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by

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The Inclusive and Sustainable Development Index: a Data Envelopment Analysis approach[1]

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Abstract

Inclusive and Sustainable Industrial Development (ISID) calls for full engagement of policymakers in industrializing countries by minimizing environmental footprint and enhancing social inclusiveness. This study investigates the progress of 118 countries towards ISID (2005-2015) through an input-oriented CCR (Charnes, Cooper, and Rhodes) slack-based (Data Envelopment Analysis) DEA model. The efficiency analyses have been carried out with two approaches: i) the ISID approach represents the aspiration of countries to promote industrialization and consequently sustain economic growth by reducing the adverse environmental and social effects which manifest in the overall economy; ii) ISIDsdg9 approach considers the same aspects of ISID but only focuses on indicators related to the industrial sector. An analytical tool is developed to measure ISID with the two different approaches. This study finds that (i) Denmark, Sweden, and Switzerland are at the top of the ranking with the ISID approach, and the Czech Republic and Switzerland are at the top of the ranking with the ISIDsdg9 approach. Throughout 2005-2013, there is no sign of catching up between developed and developing countries in progress towards ISID and ISIDsdg9.

Keywords: Slack-Based Model (SBM), Inclusive and Sustainable Industrial Development (ISID), Data Envelopment Analysis (DEA), United Nations Sustainable Development Goals (UN SDGs).

JEL code: Q01; Q54

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1 Introduction

United Nations Sustainable Development Goal (SDG) 9 aims at building resilient infrastructure, promoting inclusive and sustainable industrial development (ISID), and at fostering innovation (UNIDO, 2019)[2]. Industrialization imposes new challenges: fossil fuel and industrial processes alone account for 65% of global greenhouse gas emissions, and the social system and unprecedented effects disproportionately burden the poorest and the most vulnerable (Intergovernmental Panel on Climate Change, 2014; UNCTAD, 2019). Urgent action is needed not only to minimize the environmental degradation led by industrial pollution and its impacts but also to advance decent work and equitable social welfare as the basis for sustained, inclusive and sustainable economic growth.

ISID calls for minimizing environmental damage and social inequality while promoting industrialization. While economic growth increases the resources available for consumption in an economy as a whole, it is often accompanied by rising inequality in the distribution of resources among individuals[3] (Kuznets, 1955). Furthermore, industrializing countries often have to pass through a worsening of environmental conditions and often through increasing inequality to reach higher levels of development. The ISID definition incorporates the vision that: i) countries need industrialization as manufacturing is an engine of growth (Kaldor, 1960) and ii) the way in which countries industrialize matters as it shapes middle- and late-stage development.

Manufacturing value added (MVA) has been the most common indicator to represent the status of industrialization achieved by a country (UNIDO, 2013, 2018, 2020). MVA is an indicator of an economy's capacity to produce goods for the satisfaction of society's needs. The post-2030 Agenda (UN SDGs) calls for complementing economic indicators with environmental and social ones. ISID integrates all three dimensions of sustainable development for the industrialization – economic, social, and environmental. Despite the relevance of the ISID concept to post-2030 Agenda, the measurement of the performance of countries encompassing the three dimensions of industrialization remains a challenge.

The present study develops a monitoring tool of ISID and ISIDsdg9 for policymakers to evaluate the progress of countries towards the UN SDG9 and presents two approaches of ISID measurement: Macro-economic (ISID) and industry-specific (ISIDsdg9). ISID happens when countries can maximize manufacturing performance (and, indirectly, country GDP growth), by minimizing total CO2 emissions and inequality within the country. The underlying approach is to measure the extent industrialization affects the environmental and social performance of the overall economy. Differing from ISID, the ISIDsdg9 formulation has to do exclusively with economic, social, and environmental indicators of the manufacturing sector. The underlying

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[2] On 2 December 2013, at the 15th session of UNIDO General Conference, UNIDO member states endorsed the Lima Declaration: Towards inclusive and sustainable industrial development. The declaration stresses the relevance of inclusive and sustainable industrial development as the basis for sustained economic growth and, while respecting the processes established by the UN General Assembly, encourages appropriate consideration of the issue in the elaboration of the post-2015 development agenda.

[3] In Kuznets (1955) model, waves of economic growth do not sweep over the whole society at the same time. Growth is instead initially confined to narrow segments of the economy, leading to an increase in labour productivity and a rising dispersion of wages within these segments, so that income inequality in the economy as a whole increases.

approach is that ISID happens when manufacturing grows without worsening the environmental and social performance of the manufacturing sector. The distinction between the ISID and the ISIDsdg9 formulation derives from the theoretical background underpinning the role of the manufacturing sector in development (Kaldor, 1967). According to the Kaldor theory, manufacturing is an engine of economic growth for all the sectors of the economy as its capacity to activate backward and forward linkages, generate spillovers and boost economies of scale. The ISID approach captures the capacity of countries to promote manufacturing as an engine of growth of the overall economy by minimizing the negative social and environmental externalities. The ISIDsd9 approach is based on the SDG9 indicators approved by the UN InterAgency and Expert Group following the adoption of the Agenda 2030 (UNIDO 2017). The ISIDsdg9 formulation responds the need of monitoring the development of the manufacturing sector from an economic, social and environmental point of view.

As demonstrated by the good international practices, the notion of the post-2030 Agenda is being mainstreamed into national policies, plans, and strategies to tackle social and environmental challenges facing the countries. In 2019 alone, 47 countries are conducting voluntary national reviews[4] at the High-Level Political Forum (HLPF) of the United Nations. Even though the concept of ISID is important to policy making for sustainable development, the mechanism to quantify the trade-off mechanism among its three pillars -economic growth, social inclusiveness, and environmental sustainability- can be complicated. The literature proposes the use of composite indices for evidence-based policymaking (see among others Saltelli 2007; Nardo, Saisana, Saltelli, Tarantola, Hoffman, Giovannini, 2008), but the composite index is often constructed based on the equal weight approach in which each component receives equal weight in the final index. This principle does not explain the choice of weights and implies perfect substitutability between economic, environmental and social indicators. As pointed out by Munda (2012), the perfect substitutability principle in measuring composite indices may not be ideal as structural characteristics, and the relevance of indicators may not be uniform across countries. A search for alternative mathematical aggregation rules and compensatory approaches in practice is then needed. Data envelopment analysis (DEA) approach is a way to measure concretely and objectively the progress of economic actors towards ISID and mitigate the equal weights and the perfect substitutability bias[5] (Atkinson, Cantillon, Marlier & Nolan, 2002).

This study aims to develop a DEA based ISID and ISIDsdg9 ranking of 118 countries. To the best of our knowledge, this is the first study to rank world countries based on their performance in terms of economic, environmental, and social indicators related to the UN SDG9 by using the

[4] As part of 2030 Agenda's follow-up and review mechanisms, its agenda for Sustainable Development encourages countries to conduct regular and inclusive reviews of progress at the national and sub-national levels (paragraph 79, Sustainable Development, 2019). These national reviews are expected to serve as a basis for the regular reviews by the high-level political forum (HLPF), meeting under the auspices of ECOSOC. As stipulated in paragraph 84 of the 2030 Agenda, regular reviews by the HLPF are to be voluntary, state-led, undertaken by both developed and developing countries, and shall provide a platform for partnerships, including through the participation of major groups and other relevant stakeholders.

[5] An example is provided by Atkinson et al. (2002), who, in the context of the EU social inclusion policy claim: "in the context of the EU, there are evident difficulties in reaching agreement on such weights, given that each member state has its own national specificity".

DEA approach. The next section introduces the literature background. Section 3 describes the methodology to elaborate an aggregate index aiming at measuring the performance of countries in terms of economic, environmental and social indicators. Section 4 analyzes the ranking and findings. The section also includes considerations based on "the reality check" aiming at comparing the DEA aggregate performance of countries with performances in each single adopted economic, social, and environmental indicator to show that the aggregated performance fully reflects the performance arising from the single components. Section 5 drafts the policy implications from the analysis.

2 Literature background

DEA is an approach developed by Charnes, Cooper & Rhodes (1978) characterized by linear programming conducted with no pre-determined assumptions about the objective function and weights. The base models can be categorized as follows: slacks-based undesirable output model, radial and non-radial measures, range-adjusted measure, and directional distance function. The slacks-based undesirable output model has received increased attention in evaluating the performances of countries and regions on the resource allocation efficiency due to its capability to account for undesirable output in the optimization process (Wei, Ni, & Shen, 2009; Li, Fang, Yang, Wang & Hong, 2013). This model framework is particularly suitable for the present study aiming at capturing the undesirable outputs of industrialization such as negative environmental or social impacts. We also adopt the non-radial approach (e.g. Färe and Lovell, 1978) as the unrealism of equiproportional targets reductions to improve the overall ISID performance implied by the radial approach.

In the field of energy and environment, a thorough literature review was conducted by Sueyoshi, Yuan, and Goto (2017, pp. 104), who categorize 693 DEA studies. They start from the acknowledgment that industrialization is necessary to increase the level of prosperity of countries, but that it generates various pollutions and health problems. To analyze these trade-offs, they point out that "DEA is one of the methodologies to examine the level of sustainability". They point out an increasing number of DEA studies in the field of energy and environment especially after 2000. They conclude that some drawbacks characterize the DEA methodology: i) the imperfect modeling treatment of technology ii) the lack of statistical inference iii) the necessity of greater attention to China (Yuan, Cheng, Wang & Wang (2019) conduct a study with a focus on China). None of the studies reviewed by Sueyoshi et al. (2017) specifically analyze SDG9 indicators performance of world countries.

Zhou, Ang, and Han (2010), Arazmuradov (2011), and Kounetas (2015) review the trade-off among energy, environmental and economic performance for more than 30 countries and monitor and evaluate the possible effect of adopted international agreement and regulation, such as Kyoto Protocol[6], on environmental efficiency of countries. Their work is relevant for the present study as a strong link with the international energy and environmental policy debate, which is one of the areas of our investigation.

[6] The Kyoto Protocol is linked to the United Nations Framework Convention on Climate Change.

3 Methodology

This study follows the DEA technique for measuring economic, social and environmental performance introduced by Zhou, Poh and Ang (2016 pp. 32) based on the notion of minimizing undesirable outputs or bad (byproducts of desirable outputs such as emissions of carbon dioxide) to achieve the same level of desirable outputs or good (beneficial outputs such as production outputs) – input-orientation approach. One strand of literature considers emitted CO2 as one of the inputs in the production function. (Gollop & Swinand, 1998; Pittman, 1983). If emissions are treated as inputs, they serve as a proxy for the use of the environment in the form of its assimilative capacity. An increase (decrease) in the quantity of a pollutant emitted represents an increase (decrease) in the use of the environment's purification services (Färe, Grosskopf & Whittaker, 2007). Pittman (1981), Cropper and Oates (1992) and Reinhard, Lovell, and Thijssen (2000) follow this approach of considering emissions as input.

In the context of ISID, manufacturing performance is the "good" to maximize; the carbon emission and social inequality are the "bad" to minimize. Based on Tone (2001), this study formulates a constant returns-to-scale slack-based input model as follows (Cooper, Heron & Heward, 2007, p. 368):

$$\rho_{Input}{}^{*} = min_{\lambda,s^-,s^+}\ [1 - \left(\frac{1}{m}\right)\sum_{i=1}^{m}\frac{s_i{}^-}{x_{i0}}] \tag{1}$$

Subject to

$$x_{i0} = \sum_{j=1}^{n} x_{ij}\lambda_j + s_i{}^-(i = 1\ , \ldots , m) \tag{2}$$

$$y_{r0} = \sum_{j=1}^{n} y_{rj}\lambda_j - s_r{}^+(i = 1\ , \ldots , s) \tag{3}$$

$$\lambda_j \geq 0(\forall j), s_i{}^- \geq 0(\forall i), s_r{}^+ \geq 0(\forall r) \tag{4}$$

x_{i0} stands for input vectors, y_{r0} stands for desirable output vectors. λ_j is an intensity vector. $s_i{}^-$ stands for the surpluses in the inputs, and $s_r{}^+$ stands the deficiencies in desirable outputs. Target value $\rho_{Input}{}^*$, is between 0 and 1. $\lambda_j{}^*, s_i{}^{-*}, s_r{}^{+^*}$ stand for optimal solution values. If the decision making unit evaluated is efficient, it is taken as: $\rho_{Input}{}^* = 1$, $s_i{}^{-*} = 0$, and $s_r{}^{+^*} = 0$; If it is not, it is taken as: $\rho_{Input}{}^* < 1$. It is worth highlighting that the SBM model is designed to meeting the following two conditions: Unit variant and monotone. That means the measure should be invariant concerning the units of data and should be monotone decreasing in each slack in the input.

3.1 Dual formulations of Inclusive and Sustainable Industrial Development (ISID) indicators

The mathematical optimization does not solve another problem underlying ISID indices: the choice of the indicators composing the final ISID index. Our approach is to offer two formulations of ISID and ISIDsdg9: ISID represents the aspiration of countries to promote industrialization and consequently sustain growth by reducing the adverse environmental and social effects which manifest in the overall economy. ISIDsdg9 considers the same aspects of ISID but limits the externalities within the industrial sector and to indicators universally recognized as important to monitor SDG9.

3.2 Data section

A list of three indicators from Table 1 are proposed to quantify the three dimensions of ISID where MVApc is manufacturing value added per capita (United Nations Industrial Development Organization, 2018), $\mathrm{CO2pc}$ is CO2 emissions per capita (The World Bank, 2018) and GINI is an inequality index (Gini net index applied to incomes net of taxes from SWIID, Standardized World Income Inequality Database, 2018). MVA per capita is an SDG9 indicator representing the capacity of countries to boost industrialization and is included among the officially approved SDG9 indicators (UNIDO 2017). CO2 emissions per capita and the GINI index are selected among popular and recognized indicators to represent the impact of economic variabes on environmental variables and social variables (see among others Apergis 2016 and Milanovic 2016). ISIDsdg9 indicators are all inspired by the universally recognized SDG9 monitoring indicators (UNIDO 2017).

Table 1. ISID indicators

Dimensions	ISID		ISIDsdg9	
Manufacturing development	MVApc	Manufacturing value added per capita	MVApc	Manufacturing value added per capita
Social inclusiveness	GINI	Inequality index expressing inequality in the distribution of income within the country	MEMPGAP	The gap between each province and the best performer in terms of industrial employment share in total employment
Environmental sustainability	CO2pc	Total CO2 emission per capita	MCO2INT	Manufacturing CO_2 emission intensity (KG per value-added US$)

Source: INDSTAT2 rev.3 (United Nations Industrial Development Organization, 2018); World Development Indicators (The World Bank, 2018); Standardized World Income Inequality Database (Solt, 2018)

The differences between ISID and ISIDsdg9 is represented by the environmental and social indicators. ISIDsdg9 considers manufacturing CO2 emission intensity (CO2 emission, kt per value-added US$) as an environmental indicator. Furthermore, inspired by the global indicator framework[7] namely Indicators 9.2.1, 9.2.2 and 9.4.1 (UNSD, 2018[8]), ISIDsdg9 takes into account the manufacturing employment gap as a social indicator (the gap between a country's manufacturing employment share and that of the country with the highest share in the world). The ISID approach captures non-manufacturing specific environmental and social indicators such as total CO2 emissions per capita and the Gini index of inequality. The ISID approach captures the extent industrialization impacts environmental and social aspects on the overall economy, whereas the ISIDsdg9 approach specifically captures manufacturing related variables.

One of the best ways of making sure there is not much imbalance in the data sets is to have them at the same or similar magnitude (Sarkis, 2007). A way of making sure the data is of the same or similar magnitude across and within data sets is to min-max normalize the data. The process of min-max normalization requires two steps. The first step is to find the minimum and maximum values of each indicator by year. The second step is to divide each input or output by the range of the min-max for that specific factor.

4 Main findings and discussions

The DEA approach is the one which could probably best capture the essence of the ISID concept: Traditional composite indices capture the capacity of countries to increase all the dimensions of sustainability simultaneously. The DEA approach calculates to what extent countries minimize trade-offs across different dimensions of sustainability.

We tested the ISID specification for the period of 2005 – 2013 for 50 countries and the ISIDsdg9 specification for 118 countries over the period 2005 – 2015[9]. The DEA algorithm generates the following top and bottom five rankings, as illustrated in Table 2:

Table 2: The ranking of ISID

Top 5 ISID 2013	Bottom 5 ISID 2013
Switzerland	Chile
Denmark	Serbia
Norway	Bulgaria
Sweden	TFYR of Macedonia
Belgium	Georgia

Table 3: The ranking of ISIDsdg9

Top 5 ISIDsdg9 2015	Bottom 5 ISIDsdg9 2015
Czech Republic	Kyrgyzstan

[7] https://unstats.un.org/sdgs/metadata/?Text=&Goal=9&Target=

[8] https://unstats.un.org/sdgs/metadata/

[9] The requirement of balanced dataset for all the ISID and ISIDsdg9 variables (see Table 1) has imposed a limitation on the time series of our sample, thus, we have worked on a narrower dataset in terms of country coverage and time periods to maintain a balanced dataset across countries and time (see Table 1). Based on latest available data points in our dataset, we included final ranking of the indices for 50 countries in 2013 (ISID index) and 118 countries in 2015 for the ISIDsdg9 index (see Appendix 1-2).

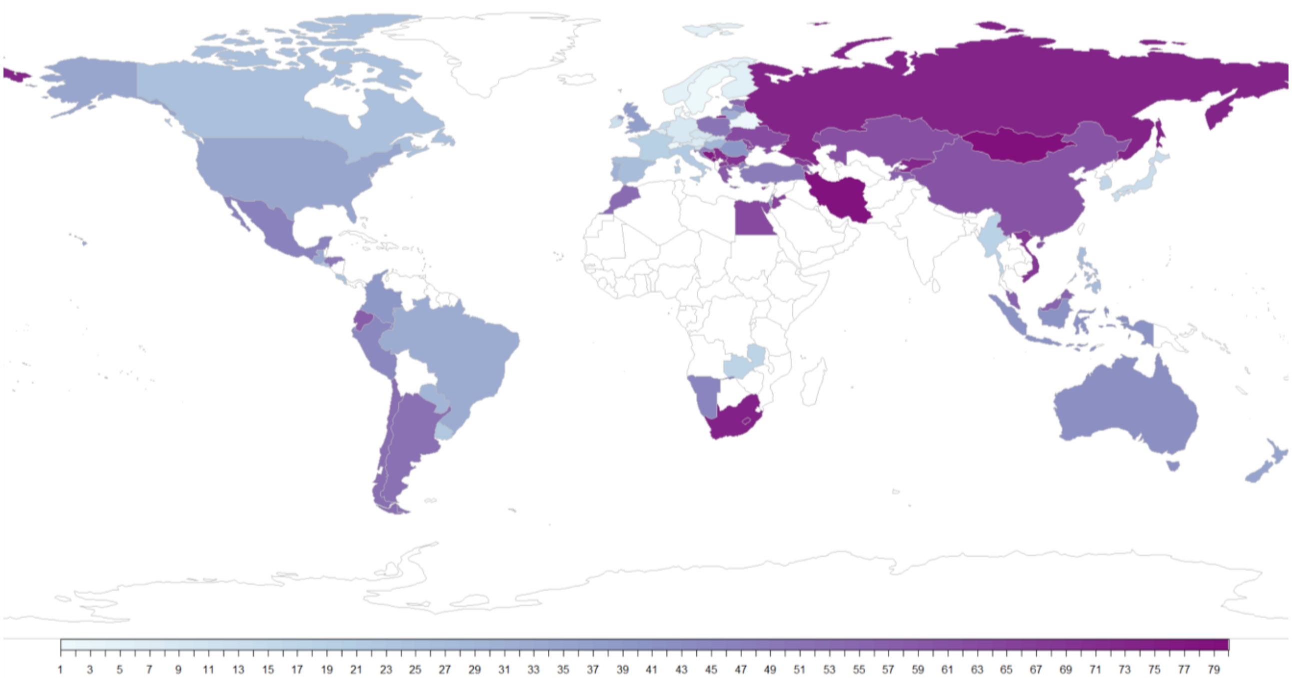
Switzerland	Iraq
Germany	Ethiopia
Japan	Nepal
Ireland	Syria

A first insight emerging from the ranking in Table 2 is that the industrialized countries are, in relative terms, more efficient in generating manufacturing value-added by minimizing the environmental footprint and social inequality. Eastern Europe countries tend to be towards the bottom of the ranking. An exception of a developed country included at the bottom of the list is Chile, which is penalized, especially by a low share of manufacturing employment in the ISID formulation.

4.1 ISID approach

Figure 1 presents the main results of ISID efficiency scores: The scale of colors represents the level of integration efficiency among countries. The lower the efficiency score, the deeper the purple. It is worth mentioning that Northern European countries like Sweden, Switzerland, Norway, and Denmark (integrated efficiency score: 1) are the best performers in the ISID regime as these countries constitute the benchmark of ISID mainstreaming (see Appendix 1 for complete ISID ranking). It also appears that the Central Asia countries are less efficient in the context of ISID. The countries without color labeling indicate missing data.

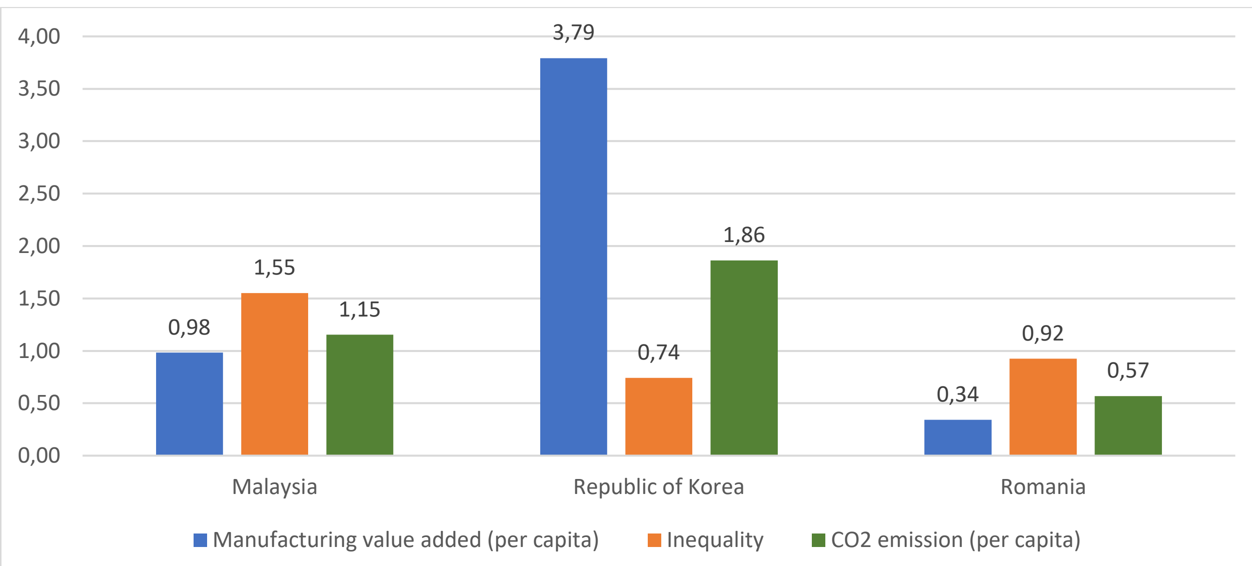
Figure 1. ISID ranking (2013)



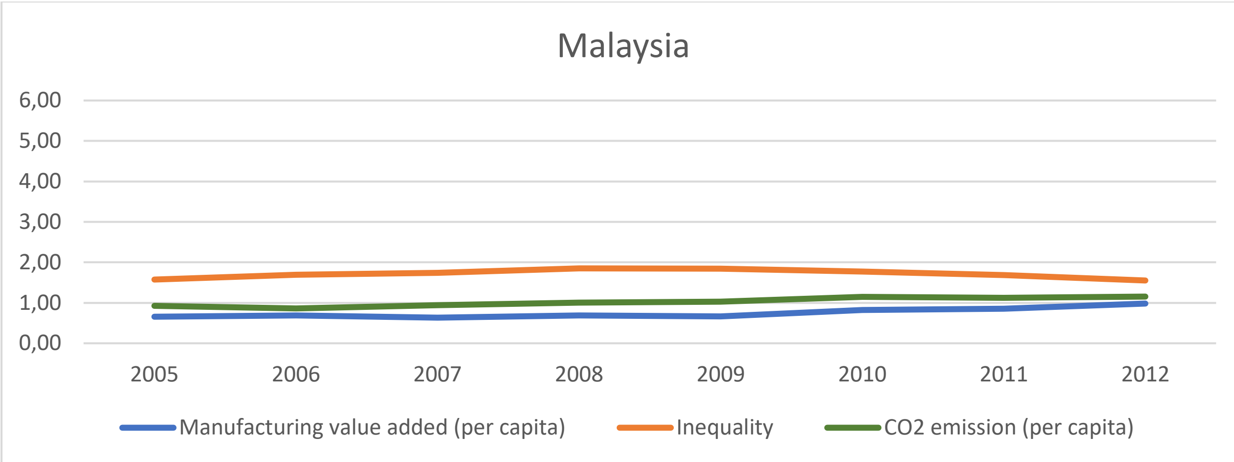
Source: Authors' elaboration based on input-oriented DEA CCR SBM model

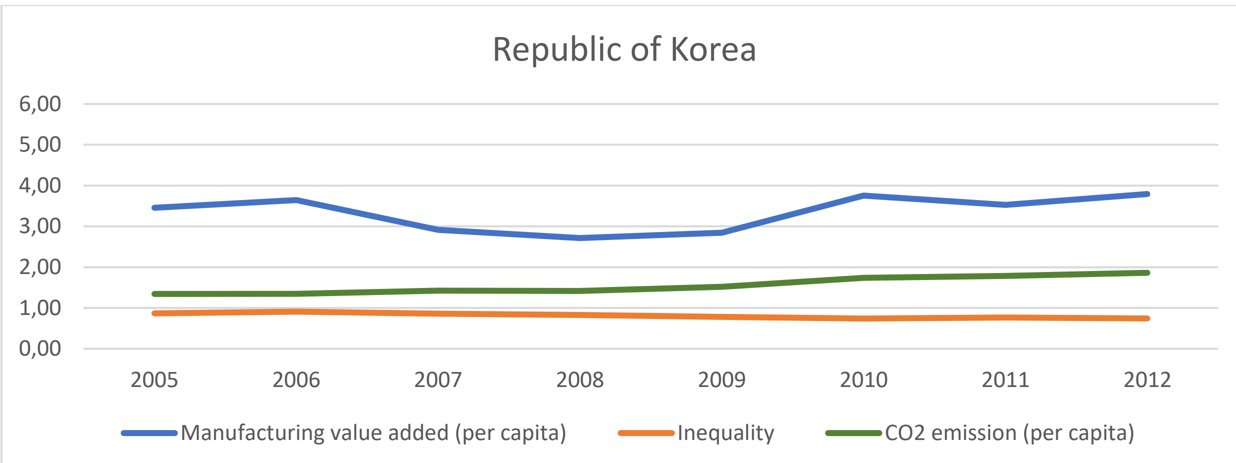
Figure 2 (upper panel) illustrates the extent to which a country performs better or worse with the DEA methodology. The Republic of Korea outperforms the other countries because it produces (relative to the median value of indicator)[10] a high level of manufacturing value-added per capita (blue bar) with relatively low levels of inequality (orange bar) and CO2 emissions per capita (green bar). While Malaysia and Romania are characterized by similar levels of CO2 emissions per capita and inequality as compared to that of the Republic of Korea, the level of manufacturing value-added is far below the median level. In other words, these countries are less efficient in generating manufacturing value-added because they pay "higher toll rates" in terms of carbon emissions and social inequality. The difference between the Republic of Korea from one side and Romania and Malaysia on the other side emerges by looking at the time series graphs (Figure 2, lower panel). The Republic of Korea stands for its excellent performance of manufacturing value added (relative to CO2 emissions per capita and inequality), whereas lower performance characterizes Romania and Malaysia. By looking at the ranking of Romania (45th) and Malaysia (37th), Figure 2 could shed light on why these countries look particularly penalized in their ranking as a result of the poor performance in social equality.

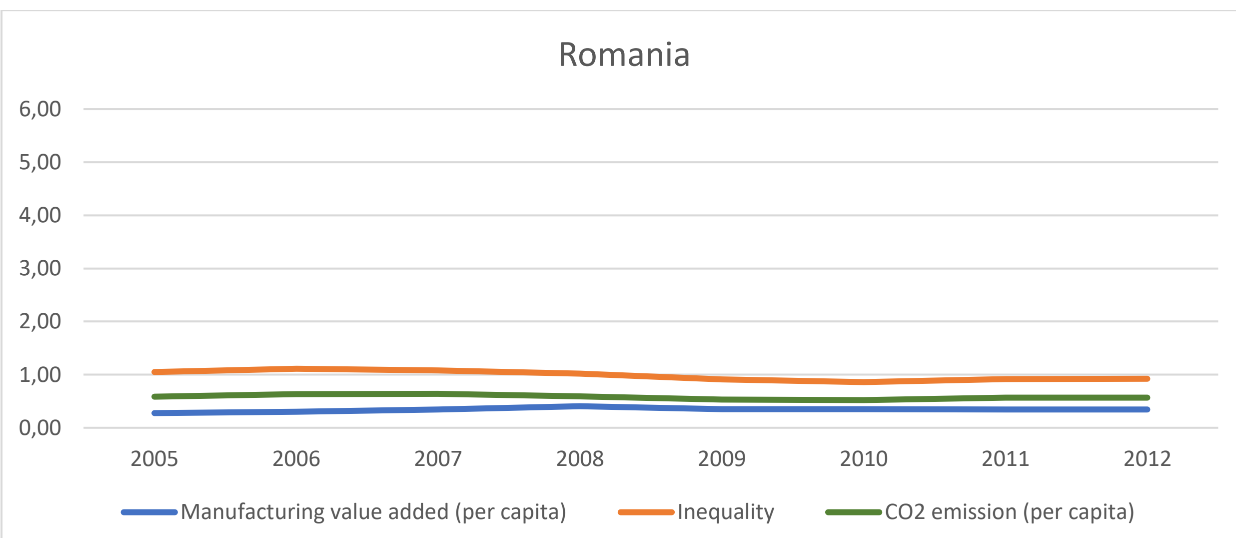
Figure 2: ISID index components analysis for 2013, Republic of Korea (10th in the ISID ranking), Malaysia (37th in the ISID ranking) and Romania (45th in the ISID ranking)



[10] To ensure a comparable scale across all variables, we normalized the key variables for ISID and ISIDsdg9 indices using the min-max approach (Sarkis, 2007) before carrying out the optmization (input-oriented DEA CCR SBM model) as described in the Section 3.2. To conduct the reality check contained in Section 4 we applied a parsimonious median-normalization to illustrate the actual performance of countries on the variables used to construct the ISID and ISIDsdg9 indices. The application of median-normalization was based on two main considerations: (i) The mid-value of each variable was not severely distorted by the outliers in the sample. (ii) Some practical implications can be made for countries, based on their distances to the comparator with mid position in the sample.







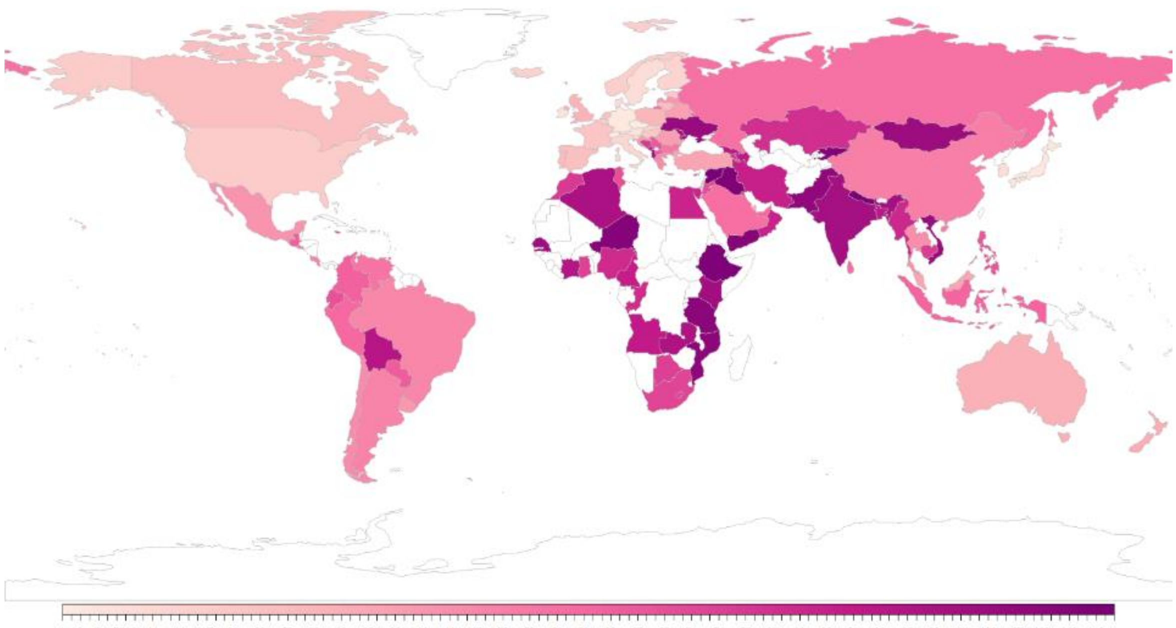
Source: INDSTAT2 rev.3 (United Nations Industrial Development Organization, 2018); World Development Indicators (The World Bank, 2018); Standardized World Income Inequality Database (2018)

Note: The median value of the sample normalizes variables

4.2 ISIDsdg9 approach

We can now turn the attention to the ISIDsdg9 approach by considering only indicators concerning UN SDG9, approved as international indicators, and focusing specifically on the manufacturing sector. Based on the dataset of 118 countries in 2015, Figure 3 presents the global ranking of ISIDsdg9 with the Czech Republic, and Switzerland positioned on the efficiency frontier (integrated efficiency score equal to 1). The performance of the Czech Republic and Switzerland is characterized by low CO2 emission intensity and high manufacturing employment share. By reviewing the ranking of countries across regions, we see that, in general, the countries in Africa and South Asia regions perform below the average.

Figure 3: ISIDsdg9 ranking for 2015

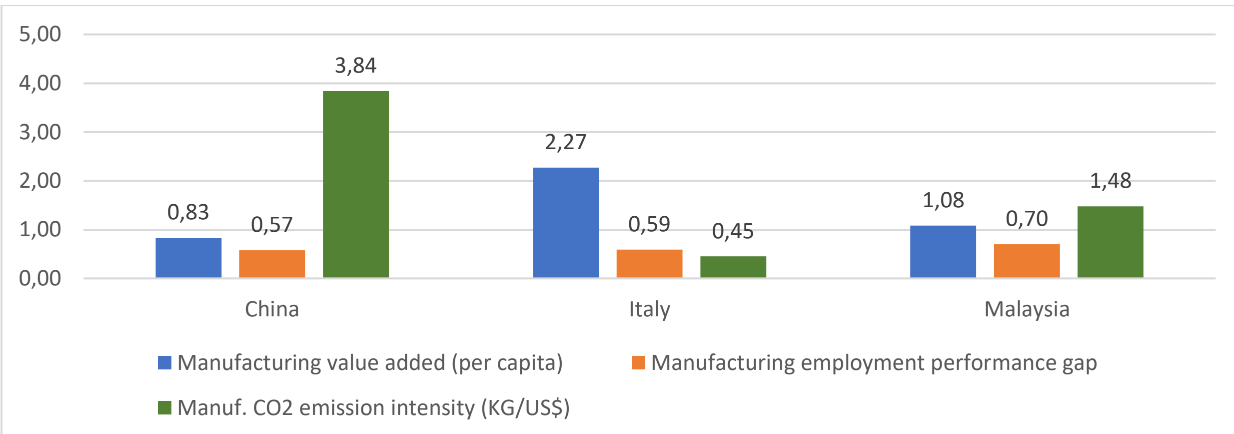


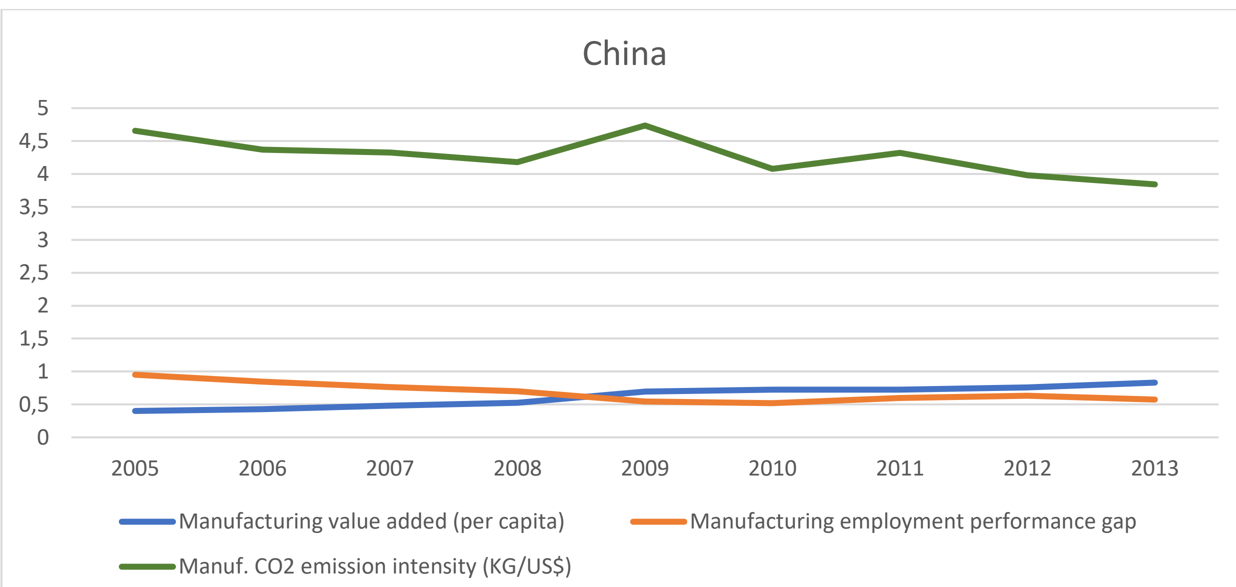
Source: Authors' elaboration based on input-oriented DEA CCR SBM model

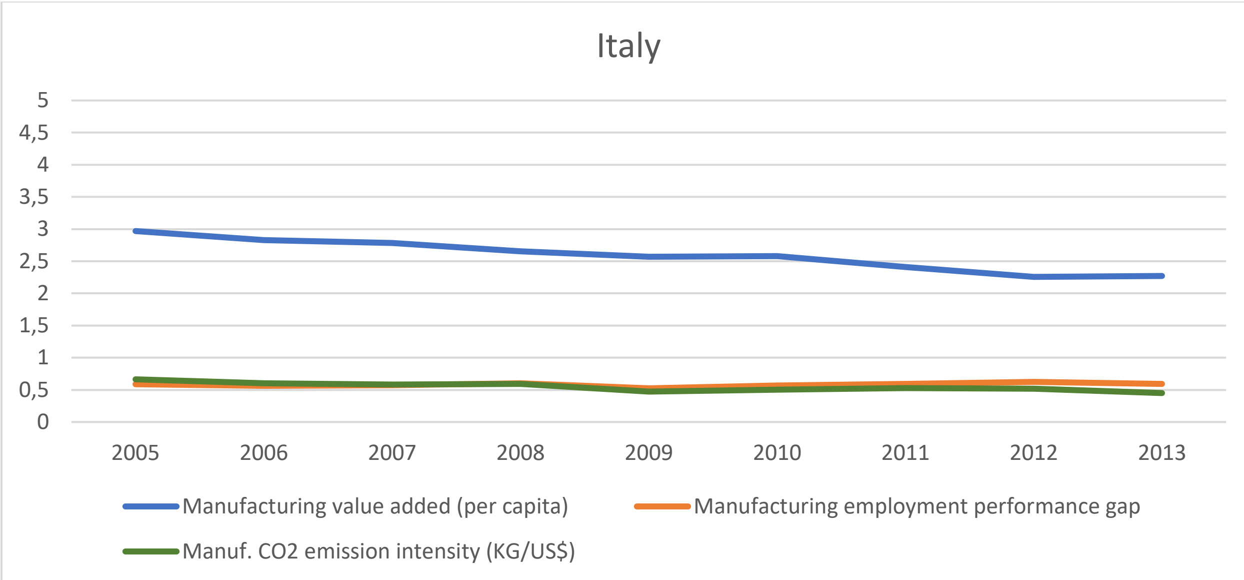
In Figure 4 (upper section), it is evident that Italy has an outstanding performance in producing MVA per capita (blue bar) relative to low levels of the manufacturing CO2 emissions intensity and the gap from the best performer in terms of manufacturing employment (orange and green lines). China and Malaysia are particularly inefficient in producing MVA per capita by reducing CO2 emissions intensity. Figure 4 (lower panel) illustrates a declining trend of efficiency score for the case of Italy, suggesting that the capability of Italy in generating manufacturing value-added has been decreasing gradually over time with a relatively stable path of emissions intensity and inequality. Italy is an example of rapid deindustrialization accelerated by the global financial crisis.

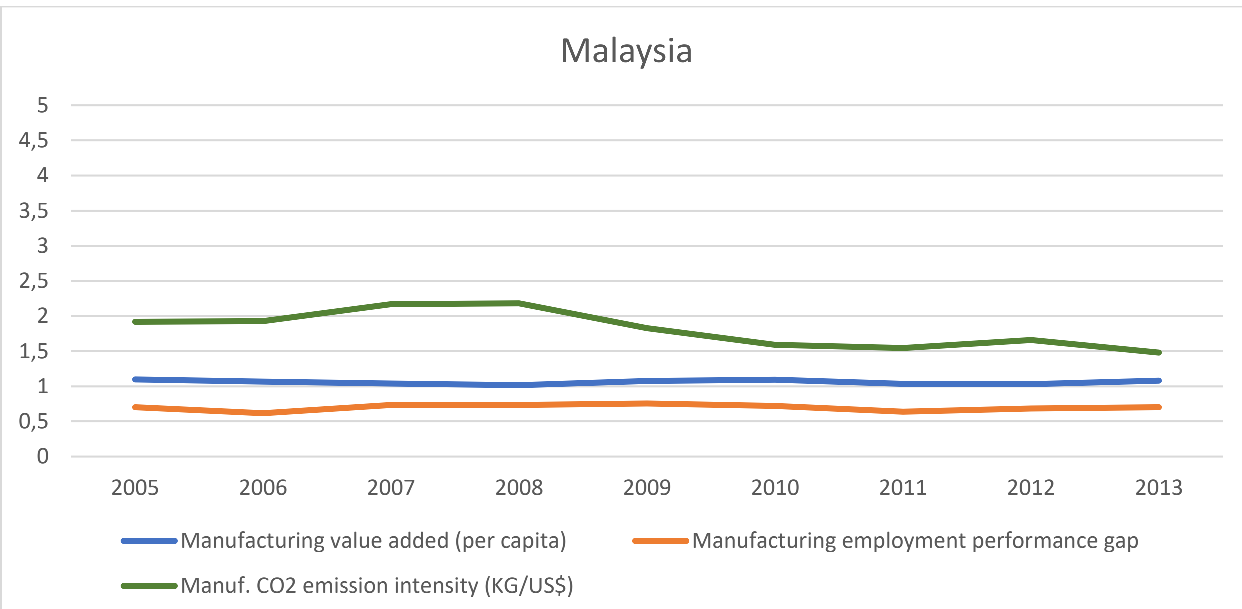
Italy has lost one place (10th in 2015) since 2005 as a result of declining MVA performance. In many developed countries, the value of industrial-led growth for society has come into question as a result of increasing inequality. In developing countries, record decreases in poverty and growing manufacturing activities have fueled higher demand for transportation and energy; these demands are now clashing with environmental challenges facing most of the developing countries. As is the case of China, its CO2 intensity for the manufacturing sector is about 3.8 times higher than the global average.

Figure 4: ISID SDG9 components analysis for 2013, Republic of Korea (10th in the ISID ranking), Malaysia (37th in the ISID ranking) and Romania (45th in the ISID ranking)









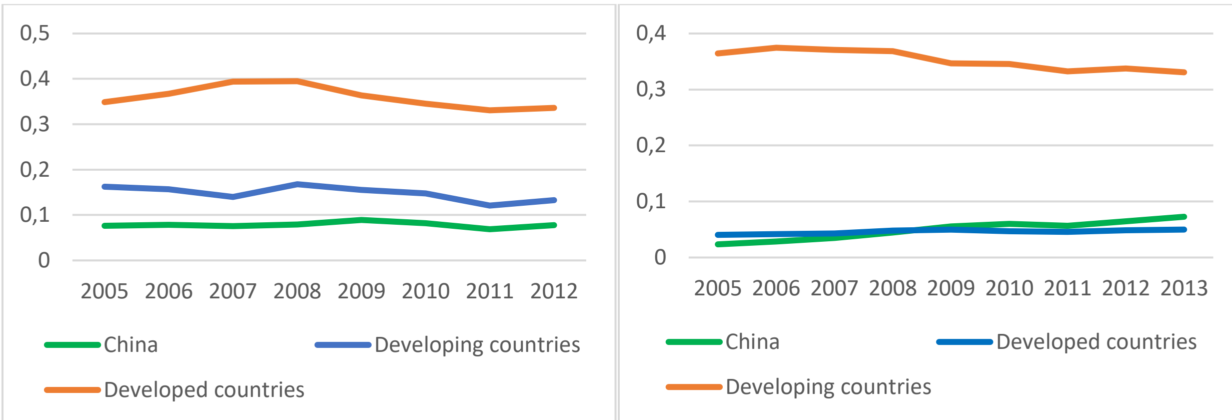
Source: INDSTAT2 rev.3 (United Nations Industrial Development Organization, 2018); World Development Indicators (The World Bank, 2018); Standardized World Income Inequality Database (Solt, 2018)

Note: The median value of the sample normalizes variables. The assumption underlying this graph is that value-added is scaled at the same level for all the included countries.

The evidence presented above is supported by average measures of the efficiency scores of ISID and ISIDsdg9 for developed and developing countries. Developed countries are the most efficient, as can be seen in our analysis in the previous section. Over the period 2005 – 2012 (for both ISID and ISIDsdg9), there is no sign of catching up between developed and developing countries. China, in the ISID model, is the most inefficient region, even lower than the average score of the other developing countries. Based on the ISIDsdg9 formulation, China is more in line with other developing countries.

4.3 Aggregate results of developed and developing countries

Figure 5: Efficiency score of ISID model (2005 – 2012); ISIDsdg9 (2005-2013)



Source (left): INDSTAT2 (UNIDO, 2017), World Development Indicators (The World Bank, 2017), SWIID (Solt, 2017); Source (right): SDG 9 Indicators (UNIDO, 2018);

Income classification: GNI per capita in US$ (Atlas methodology) (The World Bank, 2013)

5 Policy section

Policymakers face the challenge of simultaneously addressing different environmental, social, and economic goals. These challenges are associated with the core dimensions of ISID, which now features strongly in the 2030 Agenda for Sustainable Development[11]. All countries have the potentials to activate the ISID, and policymakers are encouraged to continue reviewing the best practice of ISID and accelerate their progress and pave the way for ISID. There has emerged an urgent need for an objective and comprehensive ISID policy tool to rationalize the trade-off among the multidimensional notion of ISID and well as to monitor and evaluate the progress of countries towards ISID.

An immediate question arising from here: How can this study support policymakers to formulate effective monitoring and evaluation systems and evidence-based policy interventions to achieve ISID? This study puts forward a policy tool -based on the input-oriented DEA-CCR-SBM model- to identify and benchmark the country with the best practice of ISID. There are two guiding steps for ISID benchmarking: (i) To identify the ISID best practice "role model" countries (ii) To conduct an assessment on reduction potentials. A concern with this policy tool is that it neither prescribes the specific policy tool nor introduce a one-size-fit-all solution as country conditions differ. Our approach identifies the country's role model with the ISID best practice and assesses the efforts required to reach the target. The modalities to achieve the target would require a more in-depth policy study about the specific enablers of ISID.

Figure 6 presents a two-dimensional figure on the trade-off between social equality and environmental sustainability in achieving a similar level of manufacturing development for 50 countries in 2013. The input-oriented DEA-CCR-SBM model suggests that Norway, Denmark,

[11] https://www.unido.org/inclusive-and-sustainable-industrial-development

Sweden, and Switzerland reach the efficiency frontier (red curve). They are the most efficient countries which are capable of accelerating the manufacturing sector and minimizing the negative externalities of carbon emission (CO2 emission per capita) and social inequality (GINI) at the same time.

We turn now to the ISIDsdg9 approach, in which we limit the externalities of ISID within the manufacturing sector. In Figure 7, we can characterize 118 countries based on their performance in terms of CO2 emissions intensity (CO2 emission per value-added) and manufacturing employment gap (distance from the country with highest manufacturing employment share) by assuming that these countries achieve the similar level of manufacturing development. A general observation holding for both the ISID and ISIDsdg9 approaches is that OECD countries are the most efficient and clustered towards the origin of the diagram. As illustrated by Figures 6 and 7, developing countries have, in general, the longest distance to the efficiency frontier (red curve). Based on the ISIDsdg9 approach In 2015 (Figure 7), the Czech Republic and Switzerland are the most efficient countries in generating manufacturing value-added and capable of minimizing manufacturing CO2 emissions intensity and the gap to the best performer in terms of manufacturing employment share in total employment. It is worth mentioning that the Czech Republic is characterized by the highest level of manufacturing employment in total employment and shares the frontier status with Switzerland, which has the lowest carbon intensity in the same year.

In Figures 6 for a country like Malaysia, we can establish a radiate line (from origin to DMU) reaching the target role model countries (Countries on the efficiency frontier: Switzerland, Sweden, and Denmark) or comparator (On the radiate line and closer to the frontier: Italy) for the ISID benchmarking. We can also identify the reduction potentials of a country to the role model or a comparator as if these countries could achieve similar manufacturing development as Malaysia but with a lower carbon footprint and more socially inclusive.

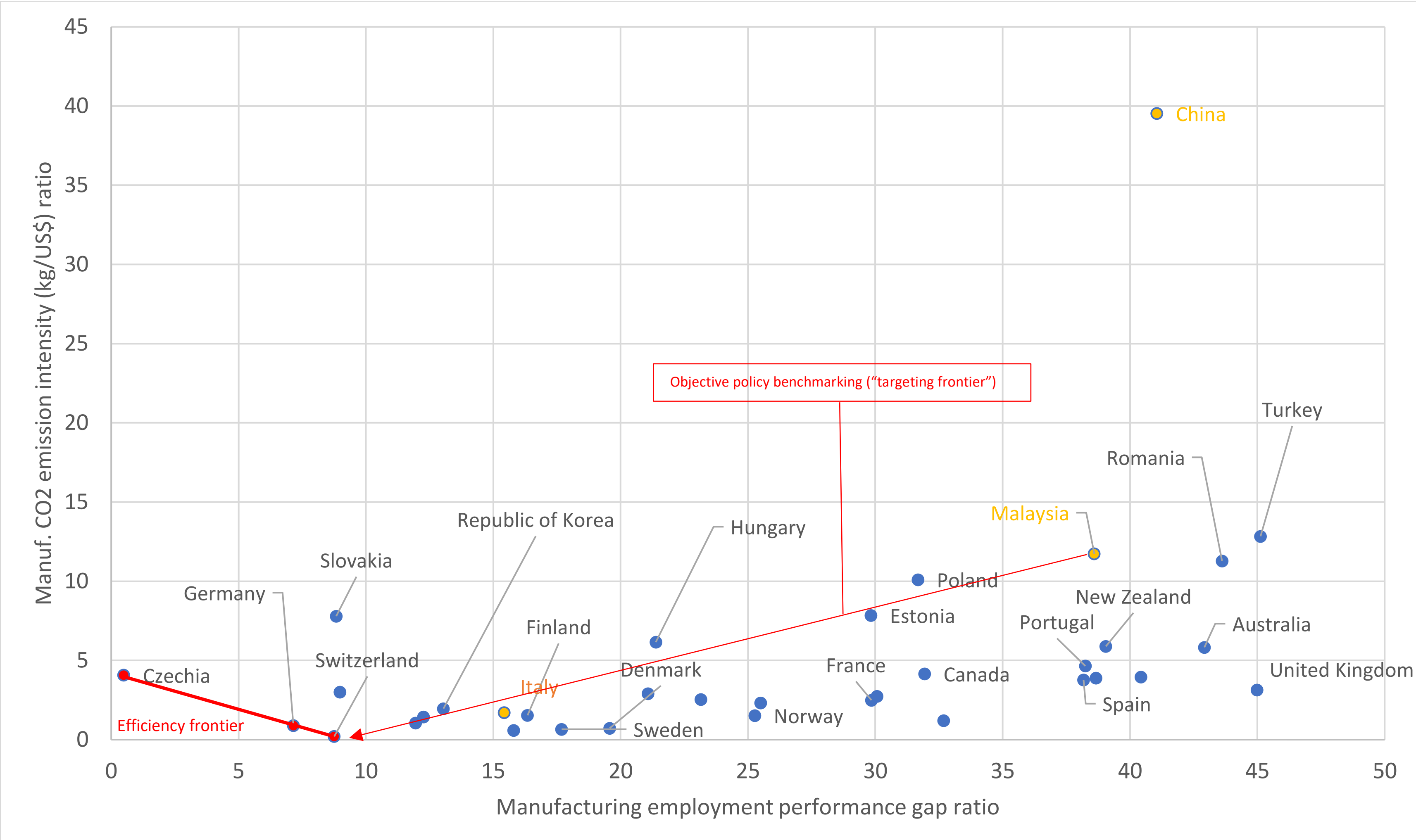
Similarly, in Figure 7, this benchmarking analysis can be applied to ISIDsdg9 for manufacturing specific policymaking. As discussed earlier, the Czech Republic and Switzerland are the countries on the efficiency frontier that serve as role model countries for the ISIDsdg9. As the ISIDsdg9 indicator considers employment within the manufacturing sector, it is expected that the model penalizes advanced countries that have been experiencing de-industrialization, like Australia and New Zealand, which are characterized by low manufacturing employment share (high gap ratio to the best performer). A more developed country, like Italy, with a strong manufacturing base and relatively low CO2 emission intensity, could be a suitable comparator for Malaysia.

Figure 6: Efficiency analysis for the full sample of 50 countries for 2013: ISID model

Source: INDSTAT2 rev.3 (United Nations Industrial Development Organization, 2018); World Development Indicators (The World Bank, 2018); Standardized World Income Inequality Database (2018)

Note: The assumption underlying this graph is that value-added is scaled at the same level for all the included countries

Figure 7: Efficiency analysis for the full sample of 118 countries for 2015: ISIDsdg9 model



Source: INDSTAT2 rev.3 (United Nations Industrial Development Organization, 2018); World Development Indicators (The World Bank, 2018); Standardized World Income Inequality Database (2018)

Note: The assumption underlying this graph is that value-added is scaled at the same level for all the included countries

Table 4: Efficiency analysis for the full sample of 50 countries for 2013: ISID model

Country	Manufacturing value added per capita (US$)	CO2 emission (kt) per capita	GINI (disposable income)	Ranking	Efficiency score	Targeted CO2 emission (after slack adjustment)	Targeted GINI (after slack adjustment)
Switzerland	14049	0.004312	29.2	1	1.00	0.004312	29.20
Denmark	7184	0.005936	25.4	1	1.00	0.005936	25.40
Sweden	7922	0.004478	25.9	1	1.00	0.004478	25.90
Austria	8356	0.006874	27.7	8	0.68	0.004707	26.08
Germany	9388	0.008889	29.1	9	0.60	0.005342	26.49
Republic of Korea	7052	0.011570	30.6	17	0.36	0.004254	25.52
Italy	**4918**	**0.005271**	**33.1**	**22**	**0.29**	**0.001599**	**24.27**
Malaysia	**2391**	**0.008033**	**41.4**	**56**	**0.09**	**0.000849**	**23.20**
China	1905	0.007544	40.1	61	0.08	0.000704	23.10

Source: INDSTAT2 rev.3 (United Nations Industrial Development Organization, 2018); World Development Indicators (The World Bank, 2018); Standardized World Income Inequality Database (Solt, 2018)

Table 5: Efficiency analysis for the full sample of 118 countries for 2015: ISIDsdg9 model

country	Manufacturing value added per capita (US$)	CO2 emission (kt) per value added (US$)	Manufacturing employment gap	Ranking	Efficiency score	Targeted CO2 emission (after slack adjustment)	Targeted Manufacturing employment gap (after slack adjustment)
Czech Republic	4929.24	0.22	27.30	1	1.00	0.22	27.30
Switzerland	13773.69	0.04	12.58	1	1.00	0.04	12.58
Germany	9485.02	0.12	19.30	3	0.98	0.12	19.13
Austria	8460.94	0.13	15.96	6	0.66	0.09	12.02
South Korea	7118.54	0.22	17.29	8	0.53	0.12	12.44
Italy	**4980.94**	**0.12**	**18.34**	**12**	**0.48**	**0.06**	**13.55**
Malaysia	**2467.67**	**0.38**	**16.51**	**36**	**0.14**	**0.06**	**7.02**
China	2016.38	0.95	18.36	51	0.07	0.08	9.81

Source: INDSTAT2 rev.3 (United Nations Industrial Development Organization, 2018); World Development Indicators (The World Bank, 2018); Standardized World Income Inequality Database (Solt, 2018)

From a policy perspective, it is also useful for an assessment of the trade-off among externalities brought by industrialization. Table 4 presents the indicator-specific efficiency values of 9 countries. According to the input-oriented DEA-CCR-SBM model, it is possible to measure the reduction potentials of a country to reach the efficiency frontier. For example, Malaysia has to reduce its CO2 emissions to 0.00085 (CO2 emissions kt, per capita) and reach social equality at the level of 23.2 (in GINI) to achieve the best ISID performance. Malaysia would be able to achieve a higher level of ISID by reducing inequality and by decreasing its carbon emission that implies the adoption of technologies and practices decoupling natural resource use and environmental impacts from economic growth.

Table 5 presents the gap between Malaysia's actual and targeted manufacturing CO2 emission intensity and manufacturing employment share for the ISIDsdg9 formulation. Based on the data in 2015, a country like Malaysia could become technically efficient in ISIDsdg9 by reducing CO2 intensity by 0.32 (CO_2 emissions kt, per value-added US$) and minimizing the employment gap by about 9.5%.

It has become apparent that, for a country like Malaysia, the binding constraint on the country to achieve higher levels of ISID and ISIDsdg9 appears to be the carbon emission. Mainstreaming ISID and ISIDsdg9 into national policies can have far-reaching impacts on communities at all levels. When environmental safeguards and social inclusiveness criteria are adequately taken into account, as ISID mandates it, industry proves to be a powerful driver of prosperity and collective wellbeing.

6 Conclusions

ISID calls for the full engagement of policymakers in industrializing countries by minimizing environmental footprint and negative social impacts. Despite this is a substantial concept finding a vast consensus of the international community, as it is reflected in the approval of the SDG9 about industrialization, inclusiveness, and environmental sustainability, from an operational point of view it is quite complicated to monitor and evaluate the progress of countries and set benchmarks. Many attempts to express ISID through composite indexes, including economic, environmental, and social indicators, are not completely useful for policymakers and practitioners. The main practical problem is that composite indices assume equal weights (the economic indicator, the environmental indicator, and the social indicator have the same importance at every level of income per capita) and are characterized by perfect substitutability (the rate of substitution across indicators to maintain the same level of ISID is constant over time). A methodology called Data envelopment Analysis overcomes these technical problems (which imply substantial difficulties in interpreting ISID correctly) by an optimization algorithm calculating optimal weights putting countries in the most favorable position in the final ranking based on the underlying economic structure. The present study applies the Data Envelopment Analysis by using two formulations: in the first one, the concept is to produce manufacturing value added per capita by minimizing total CO_2 emissions per capita and inequality in the distribution of income. This is a formulation interpreting ISID as industrialization obtained by minimizing adverse externalities of industrialization on the overall economy.

Furthermore, ISIDsdg9 formulation interprets ISID as industrialization obtained by minimizing detrimental environmental pressure impacts and negative social impacts within the manufacturing sector. In both formulations, we find that industrialized countries tend to perform better than emerging countries, but interesting distinctions also emerge. New and more appropriate formulations could emerge from further discussions and thinking, but a general finding arising from this study is that ISID should probably be dealt with methodologies able to fully capture the extent of the tradeoff between economic indicators and negative social and environmental indicators.

Annex 1. ISID ranking of 50 countries for 2013

Case: ISID (Normal)

Year: 2013

Data: UNIDO INDSTAT, IEA, SWIID

Data: MVA per capita (US$), CO2 emission per capita (Kt per capita), GINI net

country	year	rank	theta
Switzerland	2013	1	1
Denmark	2013	1	1
Norway	2013	1	1
Sweden	2013	1	1
Belgium	2013	5	0.7684605
Finland	2013	6	0.6679813
Austria	2013	7	0.4916249
Czech Republic	2013	8	0.4776648
Germany	2013	9	0.4733471
Netherlands	2013	10	0.4714312
Republic of Korea	2013	11	0.460112
France	2013	12	0.3918104
Slovenia	2013	13	0.3756631
Costa Rica	2013	14	0.3629705
Sri Lanka	2013	15	0.3315724
Brazil	2013	16	0.3228744
Slovakia	2013	17	0.2853143
Luxembourg	2013	18	0.2835943
Singapore	2013	19	0.2739699
Italy	2013	20	0.2524402
Canada	2013	21	0.2425811
Peru	2013	22	0.2174224
United States	2013	23	0.2118069
New Zealand	2013	24	0.2017948
Hungary	2013	25	0.1982384
Colombia	2013	26	0.1847103
United Kingdom	2013	27	0.1729781
Spain	2013	28	0.1726647
Australia	2013	29	0.164318
Portugal	2013	30	0.1636461
Israel	2013	31	0.1435971
Latvia	2013	32	0.119324
Croatia	2013	33	0.1139362
Indonesia	2013	34	0.105093

Lithuania	2013	35	0.0988915
Mexico	2013	36	0.098214
Poland	2013	37	0.0937966
China	2013	38	0.0902135
Estonia	2013	39	0.0852262
Turkey	2013	40	0.085142
Romania	2013	41	0.0809949
Ecuador	2013	42	0.0785311
Russian Federation	2013	43	0.0699482
Greece	2013	44	0.0611174
Cyprus	2013	45	0.0587147
Chile	2013	46	0.0540018
Serbia	2013	47	0.0499389
Bulgaria	2013	48	0.0490355
TFYR of Macedonia	2013	49	0.0409122
Georgia	2013	50	0.0371048

Annex 2: ISIDsdg9 ranking of 118 countries for 2015

Data: UNIDO SDG indicators (internal source), imputed data

Data: MVA per capita (2010 US$), CO2 emission per value added (KG/US$), Manufacturing employment share (gap to top performer)

Country	year	rank	theta
Czech Republic	2015	1	1
Switzerland	2015	1	1
Germany	2015	3	0.98001
Japan	2015	4	0.673286
Ireland	2015	5	0.661336
Austria	2015	6	0.660782
Slovenia	2015	7	0.605382
South Korea	2015	8	0.527366
Sweden	2015	9	0.502005
Denmark	2015	10	0.497102
Singapore	2015	11	0.491595
Italy	2015	12	0.480457
Slovakia	2015	13	0.475114
Finland	2015	14	0.418749
Iceland	2015	15	0.34522
Belgium	2015	16	0.345103
Norway	2015	17	0.329242
USA	2015	18	0.314011

Estonia	2015	19	0.289053
Hungary	2015	20	0.286789
France	2015	21	0.278469
Israel	2015	22	0.271913
Netherlands	2015	23	0.269019
Spain	2015	24	0.242109
Canada	2015	25	0.234541
Lithuania	2015	26	0.219128
Portugal	2015	27	0.208753
Luxembourg	2015	28	0.208368
Poland	2015	29	0.197634
Brunei	2015	30	0.191579
UK	2015	31	0.18421
Australia	2015	32	0.171908
New Zealand	2015	33	0.17042
Qatar	2015	34	0.169978
Bahrain	2015	35	0.143606
Malaysia	2015	36	0.142312
Turkey	2015	37	0.135244
Belarus	2015	38	0.124852
Romania	2015	39	0.120008
Croatia	2015	40	0.119708
Uruguay	2015	41	0.109163
Latvia	2015	42	0.10478
Mexico	2015	43	0.102243
Mauritius	2015	44	0.088464
Thailand	2015	45	0.085496
Chile	2015	46	0.07923
Greece	2015	47	0.077569
Brazil	2015	48	0.074148
Argentina	2015	49	0.073585
Costa Rica	2015	50	0.073369
China	2015	51	0.071922
Trinidad and Tobago	2015	52	0.065895
El Salvador	2015	53	0.05989
Bulgaria	2015	54	0.059814
Venezuela	2015	55	0.058152
Russia	2015	56	0.055794
Saudi Arabia	2015	57	0.052327
Sri Lanka	2015	58	0.050648
Peru	2015	59	0.049021
United Arab Emirates	2015	60	0.048325

Indonesia	2015	61	0.043846
Colombia	2015	62	0.042744
Guatemala	2015	63	0.037914
Paraguay	2015	64	0.036621
Macedonia	2015	65	0.03585
Serbia	2015	66	0.034467
Philippines	2015	67	0.032553
Ecuador	2015	68	0.032395
Tunisia	2015	69	0.032193
Jordan	2015	70	0.031639
Cyprus	2015	71	0.031495
Kuwait	2015	72	0.029865
South Africa	2015	73	0.029165
Honduras	2015	74	0.025562
Botswana	2015	75	0.025414
Cambodia	2015	76	0.024649
Morocco	2015	77	0.024432
Bosnia and Herzegovina	2015	78	0.023286
Armenia	2015	79	0.022444
Jamaica	2015	80	0.018002
Kazakhstan	2015	81	0.017889
Congo	2015	82	0.017386
Nigeria	2015	83	0.017357
Myanmar	2015	84	0.017348
Egypt	2015	85	0.017277
Oman	2015	86	0.01719
Iran	2015	87	0.016918
Cameroon	2015	88	0.01631
Montenegro	2015	89	0.0148
Angola	2015	90	0.013884
Azerbaijan	2015	91	0.013698
Bangladesh	2015	92	0.013035
Georgia	2015	93	0.012805
Bolivia	2015	94	0.012336
Côte d'Ivoire	2015	95	0.010294
China, Hong Kong Special Administrative Region	2015	96	0.010181
Zambia	2015	97	0.009609
Algeria	2015	98	0.009408
Albania	2015	99	0.009091
Moldova	2015	100	0.008946
India	2015	101	0.008745

Kenya	2015	102	0.008499
Senegal	2015	103	0.007519
Mongolia	2015	104	0.007032
Vietnam	2015	105	0.006292
Ukraine	2015	106	0.006227
Ghana	2015	107	0.006065
Pakistan	2015	108	0.005962
Haiti	2015	109	0.005539
Mozambique	2015	110	0.005475
Tanzania	2015	111	0.005249
Yemen	2015	112	0.005041
Niger	2015	113	0.004837
Kyrgyzstan	2015	114	0.004221
Iraq	2015	115	0.00296
Ethiopia	2015	116	0.002793
Nepal	2015	117	0.002331
Syria	2015	118	0.001855

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