Indicators and Targets of the Agenda 2030: do they all play on the same team?

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Abstract
The interlinkages and integrated nature of the Sustainable Development Goals are of crucial importance in ensuring that the purpose of the new Agenda is realized. Most of the Sustainable Development Goals (SDGs) have the potential to bring progress in other SDGs, but some of these synergies are stronger than others. At the same time, advancement in some goals could negatively affect progress in other areas without careful policy design. The present work provides a comprehensive literature review both of the methodologies that have been employed to study the phenomenon and of the results that have been obtained through the analysis of the specific SDGs.
Moreover, applying the most suited methodology and relying on more than 150 elementary indicators related to all the SDGs, the paper focuses on the Italian Regions, in order to study the correlation between the Goals and to check if the quantitative results are aligned with those presented in literature referring to other Countries.
From the policy perspective, this exercise is crucial: actually, starting from the business-as-usual scenarios that traditionally depict the development of the socio-economic systems without considering the introduction of new policies, we only consider a reference benchmark, a macro-dimension of the specific SDG. On the other side, the policy counterfactuals provide the ex-ante assessment of costs and benefits of planned actions and strategies aimed to achieve the SDGs, as well as their feasibility and potential trade-offs/interactions with other sustainability dimensions not directly considered by the policy intervention.

1. Introduction

In September 2015, world leaders decided to adopt the agenda entitled “Transforming our world: the 2030 Agenda for Sustainable Development”.
The 17 Sustainable Development Goals (SDGs) and the 169 targets, included in the 2030 Agenda, “are integrated and indivisible, global in nature and universally applicable” (UN 2015). Moreover, SDGs want to overcome the problems found in MDGs (Millenium Development Goals), as they identified sectoral goals without considering how attempts to achieve a goal in one sector would affect attempts of achieving it in another sector (Weitz et al. 2014). Insufficient comprehension for synergies and trade-offs across sectors have resulted in incoherent policies (Le Blanc 2015).
The interlinkages between global Goals and partnerships for implementation are of crucial importance in ensuring that the purpose of the new Agenda is realized, as the two are strongly interlinked: constructing partnerships between actors depends on comprehending which are the interactions between different policies or sectors the actors represent (Nilsson et al. 2018). Interconnections can be both negative and positive. Synergies are those interactions where progress in one Goal favours progress

in another, while trade-offs are those interrelationships where progress in one Goal hampers progress in another (Pradhan et al. 2017). On one side, identifying synergies helps underlying co-benefits, reducing costs and enhancing impact thanks to coordinated actions; on the other side, identifying trade-offs makes mitigation and management of conflicts possible (Nilsson et al. 2018). By understanding the complex relations between SDGs, researchers can support policymakers (Nerini et al. 2018).
Assessing interlinkages is not that simple: a “best technique” does not exist, and qualitative methods are still preferred as it is found in the comprehensive literature review, both of the methodologies that have been employed to study the phenomenon and of the results that have been obtained through the analysis of the specific SDGs, provided by this paper.
Moreover, applying the most suited methodology and relying on more than 150 elementary indicators related to 16 out of the 17 SDGs, the paper focuses on the Italian case, in order to study the correlation between the Goals and to check if the quantitative results are aligned with those presented in literature referring to other countries.

2. Literature review

This review aims to identify relevant literature regarding the assessment of SDGs interlinkages in terms of methodology and results. Starting from Allen et al. (2018a), a total of 45 publications were identified.
Several studies have applied system thinking and analysis approaches to SDGs (Allen et al. 2018a). In particular, the network analysis approach is used in a publication related to the interactions between all the SDG targets (Le Blanc 2015), in a research focused on the water nexus (United Nations Economic and Social Commission for Asia and the Pacific 2016), as well as in many other publications (Allen et al. 2018b; Mainali et al. 2018; Weitz et al. 2018; Santika et al. 2019; Zelinka and Amadei 2019a). Cross-impact analyses are used to assess interconnections between Goal 2, 3, 7 and 14 and the other Goals (Nilsson et al. 2016; ICSU 2017), to find all SDG targets interactions in 22 countries of the Arab region (Allen et al. 2018b) and to study all SDG 12 targets interactions with other SDG targets (Coopman et al. 2016).
Many publications decide to assess relations through a literature review, a content analysis or expert elicitation (Weitz et al. 2014; Le Blanc 2015; Vladimirova and Le Blanc 2015; Nilsson et al. 2016; ICSU 2017; Coopman et al. 2016; Le Blanc et al. 2017; Tosun and Leininger 2017; Singh et al. 2017; Zhou and Moinuddin 2017; Allen et al. 2018b; Fader et al. 2018; McCollum et al. 2018; Nerini et al. 2018; Weitz et al. 2018; Hazarika et al. 2019; Baumgartner 2019; Mainali et al. 2018; Santika et al. 2019; Zelinka and Amadei 2019).
Other studies promote or implement a nexus approach (Weitz et al. 2014; Karnib 2017; Timko et al. 2018; Mainali et al. 2018).
For what concerns quantitative assessments, other publications suggest or implement scenario modelling (Kanter et al. 2016; Obersteiner et al. 2016; Gao and Bryan 2017; Hutton et al. 2018; Scherer et al. 2018; Moyer and Bohl 2019) as well as system dynamics (Costanza et al. 2016; Collste et al. 2017; Dörgő et al. 2018; Zelinka and Amadei 2019b). Statistical methods, such as correlation analysis (Pradhan et al. 2017; Pedrosa-Garcia 2018; El-Maghrabi et al. 2018; Sebestyén et al. 2019; Zhou and Moinuddin 2017; Mainali et al. 2018), Granger causality analysis (Dörgő et al. 2018), and linear mixed effect models (Lusseau and Mancini 2019) are also adopted.
Interestingly, qualitative and semi-quantitative methods are preferred to quantitative ones. In contrast, the authors here believe that a data-driven verification of SDGs interconnections is required. Anyway, it is important to highlight that one of the main problems related to the methodology choice is the lack of data. The latter leads to

imprecise results and/or pushes scholars to implement more simplistic models. For instance, Pradhan et al. (2017) put evidence on how indicator time-series are not available for all time steps and countries. Moreover, ICSU (2017) highlights that knowledge gaps are not always caused by lack of data or information but also to access restrictions, lack of standardised data collection protocols, lack of coordination across political or sectoral boundaries, or by capacity limitations for the analysis and translation of data and other types of information into policy advice.

Moving further, as far as each publication implements different methods and investigates different SDGs at different scale levels, it becomes difficult to compare the results of the studies. Anyway, the authors here attempt to do it.

There are many studies that consider only one SDG: United Nations Economic and Social Commission for Asia and the Pacific (2016) and Hall et al. (2017) Goal 6; Coopman et al. (2016) Goal 12; Timko et al. (2018), Hazarika et al. (2019), Baumgartner (2019) Goal 15; Vladimirova and Le Blanc (2015) Goal 4; Le Blanc et al. (2017) and Singh et al. (2017) Goal 14; McCollum et al. (2018), Nerini et al. (2018) and Santika et al. (2019) Goal 7; Kanter et al. (2016) Goal 2.

Starting to consider more than one SDG, Weitz et al. (2014), Karnib (2017) and Fader et al. (2018) concentrate on the Water-Energy-Food (WEF) nexus. In Karnib (2017), direct and indirect relationships are found. Fader et al. (2018), instead, analyse each target of the nexus for its inputs and infrastructure requirements, and risk or benefit implications. They find that Goal 6 has the highest number of potential synergies. The study compares its results with other publications finding that they are in line with those found in Nerini et al. (2018) and McCollum et al. (2018), similar to those of Pradhan et al. (2017), and divergent in the case of Mainali et al. (2018).

Gao and Bryan (2017) consider Goal 2, 6, 7, 13 and 15. They analyse different scenarios achieving each target singularly and then jointly and the result is that the food production target and the water use target are those achieved in most of the pathways.

Moyer and Bohl (2019) examine Goal 1, 2, 4, 6, 7 and conclude that the greatest pursuit synergies are spending on access to water and sanitation.

Tosun and Leininger (2017) consider interrelationships between Goal 2, 3, 6, 7 and 13 and all the other Goals. They arrive to the conclusion that Goal 13 is the most linked with the others.

Collste et al. (2017) indicate that the improvements in electricity access (Goal 7) enable progress in educational attainment (Goal 4) and life expectancy (Goal 3).

Obersteiner et al. (2016) generate 42 GLOBIOM scenarios with 14 global single-policy strategies. They indicate that SDG 12 policies generate the greatest and most distributed benefits to nutrient cycling, water use, and overall food security outcomes.

Nilsson et al. (2016) and ICSU (2017) study interconnections between Goal 2, 3, 7 and 14 and the other Goals, identifying Goal 3 as the Goal with the highest number of positive interactions.

Hutton et al. (2018) using an IAM (Integrated Assessment Model) identify relations between Goal 1, 2, 8, 10, 14 and 15 in Coastal Bangladesh. They show that Goal 14 and 15 are the net losers to Goal 8.

Scherer et al. (2018) assess the environmental impacts of ending poverty and reducing inequality. They find more ‘counteracting’ relations than positives.

Besides all the mentioned studies, there are others that try to systematically assess interlinkages between all SDGs.

Le Blanc (2015) in the ranking puts Goal 12 at the top with 14 Goals related to it. Pradhan et al. (2017) conclude that Goal 3 is found to have a higher share of synergies with other SDGs in most of the countries and world population. Goal 12 is, instead, linked with most trade-offs among others.

Pedrosa-Garcia (2018) maps SDG relationships using Jordan as case study, concluding that economic factors are the main driver to achieve SDGs: growth, remittances, household consumption and reductions in inequality show the highest synergies.
El-Maghrabi et al. (2018) include 134 countries in their study. The Goals 1, 6, 7, 5, 11 and 3 have strongest correlations with other Goals. The order of the Goals alters when there are changes in the income level of the sample: Goal 16 and 13 take place of Goal 6 and 7.
Kumar et al. (2018) present that Goal 4 is the main driver to achieve the other SDGs. Dörgő et al. (2018b) affirm that sanitation and drinking water (Goal 6) is of crucial importance and changes in income (Goal 8) and inequality reduction (Goal 10) can be associated with poverty alleviation (Goal 1).
Weitz et al. (2018) claim that progress in targets 16.6 (effective institutions), 12.1 (sustainable consumption/production) and 8.4 (resource efficiency) generate the most positive net influence on the rest of SDGs. Sebestyén et al. (2019) agree with the former, claiming that 16.6 is the most important target.
For Zelinka and Amadei (2019a), influential variables (with low dependence and high influence) are Goal 6, 16 and 17, and dependent variables (with high dependence and low influence) are Goal 1, 2, 3, and 10.
Lusseau and Mancini (2019) confirm that some Goals emerge as priority for the low- and high-income countries – respectively, Goal 1 for low-income countries and Goal 10 for high-income countries.
In general, in all the studies, synergies outweigh trade-offs (except for Scherer et al. 2018). The publications analysed differ, not only in methodology implemented, but also in results. Anyway, it seems that Goal 1 (Pradhan et al. 2017; Sebestyén et al. 2019; Lusseau and Mancini 2019) and Goal 6 (El-Maghrabi et al. 2018; Kumar et al. 2018; Dörgő et al. 2018b; Zelinka and Amadei 2019a) could be considered the most synergetic SDGs.

3. How to assess SDGs interactions: the Italian case

The paper focus is to assess SDGs interlinkages in Italy to check if the results are aligned with those found in the literature review. Our analysis is just a starting point and it is to be considered as a basis for forthcoming works.
Starting from the data utilized, Fondazione Eni Enrico Mattei provided a set of more than 150 individual indicators related to the twenty Italian regions (see: Cavalli et al. 2019). Through the methodology developed by Farnia (2019), composite indexes for each SDG (except for Goal 14) were constructed.
This paper decides to use statistics to find synergies and trade-offs between SDGs. That is, carrying out a correlation analysis between unique pairs of composite indexes. The correlation r is a measure of how strongly two variables relate to each other (Sarstedt and Mooi 2014). It is important to highlight that correlation does not imply causality, meaning that synergies/trade-offs could be independently related to another process guiding both indices (Pradhan et al. 2017).
A Pearson's r value greater than 0.4 is considered to indicate a synergy between the two composite indexes, an r less than -0.4 is considered to show a trade-off. The correlation with a p-value of less than 0.05 is considered as statistically significant.
Moreover, a ranking of SDGs synergies/trade-offs pairs based on the highest correlation values is created (Figure 2).
Coming to the results, both positive and negative interactions can be observed (Figure 1). Goal 9 (*Industry, innovation and infrastructure*) has nine positive interconnections (with Goals 4, 17, 2, 8, 10, 1, 6, 16, and 12) and ranks three times in the top-ten synergy pair list (Figure 2). Goal 1 (*No poverty*) is positively correlated with nine Goals: 4, 17, 16,

6, 2, 9, 10, 8 and 11. Goal 4 (*Quality education*) has, again, nine positive interactions (with Goal 9, 17, 8, 1, 10, 2, 16, 7, and 6) and ranks five times in the top-ten synergy pair list (Figure 2). Goal 16 (*Peace, justice and strong institutions)* is interlinked with 11, 5, 2, 1, 13, 4, 7, 6, and 9.

Goal 2 (*Zero hunger*) connects positively to the Goals 17, 9, 16, 4, 1 and 5, Goal 3 (*Good health and well-being*) only to Goal 12, Goal 5 (*Gender equality*) to the Goals 16, and 2, Goal 6 (*Water and sanitation*) to the Goals 1, 9, 16, 10 and 4, Goal 7 (*Affordable and clean energy*) to the Goals 4, 8, 13, 11 and 16, Goal 8 (*Decent work and economic growth*) to the Goals 4, 7, 9, 10, 17 and 1, Goal 10 (*Reduced inequalities*) to the Goals 4, 8, 9, 17, 12, 1, and 6, Goal 12 (*Responsible consumption and production*) to the Goals 10, 17, 3, and 9, Goal 13 (*Climate action*) to the Goals 11, 7 and 16, Goal 17 (*Partnerships for all the goals*) to the Goals 9, 4, 2, 1, 10, 12, and 8.

Goal 15 (*Life on land*) has only negative interactions. It correlates negatively with the Goals 2, 5, 6, 9, 12 and 17. Goal 12 (*Responsible consumption and production*) has two negative interactions (with the Goals 15 and 13).

Figure 1. Correlation Matrix between SDGs Composite Indexes

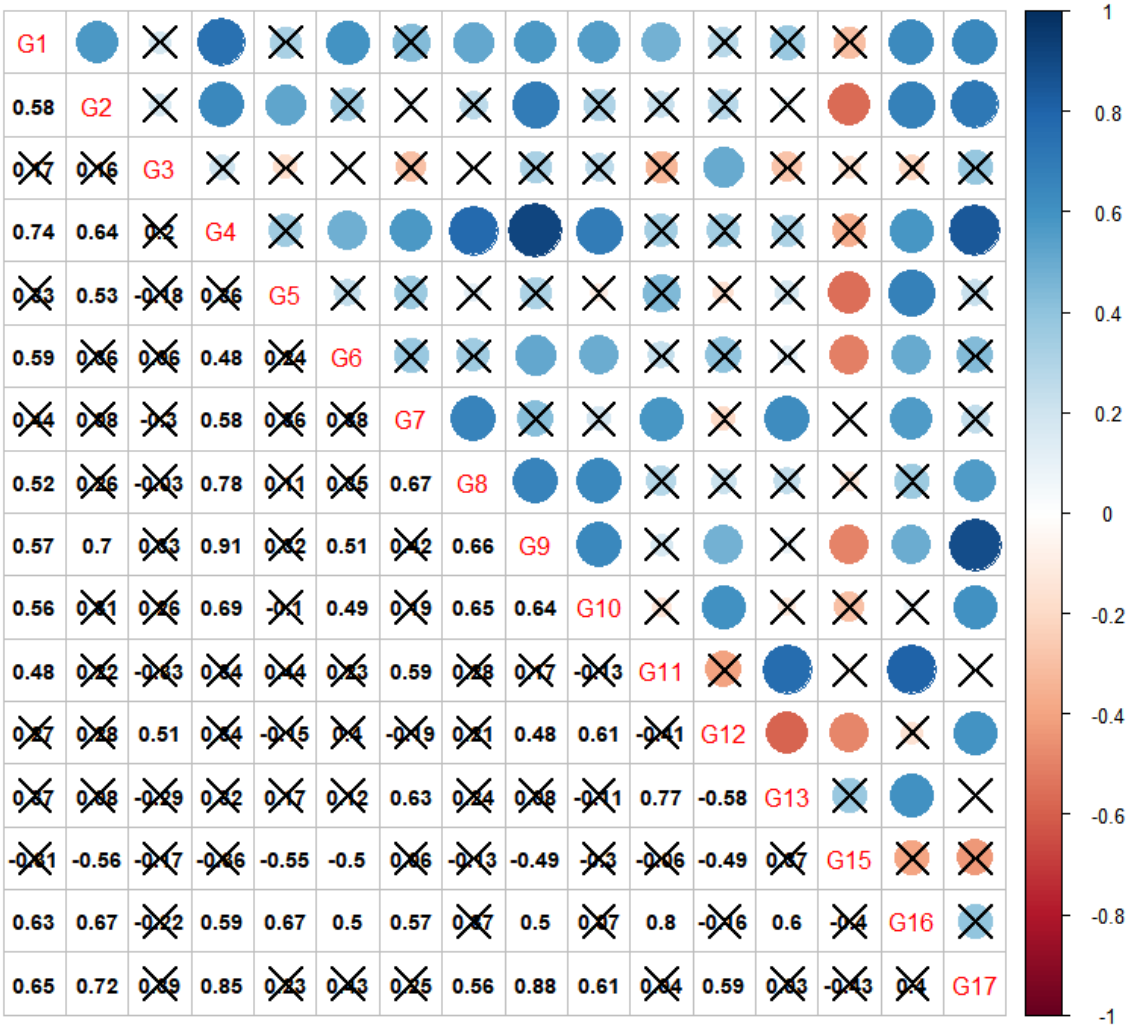
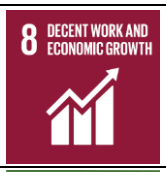
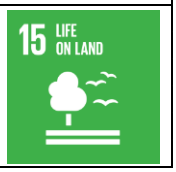


Figure 2. Top synergies/trade-offs pairs

	Top 10 synergy pairs			Top 6 trade-off pairs	
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7					
8					
9					
10					

In general, positive interactions outweigh the negatives, aligning with the results found in the literature review.
The Goals with the highest number of positive interactions are: Goal 1, Goal 4, Goal 9 and Goal 16.
For what concerns Goal 1, also El-Maghrabi et al. (2018) find that it is one of the Goals that has the strongest correlations with the other Goals.
Goal 4 is considered to be the main driver to achieve the other Goals in Kumar et al. (2018). Vladimirova and Le Blanc (2015), running a content analysis of 40 reports to understand how well UN flagship publications identify links, find that the most emphasized relationships are those between Goal 4 and Goals 8 and 5. In this paper, the correlation between Goal 4 and Goal 8 is found in the top-synergies rank (Figure 2). Goal 9 does not seem to be so important for the other publications.
Goal 16, for Zelinka and Amadei (2019a), is considered to be an influential variable (with low dependence and high influence). El-Maghrabi et al. (2018) put it into the group of the Goals with the strongest correlations with the others. Moreover, for Sebestyén et al. (2019) and Weitz et al. (2018), the target 16.6 is the most important between all the targets.
In this analysis, only six negative interactions exist. Results converge with those found by Pradhan et al. (2017) and slightly differ from those found in Baumgartner (2019). The latter affirms that Goal 15 has after Goal 12 most trade-offs with other SDGs: here, it is the contrary. Moreover, Baumgartner (2019) finds that Goal 15 has trade-offs especially with Goals 1, 3, 4, 6 and 10, that are totally different interactions from those found here. Goal 12 is considered to be the Goal with the highest number of trade-offs in Lusseau and Mancini (2019) and policies on minimizing trade-offs with Goal 12 were found to be the most effective at leveraging the whole Agenda (Obersteiner et al. 2016).

4. Conclusion

One of the aim of the present work was to provide a comprehensive literature review both of the methodologies that have been employed to study SDGs interlinkages and of the results. It is seen that qualitative and semi-quantitative methods are preferred to the quantitative ones and that results differ, considering also that they include different scale levels.
Moreover, applying a correlation analysis and relying on composite indexes based on more than 150 elementary indicators provided by Fondazione Eni Enrico Mattei, Italian SDGs interlinkages were explored.
This paper shows the existence of more positive interactions than negatives between the SDGs and this is seen in all the publications considered in the literature review (except for Scherer et al. 2018). Our analysis arrives to the conclusion that Goal 1, Goal 4, Goal 9 and Goal 16 are the most synergetic Goals and Goal 15 and Goal 12 are the Goals with the highest number of trade-offs.
It is important to evidence that the interpretation of the results requires a discussion on the limitations related to the data and the methodology. Our study is limited by the incompleteness of the data set: we had only one data point per each Italian region related to each Goal (except for Goal 14) and this constrained us to use the current approach. Furthermore, our correlation analysis is to be considered just a starting point for assessing interlinkages, as it does not imply causality and does not find which are the mechanisms behind the creation of synergies and trade-offs (Pradhan et al. 2017).
Co-benefits are underlined and costs are reduced if synergies are found as well as mitigation and management of conflicts can be implemented if trade-offs are clear. It must be enhanced that understanding the interactions becomes a fundamental aspect to create appropriate and successful policies to achieve sustainability across countries and

contexts.

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