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The Genuine Saving indicator: estimates at the subnational level in Italy.

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Abstract

In this paper we estimate the Genuine Saving (GS) of Italian regions in the period 1996-2005. The GS is a macroeconomic indicator of sustainability able to shed light on the future implications of current welfare levels, jointly considering the management of economic and natural assets. Despite the good performance of Italy as a whole during the considered period, our results show an uneven regional distribution of sustainability burdens, with the Basilicata region on an unsustainable development path, showing decreasing and negative value of GS. This results are mainly due to mismanagement of unrenewable natural resources (oil and gas). Failing this test of "weak" sustainability, the Basilicata region is likely to incur a decline of welfare levels in the future

Keywords: Natural resources, Genuine Saving, regional sustainability, capital approach

1 Introduction

The discussion about how to concretely realize a development that meets the needs of present generation without compromising the ability of future generations to meet their own needs (WCED, 1987) has animated policy and academic debate in recent years. In turn, this stimulated an intense effort to provide adequate indicators to measure sustainability. In fact, a proper set of policy-relevant measurement tools is needed to monitor progress towards sustainability. So, while at the early 90s, the lack of indicators constituted a major obstacle (Pearce et al., 1990) after two decades "the search for sustainability indicators has become something of a mini-industry in the literature on sustainable development" (Atkinson et al., 2007), with a plurality of approaches and methods. Among them, the capital approach is prominent in academic literature (United Nations Economic Commission for Europe, 2009). According to this conceptual framework, sustainability is inherently related to the management of stock and flows of capital, being it broadly defined as to include economic, environmental and human capital. Taken together they constitute the wealth of a country, over which the well-being of population is based. Under the hypothesis that economic, natural and human capital are substitute for each other, the total stock has to be maintained to allow that the future generations can reach at least the same level of well being of the present generation. Therefore, a non-declining per capita wealth has to be preserved over time to realize a sustainable development (Dasgupta et al., 2001) in intergenerational terms; consequently, a proper indicator of sustainability should shed light on the trade-offs that arises in that respect, and signal the implications in the long run of current level of well-being and resource consumption.

A wise management of resources is then crucial to guarantee intergenerational solidarity; however it matters also in a intragenerational perspective. In fact, sustainability trade offs may arise also in a spatial dimension, since a country, pursuing the well-being of its citizens may affect the well-being of citizens of other countries. Actually, similar problems may emerge also at the sub-national level (United Nations Economic Commission for Europe, 2013). The spatial scale considered is not neutral for sustainability measurement: i.e., data at the national level may outline a good performance in resource management for the country as a whole, while hiding unsustainable behaviors for specific territories and regions. At the same time, the interactions between territories that are part of the same economy could imply that "global sustainable development demands that regions "sacrifice" some degree of their own development, welfare or environmental sustainability. Such detrimental effects may be acceptable from a supraregional (or global human need) perspective", despite this circumstance poses the ethical question of to what extent unsustainability of a specific area is justified in terms of the sustainable development of a larger territory (Zuindeau, 2006, 2007). For these reasons, and according to the recent Conference of European Statisticians, the spatial dimension of sustainability should properly be addressed, and more work should be done, both to measure sustainable development at different spatial scale levels and to consider the interaction between territories.

The aim of this paper is to contribute to these topics, by estimating an indicator of sustainability based on the capital approach, the GS for Italian regions (NUTS-2), and an "ecological balance of payments" among them. The GS is a composite indicator, based on a solid economic theory and computed by the World Bank for more than 200 countries for cross-country comparisons. It considers natural assets together with economic wealth and the investments in human capital formation, all of them expressed in monetary values. The indicator is able to show if a society is increasing or depleting the total wealth it dispose of; balancing the non-renewable resources consumption (hydrocarbon endowments exploitation, pollution damages etc.) and the investments in renewable ones (human capital, net savings etc.). Consequently, it outlines the future implications of current level of welfare, including the ecological and economic dimension in interaction among them.

To the best of our knowledge, the estimates proposed in this paper constitutes the first attempt to develop a forward-looking indicator of sustainability for the Italian regions, as repeatedly advocated in recent editions of the report "Benessere Equo Sostenibile" produced by ISTAT, the Italian Institute of Statistics (ISTAT, CNEL, 2013; ISTAT, 2015).

As previously mentioned, together with the estimates of GS, we evaluate how the interactions among regions impact on their own sustainability performance, focusing on a specific topic: the management of the hydrocarbon endowments. Despite Italy is not a resource rich economy, one of its southern regions, Basilicata, has the largest onshore field in continental Europe. At the beginning of 2000s the hydrocarbons exploitation in the area increased dramatically, leading the region to cover approximately the 6% of crude oil national demand; in last years it contributed with over the 80% of crude oil production of Italy.

As the results obtained clearly show, this region is on an unsustainable path of development, mainly due to a mismanagement of natural resources considered in our accounting framework. The depletion of natural assets is not properly counterbalanced by investments in human and physical capital; consequently the total disposable wealth of the region is decreasing, making impossible that the well-being of current generation can be sustained in the future. However, only a small part of these assets is actually consumed in loco: since these resources are strategic for Italy, they contributes to the development of the whole country. Following Hamilton and Atkinson (2006), we developed an input output model to estimate the resources directly and indirectly traded ("incorporated" in goods) through an "ecological balance of payments for hydrocarbons" among regions. The results shows that, taken into account this element, Basilicata shows a less concerning situation in its resource management, but still exhibit an unsustainable path of development.

The paper is organized as follows. Section 1 describes the conceptual framework of the GS and its use in literature. Section 2 presents the theoretical ground of the GS and the "ecological balance of payment". Section 3 discuss the data and the method used, showing differences and similarity with respect to the estimates provided by the World Bank for Italy. Section 4 present and discuss results.

2 The Genuine Saving indicator: conceptual framework and related literature.

The first formulation of GS was proposed by Pearce and Atkinson (1993), based on a rearrangement of the so-called Hartwick rule (Hartwick, 1990): an economy that exploits non-renewable resources should offset their depletion with investments in renewable resources in order to maintain its total stock of wealth; this is the underlying condition that makes possible a non declining well-being over time. The intellectual root of this approach is the Hicksian concept of income, that is the maximum amount that can be consumed in one period of time without compromising the ability to afford the same level of consumption in the following period (Hicks, 1946). Following this framework Pearce and Atkinson (Pearce and Atkinson, 1992, 1993) elaborated an indicator of sustainability according to which an economy is sustainable if its savings are higher than the combined depreciation of the two forms of capital (man-made capital and natural capital).Whenever the GS takes negative values, it signals an unsustainable path of development of the economy.

According to Hamilton and Atkinson (2006), the main intuition of Pearce and Atkinson (1993) is that if total wealth is related to social welfare, looking at the changes in total wealth is possible to infer relevant information also on sustainability implications of the current consumption behaviour. In fact, whatever is the definition of sustainable development, it necessarily involves the creation and the maintaining of wealth. Then, as long as natural resource depletion is the liquidation of an asset, it should be properly included in national accounting framework as a negative contribution to income or net savings (Hamilton and Clemens, 1999; Hamilton, 2000).

It is worth noting that the model explicitly assumes that different types of capital are substitutable: then, the erosion of one stock, i.e. natural capital, can be compensated through investments in other components of wealth (i.e. physical or human capital). This is precisely the concept of "weak sustainability". This approach has been questioned by pointing out that there are at least some types of critical capital whose erosion reduces the well being in a form that cannot be compensated with investment in other types of capital: "For example, the effects on people's well-being of higher concentrations of greenhouse gases in the atmosphere (which could lead to irreversible climate change) or of losses in biodiversity may not be adequately compensated by increases in economic, human or social capital valued at today's prices. (United Nations Economic Commission for Europe (2013), p. 52). Moreover, the GS is based on a model of dynamic optimization problem that relies on strong assumptions that can hardly be considered realistic (because of market failures, imperfect information, absence of externalities and so on and so forth). Due to these problems, the GS has been criticized: whenever it assumes positive values, it still can be that the country mismanages its resources in a way that the model is not able to capture. Despite this limit (shared by several synthetic indicators see Pillarisetti and van den Bergh (2010)), it is important to notice that to have a negative GS surely means to fail a test of weak sustainability; a declining wealth, whatever its composition, makes the current level of well-being unequivocally unsustainable in the future. Then, the GS is particularly helpful in detecting development paths that are clearly unsustainable, in a framework that is able to consider jointly economic and environmental aspect; it is able to simplify the complexity of these interactions in a synthetic measure easy to understand for policy makers and broader audience. Therefore, despite its shortcomings, the GS has desirable charachteristics as a sustainability indicator, that makes it prominent and largely used in economic literature.

Several contributions try to extend both the theoretical model and the empirical specification of the GS indicator. Pezzey and Burke (2014) include the cost of the population growth, the technical progress and an higher precautionary cost for CO2 emissions with respect to the methodology applied by the World Bank. Similarly Pezzey et al. (2006) extend the GS, including technical progress and changing oil prices to provide estimates for Scotland over the period 1992-1999. Ferreira and Moro (2011) extend the empirical specification of the World Bank to include, among others, NOx (nitrogen oxides) and SOx (sulphur oxides) emissions and their external costs. GS estimates based on national statistics are provided for France (Nourry, 2008), Portugal (Mota et al., 2010) and Sweden (Lindmark and Acar, 2013). Moreover, the use of GS indicator is widespread in literature and its use go beyond the need to evaluate the performance of specific countries or territory. Uwasu and Yabar (2011), for example, analyse averages, trend and stability of GS for 84 countries from 1981 to 2005 to investigate the impact of institutions, resources and wealth accumulation in a sustainability perspective. Additionally, You (2011) uses the World Bank estimates of the GS to evaluate the role of China's energy consumption on the sustainability of its economic growth. Other scholars test the accuracy of the GS in explaining or predicting welfare changes. Gnègnè (2009) finds a significant and positive (though weak) relationship between GS and Infant Mortality Rate and Human Development Index. Greasley et al. (2014) provide a test of the ability of GS to predict changes in future well-being over the long run (more than 100 years) in Britain. Another strand of literature focuses on this indicator to explain its relationship with the resource curse. Boos and Holm-Müller (2013) analyse the determinants of GS performance, claiming that a reduction of GS rate can be an early warning of a resource curse problem, even if RC phenomenon have not yet completely displayed itself. Some scholars provide estimates of GS at a sub-national or regional level, that is a lower territorial level with respect to WB estimates (see Hanley et al. (1999) for Scotland, Brown et al. (2005) for Queensland): this is relevant for resource intensive economies, since the eventual unsustainability of resource managment in subnational areas may have implication for the sustainability of the country as a whole. This paper contributes to this specific strand of GS literature.

3 Theoretical model

The theoretical framework of this sustainability measure is elaborated by Hamilton and Clemens (1999).

The theoretical model consider the maximization of a social welfare function including "standard" consumption, but also the value of natural asset of the economy. Through the theoretical model it is demonstrated that the GS indicator is equal to the present value of the changes in utility, along the optimal growth path. As a consequence, "If Genuine Saving is negative at a point in time on the optimal path, then utility at some point in the future must be less than current utility – that is, the path is unsustainable" (Hamilton and Atkinson, 2006). In that way, the GS indicator can be interpreted as a macroeconomic indicator of sustainability, able to consider the interaction between environmental and economic dimensions.

Consider a closed economy with fixed labour supply and a single resource to produce a good that can be consumed C, invested in the production of capital K (where $\dot{K}$ is the investment in physical capital) and human capital N (with investment m) or used to abate pollution e (at cost a).

The pollution stock X varies on the basis of pollution emission h, (with h=$h(F,a)$, namely, emissions are a function of the production function F and of abatement cost a), and d, the natural absorptive capacity of the environment.

Resource stock S grows at rate g and shrinks depending on the resource use rate, or resource depletion R. The utility function U has, in its arguments, both consumption C and environmental services B, with the latter negatively related to pollution stock. There is a rate of time preference, r. The wealth W, defined to be the present value of utility on the optimal path, is maximized subject to constraints as follow:

$$maxW = \int_t^\infty U(C,B)e^{-rs}ds \tag{1}$$

$$\dot{K} = F - C - m - a \tag{2}$$

$$\dot{X} = e - d \tag{3}$$

$$\dot{S} = -R + g \tag{4}$$

$$\dot{N} = q(m) \tag{5}$$

The dynamic problem can be solved deriving the current value Hamiltonian function H, maximized at each point in time

$$H = U + \sum \gamma_i N_i \tag{6}$$

with N representing the assets and γ_i the shadow price in utils for each of them. Defining the shadow prices in consumption units (dividing γ_i for marginal utility in consumption)

$$p_i = \frac{\gamma_i}{U_C} \tag{7}$$

we finally get that the GS can be defined as equal to the net investment valued at shadow prices

$$G = \sum p_i \dot{N}_i \tag{8}$$

and

$$H = U + U_C G \tag{9}$$

Thus, "the Hamiltonian may be described as the utility prospect for the economy, since it combines both current utility and the contributions to future utility from current investment" (Hamilton and Atkinson, 2006). Moreover, it can be demonstrated that it exist a direct link between the Hamiltonian function and util denominated welfare, so that

$$U_C G = \dot{V} \tag{10}$$

Then, the GS can be defined as equal to the change in social welfare V divided by the marginal utility of consumption. From the theoretical model it derives that, according to this measure, if an economy shows a negative GS at a given point in time, then somewhere in the future utility will be lower than in the current period. In other words, the economy is on a unsustainable path.

It is important to notice that an economy may sustain its own development on the import of natural resources from other territories; then, it may be misleading to impute natural resource depletion without considering this aspect, especially when a subnational analysis is carried out: regions has to be considered in interaction among them since they are part of a larger economy. To deal with this problem, we applied to our regional case study an input-output framework elaborated by Hamilton and Atkinson (2006), to calculate an "ecological balance of payments" accounting for flows of resources between countries. The main aim of this model is to compute the direct and indirect resource use for each territory, encompassing the resource depletion needed to sustain final demand. We use this framework to calculate an "ecological balance of payment" among italian regions, considering flows of interregional trade. Defining x_{ij} as the net exports of region i to region j, and y_j as GDP for region j, we can define a (k x k) **Q** matrix where

$$q_{ij} = \begin{bmatrix} \dfrac{x_{ij}}{y_j} & i \neq j \\ \dfrac{-\sum_k x_{kj}}{y_j} & i = j \end{bmatrix}$$

Q is a squared matrix, with diagonal elements equal to the negative sum of import coefficient from other regions. Let y the (k x 1) vector of regional GDPs. We can write:

$$Qy + (c + v) = y \tag{11}$$

where c is the vector of regional final consumptions and v is the vector of regional investments. With few simple rearrangements we get

$$y = (I - Q)^{-1}(c + v) \tag{12}$$

where I is the identity matrix Let n the (k x 1) vector of regional resource depletion indexes, expressed as the ratio of regional rents from the exploitation of non-renewable natural resources (r_i) over regional GDPs:

$$n_i = \frac{r_i}{y_i}$$

According to equation (12) we can calculate the values of depletions required to support regional productions as follows:

$$d = \hat{n}(I - Q)^{-1}(c + v) \tag{13}$$

where the symbol ˆ indicates the vector diagonalization. Depletion values can be also reclassified among regions according to final demand:

$$d^{*} = n(I - Q)^{-1}\widehat{(c + v)} \tag{14}$$

The k elements of vector d^{*} are the values of resources required to support final demand of regions. As a consequence the differencecan be defined as an "ecological" balance of region i with the rest of the country, i.e. the difference between the value of resources *exploited* and resources directly and indirectly (through interregional trade) *consumed* by region i according to the level of final demand. In our estimates of regional GS we will use the vector d^{*} to correct the energy depletion component of the indicator, imputing to each region the actual level of energy resource depletion directly and indirectly generated by its consumptions.

4 Methodology and Data

Following the approach Atkinson et al. (2007), GS estimates can be defined as:

Genuine Saving:
Gross National Savings
- Capital depreciation (consumption of Fixed capital)
+ Education Expenditure
- Depletion of Energy Resources
- Depletion of Minerals
- Net Depletion of Forest
- CO2 Damages
- PM Damages

Basically, it is given by the variation of produced and human capital, less the value of natural capital consumed or destroyed through pollution. For our estimates we follow the World Bank methodology in order to calculate the Adjusted Net Savings (Bolt et al., 2002). When needed, appropriate modifications are implemented to reflect the regional equivalent of the data.

4.1 Gross savings , physical capital and education expenditures

According to the WB methodology, Gross national saving is calculated as the difference between GNI (Gross National Income) and public and private consumption plus net current transfers.

For our purposes, Regional Accounts data provided by Istat are used (ISTAT, 2012). These data are fully consistent with the European System of Accounts. Unluckily, Istat does not provide data on Gross savings and on Capital Consumption on a regional basis: then we estimate this aggregates through indirect methods.

We compute time series of gross savings and capital depreciation following the method elaborated by Bronzini et al. (2013) to calculate the Capital stock for industry for two Italian Macro-regions (Center-North and South). Consider i= region, t = year, and s= sector, the method used consists of three steps:

- Calculate $K_{i,1995,s}$, the regional gross capital stock by region and sector in a base year (1995), as the cumulative sum of investments by sector ad region from 1980 to 1995, Istat data;
- Calculate the ratio of $K_{(i,1995,s)}/ K_{(ITA,1995,s)}$, namely the regional quota of national gross capital stock;
- Under the hypothesis that, for every year, the ratio between capital consumed and new investments is regionally invariant ($R_{(i,t,s)}/I_{(i,t,s)} \simeq R_{(ITA,t,s)}/I_{(ITA,t,s)}$), the value of Capital Consumed R for every Region i, year t and sector s can be calculated as

$$R_{(i,t,s)} = R_{(ITA,t,s)} * (I_{(i,t,s)}/I_{(ITA,t,s)}) \tag{15}$$

The same methodology is used to estimate Capital Consumption and Net savings at the regional level, using Istat data on investment at the regional level, capital stock and capital depreciation at the national level (accordingly with Nace Rev. 2 classification of economic activities). Since we detect a strong correlation between Net savings and Net investment in national data, the estimate of Net Savings is based on this information: we estimate the net investment series for each region; then we disaggregate the national net savings at the regional level using the ratio (Total regional net investment)/ (Total national net investment). In this way, we are able to estimate regional time series considering the regional variation in economic structure of each specific region.

For what concerns education expenditures, the World Bank considers current public expenditure in education as a proxy of human capital formation. Regional Accounts provided by Istat collect Public expenditure for a large class of Functions according to Cofog classification (Classification Of Function Of Government), including Education Expenditure.

4.2 Natural capital: Depletion and Pollution Damages

Moving to Energy Depletion, this component of GS estimated by WB is calculated on the basis of Rents from Oil and Natural Gas extraction, where:

Rent = (Production Volume) x (International Market Price – Average Unit Production Cost)

In lack of specific data on unit production cost disaggregated on a regional basis, the Unit Rent Value in current dollars calculated by World Bank is used for our estimate. Data on regional production volumes are provided by the General Directorate for Energetic Resources of the Italian Ministry of Economic Development. For offshore oil and gas production, the data provided are disaggregated on the basis of 5 offshore marine zones (Zone A, B, C , D , F). In that cases, for each concession, the production volumes are imputed to Regions on the basis of geographic location. Then, the total value calculated is converted to obtain the Energy Depletion in current Euros.

For what concerns Mineral Depletion, the whole data computed by the World Bank for Italy is imputed to Sardinia, the only region, in the period under consideration, with extractive licenses for mineral extraction of the metals included in the GS component (tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate). Also in that case, data are converted in current Euro.

Rent from Net Forest Depletion are excluded from the estimate of GS at the Regional Level. In fact, the value of this component for Italy estimated by WB is equal to zero for the whole period considered.

To calculate the component of CO2 damage, we use the data estimated by ENEA (2010). The methodology used is based on the regional energy balances data (BER), available in the Regional Energy Informative System (SIER), which are combined with the emission factors. The outcome is an estimate of Carbon dioxide amount for each region from 1990 until 2006, and includes a comprehensive set of sectors (energy, industry, transports, residential and services, agriculture and fishing) responsible for CO2 emission. Then, consistently with WB methodology, we attibute a damage of 20 US$ per tonne emitted (Frankhauser, 1994).

Finally, according to the methodology adopted in the calculation of the World Development Indicators, PM Damage is estimated as the Willingness to Pay (WTP) to avoid mortality and morbidity attributable to particulate emissions. However, neither the data on WTP used, nor the dimension of health damage or the actual and counterfactual concentration used to calculate it, nor the list of health endpoints considered is provided. Due to this missing information, the strategy adopted to end up with an estimate consistent with the WB methodology is the following: for each year, the PM damage in current US$ is imputed to regions on the basis of regional contribution to national PM emissions. This choice is justified by the fact that PM damages are mainly related to health damages. Therefore, they are highly localised in the specific area of emissions. The data on PM emission are provided by De Lauretis et al. (2009) that apportioned at the provincial and regional level (NUTS2 and NUTS3) pollutants and greenhouse gases emissions' estimates from the National Emission CORINAIR Inventory. Unfortunately, the data are provided only for 1990, 1995, 2000 and 2005. Then our estimates of GS including PM Damage is limited to the aforementioned years.

The variables considered and data source used for the quantification of each components are presented in Table A.

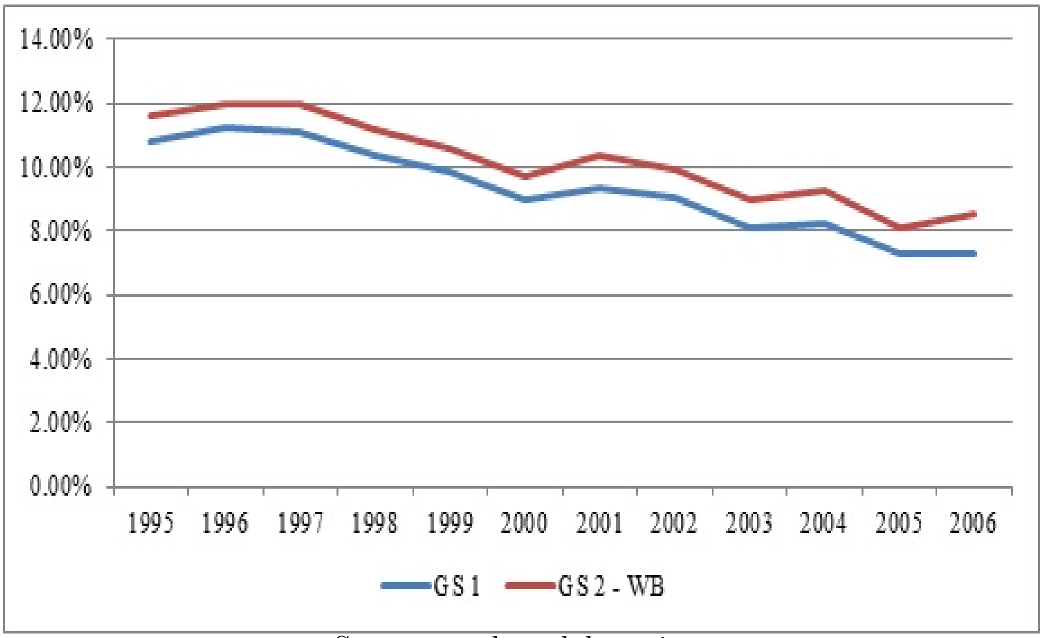
4.3 Ecological balance of payments

To account for direct and indirect resource use of each territory, encompassing the resource depletion needed to sustain final demand, we use data on interregional trade flows for year 2008 provided by IRPET (Istituto Regionale per la Programmazione Economica della Toscana). Obviously, we are aware that a large part of extractive resources consumed in Italy are imported from other countries; however, our aim is to reflect the relationship between regions in terms of sustainable management of domestic national resources, recalculating the GS component considering the direct and indirect consumption of such resources by each region. Then, we exclude the rest of the world from our accounting framework.

5 Results and discussion

For each component of GS, we calculate the level in current euros and the percentage over regional GDP. Figure 1 shows a comparison between our estimates of GS for the whole country (GS 1) and the estimates provided by the World Bank (GS 2 – WB). In general, Italy do not fail this test of

Figure 1: GS estimates for Italy, excluding PM damage (1995-2006)



Source: author elaboration.

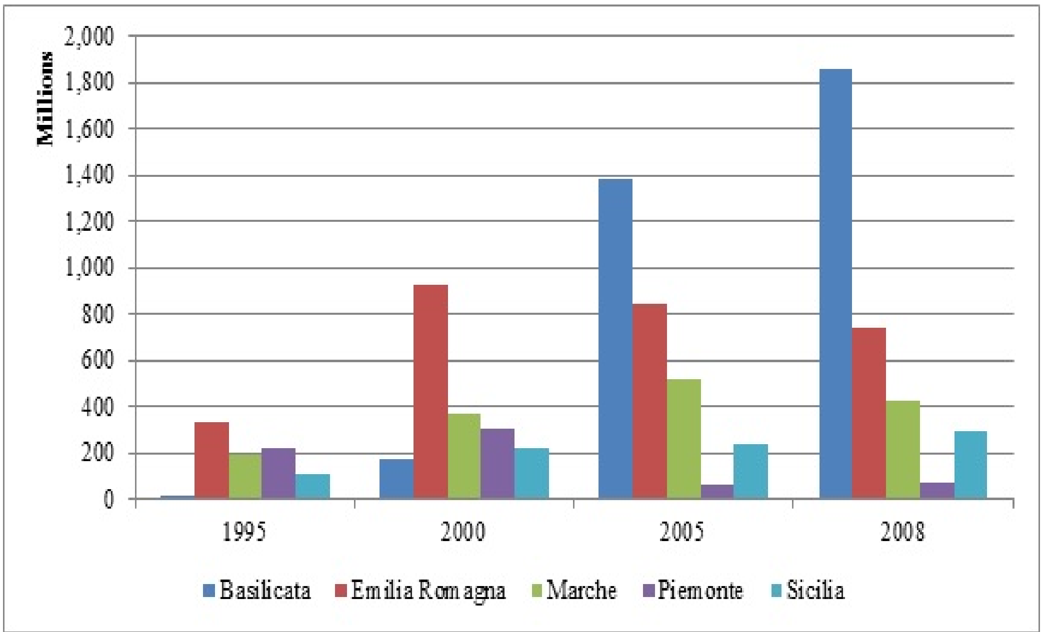
weak sustainability at the aggregate level. The differences among the two measure are modest in terms of magnitude[1]. Moreover, there are not relevant divergences in trends. Despite some differences in methodology and data, our results at the national level seems to be consistent enough with WB results, so that an analysis of the indicator at the regional level can be carried out.

Table 1 shows the level of Net regional savings as a percentage of Regional GDP. Obviously the distribution of savings is affected by the different level of development and economic performance of the regions, with a higher incidence of Northern area. Aside from the regional variation, it is worth noting a general reduction in the level of savings for all regions over the period considered. The trend of this aggregate explains the general reduction in the GS level for the whole country. Similar considerations can be made for what concerns the variable "Education". However, in this case, the southern regions are those that more intensively invest in human capital formation (Table 2), according to Istat data.

Figure 2 and Table 3 show the estimates for Mineral and Energy Depletion. The degree of consumption of natural assets in this case is considerably

[1]This difference may be related to the lack of net foreign current transfers in our estimates; on the contrary, this aggregate is included in the WB estimates. Unfortunately, data and information disaggregated at the regional level are not available.

Figure 2: Mineral and Energy Depletion in current euros for main regions of production



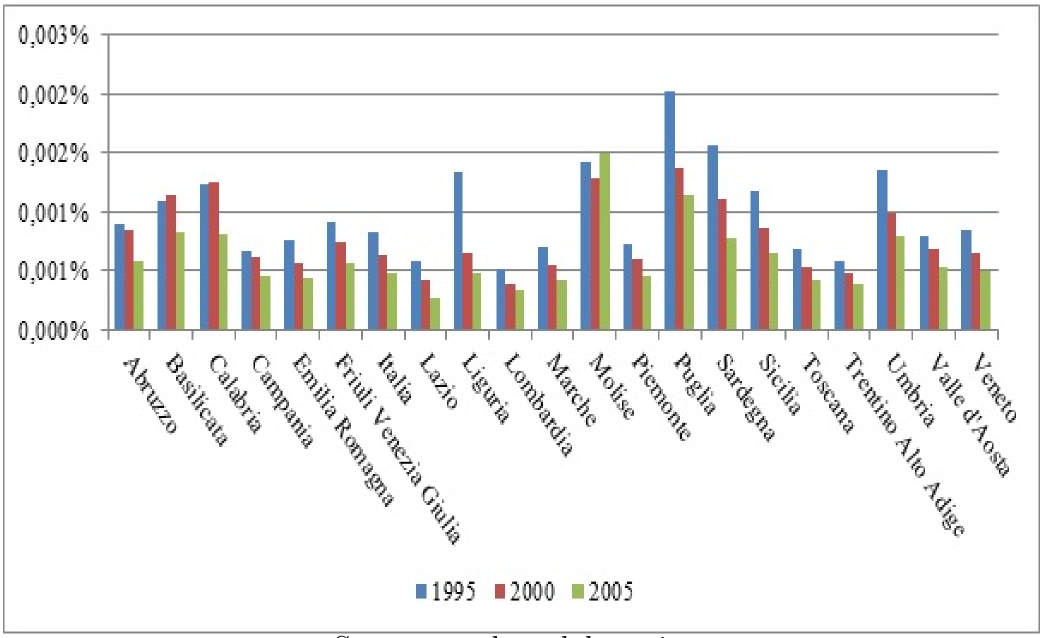
Source: author elaboration.

variable, both along temporal and spatial dimension. In general, the value for END (Energy Depletion) is quite low. In fact, Italy is certainly not a resource rich economy (the average value of energy depletion is 0,18%, with a weak upward trend in the period considered). Nonetheless, the variation between regions is particularly wide in that respect: the contribution of regions to the production of energetic resource changes considerably over the period in analysis (Figure 2).

Interestingly, Basilicata is well above the national level: the average Mineral and Energy Depletion is more than 6% of Regional GDP. In 2008 it goes above the 17% of GDP, signalling that this region heavily relies on the exploitation of its natural assets for its economic development. The increase in this region drives the national average also, with a positive trend of about 1.6%. It is worth noting that the region experimented a sharp increase of energy depletion between 2003 and 2004, because of the considerable increase in production volumes. However, the data at the national level are not able to shed light on this dynamic that, instead, has important implication on local and national sustainability, as we will see later on.

Coherently with the WB procedure, we included in our estimates also the impact of pollution damage, limited to CO_2 (Table 4) and PM damages

Figure 3: PM damage as percentage of regional GDP

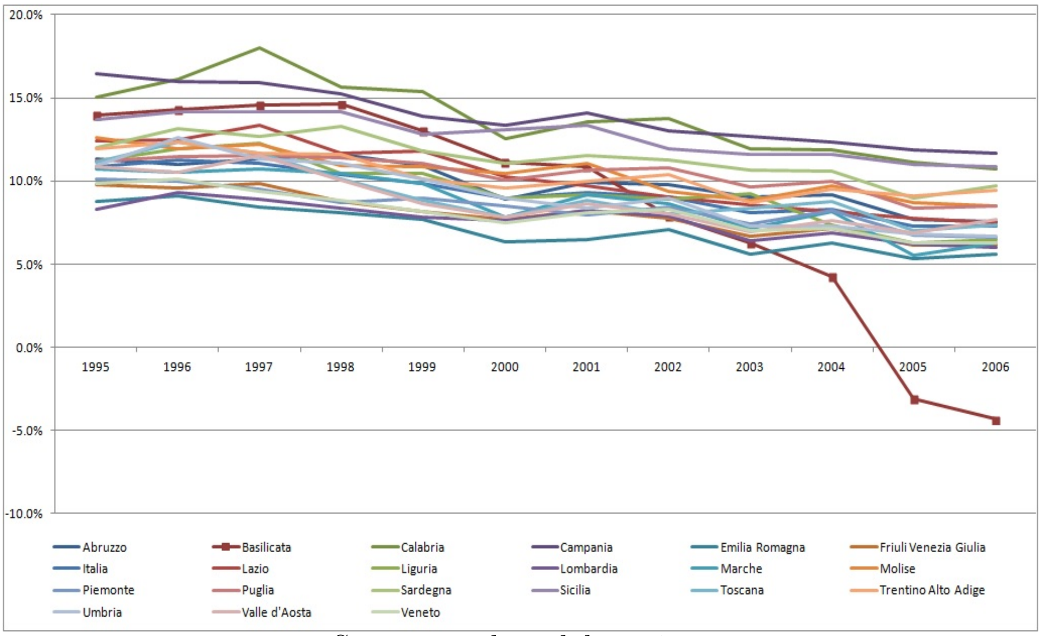


Source: author elaboration.

(only for 1995, 2000 and 2005; see Figure 3). In both cases the region with highest volume of damage is Lombardia (with an average of 1,296 millions of euro of CO2 damage and 966 millions for PM Damage in the period considered). However, Puglia region has the highest percentage of pollution damage relative to its Regional GDP; it is the second region for volume of damage relative to pollution. This dynamic is strongly related to the presence of several highly polluting plants in that region (steel plant, coal power plants ecc.). However, the incidence of Pollution Damage over the GS is modest compared to the other components: for each pollutant, the average for Italy is well below 1% of GDP; as concernings regional data, also in the worst cases, the damage in monetary terms remain below the 2%.

Finally, we calculate the GS rate for all regions, including (Table 5) and excluding (Table 6) the PM damage. The time trend is quite stable for all the regions considered. There are not dramatic differences among territories: in general, the values fluctuate from 12% to 6%, with a general reduction that characterize all areas. This worsening is driven by the decreasing in the economic aggregates of the indicator (i.e. savings) more than by the decumulation of natural assets. Nonetheless, there is one considerable exception: the case of Basilicata. This region shows a fast, sensible and stable worsening of its GS level from 1999, with values increasingly below zero from

Figure 4: GS excluding PM damage



Source: author elaboration.

2004 (Figure 4). This region is increasingly using the natural assets in its territory, without reinvesting adequately to cope with its natural capital exploitation. Then, it is strongly decumulating its wealth, and it is, according to our measure, along an unsustainable path of development.

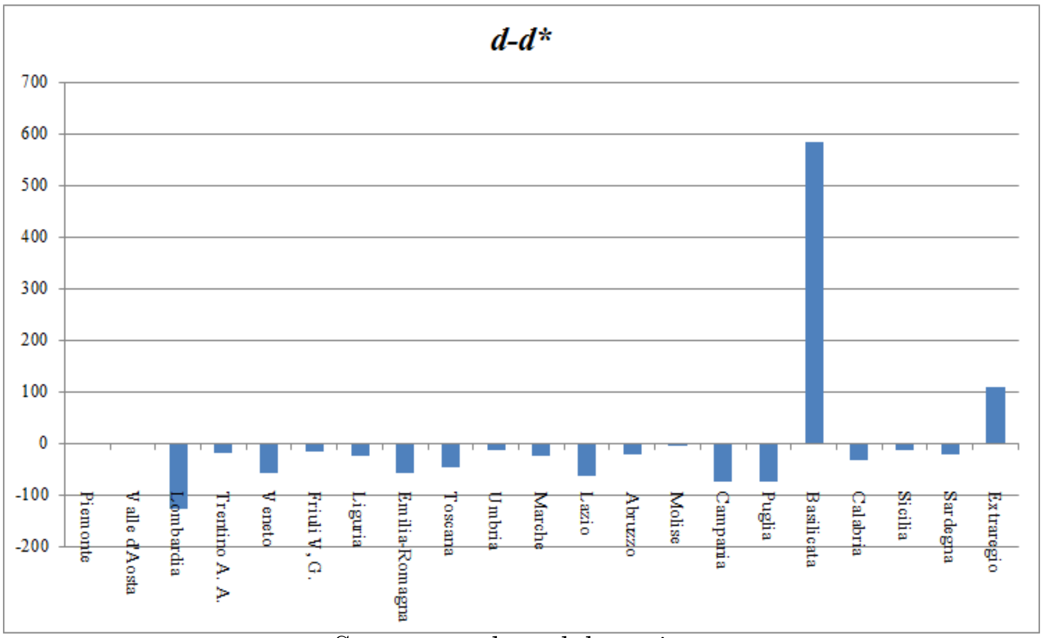
Due to the (relatively) modest impact of PM Damage on the sustainability of Italian regions, similar consideration can be made taking into account GS data that include this component.

As previously mentioned, the analysis is completed by considering an "ecological balance of payment" among regions, to correct the GS value for the amount of natural resources actually depleted by each of these regional economies. As expected, Figure 5 shows a positive balance for Basilicata, that is the only net exporter of resources towards the rest of the economy. More interestingly, considering d^* as the value of natural resource *actually consumed* in that territory, the Energy depletion component for this region falls from 17.02% in 2008 (Table 4) to 9.2%. Consequently, the value of GS calculated for that region rises from -9% to -1.2%[2].

According to this measure, Basilicata is still on an unsustainable (but less concerning) path of development.

[2]In lack of specific data, we use the average of CO2 Damage in Basilicata over the period considered to calculate the approximate value of GS with the d^*-level of consumption.

Figure 5: Ecological balance of payments among Italian regions (2008)



Source: author elaboration.

6 Conclusions

A sustainable economy can be defined, in a weak sustainability framework, as an economy that is able to reproduce its wealth and sustain the present level of wealth in the future. According to this perspective, we evaluated the sustainability performance of italian regions. The choice to focus on the regional level is justified by the need to shed light on the interaction between different territorial level and to understand if the measurement at the aggregate level can effectively mask "territorial sacrifices" at the subnational one. Obviously, also the GS suffers from several shortcomings as a measure of sustainability (Pillarisetti, 2005). Specifically for our work, the quality of estimates at the regional level strongly depends on the quality of the data available to create regional aggregates. Surely, widen the pollutants list, the environmental matrix of pollution damages and the spectrum of natural assets considered in the analysis, would support a better representation for the specificity of sustainability in the territories analysed. However, the main results of this study shows that, according to the proposed measure, despite the fact that Italy as a whole does not fail the weak sustainability test of GS, at the subnational level there is a resource-rich territory, Basilicata, clearly over an unsustainable path of development. Interestingly, as we previously mentioned, the GS rate can be interpreted as an early warning of the so called "resource curse". In fact, according to the literature, the resource boom and the heavy exploitation of natural assets are very often associated with a slowing growth rate and stagnation (Percoco (2012); Iacono (2015); Rocchi et al. (2015)). An oil-led development model for this resource rich and underdeveloped region in the south of Italy could hide a trap more than an opportunity, and deserves further research.

Table 1: Net National Savings as a percentage of regional GDP

Region	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Average
Abruzzo	7.09	6.84	7.08	6.95	6.53	5.20	5.97	5.60	4.86	5.24	3.51	3.62	3.86	1.79	5.71
Basilicata	6.88	7.28	7.89	7.70	6.52	5.95	5.72	5.42	4.86	4.58	3.64	3.97	3.44	1.40	5.87
Calabria	7.01	7.74	9.51	7.02	6.99	4.97	5.83	5.75	4.14	4.73	4.13	3.78	3.96	2.11	5.97
Campania	9.02	8.17	8.16	7.66	6.38	5.69	6.34	5.53	4.88	5.13	4.38	4.38	4.73	1.58	6.31
Emilia Romagna	7.06	7.43	6.94	6.48	6.09	5.42	5.35	5.58	4.06	4.73	3.81	3.91	4.08	1.65	5.57
Friuli V. G.	7.29	7.11	7.66	6.59	5.87	5.57	6.16	5.55	4.22	4.66	3.60	3.57	4.09	1.73	5.65
Italia	7.49	7.81	7.72	7.00	6.45	5.88	6.15	5.80	4.68	5.06	3.99	4.00	4.31	1.81	6.00
Lazio	8.86	8.84	9.86	8.26	8.48	7.15	6.65	6.03	5.36	5.02	4.49	4.34	4.75	1.80	6.94
Liguria	9.07	9.66	10.18	8.41	8.25	6.91	7.15	6.74	6.79	4.94	3.73	3.86	4.60	1.97	7.14
Lombardia	6.26	7.22	6.82	6.35	5.72	5.69	6.23	5.83	4.20	4.81	3.97	3.83	4.39	1.73	5.58
Marche	8.16	8.12	8.14	7.71	6.99	5.78	7.01	6.11	4.72	5.92	3.49	3.99	4.82	1.51	6.34
Molise	7.28	6.48	6.74	5.76	5.68	5.70	6.09	4.19	3.49	4.90	3.69	4.04	3.96	1.31	5.34
Piemonte	7.89	7.74	7.32	6.30	6.68	6.38	5.66	5.89	4.71	5.44	3.95	3.79	3.72	1.96	5.98
Puglia	6.26	6.29	6.44	6.40	6.09	5.30	5.68	5.69	4.19	4.89	3.17	3.45	3.67	2.55	5.32
Sardegna	6.38	7.12	7.04	7.54	6.17	5.59	5.93	5.53	4.86	5.45	3.78	4.45	4.87	1.58	5.82
Sicilia	7.09	7.32	7.30	7.18	5.81	6.38	6.55	5.15	4.55	5.21	4.15	4.22	4.32	1.58	5.91
Toscana	8.31	9.37	8.75	7.38	6.16	5.28	6.21	5.41	5.45	5.95	4.10	4.49	4.78	1.75	6.40
Trentino A. A.	8.15	8.56	8.10	8.17	6.49	6.49	6.86	7.11	5.38	6.00	5.22	5.18	4.88	1.99	6.81
Umbria	7.38	8.86	7.82	7.47	6.61	5.87	5.33	5.70	3.83	4.04	3.34	3.35	3.71	2.66	5.80
Valle d'Aosta	5.29	4.96	5.56	4.86	3.60	3.92	4.95	4.10	3.57	4.11	3.40	3.55	4.54	1.26	4.32
Veneto	7.90	8.00	7.39	6.84	6.31	5.65	6.19	6.23	4.73	4.93	3.94	3.89	4.04	1.92	6.00

Source: author elaboration.

Table 2: Education Expenditure as a percentage of regional GDP

Region	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Average
Abruzzo	5.16	5.31	5.43	5.44	5.29	5.20	5.24	5.29	5.41	5.23	5.20	4.99	5.00	4.62	5.15
Basilicata	7.87	8.31	8.31	8.08	7.95	7.94	8.22	7.93	8.14	7.51	7.83	7.41	7.35	7.02	7.74
Calabria	9.23	9.67	9.70	9.65	9.28	9.08	9.16	9.06	9.02	8.19	8.29	8.08	7.98	7.81	8.68
Campania	7.82	8.18	8.15	8.01	7.96	8.14	8.21	7.92	8.13	7.54	7.78	7.55	7.46	7.08	7.75
Emilia Romagna	2.75	2.83	2.74	2.67	2.62	2.49	2.55	2.60	2.68	2.55	2.71	2.67	2.66	2.55	2.67
Friuli V. G.	3.29	3.26	3.13	3.15	3.13	3.08	3.07	3.11	3.28	3.12	3.18	3.19	3.23	3.17	3.18
Italia	4.14	4.26	4.24	4.20	4.19	4.11	4.15	4.13	4.20	3.97	4.09	4.01	4.00	3.85	4.11
Lazio	4.11	4.20	4.07	4.02	3.98	3.82	3.73	3.63	3.72	3.53	3.64	3.53	3.50	3.38	3.78
Liguria	3.50	3.43	3.32	3.29	3.33	3.24	3.24	3.29	3.32	3.25	3.26	3.27	3.22	3.12	3.28
Lombardia	2.54	2.58	2.60	2.59	2.72	2.53	2.58	2.59	2.64	2.52	2.62	2.58	2.60	2.47	2.61
Marche	3.76	3.87	3.88	3.82	3.76	3.81	3.85	3.77	3.94	3.73	3.81	3.80	3.77	3.64	3.81
Molise	6.20	6.30	6.26	6.04	6.15	6.03	6.14	6.13	6.29	5.81	5.85	5.60	5.48	5.34	5.89
Piemonte	2.96	3.10	3.08	3.12	3.09	3.09	3.14	3.21	3.25	3.21	3.26	3.25	3.27	3.21	3.18
Puglia	6.58	6.82	7.05	6.82	6.72	6.84	7.02	6.94	7.08	6.56	6.78	6.54	6.58	6.38	6.69
Sardegna	6.93	7.16	6.93	6.95	6.85	6.82	6.87	6.76	6.72	6.07	6.05	6.08	5.94	5.56	6.43
Sicilia	7.77	8.02	8.13	8.10	8.17	8.21	8.19	8.06	8.15	7.63	7.78	7.48	7.50	7.21	7.75
Toscana	3.59	3.71	3.71	3.67	3.51	3.41	3.50	3.45	3.55	3.36	3.49	3.36	3.37	3.24	3.50
Trentino A. A.	4.22	4.17	4.02	3.86	4.08	3.62	3.62	3.74	3.68	3.86	4.23	4.63	4.75	4.79	4.11
Umbria	4.29	4.52	4.33	4.39	4.27	4.08	4.01	4.13	4.28	3.97	4.21	4.03	4.16	3.97	4.18
Valle d'Aosta	6.12	6.02	6.51	5.72	5.56	4.58	4.27	4.59	3.92	4.01	4.19	4.72	4.76	5.25	5.00
Veneto	2.67	2.78	2.72	2.71	2.66	2.69	2.75	2.81	2.86	2.70	2.82	2.79	2.83	2.75	2.77

Source: author elaboration.

Table 3: Energy and Mineral Depletion as a percentage of regional GDP

Region	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Average
Abruzzo	0.46	0.71	0.62	0.27	0.32	0.85	0.63	0.54	0.66	0.82	0.59	0.63	0.68	0.83	0.62
Basilicata	0.27	0.80	1.04	0.54	0.68	1.97	2.36	4.72	6.11	7.22	14.03	15.20	14.75	17.02	6.65
Calabria	0.49	0.62	0.58	0.38	0.28	0.80	0.69	0.45	0.63	0.60	0.83	0.65	0.46	0.57	0.57
Campania	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emilia Romagna	0.41	0.55	0.59	0.43	0.35	0.87	0.74	0.39	0.53	0.43	0.66	0.45	0.41	0.53	0.52
Friuli V. G.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Italia	0.12	0.16	0.16	0.10	0.09	0.22	0.19	0.14	0.17	0.18	0.25	0.23	0.21	0.25	0.18
Lazio	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Liguria	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lombardia	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marche	0.79	0.98	0.76	0.50	0.41	1.20	1.14	0.70	1.10	1.08	1.36	1.16	0.93	1.03	0.94
Molise	0.25	0.28	0.15	0.15	0.17	0.41	0.39	0.19	0.31	0.41	0.27	0.39	0.33	0.43	0.29
Piemonte	0.27	0.37	0.40	0.18	0.19	0.31	0.19	0.12	0.06	0.01	0.05	0.04	0.03	0.06	0.16
Puglia	0.07	0.15	0.13	0.15	0.18	0.27	0.29	0.22	0.18	0.12	0.16	0.09	0.08	0.12	0.16
Sardegna	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sicilia	0.19	0.23	0.21	0.11	0.11	0.33	0.24	0.25	0.26	0.53	0.30	0.27	0.36	0.33	0.27
Toscana	0.00	0.0003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trentino A. A.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Umbria	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Valle d'Aosta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Veneto	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: author elaboration.

Table 4: CO2 Damage as percentage of regional GDP

Region	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
Abruzzo	0.47	0.47	0.53	0.55	0.58	0.65	0.66	0.60	0.58	0.50	0.44	0.44	0.54
Basilicata	0.51	0.52	0.62	0.62	0.75	0.77	0.72	0.75	0.62	0.60	0.52	0.52	0.63
Calabria	0.68	0.67	0.64	0.65	0.61	0.69	0.72	0.62	0.58	0.46	0.45	0.46	0.60
Campania	0.40	0.39	0.42	0.40	0.44	0.49	0.47	0.43	0.36	0.32	0.31	0.29	0.39
Emilia Romagna	0.64	0.62	0.65	0.61	0.64	0.72	0.70	0.68	0.63	0.58	0.55	0.49	0.63
Friuli V. G.	0.79	0.82	0.98	1.00	0.80	0.95	1.00	0.91	0.81	0.66	0.64	0.61	0.83
Italia	0.69	0.66	0.72	0.72	0.73	0.80	0.79	0.71	0.61	0.54	0.52	0.50	0.66
Lazio	0.57	0.57	0.60	0.59	0.66	0.71	0.68	0.64	0.53	0.41	0.40	0.36	0.56
Liguria	1.38	1.16	1.25	1.26	1.13	1.18	1.22	1.11	0.88	0.81	0.74	0.66	1.07
Lombardia	0.53	0.52	0.53	0.54	0.59	0.61	0.60	0.52	0.45	0.41	0.41	0.41	0.51
Marche	0.43	0.46	0.51	0.54	0.52	0.57	0.53	0.53	0.43	0.39	0.43	0.36	0.47
Molise	0.62	0.56	0.64	0.76	0.79	0.85	0.76	0.77	0.63	0.61	0.58	0.75	0.69
Piemonte	0.47	0.47	0.52	0.57	0.60	0.66	0.65	0.57	0.49	0.43	0.44	0.41	0.52
Puglia	1.56	1.48	1.80	1.67	1.61	1.79	1.76	1.61	1.43	1.37	1.41	1.40	1.58
Sardegna	1.28	1.15	1.30	1.19	1.22	1.35	1.25	1.04	0.95	0.93	0.85	0.84	1.11
Sicilia	0.98	0.94	1.02	1.02	1.03	1.18	1.16	1.04	0.86	0.69	0.63	0.58	0.93
Toscana	0.80	0.73	0.80	0.90	0.81	0.90	0.88	0.80	0.65	0.58	0.56	0.53	0.74
Trentino A. A.	0.42	0.41	0.46	0.45	0.47	0.51	0.50	0.44	0.37	0.34	0.34	0.34	0.42
Umbria	0.75	0.77	0.82	0.83	0.79	0.96	0.95	0.86	0.83	0.75	0.72	0.68	0.81
Valle d'Aosta	0.58	0.49	0.56	0.55	0.56	0.64	0.63	0.64	0.52	0.52	0.72	0.61	0.59
Veneto	0.73	0.68	0.71	0.75	0.77	0.83	0.83	0.77	0.60	0.51	0.46	0.43	0.67

Source: author elaboration.

Table 5: GS as percentage of regional GDP

Region	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
Abruzzo	11.3	11.0	11.4	11.6	10.9	8.9	9.9	9.8	9.0	9.2	7.7	7.6	9.84
Basilicata	14.0	14.3	14.5	14.6	13.0	11.2	10.8	7.9	6.3	4.3	-3.1	-4.3	8.09
Calabria	15.1	16.1	18.0	15.6	15.4	12.6	13.6	13.7	12.0	11.9	11.1	10.7	13.81
Campania	16.4	16.0	15.9	15.3	13.9	13.3	14.1	13.0	12.6	12.4	11.8	11.6	13.87
Emilia Romagna	8.8	9.1	8.4	8.1	7.7	6.3	6.5	7.1	5.6	6.3	5.3	5.6	7.07
Friuli V. G.	9.8	9.5	9.8	8.7	8.2	7.7	8.2	7.7	6.7	7.1	6.1	6.1	7.99
Italia	**10.83**	**11.25**	**11.09**	**10.39**	**9.82**	**8.97**	**9.33**	**9.07**	**8.10**	**8.31**	**7.31**	**7.29**	**9.31**
Lazio	12.4	12.5	13.3	11.7	11.8	10.3	9.7	9.0	8.5	8.1	7.7	7.5	10.22
Liguria	11.2	11.9	12.2	10.4	10.4	9.0	9.2	8.9	9.2	7.4	6.3	6.5	9.39
Lombardia	8.3	9.3	8.9	8.4	7.8	7.6	8.2	7.9	6.4	6.9	6.2	6.0	7.65
Marche	10.7	10.5	10.7	10.5	9.8	7.8	9.2	8.6	7.1	8.2	5.5	6.3	8.75
Molise	12.6	11.9	12.2	10.9	10.9	10.5	11.1	9.4	8.8	9.7	8.7	8.5	10.43
Piemonte	10.1	10.0	9.5	8.7	9.0	8.5	8.0	8.4	7.4	8.2	6.7	6.6	8.42
Puglia	11.2	11.5	11.6	11.4	11.0	10.1	10.7	10.8	9.7	10.0	8.4	8.5	10.39
Sardegna	12.0	13.1	12.7	13.3	11.8	11.1	11.5	11.3	10.6	10.6	9.0	9.7	11.39
Sicilia	13.7	14.2	14.2	14.1	12.8	13.1	13.3	11.9	11.6	11.6	11.0	10.8	12.70
Toscana	11.1	12.4	11.7	10.1	8.9	7.8	8.8	8.1	8.4	8.7	7.0	7.3	9.19
Trentino A. A.	11.9	12.3	11.7	11.6	10.1	9.6	10.0	10.4	8.7	9.5	9.1	9.5	10.37
Umbria	10.9	12.6	11.3	11.0	10.1	9.0	8.4	9.0	7.3	7.3	6.8	6.7	9.20
Valle d'Aosta	10.8	10.5	11.5	10.0	8.6	7.9	8.6	8.1	7.0	7.6	6.9	7.7	8.75
Veneto	9.8	10.1	9.4	8.8	8.2	7.5	8.1	8.3	7.0	7.1	6.3	6.3	8.07

Source: author elaboration.

Table 6: GS including PM Damage as percentage of regional GDP

Region	1995	2000	2005
Abruzzo	10.41	8.06	7.08
Basilicata	12.87	10.02	-3.91
Calabria	13.83	11.30	10.33
Campania	15.77	12.71	11.39
Emilia Romagna	8.00	5.76	4.85
Friuli V. G.	8.86	6.95	5.57
Italia	**10.00**	**8.34**	**6.82**
Lazio	11.81	9.84	7.47
Liguria	9.86	8.32	5.78
Lombardia	7.75	7.20	5.84
Marche	9.99	7.27	5.09
Molise	11.19	9.20	7.19
Piemonte	9.39	7.89	6.25
Puglia	9.19	8.70	7.24
Sardegna	10.47	9.95	8.20
Sicilia	12.52	12.21	10.35
Toscana	10.40	7.26	6.60
Trentino A. A.	11.35	9.13	8.72
Umbria	9.58	8.00	6.03
Valle d'Aosta	10.05	7.16	6.34
Veneto	8.99	6.85	5.79

Source: author elaboration.

A GS estimates: method and data sources

Item	Definition	Formula	DATA
Gross national saving (GNS)	Difference between GNI and public and private consumption plus net current transfers.	Gross National Income less private and public consumption plus net current transfers	Istat, Regional Accounts (ISTAT, 2012)
Depreciation	Replacement value of capital used up in the process of production.	Estimated as a quota of National Consumption of fixed capital; for each region it is estimated as the sum of sectoral depreciation (calculated as the ratio between sectoral regional investment over total sectoral investment). The regional Gross capital stock is calculated as the sum of Gross Investment from 1980 to 1995, disaggregated on sectoral basis (Nace Rev 2). Then, for each sector, we calculated the ratio of capital consumption on the total of CC at the national basis and apply this ratio for every region, under the hypothesis that the quota of capital consumption on sectoral bases is regionally invariant. The stock is calculated as K(t)= K(t-1) - R(t) + I(t).	ISTAT (2010)
NNS Net national saving	**Difference between gross national saving and the consumption of fixed capital**		
Education expenditure	Public current operating expenditures in education, including wages and salaries and excluding capital investments in buildings and equipment.		Regional Accounts (ISTAT, 2010); Public expenditure in education (CoFoG classification) by region (Nuts 2) (ISTAT, 2010)

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Item	Definition	Formula	DATA
Energy depletion (END)	Ratio of present value (PV) of rents, discounted at 4%, to exhaustion time of the resource. Rent is calculated as the product of unit resource rents and the physical quantities of energy resources extracted. It covers coal, crude oil, and natural gas.	Rent = production volume x unit resource rent; unit rent is equal to unit price less unit cost of extraction	Unit rent data for Italy by WB (The World Bank, 2010). Data on Production volume by Ministry of Economic Development (Ministry of Economic Development, 2014); data of offshore extraction are imputed to the regions on the basis of geographic localization of platform.
Mineral depletion (MID)	Ratio of present value of rents, discounted at 4%, to exhaustion time of the resource. Rent is calculated as the product of unit resource rents and the physical quantities of mineral extracted. It covers tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate.	Rent = production volume x unit resource rent ; unit rent is equal to unit price less unit cost of extraction	Unit rent data for Italy calculated by WB (see END). The whole rent calculated for Italy in the period considered is imputed to Sardegna (the whole Italian production of minerals considered is related to extraction licenses released in that region)
CO2 damages (CO2D)	A conservative figure of \$20 marginal global damages per ton of carbon emitted was taken from Fankhauser (1994).	CO2D = emissions (tons) x \$20	Data on CO2 emission are calculated by ENEA (2010)
PM damages (PMD)	Willingness to pay (WTP) to avoid mortality and morbidity attributable to particulate emissions.	PMD = disability adjusted life years (DALYs) lost due to PM emissions x WTP	Data on PM emission disaggregated on regional basis are calculated from De Lauretis et. al (2009); the value of Damage for each region is calculated as the contribution to national emission multiplied for the total damage calculated by WB for Italy

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Item	Definition	Formula	DATA
Adjusted net saving (ANS)	Net national saving plus education expenditure and minus energy depletion, mineral depletion, net forest depletion, carbon dioxide damage, and particulate emissions damage	ANS = NNS EE ED MD NFD CO2D PMD	

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Source: author elaboration based on Bolt et al. (2002).

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