are the main drivers at regional level capable to promote positive environmental performances. An environmental accounting approach such that of Italian regional NAMEA, in fact, allows considering both the regional and sectoral dimensions.

Let us consider environmental performance (through emissions *EM* per unit of value added) for each *k*-th sector in each *r*-th region (E_k^r) as a function of production level (Y_k^r), technology (T_k^r), and environmental price (P_k^r). Emissions can be expressed as:

$$E_k^r = f\left(Y_k^r, T_k^r, P_k^r\right) \qquad [1]$$

The conceptual model refers to what developed and analysed by Mazzanti and Zoboli (2009), who assert that when technology is included in the environmental efficiency function, it is interesting to disentangle the effects related to strict technological innovation from the effects of labour productivity, using a properly defined labour productivity measure.

We run regressions testing sector and geographical effects and labour productivity as main economic driver, taking as reference a model[10] such as:

$$\ln E_k^r = A_k^r + b_1 \ln LP_k^r + b_2 \left(\ln LP_k^r\right)^2 + b_3 \ln T_k^r + b_4 \ln EE_k^r + \varepsilon_k^r \qquad [2]$$

where (E_k^r) represents emissions (*EM*) per unit of value added (*VA*) for each *k*-th sector in each *r*-th region as a function of labour productivity level (LP_k^r), private/public technology factors (T^r), and public environmental expenditures (EE^r). A_k^r assumes the role of a sector/region-specific fixed effect and ε_k^r is the error term.[11] We thus merge the NAMEA dataset with environmental public expenditures and innovation data (R&D). The coherence of data is strong give they are all generated and released by Istat, the Italian National institute of statistics.

In addition to that modelisation, we include in this regional based framework, as additional covariate, a 'spatial distance lag' variable that introduces into the model the emission/value added performances of units of production within a certain distance. Finally, given the intrinsic spatial feature of the empirical environment, the relevance of spatial dependence are also analyzed through specific diagnostic[12]. We only show in tables properly

[10] This is an Environmental Kuznets curve inspired model. We refer the reader to List and McChone (2000) for an interesting regional study analysis using US counties environmental, economic and policy factors.

[11] Both factors are lagged to mitigate endogeneity related to simultaneity: environmental expenditures are introduced for 2004 (2004-2006 is the currently available time series), while R&D is introduced using various proxies for periods 2001-2002 and 2003-2004, and variations between the two. More specifically, public environmental expenditures are captured by the following variables: current and capital regional expenditures (on GDP), and the share within current and capital allocated to environmental R&D, environmental protection, management & use of natural resource; variables capturing the variations between 2004 and 2005 are also tested. As far as R&D is concerned, we introduce private and public sector R&D (on GDP), and various covariates capturing both the variation between 2001-2002 and 2003-2004 and the interaction between private and public R&D, to provide evidence on potential joint effects.

[12] Tests are consistently performed with GEODA without geographical dummies. For the choice of the spatially corrected econometric model, we follow basically the following approach: first a OLS model is estimated. Afterwards, Lagrange Multiplier (LM) tests for the spatial error model or the spatial lag model using ordinary

spatially corrected final regression. We now briefly comment on main results aggregated by carbon, acidification, local pollutants (for the sake of brevity we focus on main 5 GHG and emissions).

4.1 Carbon dioxide

The baseline specification in Table 7 shows a significant U-shape form of the income-environment relationship[13]. Sectoral dummies show expected signs with energy and services significant (respectively with a positive and a negative sign). All in all, a first result is the relatively stronger explanatory weight of sectors compared to that of geographical elements.

Nevertheless, when correcting by means of the spatial covariate, U-shape emerges even if we omit energy[14], and sectoral and geographical dummies are significant as above. Further spatially corrections lead[15] to a final spatial lag model, which is more efficient but does not witness any relevant change in economic and statistical significances. Environmental spillovers have been calculated as the sum of sectoral emissions per unit of value added produced by neighbouring regions that may represent the role of economic agglomeration phenomena in explaining environmental performances. Those agglomerative forces could produce concentration of dirty activities into circumscribed geo-areas.

Regarding additional drivers, both capital based and current environmental expenditure by regions are not significant. The only expenditure covariate maintaining its significance after all spatial corrections are carried out is the dummy showing 'increases in capital spending' (model 2, Table 7). The sign is here and below positive for most 'spending covariates': the explanation might be that such public expenditures, though here technically lagged to avoid simultaneity, presents structural 'endogeneity' features. Expenditures are higher where environmental problems are harsher.

As far as R&D is concerned, most factors instead remain significant even after the spatial correction: the change in private R&D (model 3), the share of public R&D on regional GDP (model 4), and the dummy capturing the increase in public R&D are all significant with negative sign (model 3). Further, both public/private R&D interactions, using shares and dummy (model 5), are significant. The evidence is thus strikingly in favor of a positive correlation between (joint) public and private efforts in R&D and emission performances.

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least squares (OLS) residuals are employed to decide whether spatial correlation is present or not. If the null hypothesis of a test for a spatial autoregressive process is rejected, a spatial variant for the model is calculated.

[13] If we omit the energy sector, the U-shape vanishes and turns into a linear negative one: this may be plausible given the high emission and high productivity features of this sector.

[14] The TP is above the mean and median, but not higher than all the high value manufacturing sectors.

[15] The presented estimations in tables 7 and 8 (in the following paragraph) refer to spatially corrected models. OLS estimates and relative diagnostics for spatial dependence are available upon request from the authors. Overall, in all regressions studied the suggested spatially corrected model regards 'lag' and not 'error'. A "spatial lag" is a variable that essentially averages the region-sector neighboring values of a location which is represented in our case by a specific region-sector combination. The spatial lag can be used to compare the region-sector neighboring values with those of the location itself. Which locations are defined as neighbors in this process is specified through a row-standardized spatial weights matrix based, in our case, on the contiguity of the regions. By convention, the location at the center of its neighbors is not included in the definition of neighbors and is therefore set to zero. It has to be noted that our cross section dataset refers to 20 regions x 23 sectors. Thus our contiguity weights matrix has 460 rows, one for each combination region-sector.

Table 7 – Spatially lagged models for CO_2 emissions

	(1)	(2)	(3)	(4)	(5)
Labour productivity	-2.532**	-3.698***	-3.248***	-3.471***	-3.376***
	-2.17	-3.06	-2.64	-2.82	-2.74
Labour productivity^2	0.309**	0.465***	0.403**	0.440***	0.424***
	2.01	2.94	2.51	2.73	2.64
Environ.Spillovers(D1)	0.311***	0.283***			
	8.84	7.33			
Environ.Spillovers(D2)			0.278***	0.284***	0.272***
			6.48	6.62	6.36
Var.Env.Cap.Exp.04/05+ (dummy)		0.224**			
		2.41			
Var.Priv.Exp.2005/04-2003/02			-0.566**		
			-2.44		
PubExp GDP (share)				-41.092**	
				-2.27	
Priv.&Pub.Exp + (dummy)					-0.217**
					-2.29
Constant	4.274*	6.138***	4.644**	4.352*	4.360*
	1.93	2.67	1.98	1.86	1.86
Sectoral dummies	Yes			Yes	
Spatial Lag	0.402	0.341***	0.309***	0.291***	0.315***
		7.82	6.84	6.41	6.97
No obs.	399	418	418	418	418
Adj R-sq	0.71	0.68	0.67	0.66	0.66
Log L	-487.41	-557.09	-565.06	-565.31	-565.5
Breusch-Pagan test	216.37	346.27	328.49	307.03	305.52
LR test	62.75	40.13	27.27	24.01	28.07

4.2 Acidification

Table 8 (specification SO_X(1)) highlights that for SO_X the income-environment relationship is, as found by other authors (Marin and Mazzanti, 2009, Vollebergh et al., 2009) not significant. The drivers of emission intensity are predominantly others. Manufacturing and energy sector covariates show expected signs.

For SO_X, both current-based and capital based public spending are significant, as noted and commented on above with a positive sign (model SO_X(2) and SO_X(3)).

Nevertheless, the variation in current spending between 2005 and 2004 shows a negative sign (regression not shown): this highlights that though structural correlation may be positive in levels (such spending is a quasi-fixed factors in the short medium run), the variation of spending can negatively correlate to environmental performances, contributing then to abatement at regional level.

R&D is again highly significant with significant negative signs. The evidence shows that, differently from carbon, is only public R&D that matters after correcting by spatial dependence: the various changes in public R&D and the changes of jointly taken private and public R&D drive down emissions on value added (see model SO_X(4), not all regressions are shown).

The other acidification emission NO_X firstly presents a geographical performance in favor of all central-northern regions. In spatially corrected regressions, a U-shape income-environment relationship is confirmed. Among spending specifications, as above, no factor is significant in the spatial specification.

As far as innovation is concerned, both private and public R&D on GDP is significant with expected negative signs. The change in public R&D and the interaction between public and private R&D are also significant. A general significant effect of innovation, with emphasis on the public side and mainly on the always significant 'interaction' terms, that clearly signal an effect depending on joint implementation of innovation drivers (models NO_X(2-4)).

Table 8 – Spatially lagged models for SO_X and NO_X emissions

	SO_X(1)	SO_X(2)	SO_X(3)	SO_X(4)	NO_X(1)	NO_X(2)	NO_X(3)	NO_X(4)
Labour productivity	0.142	0.172	0.209	0.137	-2.362***	-2.43***	-2.56***	-2.53***
	0.56	0.68	0.82	0.54	-2.78	-2.87	-3.04	-3.01
Labour productivity²					0.293***	0.305***	0.320***	0.317***
					2.75	2.88	3.02	3.00
Environ.Spillovers(D1)	0.266***	0.279***	0.294***	0.246***	0.142**	0.157***	0.132***	0.139***
	5.57	5.85	5.99	5.27	2.53	4.57	3.92	4.12
Electricity surplus (dummy)	0.230	0.088	0.216		0.018	0.026	0.153*	0.140*
	1.22	0.45	1.15		0.22	0.33	1.81	1.72
Env.Reg.Curr.Exp.		69.96**			31.96*			
		2.40			2.53			
Env.Reg.Cap.Exp.			46.71**					
			2.11					
Priv.&Pub.Exp+(dum.)				-0.51***				
				-2.78				
PrivExp GDP (share)						-31.93***		
						-2.92		
PubExp GDP (share)							-36.74*	
							-2.29	
PrivExpXPubExp								-6573***
								-2.68
Constant	-3.56***	-3.73***	-3.93***	-3.09***	4.44***	4.705***	4.897***	4.820

	-3.30	-3.47	-3.61	-2.87	2.66	2.84	2.96	2.92
Sectoral dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Spatial Lag	0.219***	0.222***	0.214***	0.250***	0.632***	0.610***	0.639	0.631
	4.63	4.73	4.54	5.37	18.69	17.60	19.09	18.67
No obs.	418	418	418	418	418	418	418	418
Adj R-sq	0.49	0.49	0.49	0.50	0.70	0.70	0.70	0.70
Log L	-846.12	-843.28	-843.86	-843.31	-499.00	-497.54	-499.74	-498.60
Breusch-Pagan test	182.28	214.56	212.54	195.34	368.33	331.80	334.56	N/A
LR test	14.38	14.94	13.79	18.84	107.15	97.26	109.83	107.17

4.3 Local pollutants

In both cases, the regressions not spatially corrected show that the northern and central regions perform better than the southern and islands. Spatially (lag) corrected estimates show U-shapes in relation to income, with a TP higher than in previous cases but still within range. Most manufacturing sectors drive emissions up, while services consistently drive them down.

Table 9 – Spatially lagged models for NMVOC and PM_{10} emissions

	Spatially-lagged models					
	NMVOC(1)	NMVOC(2)	PM_{10}(1)	PM_{10}(2)	PM_{10}(3)	PM_{10}(4)
Labour productivity	-3.933***	-3.791***	-0.187	-0.153	-0.105	-0.148
	-4.14	-3.99	1.55	-1.27	-0.88	-1.22
Labour productivity^2	0.458***	0.444***				
	3.69	3.59				
Environ.Spillovers(D1)	0.336***	0.356***	0.254***	0.300***	0.297***	
	10.87	11.29	7.05	7.95	8.20	
Environ.Spillovers(D2)						0.268***
						6.87
Electricity surplus (dummy)			0.021	-0.160	-0.064	
			0.23	-1.47	-0.72	
PrivExp GDP (share)		-19.69**			-52.61***	
		-2.01			-4.38	
PubExp GDP (share)						-37.45**
						-2.22
Env.Reg.Prot.Exp (share)				-3.837**		
				-2.03		
Env.Reg.R&D.Exp (share)				-13.815***		
				-2.95		
Constant	7.815***	7.560***	-0.210	-0.018	-0.248	-1.71***
	4.30	4.17	-0.43	-0.03	-0.51	-3.30
Sectoral dummies	Yes	Yes	Yes	Yes	Yes	Yes
Spatial Lag	0.504***	0.487***	0.419***	0.387	0.389***	0.376***
	15.24	14.62	11.41	10.44	10.81	10.04
No obs.	418	418	418	418	418	418
Adj R-sq	0.89	0.89	0.73	0.74	0.74	0.73
Log L	-463.98	-461.61	-536.70	-531.32	-526.89	-539.17
Breusch-Pagan test	187.07	207.32	275.67	291.98	301.44	270.92
LR test	122.75	112.37	87.59	72.99	77.74	62.56

While on the public spending side no worthwhile results emerge, again the role of R&D seems important. Private expenditure on GDP negatively affects regional emissions on value added (Table 9, model NMVOC(1)).
PM_{10} presents somewhat different evidence: from a sectoral perspective DI (ceramic) emerge again as stronger emitter, in addition to agriculture, while services and within manufacturing DK (machinery and equipment) and DB (textile) instead present negative coefficients (not shown); the relation to productivity is linear and negative in regressions that include environmental spillovers, but turns out to be not significant when using the spatially corrected models. Evidence neatly shows that both private and public regional R&D matter.

5. Conclusions and policy insights

Our analysis aimed to demonstrate the usefulness of regional NAMEA as an empirical framework for analysis that may feed policy making. We summarise some key critical outcomes and some policy considerations.
We showed that for all emissions included in NAMEA the shift-share investigation indicates that the Lazio region, where Rome is located, is comparatively more environmentally efficient than the national average. For most emissions, we can claim from our knowledge of the Italian framework (ENEA, 2006)[16] that the main source of this difference is lower energy consumption per capita and lower energy intensity (electrical energy) on GDP, compared to the national averages. As examples, Lazio in 2003 had a value of 99.7tep/million€ GDP, the third lowest value in Italy (Italian average is 126, with Lombardy, the most industrialised and richest region, at 121). Electricity intensity was around 201.9 MWh/Million€ GDP, the lowest in Italy (288.4 is the average, with Lombardy registering 301). Finally, energy and electrical energy intensity in Lazio's manufacturing sector is the lowest in Italy. This comparative picture is embedded in a dynamic scenario which signals stagnation in environmental performance improvements, and even some 'recoupling', for Italy as a whole, over the recent years: though the intensity is 25% lower in 2007 compared to 1990 (Eurostat data), we observe a general stall starting from early-mid Ninety – according to other data sources as IEA too -, with even some increases after 2002-2003. The stagnating performance over 1992-2003 compared to other major dynamic countries in the UE is also sown by Arigoni-Ortiz et al. (2008) using IEA and WDI data: in addition, since 2003 the ktoe/00$ppp index increase 1.80% per year. This explains the worse performance if compared to EU27, still proceeding on strong decoupling between energy use and economic growth. A renewable energy strategy which is not strong as it could be, mainly in solar technology, and a still relevant use of coal, which may deepen in the current recession given its convenience, may bring about stagnating or decreasing performances. In Italy, the percentage change of energy efficiency in the period 1992-2004 is, approximately, 25 per cent of the gain achieved during the sample 1980-1992. Strong chances of improving performance of sectors that have shown stops (industry, transport) and good trends (household) are feasibly achieved by innovation diffusion and policy actions (see Arigoni-Ortiz et al., 2008 for EU and Italian sector dynamic highlights). One reason of such trends may be the fact that Italy is lagging behind other main countries in energy efficiency patent technologies (Verdolini and Galeotti, 2009), with only 214 patents over 1975-2003 (0.96% of world total, lead by main G-8 countries). The merge between

[16] ENEA is an Italian public agency operating in the fields of energy, the environment and new technologies to support competitiveness and sustainable development (www.enea.it).

innovation (R&D and patents) and regional NAMEA data for explaining innovation drivers of environmental efficiency is another direction of future research.

Thus, if we might sum up, though starting from very low energy intensity (due to historical high prices and high energy taxes), the Italian economic system stalled and even witnessed and increase in the intensity of 0.3% on average since 1990 in the industrial sector, with a worsening performance from 1992 to 2003, that only Spain matches in the EU, which peaks in the last 4 years (www.enea.it). Weakest links in industry are mechanic, textile and food bad performances counterbalance chemical and steel good ones. This partly explains the non compliance with Kyoto and some no decoupling or recoupling we observe – even using NAMEA data - for industry as well, in GHG emissions (Marin and Mazzanti, 2009a,b), which remains associated to better performance than transport and housing, which nevertheless have comparatively closed the efficiency gap over the last 10 years, though transport energy efficiency only improved after 2004, late for a robust contribution to Kyoto target achievements (www.mure2.com). These evidences thus show that the picture is mixed, possibly changing, heavily affected by sector and regional features of a country.

As far as econometric evidence on the drivers of emission efficiency is concerned, we note that income-environment relationship as related to labour productivity are presenting non linear U-shapes (carbon, NOx, NMVOC). In other cases, the dominant role played by sectors overwhelms income significance. Sectors weight relatively more than geographical factors. The additional drivers we test show that when properly correcting for spatial correlation, R&D is always very significant in driving down emission per unit of value across al emissions, both through separate effects of private and public R&D and by joint effects. Innovation seems to matter more than regional expenditures targeted on environmental externalities, and finally the role of public/private complementary innovation forces in enhancing efficiency is highlighted.

The national/EU policy framework from which we may pick up 'solutions' and drivers of stronger environmental performances is presenting (i) regulatory tools to cut energy intensity of 9% by 2016 (EU Directive 2006/32/EC), on industry, services, transport, housing (Geller et al., 2006). Housing is targeted by green auditing and the implementation of EU Directive 2002/91/EC on energy efficiency, transport by various sustainable mobility central-local programmes, by scrapping car incentives, and the 2005 EU directive on the use of bio fuels. Finally, and relevant for the region we observe here, services are affected by energy efficiency programmes and photovoltaic plans (10,000 solar roofs national plan, 2001) and 'solar municipalities plan' (2001). Though services and housing show complementary features in the possible options, solar is a main one among the others, we recall again that the better environmental performance of services should not be taken for granted, as shown in the paper. They risk to be left behind by EU and national policies on such premises. In fact, the EU has not presented so far a clear environmental policy frameworks and indications for service sector (and innovation). At best it is fragmented among different policy branches.

This paper thus shows that even with a single regional NAMEA and a national average NAMEA, it is possible to identify a series of facts that help our understanding of the structural basis of the income-environment relationship, to help to define future national and regional policies. Panel data, that have been published for Italy only recently (for 2 years, 2000 and 2005, over 20 regions), will provide a better basis for such an analysis in the future.

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