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SDGs Indicators as an Input-Output System – A Novel Approach to Utilize Interlinkages between SDGs Indicators for Impact Assessment and Projections

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Abstract

The interlinkages between different Sustainable Development Goals and their targets and indicators are already well documented in the literature. There is vast amount of research aimed at mapping theses interlinkages using network methods or correlation analysis. However, these interlinkages were not yet explored in the quantitative analysis that would allow to show their impacts on the future developments of the SDGs indicators or on the impact assessment.

In this paper, we present a novel approach to SDGs interlinkages, that utilizes the well-known input output methodology for the projections of SDG indicators and impact assessment. We produce the interlinkages matrices showing the strength and breadth of the links between various SDG targets. Furthermore, we show how such framework can be used for translating the commonly used economic indicators such as GDP and unemployment onto the projected changes of SDGs indicators considering the existing interlinkages between them. Also, this framework can be used in the variety of different applications e.g. it can be linked to the CGE model or used to project the impact of policies on SDGs indicators, given that the influence on exogenous variables is known.

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Introduction

Sustainable development goals, as its name indicates, are all about widely understood economic and social development. Consequently. the number of links between the SDGs goals, targets and indicators is vast and there is number of papers trying to systematize and evaluate this topic. Within the SDG system, there are 17 goals and 169 targets, so there are 14,196 potential interlinkages between them, if interlinkage is defined as symmetric relation and 28,392, if the relation is asymmetric.

This paper proposes a framework for the assessment of interlinkages between different Sustainable Development Goals indicators. To do that, we use novel method that aims at the estimation of full interlinkages matrix using the panel regression techniques.

The structure of this paper is as follows. In the next section, we perform short literature review to set the stage and elaborate on what has been done in the area of SDGs interlinkages. Third section presents the modelling approach, fourth is devoted to presentation of the data sources used in this exercise. Section fifth presents exemplary results – the interlinkages between SDGs, as well as the impact of external indicators and projections. As the number of data is quite large, we show just the main charts here, leaving the detailed results in the appendices. Section 6 concludes.

I. Interlinkages and factors affecting SDGs – literature review

The most popular quantitative tool to analyse interlinkages between SDGs is network analysis. In this method, the correlation between different indicators or *a priori* information of potential linkages is used to map the SDGs over a graph, which is then used to calculate some centrality measures that allow to assess how important are targets in reaching each other. Such exercise was pioneered by Le Blanc (2015).

Zhou and Moinuddin (2017) use national, time-series, data on 51 indicators to create correlation matrix of SDG targets for each country. Even though such time series may be perceived as too short to draw any conclusion on the interlinkages, this exercise is useful in showing the potential cross-country differences in potential links between SDGs. Based on literature review (for unweighted linkages) and correlations (for country-specific linkages) they calculate centrality measures and classify them.

The International Council for Science evaluated the relationships between the SDG targets (four SDGs were analysed in details) and it was found, there are 238 positive, 66 negative and 12 neutral links (Griggs, 2007). Based on the identified connections a dynamical model was developed, that supports the better outcomes through unequal reallocations of direct efforts (Dawes, 2019). The relationship of the five SDGs selected with the 1-15 goals was analysed by an empirical approach in order to attain the policy integration. In the study the relations have been neglected, because SDGs 16 and 17 are preconditions for the other goals (Tosun, 2017).

JRC (2019) analysed 220 literature sources on SDG relations has been analysed for linking the SDG targets. The literature based inter-linkages have been categorized in synergy (+1), strong synergy (>+2), trade-off (-1), strong trade-off (>-2) and ambiguity classes. It was found, that 73per cent of the interactions are synergies and the level of the disagreement among queried experts is around 50 per cent (JRC,2019). The effects of the climate change on SDGs were examined by Nerini (2019). According to a structured evidence review, climate change can undermine 16 SDGs, but combating climate change can strengthen all 17 SDGs, but undermine efforts to reach goal 12.

Based on the published SDGs network-based studies, the estimation methods, network topologies, and synergies and trade-offs between SDGs have been compared for presenting the opportunities and limitations of policy advises (Ospina, 2019).

In Cook (2019), an analytical decision framework has been adopted to assess and rank SDG targets on the basis of their “urgency”, “systemic impact” and “policy gap”, as well as benchmarking of indicators, system and network analysis of linkages between targets, policy coordination and the mapping of its shortcomings was also presented (Allen, 2019). The importance of expert knowledge in the interpretation of SDG interrelations is unquestionable. In the case of Iceland, the tourism sector has been examined based on the knowledge of four theme-based focus groups made up of expert participants. A total of 32 goal synergies and 11 trade-offs have been identified. Another application example through child health has been explored on how evaluation of relationships between SDGs can be used to manage multisectoral partnerships (Cook, 2019). The of the evidence-based decision making was identified as a key message in Blomstedt (2018). The depth of discussion of SDGs and its relationships varies. The contribution of academic papers and the media has been examined through network analysis. It can be shown that SDG3 and SDG10 received the most attention, while SDG5 showed apparent gaps (Yeh, 2019). The integration of literary knowledge and expert opinions was carried out for SDG14. It was concluded, that the Ocean SDG targets are linked to all other SDG targets, and two ocean targets (of seven in total) are most closely related to all other SDG targets (Singh, 2018). For the energy theme, 113 targets have been identified that require a change in the energy system, and evidence has been published of the relationship between the 143 targets (143 synergies, 65 compromises) and efforts SDG7 (Nerini, 2018).

By adapting the Nilsson (2016) evaluation system (indivisible, reinforcing, enabling, neutral, constraining, counteracting, canceling), a double-causality matrix of 17 goals was created, which can be used to prioritize SDGs (based on the priority indices). In this approach the SDG16, SDG12 and SDG17 got the highest PI scores (Zelinka, 2019). Relationships can be translated into system dynamics models which allows the understanding of the dynamics of relationships between goals. Integrated consideration of the global interconnected system model and planetary boundaries shows that the global safety margin will continue to decline and the SDGs will not happen by 2030 (Randers, 2019). The research highlights the importance of analysing temporal changes in the SDG system. The role of interventions is crucial for the mapping of system behaviour, that can be examined by scenario analysis. For Australia, the Sustainability Transition scenario results in 70 per cent rapid and balanced progress towards SDG targets by 2030 (Allen, 2019). An analytical model has been developed to estimate the welfare effects of progress towards SDGs, considering interactions with other SDGs. It was concluded, that the net gain of poverty reduction is doubling globally, but it is falling for poor economies (Barbier, 2019).

The SDG interaction networks have been estimated using global time series data of SDGs for countries with different income levels. The analysis covered network architecture, barriers, and opportunities to maximize SDG implementation through their interactions (Lusseau, 2019). Through the time series of indicators, the relationships between targets and objectives can be also analysed. Based on the World Bank data, a data-driven model has been developed that can explore the relationships between countries (Sebestyen, 2019). Based on the time series data of the indicators of sustainable development goals, causal relationships can also be determined. This approach lays the foundation for effective support for future interventions (Ho, 2018). In another data-driven approach, the identification of synergies and trade-offs for analyzing SDG interactions is systematized using official SDG data from 227 countries. Significant positive correlation between the pairs of indicators was classified as synergy, while significant negative correlation was classified as a trade-off, based on which global and national rankings were performed to determine the most common SDG interactions (Pradhan, 2018).

The analysis highlighted the importance of a multidisciplinary approach and under-representation of governmental and human development related goals (Van, 2019). The simulations of combined SDG policies-based analysis help to understand the causal relationships of the multiple SDG policies and the qualitative and semiquantitative methods can complement the results of simulation-based studies (Pedercini, 2019). Due to the fact of interconnectedness of the goals, cross-sectoral processes are needed to achieve policy coherence in order to successfully implement the 2030 Agenda (Breuer, 2019). Interactions are depending on key factors such as geographical context, resource bases, time horizons and governance, therefore gathering, structuring and aggregating knowledge are key mechanisms (Nilsson, 2018). The interactions vary greatly country by country and dependent on the specific goals, which urges the international cooperation (Scherer, 2018). A detailed analysis was done by the Institute for Global Environmental Strategies (IGES) in order to show the differences between nine countries (IGES, 2017). Through the theme of energy, it has been underlined that contextual dependencies need to be considered, and our review points out possible ways forward for both policymaking and the scientific community (McCollum, 2018). The need for evidence-based and science-based approaches to SDG implementation is clearly emphasized by the community of experts and policymakers now face the challenge of implementing SDGs in a simultaneous, coherent and integrated manner (Allen, 2018).

Even though, network analysis is useful tool that allows for the assessment of interlinkages as such, they do not allow for quantitative assessment of how unit change in one indicator will affect others. As the goal of this paper is to create matrix that would allow for such assessment, we decided to adopt different methodology, as described below.

II. Modelling approach

The starting point for our approach to estimate the interlinkages between sustainable development goals was the notion, that the desired achievement of the goal or target is some "output", that needs "inputs" to be produced. For instance, to eradicate poverty, given country need productive economy (measured with GDP *per capita*), good quality of education and healthy labour market (reflected in low unemployment). Therefore, to "produce" reduction in poverty indicators, given country need to put some "inputs" – high GDP *per capita*, decent values of education indicators and low unemployment rate. However, improvements in these areas support also other SDG – e.g. high education expenditures support achievement of literacy goals and low unemployment shall influence the number of injuries at work and will help to reduce informality of the economy. Moreover, reduction of poverty will contribute to the fall in inequalities and should reduce adolescent birth rate.

These relationships closely resemble input-output system – for instance to produce agriculture output, machines are needed that are built by the manufacturing sector and fuels provided by refineries. In turn, the output of agriculture sector is used in food and textile industry. Moreover, there are production factors – labour, land and capital, that are needed in each sector.

In this paper, we try to structurize the interlinkages between sustainable development goals into the matrix that will resemble standard input-output matrix for the economy and estimate the values of the coefficients, measuring the strength of the interlinkages. Such matrix will allow to answer not only to questions on the strength between interlinkages (which are quite well researched in the literature), but also would allow us to examine issues that can be resolved using the standard input output tables like:

(a) How much do I need to reduce unemployment to diminish poverty by one percentage point and how it will affect other SGGs indicators?

(b) How much do I need to increase GDP *per capita* to reduce the proportion of people living in slums, considering interlinkages between poverty, unemployment and living in slums?

(c) How increase in health expenditures will affect other SDGs indicators, related to e.g. poverty?

In the standard input-output tables apart from the intermediate inputs, there are also production factors – land, capital, labour etc. In our case, we do not know the amount of capital engaged to achieve each goal. Instead, we use expenditures on different categories as a percentage of GDP and GDP *per capita* to measure *per capita* expenditures on various services. Among these indicators, we included the following measures based on data availability and statistical significance on the interlinkages between indicators and different policy measures:

- GDP per capita ($);
- Expenditure on environment protection (percentage of GDP);
- Investment (percentage of GDP);
- Population;
- Government expenditures (percentage of GDP);
- Unemployment rate;
- Households consumption (percentage of GDP);
- Expenditure on public order and safety (percentage of GDP);
- Expenditures on military services (percentage of GDP);
- Expenditure on general public services (percentage of GDP);
- Health expenditures (percentage of GDP);
- Expenditure on economic affairs (percentage of GDP);
- Gov't education expenditure (percentage of GDP);
- Expenditure on social protection (percentage of GDP);
- Expenditure on housing and community amenities (percentage of GDP);
- Research & development expenditures (percentage of GDP).

To populate the matrix with elasticity coefficients, we adopted production function approach as a starting point. For this purpose, we used the Cobb-Douglas production function, where the value of given indicator is explained as:

$$x_i = A_i \prod_{j \neq i} x_{,}^{\alpha_{ij}} \prod_{k \in F} f_k^{\beta_{ik}}$$

Where x_i is indicator i, f_k is intervention measure k and α_{ij} and β_{ik} are elasticities. Such production function can be linearized to:

$$\log(x_i) = \sum_{j \neq i} \alpha_{ij} \log(x_j) + \sum_{k \in F} \beta_{ik} \log(f_k) + \gamma_i$$

Therefore elasticities α_{ij} and β_{ik} can be easily organized to matrices, such that we have:

$$logX = AlogX + BlogY$$

Where X is vector containing logged values of SDGs indicators for given country and given year, $A = [\alpha_{ij}]$ is the square matrix containing all pairwise elasticities between different indicators and $B = [\beta_{ik} \quad \gamma_i]$ is the matrix with elasticities of indicators to intervention measures (including constant) and Y is the vector containing logged values of all the intervention measures (and 1 to reflect constant). With such approach, the values of X can be calculated as:

$$logX = (I - A)^{-1}BlogY$$

These will show, how the values of indicators X will react to the changes to Y, including interlinkages between SDGs.

This concept is very simple, but the most challenging task is to estimate the matrices A and B. Ideally, they should be estimated at country-by-country basis, as these functions are slightly different in the real world depending on the individual country characteristics. However, we do not have enough empirical data to estimate such function individually for each country. Nevertheless, it would be beneficial to narrow-down the group of countries for which these matrices are estimated, considering the characteristic traits of given group of countries. Therefore, given that the tool is designed primarily to be used for the Arab countries, we decided to adopt the following procedure:

(a) In the first step, we tried to estimate model for each indicator using the subsample of Arab countries. If this approach yields robust and credible results, then the coefficient for Arab states were used;

(b) Then we estimated equations for the income level subgroups, according to the World Bank classification: low, lower middle, upper middle- and high-income group. If the results were reliable, they were used in the second order;

(c) If neither coefficients estimated on the Arab subsample nor at the income level subsample were credible, than the estimations were performed using the full set of available countries.

To estimate the matrices, we wanted to use as much data as possible and apply panel regression models on the subsample of countries as described above. However, as the list of indicators as well as intervention measures is quite long, including full list will result in overfitting the model and due to the various coverage for different indicators there may be even too few observations to estimate the model. To avoid this problem, we decided to adopt the following procedure:

(a) We started from the potential interlinkages between different SDGs as listed by the United Nations Statistics Division. Also, UN ESCWA experts defined interlinkages of SDGs to intervention measures. These allowed to create initial list of independent variables for each indicator. The list of potential interlinkages is presented in appendix 1;

(b) We ran standard OLG stepwise regression on the full dataset with quite low significance level for addition to the model (0.1);

(c) Such list of automatically selected independent was a starting point for further removal of corelated variables to remove collinearity problems. For this reason, the number of indicators for each target was limited to 3;

(d) Variables was plugged into the random effect panel regression model;

(e) Coefficients from such models were arranged into A and B matrices.

This method is far from perfect, but it allows for quite fast and consistent development of econometric models for all the considered indicators, even if their number is quite large (in our case it was 232 indicators with enough data coverage).

III. Data and coverage

Data availability is, by and large, the most important obstacle that we faced while constructing the tool. For many of the SDGs indicators, the country coverage is poor and time series for some countries are incomplete. Therefore, not all SDGs indicators could be included in the estimation exercise.

For the collection of the data that can be used for modelling the following databases were used:

(a) Most of the data of this study were collected the from the UN Global SDG Indicators Database: https://unstats.un.org/sdgs/indicators/database/ The context of the Sustainable Development Goals (and its indicators) is based on data from the UN Global Database. The database contains indicators for all 17 goals (and 169 targets). The geographical coverage of the database means 315 different geographical units, but the amount of data available varies considerably country by country and non-countries (e.g. regional geographical units) were excluded. Our rule of thumb for including the given indicator in the database was the country coverage greater than 100 and more than average of 5 observations per country. This resulted in selection of 232 indicators. Unfortunately, not all targets could be reflected (though there are indicators for each goal);

(b) The main source for policy measures was IMF. We used the IMF data on expenditures by function (COFOG), but the country coverage is relatively poor, even if we considered the fact that for some countries there is information at the general government level and for some there is information on indicators for Central Government or Budgetary Central Government;

(c) We used WEO (World Economic Outlook) database as a source of data for broad macroeconomic indicators as GDP, GDP *per capita* or GDP *PPP*;

(d) For some indicators, we used additional information from the World Bank World Development Indicators database. We sourced there such indicators as health expenditure as a percentage of GDP, education expenditure as a percentage of GDP or R&D expenditures. Even though the definitions are less precise than in case of IMF database, the country and time coverage is much larger there.

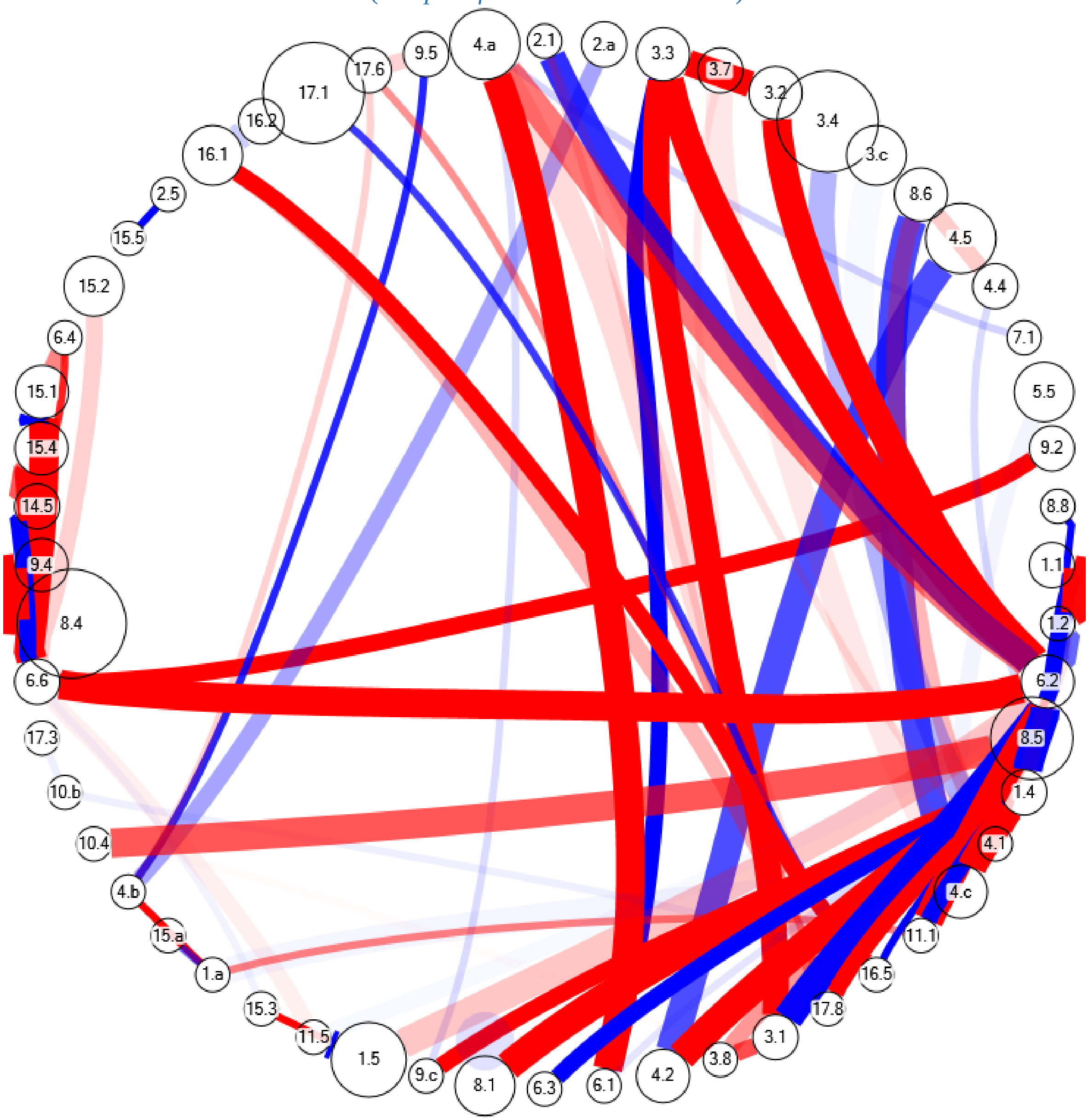
IV. Results

A. Interlinkages matrices

In total, we considered 232 SDGs indicators, out of which 63 was considered exogenous. The equations for exogenous SDGs variables were not estimated (as the level of these variables is due to the decision of the government), but they could enter as the explanatory variable for equations explaining the evolution of other matrices. Consequently, 169 equations were estimated to calculate the value of endogenous variables and interlinkages. We used GLS random effects panel data estimation as implemented in Stata software.

As the number of indicators is quite large, presentation of the results is quite challenging task. In this paper, we will show the matrix of interlinkages graphically and the matrix of interlinkages will be relegated to the Excel appendix 2. Instead, figure 1 shows the picture of interlinkages. Most of the observed relationships were positive, which means that achievement of given target reinforces achieving other goals. However, in some cases, such, as targets 4.2 and 4.5 or 8.6 versus 4.c, there are trade-offs between SDGs, meaning that increase in one indicator would hinder the achievement of other goals. In most cases, such relationships reflect the trade-off between quantity and quality, but otherwise, these interlinkages should be examined on case-by-case basis.

Figure 1. Graph of interlinkages between different SDGs resulting from interlinkages matrix
(*Sample of all available countries*)



Note: The width of interlinkages depicts the number of indicators between targets that are interlinked, and the opacity depends on the strength of the strongest interlinkage (the value of the coefficient).

B. Impact of external variables

In this model apart from the interlinkages, we aim at the assessment of the impact of other (exogenous) indicators on achieving the SDG targets. Among these indicators, there are several indices that are general (like GDP, unemployment and population) and can have some impacts on most of the indicators and there are some that are target-specific (like outlays on education, health or R&D) that can affect only indicators that are related to specific area. Furthermore, some of the SDGs indicators are, in fact, the outcome of government unilateral and sovereign decision – therefore it would not make sense to formulate any predictions for their values. Nevertheless, they can enter the equations for other indicators as the dependent variables. The matrix of these coefficient is part of the appendix 1.

Figure 2. The number of positive and negative interlinkages

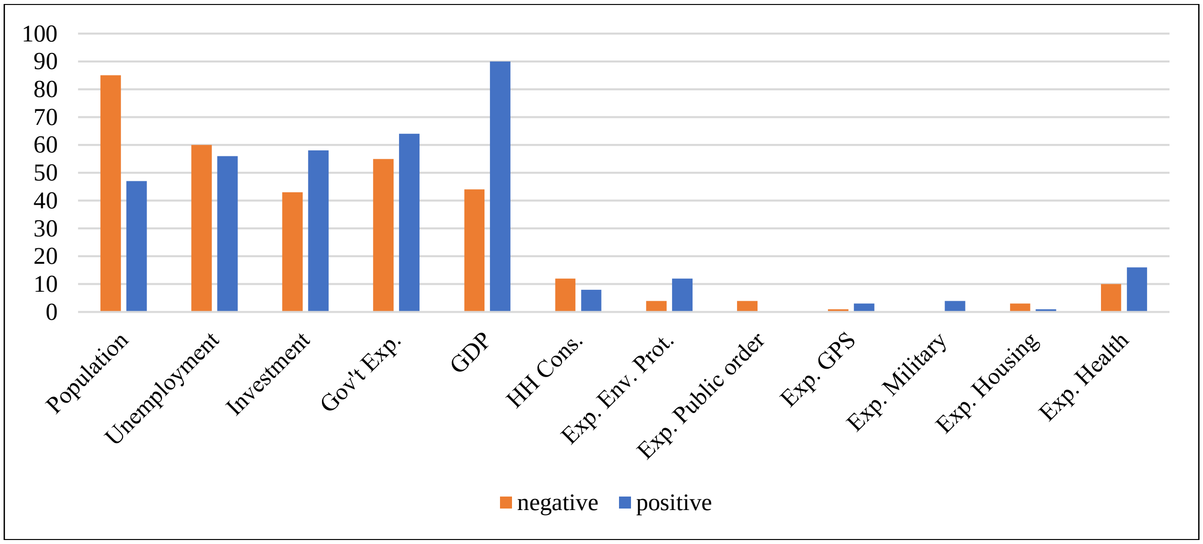


Figure 2 shows the number of positive and negative interlinkages for each of the indicator. In general, high GDP and Investments heavily support achieving SDGs, while the population makes them more difficult to reach, which is in line with expectations. Negative impact fall in unemployment on some indicators may be surprising, but in some cases, high unemployment may support reaching the goals that require a lot of workforce in healthcare or education. Figure 2 also depicts that these *overarching* external indicators supports reaching many targets, while the remaining are relatively narrow.

C. Indicators projection for the Arab countries

Another output of the project can be the projections of SDGs indicators for Arab countries. As the relationship between SDGs indicators and such variables as GDP, unemployment and population were estimated, external forecasts of these variables can be used to project the value of indicators and assess the progress of countries in reaching the SDGs. Once these projections are ready, one can use methods as described in Nia (2017) for the tracking progress towards SDGs and assessing the achievement of these goals in the *baseline* scenario. This *baseline* scenario can be further used to compare with the scenarios with *policies*, to assess the impact of e.g. increase of expenditures on health on interconnected SDGs targets.

As the number of indicators is quite large (169-220 endogenous variables, depending on the model specification), it is difficult to present them all in one graph. Nevertheless, figure 3 shows the exemplary dashboard, that can be used to present results on whether given target will be achieved or not. These projections can also be presented on interactive charts etc. Full projections are presented in the Excel appendix 3.

Figure 3. Exemplary dashboard, showing whether the given country achieved goal until 2000 and 2015 and if it will be achieved in 2030

Goal	arget	ind	SeriesDescription	SeriesCode	Target	Progress	Off Track	2000	2015	2030
1	1.1	1.1.1	Employed population below international poverty line, by sex and age (%)	SI_POV_EMP1	<5	5-20	>20	0.1	0.1	0.0
1	1.1	1.1.1	Proportion of population below international poverty line (%)	SI_POV_DAY1	<5	5-20	>20	3.8	0.2	0.1
1	1.2	1.2.1	Proportion of population living below the national poverty line (%)	SI_POV_NAHC	<5	5-20	>20	5.5	5.5	4.6
1	1.4	1.4.1	Proportion of population using basic drinking water services, by location (%)	SP_ACS_BSRVH2O	>95	95-65	<65	90.1	93.5	94.3
1	1.4	1.4.1	Proportion of population using basic sanitation services, by location (%)	SP_ACS_BSRVSAN	>95	95-65	<65	84.1	87.5	94.2
1	1.5	1.5.1	Number of deaths and missing persons attributed to disasters per 100,000 population	VC_DSR_MTMP	<0.1	0.1-0.5	>0.5			
1	1.5	1.5.3	Score of adoption and implementation of national DRR strategies in line with the Send	SG_DSR_LGRGSR	>0.55	0.55-0.30	<0.30			
1	1.5	1.5.4	Proportion of local governments that adopt and implement local disaster risk reductio	SG_DSR_SILS	>95	95-65	<65			
1	1.a	1.a.2	Proportion of total government spending on essential services, education (%)	SD_XPD_ESED	>20	20-10	<10	11.4	11.4	11.4
2	2.1	2.1.1	Prevalence of undernourishment (%)	SN_ITK_DEFC	<5	5-20	>20	10.2	4.6	3.8
2	2.2	2.2.1	Proportion of children moderately or severely stunted (%)	SH_STA_STUNT	<5	5-20	>20	23.8	9.9	9.6
2	2.2	2.2.2	Proportion of children moderately or severely overweight (%)	SH_STA_OVRWGT	<5	5-10	<10	14.9	12.2	12.3
2	2.2	2.2.2	Proportion of children moderately or severely wasted (%)	SH_STA_WASTE	<5	5-10	<10	6.4	4.2	4.0
2	2.c	2.c.1	Consumer Food Price Index	AG_FPA_CFPI	<0.5	0.5-1	>1		0.9	1.2
3	3.1	3.1.1	Maternal Mortality Ratio (per 100,000 live births)	SH.STA.MMRT	<70	70-150	>150	164.0	100.0	100.0
3	3.1	3.1.2	Proportion of births attended by skilled health personnel (%)	SH_STA_BRTC	>95	95-65	<65	94.2	97.0	92.5
3	3.2	3.2.1	Infant mortality rate (deaths per 1,000 live births)	SH_DYN_IMRT	<5	5-10	>10	33.3	21.4	19.3
3	3.2	3.2.1	Under-five mortality rate, by sex (deaths per 1,000 live births)	SH_DYN_MORT	<5	5-10	>10	38.9	24.9	22.4
3	3.2	3.2.2	Neonatal mortality rate (deaths per 1,000 live births)	SH_DYN_NMRT	<5	5-10	>10	21.2	15.5	13.4
3	3.3	3.3.1	Number of new HIV infections per 1,000 uninfected population, by sex and age (per 1,	SH_HIV_INCD	<5	5-10	>10	0.0	0.1	0.0
3	3.3	3.3.2	Tuberculosis incidence (per 100,000 population)	SH_TBS_INCID	<5	5-65	>65	72.0	74.0	100.7
3	3.3	3.3.3	Malaria incidence per 1,000 population at risk (per 1,000 population)	SH_STA_MALR	<5	5-65	>65	0.3	0.0	0.0
3	3.4	3.4.1	Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respira	SH_DTH_NCOM	<15	15-25	>25	20.4	14.4	13.8
3	3.4	3.4.2	Suicide mortality rate, by sex (deaths per 100,000 population)	SH_STA_SCIDE	<3	3-5	>5	4.0	3.2	3.0
3	3.6	3.6.1	Death rate due to road traffic injuries (per 100,000 population)	SH_STA_TRAF	<10	10-20	>20	24.0	23.8	23.3
3	3.7	3.7.1	Proportion of women of reproductive age (aged 15-49 years) who have their need for	SH_FPL_MTMM	>75	75-65	<65	72.9	77.9	86.2
3	3.7	3.7.2	Adolescent birth rate (per 1,000 women aged 15-19 years)	SP_DYN_ADKL	<10	10-30	>30	4.8	9.7	9.9
3	3.8	3.8.1	Universal health coverage (UHC) service coverage index	SH_ACS_UNHC	>80	80-65	<65	57.0	76.0	78.0
3	3.9	3.9.1	Age-standardized mortality rate attributed to household and ambient air pollution (de	SH_STA_ASAIRP	<20	20-85	>85		43.0	39.3
3	3.9	3.9.2	Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (death	SH_STA_WASH	<5	5-20	>20		1.9	1.6
3	3.9	3.9.3	Mortality rate attributed to unintentional poisonings, by sex (deaths per 100,000 popu	SH_STA_POISN	<5	5-20	>20	1.2	0.8	0.6
3	3.a	3.a.1	Age-standardized prevalence of current tobacco use among persons aged 15 years and	SH_PRV_SMOK	<15	15-20	>20	16.4	15.6	14.0
3	3.c	3.c.1	Health worker density, by type of occupation (per 10,000 population)	SH_MED_HEAWOR	>30	30-15	<15	2.8	4.6	4.9
3	3.d	3.d.1	International Health Regulations (IHR) capacity, by type of IHR capacity (%)	SH_IHR_CAPS	>95	95-65	<65	100.0	100.0	100.0
3	3.d	3.d.1	International Health Regulations (IHR) capacity, by type of IHR capacity (%)	SH_IHR_CAPS	>95	95-65	<65	100.0	100.0	100.0
4	4.1	4.1.1	Minimum proficiency in mathematics, by education level and sex (%)	SE_MAT_PROF	>90	90-65	<65	57.4	19.0	20.1
4	4.2	4.2.2	Participation rate in organized learning (one year before the official primary entry age	SE_PRE_PARTN	>90	90-65	<65	3.4	100.0	100.0
4	4.4	4.4.1	Proportion of youth and adults with information and communications technology (ICT	SE_ADT_ACTS	>75	75-50	<50			
4	4.5	4.5.1	Gender parity index for achievement in mathematics, by education level (ratio)	SE_GPI_MATACH	>0.95	0.95-0.65	<0.65	0.7	1.2	1.2
4	4.5	4.5.1	Gender parity index for participation rate in organized learning (one year before the o	SE_PRE_GPIPARTN	>0.95	0.95-0.65	<0.65	0.9	1.0	0.9
4	4.5	4.5.1	Gender parity index of trained teachers, by education level (ratio)	SE_GPI_TRATEA	>0.95	0.95-0.65	<0.65			
4	4.5	4.5.1	Language test parity index for achievement in mathematics, by education level (ratio)	SE_LGP_ACHIMA	>0.95	0.95-0.65	<0.65	0.7	1.3	1.2
4	4.5	4.5.1	Low to high socio-economic parity status index for achievement in mathematics, by ed	SE_SEP_MATACH	>0.95	0.95-0.65	<0.65		0.5	0.6
4	4.5	4.5.1	Rural to urban parity index for achievement in mathematics, by education level (ratio)	SE_URP_MATACH	>0.95	0.95-0.65	<0.65	1.4	0.4	0.4
4	4.a	4.a.1	Schools with access to basic drinking water, by education level (%)	SE_ACC_DWAT	>95	95-65	<65			
4	4.a	4.a.1	Schools with access to the internet for pedagogical purposes, by education level (%)	SE_ACC_INTN	>95	95-65	<65			
4	4.a	4.a.1	Schools with access to access to single-sex basic sanitation, by education level (%)	SE_ACC_SANI	>95	95-65	<65			
4	4.a	4.a.1	Schools with access to computers for pedagogical purposes, by education level (%)	SE_ACC_COMP	>95	95-65	<65			
4	4.a	4.a.1	Schools with access to electricity, by education level (%)	SE_ACC_ELEC	>95	95-65	<65			
4	4.a	4.a.1	Schools with basic handwashing facilities, by education level (%)	SE_ACC_HNWA	>95	95-65	<65			
4	4.c	4.c.1	Proportion of teachers who have received at least the minimum organized teacher tra	SE_TRA_GRDL	>95	95-65	<65	94.2	100.0	68.2
5	5.3	5.3.1	Proportion of women aged 20-24 years who were married or in a union before age 15 (	SP_DYN_MRBF15	<1	1-10	>10		0.4	0.5
5	5.3	5.3.1	Proportion of women aged 20-24 years who were married or in a union before age 18 (	SP_DYN_MRBF18	<5	5-20	>20		2.5	2.5
5	5.5	5.5.1	Proportion of elected seats held by women in deliberative bodies of local governmen	SG_GEN_LOCGELS	>30	30-15	<15			
5	5.5	5.5.1	Proportion of seats held by women in national parliaments (% of total number of seat	SG_GEN_PARL	>30	30-15	<15	3.4	31.6	51.1
5	5.5	5.5.2	Proportion of women in managerial positions (%)	IC_GEN_MGTL	>30	30-15	<15	5.2	9.4	12.2
5	5.b	5.b.1	Proportion of individuals who own a mobile telephone, by sex (%)	IT_MOB_OWN	>90	90-20	<20			
6	6.1	6.1.1	Proportion of population using safely managed drinking water services, by urban/rura	SH_H2O_SAFE	>95	95-65	<65			
6	6.2	6.2.1	Proportion of population practicing open defecation, by urban/rural (%)	SH_SAN_DEFECT	<5	5-20	>20	5.9	0.8	3.0
6	6.2	6.2.1	Proportion of population using safely managed sanitation services, by urban/rural (%)	SH_SAN_SAFE	>95	95-65	<65	18.5	17.7	13.1
6	6.2	6.2.1	Proportion of population with basic handwashing facilities on premises, by urban/rura	SH_SAN_HNDWSH	>95	95-65	<65	82.1	83.6	54.7
6	6.3	6.3.1	Proportion of safely treated domestic wastewater flows (%)	EN_WWT_WWDS	>80	80-65	<65		17.7	24.7
6	6.4	6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater r	ER_H2O_STRESS	<25	25-75	>75		100.0	100.0

V. Conclusions and direction for future research

This paper presents the overall framework for the estimation of the interlinkages of SDGs and how it can be used for impact analysis or future projections. We estimated 169 separate econometric panel models for each of the SDG indicator, so the number of interlinkages is quite large. Also, we shown, how this matrix can be used:

(a) For integrated forecasting of the future developments of SDGs indicators – based on external projections of social and economic quantities, such as GDP, unemployment, population, the future trajectory of SDGs indicators can be forecasted;

(b) For impact analysis – policy influence on GDP and unemployment resulting from other kind of modelling (e.g. CGE modelling) can be translated into the impact on SDGs indicators through interlinkages matrix;

(c) For costing the achievement of SDGs – as outlays spent on achieving one SDGs will affect also the distance to be achieved for other indices;

(d) As a standalone tool, that can be used for the assessment of relative strength between different interlinkages.

There are few main conclusions from the analysis. Firstly, there are lot of both positive and negative interlinkages between SDGs and attempts to cost the achievement of SDGs or to project future developments without considering them is seriously flawed. Secondly, developments of *overarching* indicators, such as GDP *per capita*, unemployment and population shape the projections of many SDGs targets and general economic development is crucial for the fast achievement of the desired values of SDGs indicators. Thirdly, achievement of many SDGs would be difficult and there are very few policy areas in which there are golden bullets to allow for quick achievement of given target.

As the number of interlinkages is huge, it is difficult to analyse them case-by-case. Nevertheless, it would be beneficial for the analysis, to present and describe interlinkages for each goal separately and possibly correcting the matrices presented above. Full understanding of the relationships that we briefly described above (and presented on figure 2) as well as the influence of external policy indicators on reaching SDGs is required for building robust projections that will tell what the countries should do to reach as many SDGs as possible. Furthermore, as these interlinkages are country-specific, it would be beneficial to explore the difference in reaction of countries to different fiscal stimulus, and how efficient are different tools in reaching the SDGs targets, depending on individual characteristics of the country. This should be further explored in future research.

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