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Polluting my neighbours: linking environmental accounts to a multi-regional input-output model for Italy, methodology and first results

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Introduction

This paper aims at testing a multiregional I-O model including environmental equations for estimating the impact of economic activities at regional and multiregional level on the environment for year 2001.

A regional economic-environmental model lacking of interindustry relations will not fully show the environmental effects in terms of green-house gas pollutants generated by a change in the final demand. Moreover, if we do not take into consideration foreign and interregional flows, we will miss an important part of pollutants origin and destination; if a region, after an increase in the demand, starts importing finished, semi-finished products, or raw materials from another region, is, conversely, exporting pollutants even though these are not produced in the importing region. At the same time, if another region is exporting goods and services, it starts producing pollutants to meet a demand coming from other regions. If we keep separate regional patters, we will never acknowledge the actual responsibilities of those who first produced the pollutants, and would only highlight a highly environmentally-friendly region and another one with high levels of pollutants. The attribution of pollutants to direct and indirect polluters would be consistent with the principle of "responsibility of the producer". How can we assess the case of the two regions described above? How can we act from the point of view of economic and environmental policies? A multi-region input-output pattern expanded to the environmental accountancy allows to quantify the path that leads from the location of demand to production of pollutants within a country in response to final demand impulse. This type of information is also policy-valuable in order to design integrated economic and environmental policies aiming at reaching emission targets.

The paper will also provide a description of the I-O multiregional model integrated with environmental relationships currently available at IRPET .

The analysis will be divided in three parts. In the first one, a description of the analytical framework of environmental-economic analysis. In the second part, the extended multiregional table and model will be presented, while in the last section of the paper the main results of the model simulations will be shown.

1. The analytical framework and the italian experience

The most used accounting framework at international level for collecting information on environmental issues and sustainable development is the DPSIR (Driving forces, Pressures, State, Impacts, Responses). This framework links the driving forces, i.e., the whole anthropic activities, with the pressure they originate in the environment. Pressures in turn result in the change of the state of the environment, which usually results in negative impacts on the environment itself. To mitigate the negative consequences that the anthropic activities could have on the environment, there are some responses that can be implemented to interrupt the chain of effect in any of the terms, working on the driving forces, the pressures, the state, the impact and the mechanisms linking one issue to the other.

This framework is the necessary starting point in order to move from the accounting framework a model explaining the impact of economic activities on the environment. In order to achieve this result we need to know: *i*) the economic structure; *ii*) geomorphologic features of an area; *iii*) weather and climate patterns operating on limited areas; *iv*) the absorption capacity of the natural system, and the links between environmental conditions and health.

The first step in this complex mechanism is the stress of the anthropic system carried out on the environment by both any productive activity, and by the consumption activity of the households. In order to estimate this causal relationship we need to quantify the interaction between economy and environment within a consistent accounting framework represented by the National Accounting Matrix including Environmental Accounts. NAMEA is a satellite account of National Accounts, inserted within the guide "Integrated Environmental and Economic Accounts 2003" SEEA 2003, published by the United Nations, European Commission, International Monetary Fund, OECD and World Bank.

This hybrid matrix with a NAM module in monetary terms – following the principles of economic accountancy - is matched by an EA environmental module in physical terms. The economic module describes the circular flow of income from its production to its distribution and ultimately its final use because a NAM includes all the main flows of an economic system such as: supply and demand of goods and services that pass through the market; the products, productive activities and factors of production; the institutional sectors (enterprises, households, public administration). . The environmental module in turn describes the link between the anthropic activity and the environment, through the estimate of the use of resources and the production of pollutants. In both implementations of the modules, they have been adjusted to the actual availability of data and specific targets, to meet precise research needs.

Beginning with the early work of the Dutch Institute of Statistics CBS in the 1990s, included mostly in the work of Keuning and de Haan, and later with the pilot study, standard charts, and guide lines published by Eurostat between the late 1990s and the early 2000s, the structure, the informative contents, the analysis of the NAMEA framework, have been considerably known, debated and evaluated.

The target of this study is to go one step beyond in the making and in the use of NAMEA. At present, in Italy, NAMEA is compiled and used mainly at national level. A project to produce economical-environmental matrices for Italian regions provides for the implementation of simplified NAMEA frameworks, hardly informative or innovative. This simplified structure does not include: i) models of the single regional economic systems; ii) pattern of regional intersectoral links nor a pattern of inter-regional links. For each economical activity and for the household expenditure, relevant to the environmental repercussions, the simplified framework simply matches a matrix of environmental pressures with a matrix containing information on value added, employment, and household consumption. The information resulting from this kind of framework is hardly satisfactory and does not meet the needs of those who are in charge of economic or environmental policy decisions. With reference to the first reason that brought to the implementation of this project, for each Italian region we are attempting to match the matrices relevant to the environmental pressures with the matrices of economic accounts. This project is an innovation above all for the Italian regions: the very few attempts to apply the multi-regional economical-environmental patterns have occurred on a national benchmark basis. There have been real obstacles in the exhaustiveness of the links represented (considering too few nations) and in the meaningfulness of the results (lacking the data, in some cases it is assumed that the technologies used in the exporting country is the same as the importing country . It is true that the environmental issues can’t be effectively analyzed on a local or small-area scale. It is also true that some of the environmental targets are developed on a national scale, and that therefore policy makers need to apply strategies to reach the targets within their area of competence, even though environmental pressures cannot be stemmed by administrational boundaries. This element pertains to the second reason that brought us to develop this project: a step beyond in the application of NAMEA.

In view of the commitments taken under the ratification of the Kyoto protocol, each nation has its own target in the reduction of greenhouse gases, compared to the level registered in 1990. This target must be implemented within the national territory: to bring about coordinated and coherent strategies and decisions to decrease polluting emissions, having a multi-region environment-economy model is therefore crucial. An adequate information system needs inter-regional links highlighting the economic flows between regions and between sectors of a region and sectors of other regions. Unless we have this, there is no way we can understand which intermediate or final consumptions, of which regions, are mainly responsible for the polluting emissions, later to be assessed on a national scale. Analysis carried out according to the simplified frameworks of matrices such as NAMEA could result in the awareness that in several regions, emissions come mainly from the production of a special economic sector (for instance power plants); but who are the users of the goods and services produced by that business, and where do they live?

In the same way, to have an information system that is able to support decisions made in economic and environmental policies, we need inter-sectional matrices for all the regions, highlighting the emissions linked to any import flow. Unless we have this, as in the above example, importing energy from a region that produces this energy only through renewable sources, or from a region that uses exclusively coal, would result in the same environmental effects.

So far, three NAMEA-type matrices have been developed in Italy on a regional basis (NUTS2): a pilot experience in Tuscany, the development of the matrices in Lazio and Emilia Romagna.

The first one, (ISTAT and IRPET) was completed in 2004 , as starting point for the data of the air pollutants it used the the Regional Inventory on Pollutant Sources (IRSE), carried out by the Department for the Area and Environment Policies (Tuscany

Region government). The second regional experience developed later by ISTAT starting from a different information basis for the data of the inventory of air pollutants CORINAIR, carried out by APAT and available on a provincial basis. This inventory is consistent with the national inventory, but its informational content is lower than the one developed for Tuscany. The methodological notes published by Istat on the implementation of NAMEA for Region Lazio, refer to a general consistency and comparability with the methodology followed on a national basis, without giving any details on the development of some issues that are obviously different, also due to the different availability of data on a different area scale.

The third experiment, completed in mid 2007, was carried out by IRPET and Environmental Engineering of Emilia Romagna region, within the Interreg IIIC Grow Project RAMEA (Regional Accounting Matrix including Environmental Accounts), partly financed by the European Union and including regions of South East England and North Brabandt. The data of the environmental pressures are, as in the case of Lazio, those of the inventory of air pollutants CORINAIR, carried out by APAT and available on a provincial basis. The detailed methodology used to develop the regional NAMEA for Emilia Romagna (called RAMEA, within the Grow project) was described in the minutes to ARPA ER, Environmental Engineering, and assessed by the partners of the EU project.

Besides the starting archive of the data on the air pollutants and aggregation of the NAMEA activities considered within each regional matrix (33 for Tuscany and Emilia Romagna, 24 for Lazio), the most important difference among the three regional experiences lies in the composition of the regional NAMEA both economically and environmentally. In Lazio and Emilia Romagna, the environmental module considers only air pollutants, while the Tuscan matrix considers also the use of virgin natural resources. The economic module in Lazio region is made up by three vectors representing for each NAMEA activity the value added, the employment, (for the companies' activity) and the expenditure for the utilities of the families (for the family activities). Conversely, for Tuscany and Emilia Romagna, the economic module is made up by the input-output matrix developed by IRPET for all the Italian regions. Another implicit difference between the two experience is the use of value added at constant prices as proxy of output in the Lazio regional NAMEA which implies significant biases in estimating the related emission coefficients

2. The multi-regional model

2.1 Some outlines on the multiregional table construction

2.1.1 Balancing methodology

The methodology that will briefly described in this paragraph resumes some of the constructive ideas of the previous (Casini Benvenuti, Martellato and Raffaelli 1995), and updates the methodology extensively described in Casini Benvenuti and Paniccià (2003) especially by taking into account the new methodology utilized associated with the first Supply Use tables released by the Italian Central Statistical Office (ISTATI since 2005.

The multiregional table has been estimated through the GLS estimator proposed by Stone et al. (1942) (henceforth SCM) later developed by Byron (1978) and presented in Appendix 1[1].

The balancing structure of the multiregional table is mainly specified according to five groups of constraints. First, at regional level, both supply and demand of products and formation and use (supply table) of output must be consistent. Second, consistency should also be achieved regarding the national SUT, that is the sum of the regional SUT must be equal to the national one except for interregional trade. Third, constraints supplied from regional accounts must be fulfilled, usually these data are provided in more aggregated form (value added, indirect taxes) or by components (see for instance final domestic demand). Fourth, equality must be achieved between interregional flows of import and export by products at national level. Fifth, The sum of regional SUT region wide must be equal to the national one.

[1]The main resons why the SCM has been preferred to other methods has been well summarized by Round J. (2003), the author presents a review of the most utilized balancing methods (about SAM balancing): rAs, Cross Entropy and SCM, and clearly expresses his opinion in conclusion (p. 179, para.3) "... *In spite of the apparent preference for the cross-entropy (CE) method by many compilers of SAMs, the Stone Byron method (SCM ed.) (possibly extended to include additional constraints) does seem to have some advantages over alternative methods In particular, it allows us to incorporate judgement on the relative reliability of dta sources and its is therefore closer to the spirit of the problem at hand."*. Furthermore we could add that SCM method is very sensitive to the degree of biasness of the initial estimates forcing the analysit to put more attention to the those estimates tham the other methods do, so it fits with the Round's recommendation on the same article *"….It is a far better strategy to concentrate on improving the initial estimates and to use the smoothing techniques only in extremis or as final resort"*

$$
[1]\quad
\begin{array}{ll}
i. & \mathbf{q} + i' \cdot T + \mathbf{m} \equiv \mathbf{U} \cdot i + \mathbf{F} \cdot i + T \cdot i + \mathbf{e} \\
ii. & \mathbf{x} \equiv i' \cdot \mathbf{U} + i' \cdot \mathbf{Y} \\
iii. & \overline{\mathbf{Y}} \equiv \mathbf{Y} \cdot \mathbf{G}_Y \\
iv. & \overline{\mathbf{F}} \equiv \mathbf{G}_F \cdot \mathbf{F} \\
v. & \mathbf{i} \cdot T^* \equiv T^* \cdot \mathbf{i}' \\
vi. & T^* \equiv \Theta \cdot vec(T) \\
vii. & \sum_{j=1}^{k} \begin{bmatrix} & {}_jU & {}_jF & {}_je \\ {}_jS & & & \\ & {}_jY & & \\ {}_jm & & & \end{bmatrix} = \begin{bmatrix} & {}_{ita}U & {}_{ita}F & {}_{ita}e \\ {}_{ita}S & & & \\ & {}_{ita}Y & & \\ {}_{ita}m & & & \end{bmatrix}
\end{array}
$$

where[2]:

i = column vector (k·n)
q = products output (k·n) that is: $q = i' \cdot S$
x = industry output (k·m) that is: $x = S \cdot i$
S =block diagonal regional Supply matrices [(k·m) ·(k·n)]
m = products foreign import (k·n)
T = multiregional trade flows matrix [(k·n) ·(k·n)] (off- blocks diagonal)
T*= sectoral interregional trade consolidated at national level
Θ = operator use to sum up the sectoral interregional import and export
U =block diagonal regional Use matrices [(k·n) ·(k·m)]
F = block diagonal regional domestic final demand matrices [(k·n) ·(k·df)]
e = products foreign export (k·n)
Y =block diagonal regional primary input components [(k·p) ·(k·m)]
Y =block diagonal regional primary input components constraints [(k·p) ·(k·m*)]
F =block diagonal regional domestic final demand components constraints [(k·df)]
G_y= aggregation matrix from m sectors to m* industry provide by regional accounts
G_f= aggregation matrix for the df final demand components supplied from regional accounts

The first two identities constitute the first accounting group while [1.*iii*] and [1.*iv*] should ensure the consistency of the balanced dataset with the official figures provided by ISTAT. Identities [1.*v*] and [1.*vi*] allow to fulfil the equality between interregional import and export for each single product at national level while [8.*vi*i] must guarantee the consistency of the consolidation of regional SUT with the national table.

2.1.2 The initial estimates

A crucial step in balancing the multiregional table is the provision of a unbiased initial dataset. Unlike other methodologies (see for instance rAs) SCM estimator is very

[2] Given: k = number of region; n = number of products; m = number of sectors; m* = number of sectors supplied by official regional accounts; df = domestic final demand components; p = primary input components

sensitive to initial data inserted in the balancing accounting system. Biased initial estimates could lead to either non convergence of the conjugate gradient or final values with unexpected negative/positive sign. Far from being a weakness of the methodology we think this is an important feature of the estimator because can be interpreted as an important warning of inconsistencies in the matrix V, in the constraints and/or biases in the initial estimates. This can therefore be a spur to check more carefully the components of the solution to the algorithm.

Therefore we experienced that the Round's recommendation as in note 1, is particularly true while using SCM methodology.

Referring to other publications about a most detailed description of the estimate of the initial dataset we could concentrate our attention on three important parts of the table.

Starting from the regional Use matrices, the estimate as follows three complementary directions. First, a set of regionalized use tables through industry-mix[3] have been obtained. The starting matrix is the national matrix B[4] at a higher level of disaggregation. Second for some industries, (especially machinery, electronic and transport equipment) the regional parameters extracted from the survey System of Enterprises Accounts have been utilized. Third *ad hoc* figures and adjustment drawn from other sources have been inserted in the Use tables[5].

Other important parts of the regional SUT are the supply tables. Even in this case we have followed two estimate approach: *i*) industry mix *ii*) *ad hoc* information on output composition.

The estimate of the trade flows among regions, is one of the most relevant problems for the building of multi-regional I-0 tables, especially because the common situation is a lack of data concerning that trade. a broad amount of literature suggests,

[3] Shen 1960.

[4] Where the *i-j nth* element is:

$$b_{ij} = \frac{u_{ij}}{x_j}$$

[5] This happened for instance for the production of electricity. The prevalence of different type of power plant amongst regions (from hydropower to thermoelectric power) implies a significant difference in the intermediary input structure.

for estimating matrix T, the class of gravity models derived by newtonian physics (for a good review see Isard 1998)[6].

Their economic masses are represented by the total output X (net of foreign exports) in the *r-th* and the total domestic demand D (net of foreign import) in the *s-th* region. Q is the total amount of products of sector *i-th* and f(δ) is the decay function. It is possible to hypothesize that such function should be inversely proportional to the economic distance, and also to other variables that will be discussed.

The first variable to be included is the distance, as proxy of the transport cost, between region *r-th* and region *s-th*. Its calculation is based on provinces (NUTS-3) making up regions, so the distance between two regions is equal to the average distance between their own provinces. This methodology allows to compute the distance of a region (diagonal of the matrix) as average distance among provinces of the same region.

Another important explanatory variable is the propensity to intra-industry trade which can be caused by (Stone 1997, quoted in Munroe and Hewings 2000):

a) Industry based determinants (vertical product differentiation, vertical interregional production integration, cost structure);

b) Regional characteristics (mainly income level) product.

Another cause is strictly linked to classification and its degree of aggregation.

This is a sector-specific variable and it has been measured by the Grubel-Lloyd index computed at national level for foreign trade. The hypothesis is that, *ceteris paribus*, a higher propensity to intra-industry trade could reduce the effect of the economic distance. Another sector specific explanatory variable is the degree of trade-ability. This (see Bower et al. 1983) should indicate the propensity of the products of a sector to be traded, given their physical features. This indicator has been proxied by a trade openess index computed at national level.

The relative regional economic size (share of GDP) should act as region specific factor.

Therefore, the deterrence model should be the following:

[6] The main hypothesis suggests basically that the flows between two regions are directly proportional to their "economic masses" and inversely proportional to a decay (deterrence) function, which should represent the cost of transaction between the *r-th* and *s-th* region for sector *i-th*. Following the Leontief-Strout (1963) formalization we can write :

$$ {}_{rs}t_i = ({}_rX_i \cdot {}_sD_i)/Q_i \cdot f({}_{rs}\delta_i) $$

The interregional flows between *r* and *s* are function of the output mass X (expulsion force), from the demand mass *s* (attraction force), through a connection or decay function.

$$_{rs}f_i = \ell(_{rs}d, IIT_i, TRADE_i, _{r}SIZE) \text{ r,s=1,number of regions ; i=1,number of sectors} \quad \textbf{(2)}$$

where:
IIT = Grubel-Lloyd Intra Industry Trade index
d = economic distance
TRADE = degree of trade-ability
SIZE = region economic size

Problems arise in finding data on interregional trade. No data are available in value terms on interregional flows, the only information existing for estimating and testing the deterrence function, can be drawn by an ISTAT survey on commodities interregional flows (ISTAT 1998), in quantity (tons) and aggregated by 5 macro-sectors,

Given the high aggregation and the heterogeneity of the macro-sectors, we decided to perform a pooled (regions/sectors) regression, and following the literature our estimation strategy has been the following:

1) Computing the difference between the flow calculated without any deterrence function interaction and the actual ones. This step would allow to isolate the effect of the decay function on the multi-regional flows. Our estimate has been based on the data of commodity flows in quantity for five macro-sectors, so for each *k-th* of them, we can write the following equation:

$$_{rs}\phi_k = {}_{rs}Actual_i / {}_{rs}Expected_i \quad \textbf{(3)}$$

where:
Expected = ($_{r.}$tons $_i$ · $_{.s}$tons $_i$)/ tons $_i$
2) once defined $_{rs}\phi_k$ this will allow to estimate the following pooled model in log-log specification:

$$\log(_{rs}\phi_k) = a + b\cdot\log(_{rs}d) + c\cdot\log(IIT_i) + d\cdot\log(TRADE) + e\cdot\log(_{r}SIZE) \quad \textbf{(4)}$$

r,s=1,number of regions; k = 1, number of macro-branches

In the footnote[7] the results of regression which are encouraging both in terms of goodness of fit, parameters signs and specification tests.

We can extrapolate this function for all products by inserting the deterrence explanation variables in equation [5]. Reminding symbology of accounting framework

[7] Parameters estimate of the deterrence function:

Explanatory variables	Parameters	Standard eErrorerrors	R-square bar
Intercept	0.8848416	0.338283	0.4971
1/distance	0.866112	0.050175	
IIT index	0.1377696	0.050724	df.
TRADE	0.4285248	0.073161	970
SIZE	-0.185568	0.102852	

Source: authors calculations on IRPET data equations [1] computing the initial interregional trade flows should be expanded and modified follows for each manufacturing products:

$$ {}_{rs}t^{*}{}_{i} = a \cdot \{[({}_{r.}q_{i} - {}_{r.}e_{i}) \cdot ({}_{.s}dt_{i} - {}_{.s}m_{i})]/t_{i}\} \cdot \left[\cdot (1/{}_{rs}d)^{b} \cdot (IIT_{i})^{c} \cdot (TRADE_{i})^{d} \cdot ({}_{r}SIZE)^{e} \right] \quad \textbf{(5)} $$

where the economic masses are represented by: product output less foreign export and domestic demand less foreign import.

Another important component of the balancing process could be also added to the procedure. Indeed the equation estimate will produce a variance estimate which could utilize as proxy of reliability.

2.2 The multiregional I-O table embedding pollutants emissions

The experimental building of a multi-regional economic-environment input-output pattern referred first to air pollutants, due to the availability of information and a consolidated interpretation of the links between the economic system and the environmental one.

The basic data used to build environmental models relevant to the twenty regional accountant matrices come from a project that the Agency for the Protection of the Environment and for Technical Services APAT carried out with reference to the whole of Italy, consistently with the EU levels for the pollutant inventories. The main target of an inventory of pollutant sources is to supply the assessment of the amount of pollutants created within a specific area. The Italian inventory of the pollutant sources assessed on a national level, as reported by the office tasks of APAT, and as integral part of the National Statistic System (SISTAN), is meant to report to the European Agency for the Environment the national data and to report these data according to the format required by the diverse international conventions and by the European Union (APAT, 2004). Within the EU program CORINE (Coordinated Information on the Environment in the European Union, the CORINAIR project, (Coordination-Information-AIR) aims to collect and organize the information on the air pollutants, of which APAT is in charge in Italy. According to the top down method the national inventory has been later distributed among the Italian provinces. This procedure has proved necessary when not all the regions or provinces had implemented an inventory of the pollutant sources relevant to their jurisdiction. Moreover, even where inventories on a regional or provincial scale exist, not all have been carried out following the same building methodology, and can be therefore comparable. APAT's project tried to fill the gaps, supplying data on air pollutants created in every Italian province.

The starting point is therefore a national inventory, carried out in compliance with the International and EU commitments, and consistently with the methodologies used by other European countries. The provincial inventories describe the process generating the pollutants, the kind of pollutants, and the amount of pollutants, according to a specific unit of measurement.

The process generating the pollutants is defined by a nomenclature used on a European level, EMEP-CORINAIR, classifying the activities according to the Selected Nomenclature for Air Pollution, SNAP. Such classification is hierarchical and it is made up of macro-sectors[8], sectors and activities. On a provincial level there are data on a vast typology of air pollutants. Nevertheless, the pollutants that are considered more often are those relevant to natural gas (CH4), carbon monoxide (CO), carbon dioxide (CO2), non-natural gas volatile organic compounds (COVNM), nitrous oxide (N2O), ammonia (NH3), nitrogen oxide (NOX), lead (Pb), particulate under 10 micron (PM10), sulphur oxide (SO2). For all these substances, pollutants are expressed in tons, except for lead expressed in kilos.

We are completely lacking other information that appears on a national level and could help in the building of NAMEA-type matrices, but appears in other inventories. On a provincial and regional level (as the data can be obtained only through the aggregation of the provincial data) we have no information on the typology of the polluting source, nor on the levels of activity and the relevant polluting factors.

As for the definition of the typology of the polluting sources, they are generally defined as point sources, linear sources, spread out sources or area sources according to the form, to the opportunity of individuating them in the area, to the amount of pollutant. A large industry represents a point source, a highway is a linear source, while house-heating pollutants come from a spread-out or area source.

As for the assessment methods, pollutants of point sources are obtained from the declarations of each company or from the gauging carried out constantly or by samples. Pollutants from spread-out sources are assessed by a suitable gauge of the activity, linked to the amounts produces, and by a an emission factor expressing the polluting amount generated for each unitary amount of the gauge.

[8] Macro-sectors are as follows: 01: combustion – energy and transformation industries; 02: combustion – non-industrial; 03: combustion – industries; 04: productive processes; 05: extraction, and distribution of fossil/geothermic fuels; 06: use of solvents; 07: road transport; 08: other movable sources; 09: treatment and disposal of waste; 10: agriculture and farming; 11: other sources of pollutants and absorption.

Pollutants from linear sources are usually assessed from specific patterns. When the data needed to assess the pollutants are not available, for each SNAP processes taken into consideration, (the amount obtained fro the various typologies of the sources and the method followed to assess each pollutant by its source), the method to impute the pollutants to the activity of companies and families becomes less definite.

The macro-sectors within which air pollutants concentrate more are those linked to transportation (first of all road transportation, but off road transportation takes its share), of industry burning and in the production of energy. This sector seems to have more pressure in terms of climate-changing gases and acidifying substances. As for green-house effect gases, we can't neglect the sector of heating (please see details in the Appendix 3).

On top of the most developed regions of Northern and Central Italy (Lombardy, Veneto, Emilia Romagna, Piedmont, and Tuscany), some Southern regions and the islands, in particular Puglia and Sicily report high amounts of green-house effect gases as well.

Once the data of the regional air pollutants are assessed as exogenous, and classifies according to the SNAP, we need to make sure there is a coherence between statistical data appearing in the environmental module and the structure of the economic module.

The detailed methodology of the building of the regional NAMEA matrices for the Italian regions will be the item of a project to be published in the near future, we will only describe the steps that were taken. Macro-sectors, sectors and the activity of the classification of the pollutants are not in a objective classification with the economic sectors of economic activity of the regional accountancy. First of all it must be said that not all the pollutants contained in the inventories can be attributed to family and business activities; there are pollutants generated by natural processes, that are therefore not included in the NAMEA calculations. Then, we must consider the question of cross-border pollution; in this respect, in this early stage of the project, we have resorted to a simplifying hypothesis: the pollutants due to transportation generated in region A by residents in region B match the pollutants due to transportation generated in region B by the residents in region A. This assumption allows the allotment of the pollutants shared out in each region within anthropic activities carried out in the region itself. This is a heavy hypothesis that could bring to a misinterpretation of the results, as we will describe in a while. Especially in reference to the islands, within which the pollutants generated by the airports are allotted, while these could be attributed to other non-residing subjects (families and companies). We will have to consider this issue in the later developments of this project.

With these hypothesis, the next step is the attribution of the pollutants coming from the anthropic system on a regional scale consistently with the principles that brought to the implementation of the accountancy, to decide which economic sectors of activity and which family activities are responsible for the pollutants assessed within each polluting process. Through a workshop on environmental accountancy, Eurostat has published a guide to fill out of a NAMEA for air pollutants; likewise, for the Regione Tuscany, IRPET and ISTAT have published a guide to fill in NAMEA matrices on a regional scale. The two cases refer to the information found in the respective initial environment archives, more accurate than those in the regionalized APAT inventory. Moreover, the methodology used to build NAMEA for the regione Tuscany mentions a matrix of use of energy according to the energy source, to the branch using the energy, and to the reason for which the energy is used. This information was made available by Istat only within the convention finalized to the building of the Tuscan matrix, therefore it cannot be published or used on other occasions.

Compared to the existing methods, we need to use alternative methods as well. The frame of the work is still the same; the first step makes a quality connection between polluting processes and anthropic activities. For each process classified according to SNAP, connections with one or more NAMEA activities are highlighted (business or family activities, as in the attached chart). The second step computes within that activity the pollutants generated by processes that can be traced univocally to one of the NAMEA activities, while the pollutants generated by more than one NAMEA activity are allotted among the same activities through the most suitable method on the basis of the knowledge of the method of building of the environmental data, of the method of building of the economic details and the actual availability of data on a regional scale.

It is therefore within this second step that the lower number of available data does not allow the repetition of methodologies that have already been published and consolidated. A large part of the SNAP processes are ascribable to one single NAMEA activity, while for other processes, all the activities need to be shared out (see details in the Appendix 4).

For each of the SNAP processes that cannot be attributed to a single NAMEA activity, the most suitable method to share out pollutants among the NAMEA activities spotted in the first step. In particular, for the burning processes in business and institutional plants, and in agriculture, silviculture and aquaculture, for each region the value of the production carried out in each sector has been used. For the processes relevant to the production of chipboard, wood painting and other industrial application of solvents, for the degreasing of metal, and the treatment of rubber, for each region the number of operators for the specific sections considered by APAT in the assessment of the pollutants have been used. For the burning processes in boilers, turbines and internal combustion fix engines in industries and for off-road transportation we used jointly the consumption of energy for group of economic activity ATECO and for the purpose; and the value of the production for branch on a regional level. For the sectors of the macro-sectors of road transport we used a more complex mechanism that has taken into consideration the statistics of the Board of Energy and Ore Resources of the Ministry of Productive Activities on the sales of fuel for road transport on an area level, of the data of regional energetic statements drawn up by ENEA (National Agency for Renewable Energy), of ISTAT data on the purchase of energetic products of industries by energy product and group of economic activity, of the Istat assessments of gross capital in means of road transportation for owner branch.

The specific proceedings used for each SNAP process have allowed the sharing out, for each region, of the pollutants generated by processes at first attributed to more than one NAMEA activity.

At the end of the sharing out, for the NAMEA activities, the pollutants connected to each activity were added, obtaining for each region a matrix with a number of lines corresponding to the number of NAMEA activities, and a number of columns for the kind of pollutants inventoried. To facilitate the reading of the results and to summarize the comments, using the conversion factors we had, the pollutants were transformed into two environmental issues: climate-changing gas pollutants and pollution of acidification precursors.

It was thus possible to associate each NAMEA activity of each Italian region a specific value of climate-changing polluting gases and a specific value of acidification precursors. This result has then been linked to the functioning of a multi-regional input output model for the Italian regions, as we will describe later.

2.3 The model structure with extension to environmental accounting

Once estimated the multiregional SUT it is possible to proceed towards the ex-ante representation of I-O relationships. In doing that we intentionally skip the debate on the technology representation (industry-product), which is not the focus of our paper. We can only say that the model will be structured after an industry technology transformation along with symmetric industry by industry I-O matrices.

The model is based on two main causal relations:

1) technical: which is the main determinant of the regional intermediary demand;
2) allocative: which is the determinant of the production distribution among regions. Given the exogenity of the final demand, we can formalize them as follow:

$$d = A \cdot x + f \qquad \textbf{(6.1)}$$

$$x = T \cdot d \qquad \textbf{(6.2)}$$

The causation of the total demand is measured by the technical coefficients, as for the allocative pattern by the interregional trade coefficients matrix T. This is the typical approach of Chenery (1953)-Moses(1955) class of models, in between the pool approach (Leontief et al. 1977) and the "pure" interregional model (Isard 1960). In the model we assume competitive interregional import with regional output and foreign import.

Hereafter the structural form:

$$\begin{aligned}
&[i] \quad x + s_x + mw + mr = A \cdot x + d + c_x + ew + er \\
&[ii] \quad d = c_k + g + i + dsc \\
&[iii] \quad c_x = H \cdot x \\
&[iv] \quad s_x = S_x \cdot x \\
&[v] \quad mw = \hat{M} \cdot (A \cdot x + d + c_x) \\
&[vi] \quad mr = \widehat{B} \cdot (I - M) \cdot [(A \cdot x + d + c_x)] \\
&[vii] \quad er = \breve{B} \cdot (I - M) \cdot [(A \cdot x + d + c_x)]
\end{aligned} \qquad \textbf{(7)}$$

where:

x = Output at basic prices
s_x = Net Taxes on intermediary products
mw = Foreign import (fob)
mr = Interregional Import
df = Final regional domestic demand net of taxes on products
ew = Foreign export (fob) net of taxes on products
ewt = Foreign export (fob) gross of taxes on products

er = Interregional export
c_k = Exogenous Household expenditure
c_x = Endogenous Household expenditure
g = Government and NPISHs expenditure
I = Gross Fixed Investments
Dsc = Changes in inventories
A = Intermediate input coefficients.
S_x = Net Product Taxes coefficients on intermediary products coefficients
M = Foreign import coefficients
B, B = Interregional import-export coefficients from the transformation of the multi-regional trade flows coefficients matrix T.
In particular:

$$T = I - \hat{B} + \breve{B} \quad \textbf{(8)}$$

The interpretation of the structural form is the following: the initial equation defines the sectoral resource and uses, as identity [7.*ii*] compounds the domestic final demand. The net taxation on intermediary input is linked to regional sectorial output (equation [7.*iv*]). In the equation [7.*v*] foreign import as function of total domestic demand net of taxes on product, as equations 7.*vi* and 7.*vi*i explain the interregional trade both import and export.

Household expenditure is divided into two components. The first one –c_k- is exogenous and it is made up by expenditure related to public transfers (mainly pensions) and non resident consumption (mainly tourism). The second one –c_x- is endogenous and linked to primary and, partially, secondary distribution represented in the parameters in H (equation [7.*iii*]).

In equation [9] the reduced form of the model determining the regional output:

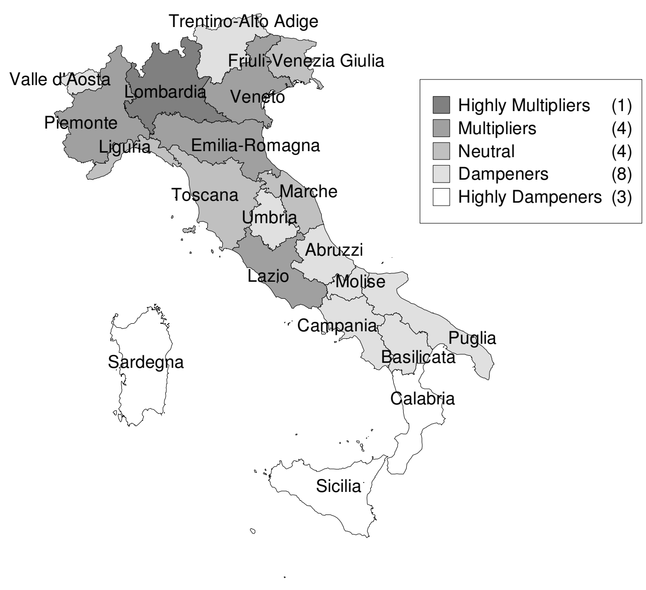
$$x = \left\{ (I + S_x) - \underbrace{T \cdot (I - M)}_{R} \cdot [A + H] \right\}^{-1} \cdot \left\{ \underbrace{[T \cdot (I - M)]}_{R} \cdot \underbrace{[d + ew]}_{fd} \right\} \quad \textbf{(9)}$$

we could write:

$$x = \underbrace{\{(I + S_x) - R \cdot [A + H]\}^{-1}}_{INV} \cdot \{R \cdot fd\} \quad \textbf{(10)}$$

If we provide an impulse to the regional final demand the result in term of aggregated value added will be function both of the allocative and technological patterns embedded in the inverse matrix in [10] and of the final demand injection pattern. By dividing the value added totals resulting from the solution of the reduced forms and by appropriate sums of final demand injections, we will end up with some indicators showing either a dampener or multiplier region. We define dampener when the change of the value added in a *r-th* region is lower than the final demand change of the same region, so the result is smaller than unity. For that region, the allocative and technological pattern embedded in the inverse act as dampeners , because the value added is partially spilled over other regions. If the result for a region is greater than unity, we may instead conclude that for region *r-th* the allocative and technological patterns act as multipliers. Figure 1 shows the value added multipliers and dampeners by region.

Figure 1. Dampeners and Multipliers regions



Source: authors calculations on IRPET data

From the figure above, we can trace the profile of the multipliers regions: Piemonte, Lombardia (the highest ratio) Veneto, Emilia Romagna and Lazio, in successive order figure those regions which are very close to unity , that we call neutral: Tuscany, Friuli Venezia Giulia, Liguria and Marche. Except for Valle d'Aosta and Trentino Alto Adige, where the strong tourism expenditure and the small regional dimension could affect the result, the dampeners and highly dampeners regions are all southern regions and Umbria.

Back to main topic of the paper model in [7] could be completed with a recursive equation explaining pollutants emission as proportion of regional output and part of regional domestic consumption (heating and transportation). The following relationship should be added to the model represented in [7]:

$$p = \hat{P}_x \cdot x + \hat{P}_c \cdot (c_x + c_k) \qquad \textbf{(7.viii)}$$

where:
p = pollutants emissions (see chapter 2.2)
P_x= coefficients of pollutants emission per unit of regional output
P_c = coefficients of pollutants emission per unit of domestic regional consumption

The reduced form representation will be following:

$$p = \left(\hat{P}_x + \hat{P}_c \cdot H\right) \cdot \left[INV \cdot \left(R \cdot fd\right)\right] + \hat{P}_c \cdot c_k \qquad \textbf{(11)}$$

Equation [11] will be the operative algorithm utilized in the following section of the paper.

3. Main results

A very detailed series of table are presented in Appendix 5 while here we will perform a simple decomposition analysis for isolating the main determinats of economic origin and destination of pollutants. We could start with Table 1a showing the GWP and PAE gases regional distribution, what is interesting for the analysis is the difference between the localization of GWP and PAE emission and the correspondent regional distribution of output. Those differences are persistent even considering only the domestic economic flows and GWP-PAE emissions, that is, net of foreign trade contributions. In particular, in southern Italy the emissions incidence is higher than output share as the reverse situation could be seen in the other macroareas.

Table 1a. Emissions of Global Warming Potential (GWP) and Potential Acid Equivalent (PAE) after SNAP11

Region	GWP from domestic demand	GWP from foreign demand	PAE from domestic demand	PAE from foreign demand
1-2	30,941,055	10,129,483	4,139	1,163
3	66,087,494	20,190,300	9,304	3,024
4	5,421,206	1,307,855	791	319
5	42,936,464	14,313,526	7,528	2,827
6	11,241,036	3,944,920	1,502	553
7	18,713,653	4,305,822	1,819	424
8	31,842,787	12,217,154	4,855	2,185
9	26,908,342	8,452,396	4,017	1,239
10	8,953,494	2,265,865	1,183	338
11	7,740,478	1,516,724	1,246	272
12	28,495,314	4,246,304	3,283	580
13-14	9,116,101	1,638,011	1,485	291
15	19,088,753	2,710,898	2,864	540
16	37,567,942	11,241,109	4,000	1,079
17	3,677,099	586,388	603	110
18	10,897,840	949,198	2,718	310
19	41,457,988	9,052,940	7,462	1,745
20	19,341,283	6,087,101	2,793	871
ITA	420,428,328	115,155,993	61,591	17,870

Macroareas	GWP from domestic demand	GWP from foreign demand	PAE from domestic demand	PAE from foreign demand
North-West	28,495,314	4,246,304	3,283	580
North-East	9,116,101	1,638,011	1,485	291
Centre	19,088,753	2,710,898	2,864	540
South	37,567,942	11,241,109	4,000	1,079

Table 1b. (GWP) and (PAE) gases vs. output incidence

Macroareas	GWP+PAE from domestic demand	Output+H.Consumpt.	Difference
North-West	27.2	31.0	-3.7
North-East	22.1	23.1	-1.0
Centre	17.1	21.1	-4.0
South	33.6	24.8	8.7
ITA	100.0	100.0	

Source: authors calculation on multiregional I-O table and NAMEA

The determinants of GWP and PAE localization (spatial distribution) shown in Table 1a and 1b. could be explained by using equations [9 10 11] which allow to decompose and specify five distinct factors of differentiation across the macroregions between the emission and output share, that is: *i*) difference in regional specific emission coefficients ii) region wide changes in industry technology; i*ii*) difference in output and consumption mix; *iv*) net foreign and interregional trade pattern; *v*) exogenous final demand.

The first factor estimates the changes across regions of coefficients *P*, which embody differences in using environmental friendly technologies. The second factor quantify the spatial differences in matrices *A* and *H*. Interregional and foreign trade are expressed by *R*, and it is a very important informative content provided by multiregional I-O model. This allows to take into account the imported and exported pollution linked to trade pattern. The exogenous final demand is represented by *fd*. Significant in determining the aggergated amount of emission are the % composition of vector x and c_x .

For the sake of simplicity we could take foreign trade out of our analysis and performing a decomposition analysis in order to isolate the 5 factors above only in terms interregional trade (see Appendix 5 table 1). The results of this decomposition are shown in the following table

Table 2. Determinants of the differences between output and (GWP+PAE) shares

	Emission-output differences	Absolute Contributions					
		Emission coefficient	Industry technology	Output mix	Interregional trade	Exogenous demand	Residuals
North-West	-3.7	-1.6	-0.5	-0.8	1.8	-2.1	-0.4
North-East	-1.0	-0.4	-0.2	-0.2	0.4	-0.5	-0.1
Centre	-4.0	-0.3	-0.3	-0.3	-0.1	-2.6	-0.4
South	8.7	3.3	1.6	1.7	-3.1	3.7	1.5

Source: authors calculation on multiregional I-O table and NAMEA
Note: discrepancies are due to rounding effects

Table 2 tells us that southern Italy suffers from a gap in environmental technology, which contributes, *ceteris paribus,* to the overall emission-output difference by 3.8 percentage point (38% of the difference). On the other hand North-West and Nort-East could make use of relative more efficient environmental technologies. Interesting to note the role played by the interregional trade, everything else equal it should provoke an increase in the difference emission-output shares for the northern macroregions, in absolute and % terms, making them, ceteris paribus, as net importers of pollution while southern Italian is the net exporter. To be remarked the high negative contributions of exogenous demand for central regions, this value could be explained by the strong component of public expenditure assigned to the capital region Lazio.

Another important factors in determining the macroregional difference is the output mix which clearly disadvantages southern Italy where the concentration of highy pollutant industries is relatively higher.

Conclusions

The analysis performed in this paper using a multiregional I-O model integrated with environmental equations allows to take into accounts more properly of the main components explaining the regional localization of greenhouse emissions. This is the first preliminary attempt to make this kind of analysis in Italy and the results are quite encouraging.

Nay are the components which could influence the origin and localization of GWP and PAE pollutants and by studying only the final part of the process that is, the localization of the production could produce significant biases in terms of both economic and environmental analysis and policy evaluation and design.

Only knowing on the one hand the characteristics of regional socio economic system, on the other hand the processes allowing to estimate the regional emissions, is possible to carry out appropriate integrated environmental socio economic analysis.

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Appendix 1

The main hypothesis assumes that the flows to be balanced are subjected to accounting constraints and can vary according to the relative reliability of preliminary estimate. Instead of the linear bi-proportioning rAs, the concept of variance and covariance (Var-Cov), associated to the reliability of the initial accounting set T(0) is explicitly introduced. The solution proposed by the authors consists in the application of a GLS estimator to the following problem: given an accounting matrix T (vectorization t) subject to k number of constraints, according to the aggregation matrix G:

[1] $$k = G \cdot t$$

Using the initial estimate T(0) we obtain:

[2] $$k + \varepsilon = G \cdot t(0)$$

Assuming that the initial estimate T(0) is unbiased and has the following characteristics

[3] $$t(0) = t(1) + \varepsilon \qquad E(\varepsilon) = 0 \qquad E(\varepsilon\varepsilon') = V$$

The use of GLS will lead therefore to the estimate of a vector t^* (1) that will satisfy the accounting constraints in [1] and will be as near as possible to the actual data t (1).
The estimator able to produce such an estimate is the following:

[4] $$t^*(1) = (I - V \cdot G' \cdot (G \cdot V \cdot G')^{-1} \cdot G) \cdot t(0) + V \cdot G' \cdot (G \cdot V \cdot G')^{-1} \cdot k$$

It is demonstrated that this kind of estimator is BLU, and it's variance is given by:

[5] $$V^* = V - V \cdot G' \cdot (G \cdot V \cdot G')^{-1} \cdot G \cdot V$$

A seminal contribution to the development of the SCM methodology was provided by R.P.Byron (1977,1978). According to the author the estimator SCM can be seen as a solution to a minimization of a quadratic loss function of the kind:

[6] $$\vartheta = .5 \cdot \left(t^*(1) - t(1)\right)' \cdot V^{-1} \cdot \left(t^*(1) - t(1)\right) + \lambda \cdot \left(G \cdot t^*(1) - k\right) = \min$$

where:
ϑ = quadratic loss
λ = Lagrange multipliers
The first class conditions for minimizing the previous equation correspond to the following values of Lagrange multipliers:

[7.1] $$\lambda = (G \cdot V \cdot G)^{-1} \cdot (G \cdot t(0) - k)$$

so:

[7.2] $$t^*(1) = t(0) - V \cdot G' \cdot \lambda^*$$

that refers back to the estimator in [4]. The contribution of R.P.Byron has allowed to overcome one of the problems that had hindered the use of the SCM procedure in the balancing of significant sets of national accounts and SAM, or rather the computational difficulty of the matrix $(GVG')^{-1}$. R.P.Byron proposed the conjugate gradient algorithm to reach an estimate of the Lagrange multipliers, by means of the system of linear equations:

[7.3] $$(G \cdot V \cdot G') \cdot \lambda = (G \cdot t(0) - k)$$

Since GVG' is symmetric defined positive, the conjugate gradient method provides a good solution of the λ coefficients. As also stressed recently (Nicolardi 1999), even with very powerful computers, this method retains advantages compared to direct estimate using eq.[7.3] of large systems of accounts to balance. These are:

1) increasing control provided by the algorithm over possible inconsistencies of the initial estimates and of the Var-Cov matrix;
3) possibility to avoid the numerical instability tied to the inversion of the sparse matrix GVG'.

Appendix 2

NAMEA Code	NACE	COICOP	Description
1	A		Agriculture, hunting and forestry
2	B		Fishing
3	CA		Mining and quarrying of energy producing materials
4	CB		Mining and quarrying, non energy producing materials
5	DA		Food products, beverages and tobacco
6	DB		Textiles and textile products
7	DC		Leather and leather products
8	DD		Wood and wood products
9	DE		Pulp, paper and paper products
10	DF		Coke, refined petroleum products and nuclear fuel
11	DG		Chemicals, chemical products and man-made fibres
12	DH		Rubber and plastic products
13	DI		Other non-metallic mineral products
14	DJ		Basic metals and fabricated metal products
15	DK		Machinery and equipment n.e.c.
16	DL		Electrical and optical equipment
17	DM		Transport equipment
18	DN		Manufacturing n.e.c.
19	E		Electricity, gas and water supply
20	F		Construction
21	G		Wholesale and retail trade
22	H		Hotels and restaurants
23	I		Transport, storage and communication
24	J		Financial intermediation
25	72-74		Business activities, R&D and IT
26	L		Public administration
27	M		Education
28	N		Health and social work
29	O-P-Q		Other community, social and personal service activities
30	70-71		Real estate and renting
31		CP072	Households - Transport
32		CP045	Households - Heating
33		Others	Households - Others expenditures

Region code	Description	Area
1	Piemonte	North West
2	Valle d'Aosta	North West
3	Lombardia	North West
4	Trentino Alto Adige	North East
5	Veneto	North East
6	Friuli Venezia Giulia	North East
7	Liguria	North West
8	Emilia Romagna	North East
9	Tuscany	Centre
10	Umbria	Centre
11	Marche	Centre
12	Lazio	Centre
13	Abruzzo	South
14	Molise	South
15	Campania	South
16	Puglia	South
17	Basilicata	South
18	Calabria	South
19	Sicilia	Islandss
20	Sardegna	Islandss

Appendix 3

Tab. 1. Emissions of air pollutants in Italy in the SNAP processes. Values in tonnes

MSet	CH_4	CO	CO_2	COVNM	N_2O	NH_3	NO_X	Pb*	PM	SO_2
1	12,377	36,715	151,007,915	7,534	5,519	121	167,229	3,785	18,272	463,573
2	23,727	449,834	70,512,204	39,300	7,757	0	74,395	5,360	19,987	21,612
3	6,369	352,199	79,312,826	5,673	3,649	56	146,968	171,222	24,297	131,078
4	10,035	112,402	26,368,950	88,892	23,552	9,079	7,807	67,564	21,860	43,515
5	255,458			57,502					572	
6			1,529,850	490,809					24	
7	38,043	3,478,202	109,527,048	649,013	9,830	15,342	703,620	677,358	57,936	11,809
8	2,798	463,136	22,352,339	177,725	4,361	38	263,004	14,413	28,648	90,307
9	464,277	248,941	508,231	18,291	330	6,000	12,073	4	11,372	9,540
10	812,198	11,792		1,226	75,106	402,025	434		2,045	
TOT^	1,625,282	5,153,222	461,119,364	1,535,964	130,103	432,662	1,375,530	939,705	185,012	771,434

** Pb given in kg.*

^ Tot refer to the total emissions in Italy after emissions in SNAP11 Nature

Source: authors calculation on APAT inventory of emissions

Tab. 2. Emissions of air pollutants in Italy in the SNAP processes. Rates per cent of national emissions

MSet	CH_4	CO	CO_2	COVNM	N_2O	NH_3	NO_X	Pb	PM	SO_2
1	0.8	0.7	32.7	0.5	4.2	0.0	12.2	0.4	9.9	60.1
2	1.5	8.7	15.3	2.6	6.0	0.0	5.4	0.6	10.8	2.8
3	0.4	6.8	17.2	0.4	2.8	0.0	10.7	18.2	13.1	17.0
4	0.6	2.2	5.7	5.8	18.1	2.1	0.6	7.2	11.8	5.6
5	15.7	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.3	0.0
6	0.0	0.0	0.3	32.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.3	67.5	23.8	42.3	7.6	3.5	51.2	72.1	31.3	1.5
8	0.2	9.0	4.8	11.6	3.4	0.0	19.1	1.5	15.5	11.7
9	28.6	4.8	0.1	1.2	0.3	1.4	0.9	0.0	6.1	1.2
10	50.0	0.2	0.0	0.1	57.7	92.9	0.0	0.0	1.1	0.0
TOT^	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

^ Tot refer to the total emissions in Italy after emissions in SNAP11 Nature

Source: authors calculation on APAT inventory of emissions

Tab. 3. Emissions of Global Warming Potential (GWP) and Potential Acid Equivalent (PAE). Values in tonnes and rates per cent of national emissions

Mset	GWP[a]	PAE[b]
1	152,978,573.6	18,129.2
2	73,415,034.3	2,292.6
3	80,577,924.4	7,294.4
4	33,880,872.9	2,063.6
5	5,364,613.0	0.0
6	1,529,850.5	0.0
7	113,373,163.5	16,567.6
8	23,762,905.4	8,541.8
9	10,360,263.9	913.5
10	40,338,929.4	23,658.0
TOT^	535,582,130.8	79,460.8

Mset	GWP	PAE
1	28.6	22.8
2	13.7	2.9
3	15.0	9.2
4	6.3	2.6
5	1.0	0.0
6	0.3	0.0
7	21.2	20.9
8	4.4	10.7
9	1.9	1.1
10	7.5	29.8
TOT^	100.0	100.0

^ Tot refer to the total emissions in Italy after emissions in macrosector 11 Nature

a GWP (Global Warming Potential). In NAMEA si utilizzano i seguenti fattori di conversione:
CO2: 1; N2O: 310; CH4:21

b PAE (Potential Acid Equivalent). In NAMEA si utilizzano i seguenti fattori di conversione:
SO2: 1/32; NOx: 1/46; NH3: 1/17

Source: authors calculation on APAT inventory of emissions

Tab. 4. Emissions of air pollutants in Italy after SNAP11. Values in tonnes

Reg	CH_4	CO	CO_2	COVNM	N_2O	NH_3	NO_X	Pb*	PM	SO_2
1	181,006	344,443	26,516,882	109,317	30,476	40,652	101,564	69,368	15,250	15,923
2	5,246	12,864	1,102,089	2,863	303	1,163	5,341	2,754	582	647
3	325,320	577,035	73,416,812	223,063	19,455	102,882	183,245	145,452	22,444	73,383
4	31,174	72,670	5,466,119	20,012	1,967	8,482	23,523	14,170	3,118	3,197
5	134,562	336,086	50,489,855	124,587	12,694	61,810	125,171	77,100	17,012	127,929
6	27,208	123,931	13,758,134	48,375	2,765	11,542	34,441	26,361	5,001	20,077
7	38,077	207,136	21,774,242	63,363	1,404	1,498	50,163	31,502	6,167	34,045
8	162,668	341,581	36,702,599	125,620	12,714	58,283	106,846	62,195	14,325	41,205
9	67,820	330,946	32,285,922	113,124	5,333	12,778	86,678	62,720	11,010	83,840
10	23,265	80,003	9,869,865	21,128	2,779	10,186	26,506	19,546	4,327	11,093
11	34,362	117,622	7,595,665	39,756	3,034	10,954	31,040	18,167	4,099	6,343
12	113,065	447,094	28,568,099	128,682	5,813	18,186	92,889	78,779	10,839	24,792
13	31,227	126,503	7,486,084	34,024	2,403	7,555	36,805	19,872	4,842	3,611
14	11,149	26,607	1,336,384	6,612	944	4,076	7,424	3,832	1,260	560
15	106,616	456,137	17,867,761	130,703	5,465	20,679	85,323	74,026	10,957	10,635
16	78,464	699,574	45,460,472	101,735	5,492	13,659	102,132	103,029	22,301	65,745
17	19,541	43,292	3,249,336	13,108	1,942	5,363	13,363	7,355	2,009	3,423
18	37,138	206,486	10,284,651	46,652	2,526	7,102	70,405	24,540	7,800	34,551
19	110,408	443,940	46,133,900	132,189	6,640	17,497	149,339	68,970	15,968	157,802
20	86,966	159,271	21,754,493	51,050	5,954	18,314	43,334	29,969	5,701	52,633
ITA	1,625,282	5,153,222	461,119,364	1,535,964	130,103	432,662	1,375,530	939,705	185,012	771,434

** Pb given in kg.*

Source: authors calculation on APAT inventory of emissions

Tab. 5. Emissions of air pollutants in Italy after SNAP11. Rates per cent of national emissions

Reg	CH_4	CO	CO_2	COVNM	N_2O	NH_3	NO_X	Pb	PM	SO_2
1	11.1	6.7	5.8	7.1	23.4	9.4	7.4	7.4	8.2	2.1
2	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.3	0.3	0.1
3	20.0	11.2	15.9	14.5	15.0	23.8	13.3	15.5	12.1	9.5
4	1.9	1.4	1.2	1.3	1.5	2.0	1.7	1.5	1.7	0.4
5	8.3	6.5	10.9	8.1	9.8	14.3	9.1	8.2	9.2	16.6
6	1.7	2.4	3.0	3.1	2.1	2.7	2.5	2.8	2.7	2.6
7	2.3	4.0	4.7	4.1	1.1	0.3	3.6	3.4	3.3	4.4
8	10.0	6.6	8.0	8.2	9.8	13.5	7.8	6.6	7.7	5.3
9	4.2	6.4	7.0	7.4	4.1	3.0	6.3	6.7	6.0	10.9
10	1.4	1.6	2.1	1.4	2.1	2.4	1.9	2.1	2.3	1.4
11	2.1	2.3	1.6	2.6	2.3	2.5	2.3	1.9	2.2	0.8
12	7.0	8.7	6.2	8.4	4.5	4.2	6.8	8.4	5.9	3.2
13	1.9	2.5	1.6	2.2	1.8	1.7	2.7	2.1	2.6	0.5
14	0.7	0.5	0.3	0.4	0.7	0.9	0.5	0.4	0.7	0.1
15	6.6	8.9	3.9	8.5	4.2	4.8	6.2	7.9	5.9	1.4
16	4.8	13.6	9.9	6.6	4.2	3.2	7.4	11.0	12.1	8.5
17	1.2	0.8	0.7	0.9	1.5	1.2	1.0	0.8	1.1	0.4
18	2.3	4.0	2.2	3.0	1.9	1.6	5.1	2.6	4.2	4.5
19	6.8	8.6	10.0	8.6	5.1	4.0	10.9	7.3	8.6	20.5
20	5.4	3.1	4.7	3.3	4.6	4.2	3.2	3.2	3.1	6.8
ITA	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: authors calculation on APAT inventory of emissions

Tab. 6. Emissions of Global Warming Potential (GWP) and Potential Acid Equivalent (PAE) after SNAP11. Values in tonnes and rates per cent of national emissions

Reg	GWP	PAE	Reg	GWP	PAE
1	39,765,722.3	5,096.8	1	7.04	6.04
2	1,306,063.7	204.07.00	2	0.02	0.03
3	86,279,555.7	12,328.6	3	16.01	15.05
4	6,730,651.5	1,110.2	4	1.03	1.04
5	57,250,783.6	10,354.7	5	10.07	13.00
6	15,186,659.1	2,055.1	6	2.08	2.06
7	23,009,252.6	2,242.5	7	4.03	2.08
8	44,059,821.3	7,038.8	8	8.02	8.09
9	35,363,227.4	5,256.0	9	6.06	6.06
10	11,220,046.3	1,522.1	10	2.01	1.09
11	9,257,772.0	1,517.4	11	1.07	1.09
12	32,744,399.5	3,863.8	12	6.01	4.09
13	8,886,849.1	1,357.4	13	1.07	1.07
14	1,863,008.1	418.06.00	14	0.03	0.05
15	21,800,869.0	3,403.6	15	4.01	4.03
16	48,810,843.8	5,078.2	16	9.01	6.04
17	4,261,645.5	713.00.00	17	0.08	0.09
18	11,847,540.6	3,028.0	18	2.02	3.08
19	50,510,768.3	9,207.0	19	9.04	11.06
20	25,426,651.4	3,664.2	20	4.07	4.06
ITA	535,582,130.8	79,460.8	ITA	100.00.00	100.00.00

Source: authors calculation on APAT inventory of emissions

Appendix 4

SNAP	Process description	NAMEA code
10100	Public power and district heating plants	19
10300	Petroleum refining plants	10
10400	Solid fuel transformation plants	10
10506	Pipeline compressors	19
20200	Residential plants	32
30203	Blast furnace cowpers	14
30204	Plaster furnaces	13
30301	Sinter and pelletizing plants	14
30302	Reheating furnaces steel and iron	14
30303	Gray iron foundries	14
30304	Primary lead production	14
30305	Primary zinc production	14
30307	Secondary lead production	14
30308	Secondary zinc production	14
30309	Secondary copper production	14
30310	Secondary aluminium production	14
30311	Cement (Except decarbonizing considered in items 04.06.12/13/14)	13
30312	Lime (includ. iron and steel and paper pulp industr.)(Except decarbonising)	13
30313	Asphalt concrete plants	10
30314	Flat glass (Except decarbonizing considered in items 04.06.12/13/14)	13
30315	Container glass (Except decarbonizing considered in items 04.06.12/13/14)	13
30316	Glass wool (except binding) (Except decarbonizing)	13
30317	Other glass (Except decarbonizing considered in items 04.06.12/13/14)	13
30319	Bricks and tiles	13
30320	Fine ceramic materials	13
30321	Paper-mill industry (drying processes)	9
30322	Alumina production	14
40100	Processes in petroleum industries	10
40201	Coke oven (door leakage and extinction)	10
40202	Blast furnace charging	14
40203	Pig iron tapping	14
40206	Basic oxygen furnace steel plant	14
40207	Electric furnace steel plant	14
40208	Rolling mills	14
40209	Sinter and pelletizing plant (except comb. 03.03.01)	14
40301	Aluminium production (electrolysis)	14
40302	Ferro alloys	14
40303	Silicium production	14
40401	Sulfuric acid	11
40402	Nitric acid	11
40403	Ammonia	11
40404	Ammonium sulphate	11
40405	Ammonium nitrate	11
40407	NPK fertilisers	11
40408	Urea	11
40409	Carbon black	11
40410	Titanium dioxide	11
40501	Ethylene	11
40502	Propylene	11
40503	1,2 dichloroethane - includes 04.05.04 (except 04.05.05)	11
40505	1,2 dichloroethane + vinylchloride (balanced process)	11
40506	Polyethylene Low Density	11
40507	Polyethylene High Density	11
40508	Polyvinylchloride	11
40509	Polypropylene	11
40510	Styrene	11
40511	Polystyrene	11
40513	Styrene-butadiene latex	11
40514	Styrene-butadiene rubber (SBR)	11
40515	Acrylonitrile Butadiene Styrene (ABS) resins	11
40516	Ethylene oxide	11
40517	Formaldehyde	11

40518	Ethylbenzene	11
40519	Phtalic anhydride	11
40520	Acrylonitrile	11
40521	Adipic acid	11
40527	Other (phytosanitary,...)	11
40603	Paper pulp (acid sulfite process)	9
40604	Paper pulp (Neutral Sulphite Semi-Chemical process)	9
40605	Bread	5
40606	Wine	1
40607	Beer	5
40608	Spirits	5
40610	Roof covering with asphalt materials	20
40611	Road paving with asphalt	20
40612	Cement (decarbonizing)	13
40613	Glass (decarbonizing)	13
40614	Lime (decarbonizing)	13
40615	Batteries manufacturing	16
40618	Limestone and dolomite use	13
40619	Soda ash production and use	13
50101	Open cast mining	3
50102	Underground mining	3
50103	Storage of solid fuel	10
50201	Land-based activities	3
50302	Land-based activities (other than desulfuration)	3
50401	Marine terminals (tankers, handling and storage)	10
50402	Other handling and storage (including pipeline) (q)	10
50501	Refinery dispatch station	10
50502	Transport and depots (except 05.05.03)	10
50503	Service stations (including refuelling of cars)	21
50601	Pipelines (Except combustion in compressor stations, included in item 01.05.06)	23
50603	Distribution networks	19
60101	Paint application : manufacture of automobiles	17
60102	Paint application : car repairing	21
60103	Paint application : construction and buildings (except item 06.01.07)	20
60104	Paint application : domestic use (except 06.01.07)	33
60105	Paint application : coil coating	14
60106	Paint application : boat building	17
60202	Dry cleaning	29
60301	Polyester processing	11
60302	Polyvinylchloride processing	11
60303	Polyurethane processing	12
60304	Polystyrene foam processing (Except 06.05.04)	20
60306	Pharmaceutical products manufacturing	11
60307	Paints manufacturing	11
60308	Inks manufacturing	11
60309	Glues manufacturing	11
60312	Textile finishing	6
60313	Leather tanning	7
60401	Glass wool enduction	13
60403	Printing industry	9
60404	Fat, edible and non edible oil extraction	5
60405	Application of glues and adhesives	33
60408	Domestic solvent use (other than paint application)(Except aerosols)	33
60409	Vehicles dewaxing	17
80100	Military	26
80200	Railways	23
80300	Inland waterways	23
80402	National sea traffic within EMEP area	23
80403	National fishing	2
80501	Domestic airport traffic (LTO cycles - <1000 m)	23
80502	International airport traffic (LTO cycles - <1000 m)	23
80503	Domestic cruise traffic (>1000 m)	23
80600	Agriculture	1
80700	Forestry	1
90201	Incineration of domestic or municipal wastes	29
90202	Incineration of industrial wastes (except flaring)	29
90203	Flaring in oil refinery	10
90205	Incineration of sludges from waste water treatment	29

90207	Incineration of hospital wastes	29
90208	Incineration of waste oil	29
90401	Managed Waste Disposal on Land	29
90402	Unmanaged Waste Disposal Sites	29
90700	Open burning of agricultural wastes (except 10.03)	1
91001	Waste water treatment in industry	29
91002	Waste water treatment in residential/commercial sect.	29
91003	Sludge spreading	29
91005	Compost production	29
100100	Cultures with fertilizers	29
100103	Rice field	1
100200	Cultures without fertilizers	1
100300	On-field burning of stubble, straw,...	1
100401	Dairy cows	1
100402	Other cattle	1
100403	Ovines	1
100404	Fattening pigs	1
100405	Horses	1
100406	Mules and asses	1
100407	Goats	1
100412	Sows	1
100414	Buffalo	1
100415	Other	1
100501	Dairy cows	1
100502	Other cattle	1
100503	Fattening pigs	1
100504	Sows	1
100505	Ovines	1
100506	Horses	1
100507	Laying hens	1
100508	Broilers	1
100509	Other poultry (ducks,gooses,etc.)	1
100511	Goats	1
100512	Mules and asses	1
100514	Buffalo	1
100515	Other	1
100900	Manure management regarding nitrogen compounds	1

Source: authors calculation

SNAP	Descrizione del processo	NAMEA code
20100	Non-industrial combustion plants-Commercial and institutional plants	21-30
20300	Plants in agriculture, forestry and aquaculture	1-2
30100	Comb. in boilers, gas turbines and stationary engines	11-20
40601	Chipboard	8, 18
60107	Paint application : wood	8, 18
60108	Other industrial paint application	15-16
60201	Metal degreasing	15, 16, 18
60305	Rubber processing	11-12, 18
07xxxx*	Road transports	1-31
80800	Other mobile sources and machinery-Industry	11-20

Road transports processes refer to the SNAP macro sector 07.
Source: authors calculation

Appendix 5

Tab. 7. Emissions of Global Warming Potential (GWP) and Potential Acid Equivalent (PAE) after SNAP11

Region	GWP from domestic demand	GWP from foreign demand	PAE from domestic demand	PAE from foreign demand
1-2	30,941,055	10,129,483	4,139	1,163
3	66,087,494	20,190,300	9,304	3,024
4	5,421,206	1,307,855	791	319
5	42,936,464	14,313,526	7,528	2,827
6	11,241,036	3,944,920	1,502	553
7	18,713,653	4,305,822	1,819	424
8	31,842,787	12,217,154	4,855	2,185
9	26,908,342	8,452,396	4,017	1,239
10	8,953,494	2,265,865	1,183	338
11	7,740,478	1,516,724	1,246	272
12	28,495,314	4,246,304	3,283	580
13-14	9,116,101	1,638,011	1,485	291
15	19,088,753	2,710,898	2,864	540
16	37,567,942	11,241,109	4,000	1,079
17	3,677,099	586,388	603	110
18	10,897,840	949,198	2,718	310
19	41,457,988	9,052,940	7,462	1,745
20	19,341,283	6,087,101	2,793	871
ITA	420,428,328	115,155,993	61,591	17,870

Source: authors calculation on multiregional I-O table and NAMEA

Tab. 8. Emissions of Global Warming Potential (GWP) and Potential Acid Equivalent (PAE) after SNAP11. Emissions generated from regional demand which remain into the region. Rates per cent

Region	Leontievian Model	Keynesian Model
1-2	66.7%	50.3%
3	73.0%	54.1%
4	72.0%	52.1%
5	64.8%	49.8%
6	58.9%	40.7%
7	67.9%	53.8%
8	62.3%	45.9%
9	64.2%	49.9%
10	44.8%	24.5%
11	62.2%	43.2%
12	69.1%	52.6%
13-14	61.8%	25.6%
15	76.3%	64.9%
16	53.0%	44.1%
17	40.1%	14.5%
18	66.0%	47.8%
19	70.1%	63.9%
20	60.5%	49.4%

Source: authors calculation on multiregional I-O table and NAMEA

Tab. 9. Emissions of Global Warming Potential (GWP) after SNAP11 from domestic demand in a Leontievian Model. Sources (rows) and destinations (columns). Values in tonnes

	North West	North East	Centre	*of which Lazio*	South	Islands	ITALIA
North West	91.0	9.7	6.4	*2.1*	6.7	5.1	119.0
North East	8.9	66.4	7.1	*2.0*	5.9	4.1	92.4
Centre	6.8	7.6	50.5	*21.0*	7.1	4.0	75.9
of which Lazio	*2.8*	*2.8*	*21.5*	*19.7*	*3.7*	*1.7*	*32.4*
South	6.0	5.3	5.8	*2.5*	57.0	5.5	79.6
Islands	3.1	2.5	2.3	*0.9*	3.6	42.1	53.5
ITALIA	115.7	91.4	72.1	*28.5*	80.3	60.8	420.4

Source: authors calculation on multiregional I-O table and NAMEA

Tab. 10. Emissions of Global Warming Potential (GWP) after SNAP11 from domestic demand. Sources (rows) and destinations (columns). Values in tonnes

	North West	North East	Centre	*of which Lazio*	South	Islands	ITALIA
North West	57.0	10.3	7.5	*2.8*	7.8	5.5	88.1
North East	10.6	42.4	8.0	*2.7*	7.0	4.5	72.5
Centre	8.9	8.8	33.4	*14.2*	9.5	5.0	65.5
of which Lazio	*4.1*	*3.7*	*15.0*	*12.7*	*5.4*	*2.5*	*30.7*
South	7.9	6.6	6.9	*3.1*	39.7	5.5	66.5
Islands	4.7	3.6	3.4	*1.4*	4.7	33.4	49.8
ITALIA	89.1	71.6	59.2	*24.2*	68.7	53.7	342.4

Source: authors calculation on multiregional I-O table and NAMEA

Tab. 11. Emissions of Global Warming Potential (GWP) after SNAP11 from domestic demand. Sources (rows) and destinations (columns). Rates per cent

	North West	North East	Centre	*of which Lazio*	South	Islands	ITALIA
North West	64.0	14.3	12.7	*11.5*	11.3	10.2	25.7
North East	11.8	59.3	13.6	*11.0*	10.2	8.3	21.2
Centre	9.9	12.2	56.3	58.9	13.9	9.2	19.1
of which Lazio	*4.6*	*5.1*	*25.3*	*52.6*	7.9	4.7	9.0
South	8.9	9.2	11.7	*12.7*	57.7	10.2	19.4
Islands	5.3	5.0	5.8	*5.9*	6.8	62.1	14.5
ITALIA	100.0	100.0	100.0	*100.0*	100.0	100.0	100.0

Source: authors calculation on multiregional I-O table and NAMEA

Tab. 12. Emissions of Global Warming Potential (GWP) after SNAP11 from domestic demand. Sources (rows) and destinations (columns). Rates per cent

	North West	North East	Centre	*of which Lazio*	South	Islands	ITALIA
North West	64.8	11.6	8.5	*3.2*	8.8	6.2	100.0
North East	14.6	58.5	11.1	*3.7*	9.7	6.1	100.0
Centre	13.5	13.4	51.0	*21.8*	14.5	7.6	100.0
of which Lazio	*13.3*	*11.9*	*48.8*	*41.5*	*17.7*	*8.3*	*100.0*
South	11.9	9.9	10.4	*4.6*	59.6	8.2	100.0
Islands	9.5	7.2	6.8	*2.9*	9.4	67.1	100.0
ITALIA	26.0	20.9	17.3	*7.1*	20.1	15.7	100.0

Source: authors calculation on multiregional I-O table and NAMEA

Tab. 13. Net export of Global Warming Potential (GWP) after SNAP11 from domestic demand. Sources (rows) and destinations (columns). Values in millions of tonnes

	North West	North East	Centre	*of which Lazio*	South	Islands	ITALIA
North West	0.0	-0.3	-1.4	*-1.3*	-0.1	0.8	-1.0
North East		0.0	-0.7	*-1.0*	0.5	0.9	0.9
Centre			0.0	*-0.7*	2.6	1.6	6.2
of which Lazio				*0.0*	*2.4*	*1.1*	*6.5*
South					0.0	0.8	-2.2
Islands						0.0	-4.0
ITALIA							0.0

Source: authors calculation on multiregional I-O table and NAMEA

Tab. 14. Emissions of GWP from domestic demand in a Keynesian Model. Sources (rows) and destinations (columns). Values in millions of tonnes

	1-2	3	4	5	6	7	8	9	10	11	12	13-14	15	16	17	18	19	20	ITA
1-2	12.3	3.2	0.2	1.3	0.4	0.9	1.0	0.7	0.3	0.2	0.9	0.3	0.4	1.2	0.1	0.3	0.9	0.7	25.3
3	2.6	26.6	0.3	2.9	0.8	1.4	2.1	1.6	0.7	0.5	1.6	0.6	0.7	2.3	0.3	0.7	2.0	1.3	49.0
4	0.4	0.8	2.3	0.6	0.2	0.2	0.4	0.3	0.2	0.1	0.3	0.1	0.1	0.5	0.1	0.1	0.4	0.2	7.4
5	1.1	2.5	0.3	16.6	0.9	0.6	1.8	1.1	0.5	0.3	1.0	0.4	0.4	1.4	0.2	0.3	1.1	0.6	31.0
6	0.3	0.6	0.1	0.8	3.6	0.2	0.4	0.3	0.1	0.1	0.3	0.1	0.1	0.4	0.0	0.1	0.3	0.2	8.0
7	0.6	1.0	0.1	0.6	0.2	8.4	0.5	0.4	0.2	0.1	0.3	0.1	0.2	0.4	0.1	0.1	0.3	0.3	13.8
8	1.1	2.3	0.2	2.2	0.6	0.6	11.5	1.5	0.5	0.3	1.0	0.4	0.4	1.4	0.2	0.3	1.0	0.7	26.1
9	0.8	1.7	0.1	1.4	0.4	0.5	1.5	10.7	0.5	0.3	0.9	0.4	0.4	1.1	0.2	0.3	0.9	0.6	22.7
10	0.1	0.3	0.0	0.2	0.1	0.1	0.2	0.2	1.8	0.1	0.2	0.1	0.1	0.3	0.0	0.0	0.2	0.1	4.0
11	0.3	0.7	0.1	0.6	0.2	0.2	0.5	0.3	0.3	2.6	0.4	0.2	0.2	0.6	0.1	0.1	0.4	0.3	8.0
12	1.2	2.2	0.2	1.6	0.5	0.7	1.4	1.2	0.7	0.4	12.7	0.9	1.0	2.3	0.4	0.7	1.6	0.9	30.7
13-14	0.2	0.4	0.0	0.3	0.1	0.1	0.3	0.2	0.1	0.1	0.3	1.8	0.1	0.5	0.1	0.1	0.3	0.2	5.2
15	1.0	1.8	0.2	1.2	0.3	0.5	1.0	0.9	0.4	0.3	1.4	0.6	10.7	2.5	0.4	0.5	1.4	0.8	26.1
16	0.7	1.4	0.1	0.9	0.2	0.3	0.7	0.6	0.3	0.2	0.8	0.4	0.5	14.3	0.3	0.4	1.0	0.5	23.7
17	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.1	0.0	0.1	0.0	0.9
18	0.4	0.8	0.1	0.5	0.1	0.2	0.4	0.3	0.1	0.1	0.5	0.1	0.3	0.9	0.1	4.6	1.0	0.3	10.6
19	0.9	1.9	0.1	1.1	0.3	0.5	0.9	0.8	0.4	0.2	1.1	0.4	0.5	1.7	0.2	0.7	23.6	0.9	36.2
20	0.4	0.8	0.1	0.5	0.1	0.2	0.4	0.3	0.2	0.1	0.4	0.2	0.2	0.6	0.1	0.1	0.6	8.3	13.6
ITA	24.4	49.1	4.4	33.3	8.9	15.6	25.0	21.5	7.4	6.1	24.2	7.1	16.5	32.6	3.0	9.6	36.9	16.8	342.4

Source: authors calculation on multiregional I-O table and NAMEA

Tab. 15. Net export of GWP from domestic demand in a Keynesian Model. Sources (rows) and destinations (columns). Values in millions of tonnes

	1-2	3	4	5	6	7	8	9	10	11	12	13-14	15	16	17	18	19	20	ITA
1-2	0.0	0.5	-0.2	0.3	0.1	0.3	0.0	0.0	0.2	-0.1	-0.3	0.1	-0.6	0.5	0.1	-0.1	0.0	0.2	0.9
3		0.0	-0.5	0.4	0.1	0.4	-0.1	-0.1	0.4	-0.2	-0.7	0.2	-1.1	1.0	0.2	-0.1	0.1	0.5	-0.1
4			0.0	0.4	0.1	0.1	0.2	0.2	0.2	0.0	0.1	0.1	0.0	0.4	0.0	0.1	0.2	0.2	3.0
5				0.0	0.1	0.0	-0.4	-0.3	0.2	-0.2	-0.6	0.1	-0.8	0.5	0.1	-0.1	-0.1	0.2	-2.3
6					0.0	0.0	-0.1	-0.1	0.1	-0.1	-0.2	0.0	-0.2	0.1	0.0	0.0	0.0	0.0	-0.9
7						0.0	-0.1	-0.2	0.1	-0.1	-0.3	0.0	-0.4	0.1	0.0	-0.1	-0.1	0.0	-1.8
8							0.0	0.0	0.3	-0.1	-0.3	0.1	-0.6	0.7	0.1	0.0	0.1	0.3	1.1
9								0.0	0.3	-0.1	-0.3	0.2	-0.5	0.5	0.1	0.0	0.1	0.3	1.1
10									0.0	-0.2	-0.5	-0.1	-0.4	-0.1	0.0	-0.1	-0.2	-0.1	-3.3
11										0.0	0.0	0.1	-0.1	0.4	0.1	0.0	0.1	0.2	2.0
12											0.0	0.6	-0.4	1.5	0.4	0.3	0.5	0.6	6.5
13-14												0.0	-0.5	0.2	0.0	-0.1	-0.1	0.0	-1.9
15													0.0	1.9	0.4	0.3	0.8	0.6	9.5
16														0.0	0.1	-0.5	-0.7	-0.1	-8.9
17															0.0	-0.1	-0.2	0.0	-2.0
18																0.0	0.3	0.1	1.1
19																	0.0	0.4	-0.7
20																		0.0	-3.3
ITA																			0.0

Source: authors calculation on multiregional I-O table and NAMEA

Tab. 16. Emission of GWP per unit of production from domestic demand. Sources (rows) and destinations (columns). Values in tonnes/€.

	1-2	3	4	5	6	7	8	9	10	11	12	13-14	15	16	17	18	19	20
1-2	-	183	164	288	315	453	214	260	471	168	142	241	199	686	351	339	579	662
3	209	-	169	289	306	422	214	262	454	174	140	242	192	622	318	324	527	601
4	218	184	-	314	344	418	229	260	396	189	154	226	207	678	354	334	657	749
5	214	179	177	-	327	387	213	265	440	186	139	236	197	699	323	330	593	660
6	215	173	157	280	-	388	203	245	398	174	143	222	192	707	320	339	641	700
7	225	181	171	278	305	-	211	252	443	174	149	242	201	662	335	353	582	707
8	221	181	177	289	312	393	-	266	427	186	139	241	194	685	319	325	594	649
9	219	177	170	281	305	383	208	-	442	183	147	255	200	665	318	353	604	679
10	206	166	154	262	291	358	194	245	-	173	145	226	191	733	307	349	631	702
11	210	169	160	273	294	385	201	247	438	-	145	227	190	711	314	350	602	673
12	209	172	168	260	296	356	194	235	411	159	-	256	197	620	334	350	543	653
13-14	210	163	152	260	297	368	193	246	454	161	150	-	192	776	334	355	602	699
15	225	166	162	265	293	349	197	235	425	164	151	237	-	686	317	359	616	705
16	219	162	156	257	280	337	194	228	412	154	135	222	188	-	309	333	559	662
17	183	156	144	250	299	335	183	254	491	137	139	225	190	782	-	366	480	712
18	213	158	151	252	274	321	188	221	402	149	130	218	183	604	296	-	561	648
19	206	160	156	254	274	328	190	224	404	148	133	224	188	604	322	329	-	634
20	196	164	160	260	287	339	193	232	411	152	140	209	182	649	271	329	544	-

Source: authors calculation on multiregional I-O table and NAMEA

Tab. 14. Emissions of GWP from domestic demand in a Keynesian Model. Sources (rows) and destinations (columns). Values in millions of tonnes

	1-2	3	4	5	6	7	8	9	10	11	12	13-14	15	16	17	18	19	20	ITA
1-2	12.3	3.2	0.2	1.3	0.4	0.9	1.0	0.7	0.3	0.2	0.9	0.3	0.4	1.2	0.1	0.3	0.9	0.7	25.3
3	2.6	26.6	0.3	2.9	0.8	1.4	2.1	1.6	0.7	0.5	1.6	0.6	0.7	2.3	0.3	0.7	2.0	1.3	49.0
4	0.4	0.8	2.3	0.6	0.2	0.2	0.4	0.3	0.2	0.1	0.3	0.1	0.1	0.5	0.1	0.1	0.4	0.2	7.4
5	1.1	2.5	0.3	16.6	0.9	0.6	1.8	1.1	0.5	0.3	1.0	0.4	0.4	1.4	0.2	0.3	1.1	0.6	31.0
6	0.3	0.6	0.1	0.8	3.6	0.2	0.4	0.3	0.1	0.1	0.3	0.1	0.1	0.4	0.0	0.1	0.3	0.2	8.0
7	0.6	1.0	0.1	0.6	0.2	8.4	0.5	0.4	0.2	0.1	0.3	0.1	0.2	0.4	0.1	0.1	0.3	0.3	13.8
8	1.1	2.3	0.2	2.2	0.6	0.6	11.5	1.5	0.5	0.3	1.0	0.4	0.4	1.4	0.2	0.3	1.0	0.7	26.1
9	0.8	1.7	0.1	1.4	0.4	0.5	1.5	10.7	0.5	0.3	0.9	0.4	0.4	1.1	0.2	0.3	0.9	0.6	22.7
10	0.1	0.3	0.0	0.2	0.1	0.1	0.2	0.2	1.8	0.1	0.2	0.1	0.1	0.3	0.0	0.0	0.2	0.1	4.0
11	0.3	0.7	0.1	0.6	0.2	0.2	0.5	0.3	0.3	2.6	0.4	0.2	0.2	0.6	0.1	0.1	0.4	0.3	8.0
12	1.2	2.2	0.2	1.6	0.5	0.7	1.4	1.2	0.7	0.4	12.7	0.9	1.0	2.3	0.4	0.7	1.6	0.9	30.7
13-14	0.2	0.4	0.0	0.3	0.1	0.1	0.3	0.2	0.1	0.1	0.3	1.8	0.1	0.5	0.1	0.1	0.3	0.2	5.2
15	1.0	1.8	0.2	1.2	0.3	0.5	1.0	0.9	0.4	0.3	1.4	0.6	10.7	2.5	0.4	0.5	1.4	0.8	26.1
16	0.7	1.4	0.1	0.9	0.2	0.3	0.7	0.6	0.3	0.2	0.8	0.4	0.5	14.3	0.3	0.4	1.0	0.5	23.7
17	0.0	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.1	0.0	0.1	0.0	0.9
18	0.4	0.8	0.1	0.5	0.1	0.2	0.4	0.3	0.1	0.1	0.5	0.1	0.3	0.9	0.1	4.6	1.0	0.3	10.6

	1-2	3	4	5	6	7	8	9	10	11	12	13-14	15	16	17	18	19	20	ITA
19	0.9	1.9	0.1	1.1	0.3	0.5	0.9	0.8	0.4	0.2	1.1	0.4	0.5	1.7	0.2	0.7	23.6	0.9	36.2
20	0.4	0.8	0.1	0.5	0.1	0.2	0.4	0.3	0.2	0.1	0.4	0.2	0.2	0.6	0.1	0.1	0.6	8.3	13.6
ITA	24.4	49.1	4.4	33.3	8.9	15.6	25.0	21.5	7.4	6.1	24.2	7.1	16.5	32.6	3.0	9.6	36.9	16.8	342.4

Tab. 15. Net export of GWP from domestic demand in a Keynesian Model. Sources (rows) and destinations (columns). Values in millions of tonnes

	1-2	3	4	5	6	7	8	9	10	11	12	13-14	15	16	17	18	19	20	ITA
1-2	0.0	0.5	-0.2	0.3	0.1	0.3	0.0	0.0	0.2	-0.1	-0.3	0.1	-0.6	0.5	0.1	-0.1	0.0	0.2	0.9
3		0.0	-0.5	0.4	0.1	0.4	-0.1	-0.1	0.4	-0.2	-0.7	0.2	-1.1	1.0	0.2	-0.1	0.1	0.5	-0.1
4			0.0	0.4	0.1	0.1	0.2	0.2	0.2	0.0	0.1	0.1	0.0	0.4	0.0	0.1	0.2	0.2	3.0
5				0.0	0.1	0.0	-0.4	-0.3	0.2	-0.2	-0.6	0.1	-0.8	0.5	0.1	-0.1	-0.1	0.2	-2.3
6					0.0	0.0	-0.1	-0.1	0.1	-0.1	-0.2	0.0	-0.2	0.1	0.0	0.0	0.0	0.0	-0.9
7						0.0	-0.1	-0.2	0.1	-0.1	-0.3	0.0	-0.4	0.1	0.0	-0.1	-0.1	0.0	-1.8
8							0.0	0.0	0.3	-0.1	-0.3	0.1	-0.6	0.7	0.1	0.0	0.1	0.3	1.1
9								0.0	0.3	-0.1	-0.3	0.2	-0.5	0.5	0.1	0.0	0.1	0.3	1.1
10									0.0	-0.2	-0.5	-0.1	-0.4	-0.1	0.0	-0.1	-0.2	-0.1	-3.3
11										0.0	0.0	0.1	-0.1	0.4	0.1	0.0	0.1	0.2	2.0
12											0.0	0.6	-0.4	1.5	0.4	0.3	0.5	0.6	6.5
13-14												0.0	-0.5	0.2	0.0	-0.1	-0.1	0.0	-1.9
15													0.0	1.9	0.4	0.3	0.8	0.6	9.5
16														0.0	0.1	-0.5	-0.7	-0.1	-8.9
17															0.0	-0.1	-0.2	0.0	-2.0
18																0.0	0.3	0.1	1.1
19																	0.0	0.4	-0.7
20																		0.0	-3.3
ITA																			0.0

Tab. 16. Emission of GWP per unit of production from domestic demand. Sources (rows) and destinations (columns). Values in tonnes/€.

	1-2	3	4	5	6	7	8	9	10	11	12	13-14	15	16	17	18	19	20
1-2	-	183	164	288	315	453	214	260	471	168	142	241	199	686	351	339	579	662
3	209	-	169	289	306	422	214	262	454	174	140	242	192	622	318	324	527	601
4	218	184	-	314	344	418	229	260	396	189	154	226	207	678	354	334	657	749
5	214	179	177	-	327	387	213	265	440	186	139	236	197	699	323	330	593	660
6	215	173	157	280	-	388	203	245	398	174	143	222	192	707	320	339	641	700
7	225	181	171	278	305	-	211	252	443	174	149	242	201	662	335	353	582	707
8	221	181	177	289	312	393	-	266	427	186	139	241	194	685	319	325	594	649
9	219	177	170	281	305	383	208	-	442	183	147	255	200	665	318	353	604	679
10	206	166	154	262	291	358	194	245	-	173	145	226	191	733	307	349	631	702
11	210	169	160	273	294	385	201	247	438	-	145	227	190	711	314	350	602	673
12	209	172	168	260	296	356	194	235	411	159	-	256	197	620	334	350	543	653
13-14	210	163	152	260	297	368	193	246	454	161	150	-	192	776	334	355	602	699
15	225	166	162	265	293	349	197	235	425	164	151	237	-	686	317	359	616	705
16	219	162	156	257	280	337	194	228	412	154	135	222	188	-	309	333	559	662
17	183	156	144	250	299	335	183	254	491	137	139	225	190	782	-	366	480	712
18	213	158	151	252	274	321	188	221	402	149	130	218	183	604	296	-	561	648
19	206	160	156	254	274	328	190	224	404	148	133	224	188	604	322	329	-	634
20	196	164	160	260	287	339	193	232	411	152	140	209	182	649	271	329	544	-