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THE INCLUSIVE AND SUSTAINABLE DEVELOPMENT INDEX: A DATA ENVELOPMENT ANALYSIS APPROACH

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

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Abstract

Inclusive and Sustainable Industrial Development (ISID) calls for the full engagement of policymakers in industrializing countries by minimizing the environmental footprint and enhancing social inclusiveness. This study investigates the progress 118 countries have made towards achieving ISID (2005–2015) based on an input-oriented CCR (Charnes, Cooper and Rhodes) slack-based (Data Envelopment Analysis) DEA model. Efficiency analyses were carried out using two approaches: i) the ISID approach reflects countries' determination to promote industrialization and consequently, to sustain economic growth by reducing the adverse environmental and social effects that manifest in the economy; ii) the ISIDsdg9 approach considers the same factors as the ISID approach, but focusses on indicators related to the industrial sector only. An analytical tool is developed to measure ISID using the two different approaches. This study finds that (i) Denmark, Sweden and Switzerland are ranked at the top in the ISID approach, while Czechia and Switzerland are at the top of the ranking in 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

1 Introduction

The 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)[1]. Industrialization comes with challenges: fossil fuel and industrial processes alone account for 65 per cent 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 necessary, not only to minimize the environmental degradation caused 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. Because economic growth increases the resources made available for consumption in an economy as a whole, it is often accompanied by rising inequality in the distribution of those resources among individuals[2] (Kuznets, 1955). Furthermore, industrializing countries often experience a deterioration of environmental conditions, frequently due to the increasing inequality to reach higher levels of development. The ISID definition builds on the notions that: i) countries need industrialization, because manufacturing is an engine of growth (Kaldor, 1960), and ii) the way in which countries industrialize matters, as it influences their middle- and late stages of development.

Manufacturing value added (MVA) has been the most common indicator representing the level of industrialization achieved by the given country (UNIDO, 2013, 2018, 2020). MVA is an indicator of an economy's capacity to produce goods to meet 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 industrialization – economic, social and environmental. Despite the relevance of the ISID concept for the post-2030 Agenda, measuring a country's performance based on the three dimensions of industrialization remains challenging.

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[1] On 2 December 2013, at the 15th session of UNIDO's General Conference, UNIDO member states endorsed the Lima Declaration: Towards inclusive and sustainable industrial development. The declaration emphasizes 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 ISID in the elaboration of the post-2015 development agenda.

[2] In the Kuznets (1955) model, waves of economic growth do not sweep over the entire 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.

The present study develops an ISID and ISIDsdg9 monitoring tool for policymakers to evaluate their country's progress towards achieving UN SDG9, and presents two approaches to measuring ISID: macro-economic (ISID) and industry-specific (ISIDsdg9) indicators. ISID occurs when countries attain the ability to maximize their manufacturing performance (and, indirectly, to maximize their GDP growth), by minimizing total CO_2 emission and inequality. This approach measures the extent to which industrialization affects the overall economy's environmental and social performance. The ISIDsdg9 formulation, on the other hand, focusses exclusively on economic, social, and environmental indicators of the manufacturing sector. In this approach, ISID occurs when manufacturing grows without a deterioration of the manufacturing sector's environmental and social performance. The distinction between the ISID and the ISIDsdg9 formulations derives from the theoretical background underpinning the manufacturing sector's role in development (Kaldor, 1967). According to the Kaldor theory, manufacturing is an engine of economic growth for all sectors of the economy due to 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 for the overall economy by minimizing 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 to the need to monitor the manufacturing sector's development from an economic, social and environmental perspective.

As good international practices demonstrate, the concept of the post-2030 Agenda is being mainstreamed into national policies, plans and strategies to tackle the social and environmental challenges countries face. In 2019 alone, 47 countries conducted voluntary national reviews[3] at the High-Level Political Forum (HLPF) of the United Nations. Although the concept of ISID is important for 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 policy making (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 where each component receives equal weight in the final index. This does

[3] As part of the 2030 Agenda's follow-up and review mechanisms, its agenda for sustainable development encourages countries to conduct regular and inclusive reviews of progress made 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.

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 thus necessary. Data Envelopment Analysis (DEA) is one way to concretely and objectively measure economic actors' progress towards ISID and mitigate the equal weights and perfect substitutability bias[4] (Atkinson, Cantillon, Marlier and Nolan, 2002).

This study aims to develop a DEA based on the ISID and ISIDsdg9 rankings of 118 countries. To the best of our knowledge, this is the first study to rank countries based on their performance in the economic, environmental and social indicators related to UN SDG9 using the DEA approach. The next section presents a literature review. Section 3 describes the methodology used to develop an aggregate index with the aim of measuring countries' performance in terms of economic, environmental and social indicators. Section 4 analyzes the rankings and findings. It also includes considerations based on "the reality check" aiming to compare countries' DEA aggregate performance with the performances in each individual economic, social and environmental indicator to demonstrate that the aggregated performance fully reflects the single components' performance. Section 5 discusses the analysis' policy implications.

2 Literature review

The DEA approach was developed by Charnes, Cooper and Rhodes (1978) and is 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 been receiving increasing attention in the evaluation of countries' and regions' performances in resource allocation efficiency owing to its ability to account for undesirable output in the optimization process (Wei, Ni and Shen, 2009; Li, Fang, Yang, Wang and Hong, 2013). This model framework is particularly suitable for the present study which aims to capture 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 target reductions improves the overall ISID performance implied by the radial approach.

[4] 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".

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

Zhou, Ang and Han (2010), Arazmuradov (2011), and Kounetas (2015) review the trade-offs between the energy, environmental and economic performance of more than 30 countries and evaluate the possible effects of adopted international agreements and regulations, such as the Kyoto Protocol[5], on countries' environmental efficiency. Their work is relevant for the present study due to its strong link with the international energy and environmental policy debate, which is one of the areas of our investigation.

3 Methodology

This study follows the DEA method for measuring countries' economic, social and environmental performance developed by Zhou, Poh and Ang (2016, pp. 32) based on the notion of minimizing undesirable outputs or "bad" effects (the byproducts of desirable outputs such as carbon dioxide emission) to achieve the same level of desirable outputs or "good" effects (beneficial outputs such as production outputs), i.e. the input-orientation approach. One strand of literature treats CO_2 emissions as an input to the production function (Gollop and Swinand, 1998; Pittman, 1983). If emissions are treated as inputs, they serve as a proxy for the environment in terms 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 and Whittaker, 2007). Pittman (1981), Cropper and Oates (1992) and Reinhard, Lovell and Thijssen (2000) follow this approach and consider emissions to be an input.

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

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

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

Subject to

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

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

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

x_{i0} stands for input vectors, y_{r0} stands for desirable output vectors. λ_j is an intensity vector. $s_i{}^{-}$ denotes the surpluses in inputs, and $s_r{}^{+}$ stands the deficiencies in desirable outputs. Target value $\rho_{Input}{}^{*}$, is between 0 and 1. $\lambda_j{}^{*}, s_i{}^{-*}, s_r{}^{+*}$ represents 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 meet the following two conditions: unit variant and monotone. This means that the measure should be invariant for the units of data and 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. We offer the two formulations, ISID and ISIDsdg9: ISID represents the aspiration of countries to promote industrialization and consequently, to sustain growth by reducing the adverse environmental and social effects that manifest in the economy. ISIDsdg9 considers the same factors as the ISID approach, but limits the externalities to the industrial sector and to indicators universally recognized as being important for monitoring 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), CO2pc is CO_2 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 countries' capacity to boost industrialization and is included among the officially approved SDG9 indicators (UNIDO, 2017). CO_2 emissions per capita and the GINI index are selected from widely recognized indicators to represent the impact of economic variables on both environmental and social variables (see, among others, Apergis, 2016; Milanovic, 2016). The ISIDsdg9 indicators are based on 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 CO_2 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 are represented by the environmental and social indicators. ISIDsdg9 considers manufacturing CO_2 emission intensity (CO_2 emission, kt per value added US$) as an environmental indicator. Furthermore, inspired by the global indicator framework[6], namely Indicators 9.2.1, 9.2.2 and 9.4.1 (UNSD, 2018[7]), ISIDsdg9 considers the manufacturing employment gap to be a social indicator (the gap between a country's share of manufacturing employment and that of the country with the highest share in the world). The ISID approach captures non-manufacturing-related environmental and social indicators such as total CO_2 emissions per capita and the Gini index of inequality. The ISID approach captures the extent to which industrialization impacts environmental and social factors in the overall economy, whereas the ISIDsdg9 approach specifically captures manufacturing-related variables.

One of the best ways to ensure that the imbalance in the data sets is as minimal as possible is for them to have the same or similar magnitude (Sarkis, 2007). One way of ensuring that the data is of the same or similar magnitude across and within data sets is to min-max normalize the data.

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

The process of min-max normalization involves two steps. The first step is to identify the minimum and maximum value of each indicator by year. The second step entails dividing each input or output by the range of the min-max for that specific factor.

4 Main findings and discussions

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

We tested the ISID specification for the period 2005–2013 for 50 countries, and the ISIDsdg9 specification for 118 countries for the period 2005–2015[8]. The DEA algorithm generates the following top and bottom five rankings:

Table 2: The ISID ranking

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

Table 3: The ISIDsdg9 ranking

Top 5 ISIDsdg9 2015	Bottom 5 ISIDsdg9 2015
Czechia	Kyrgyzstan
Switzerland	Iraq
Germany	Ethiopia
Japan	Nepal
Ireland	Syria

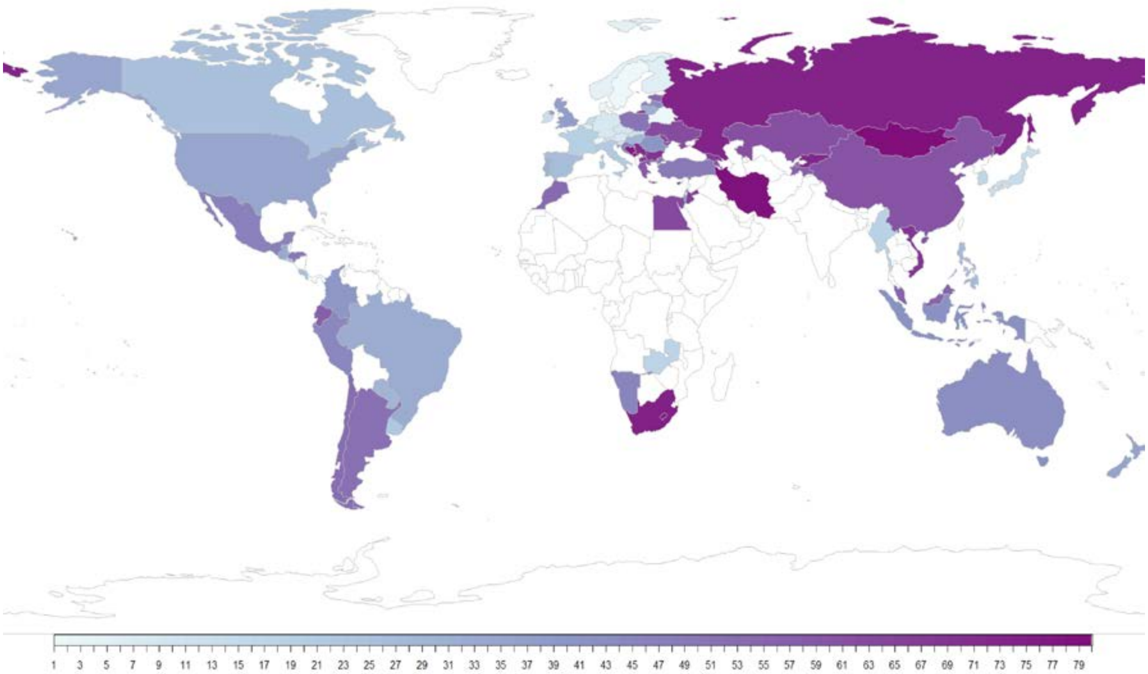
[8] The requirement of balanced datasets for all ISID and ISIDsdg9 variables (see Table 1) imposed a limitation on the time series of our sample, thus, we used a narrower dataset in terms of country coverage and time periods to maintain a balanced dataset across countries and time (see Table 1). Based on the latest available data points in our dataset, we included the 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).

One initial insight that emerges from the ranking in Table 2 is that industrialized countries are more efficient, in relative tems, in generating manufacturing value added by minimizing the environmental footprint and social inequality. Eastern European countries tend to be found at the bottom of the ranking. An exception of a developed country included at the bottom of the list is Chile, due to its low share of manufacturing employment in the ISID formulation.

4.1 ISID approach

Figure 1 presents the main results of the ISID efficiency scores: the scale of colors represents the level of the countries' integration efficiency. The lower the country's efficiency score, the deeper the purple. It is worth noting that northern European countries such as Sweden, Switzerland, Norway and Denmark (integrated efficiency score: 1) are the best performers in terms of ISID as these countries represent the benchmark of ISID mainstreaming (see Appendix 1 for a complete ISID ranking). It also appears that Central Asian countries are less efficient in the context of ISID. Countries without color labeling indicate missing data.

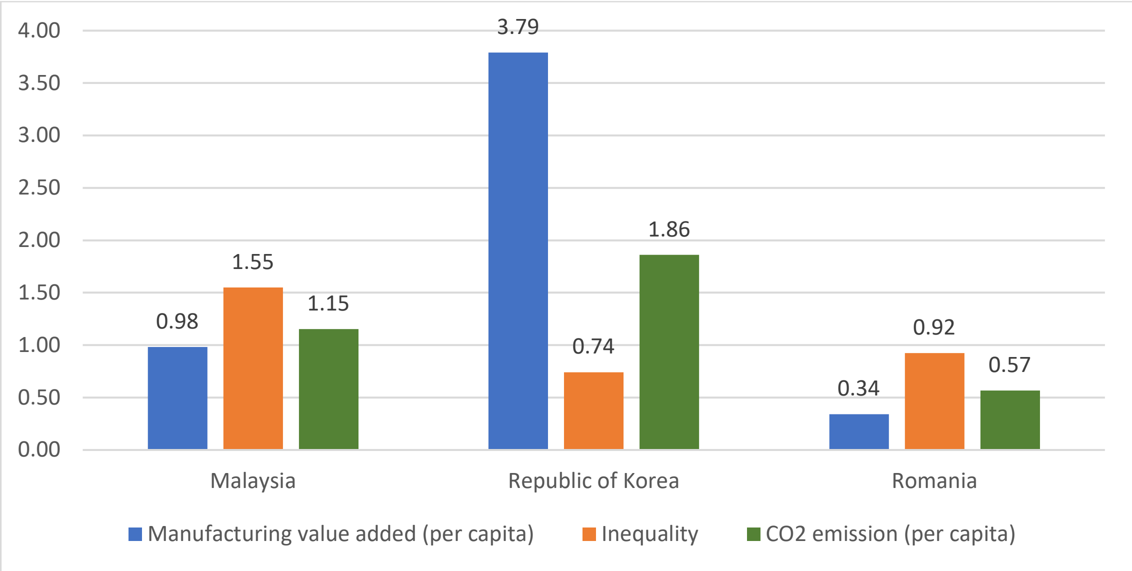
Figure 1: ISID ranking (2013)



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 according to the DEA methodology. The Republic of Korea outperforms the other countries because it produces (relative to the indicator's median value)[9] a high level of manufacturing value added per capita (blue bar) with relatively low levels of inequality (orange bar) and CO_2 emissions per capita (green bar). While Malaysia and Romania are characterized by similar levels of CO_2 emissions per capita and inequality in comparison to the Republic of Korea, their 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 on one side and Romania and Malaysia on the other is evident when looking at the time series graphs (Figure 2, lower panel). The Republic of Korea's performance in manufacturing value added is outstanding (relative to CO_2 emissions per capita and inequality), whereas Romania and Malaysia's performance is far less impressive. When looking at the rankings of Romania (45th) and Malaysia (37th), Figure 2 sheds light on why these countries' ranking is so low, namely as a result of their poor performance in social equality.

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



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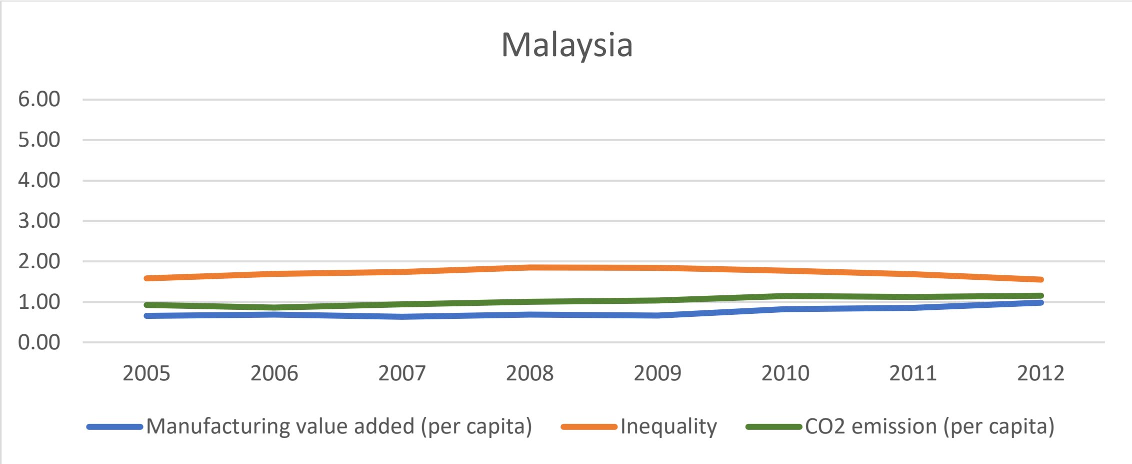
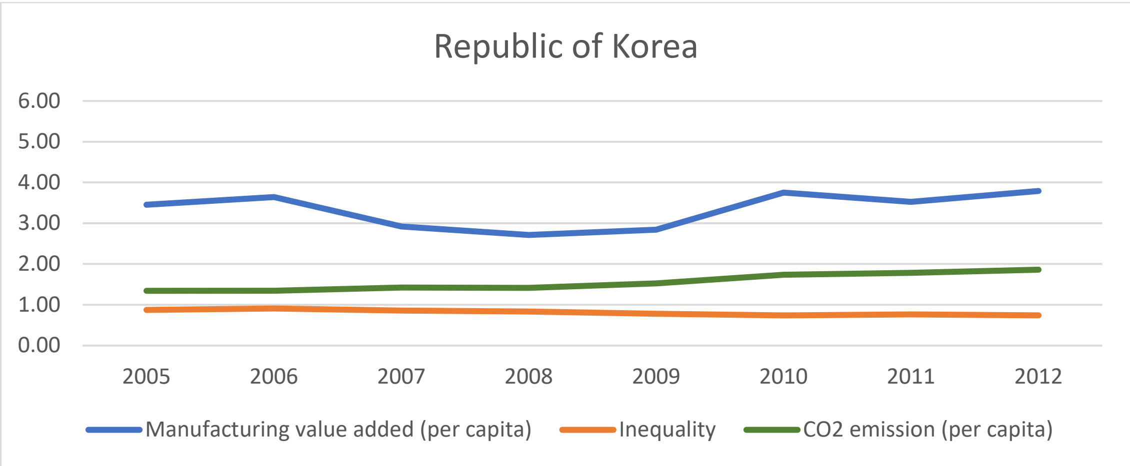
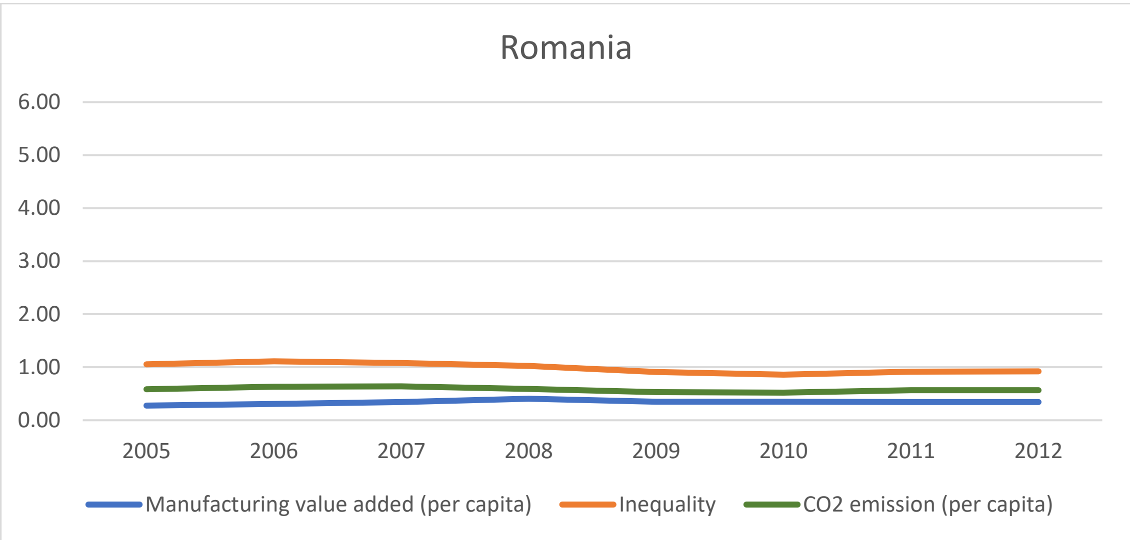
[9] To ensure a comparable scale across all variables, we normalized the key variables for ISID and ISIDsdg9 indices using the min-max approach (Sarkis, 2007) before carrying out the optmization (input-oriented DEA CCR SBM model) as described in Section 3.2. To conduct the reality check contained in Section 4, we applied a parsimonious median-normalization to illustrate the actual performance of countries in 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.





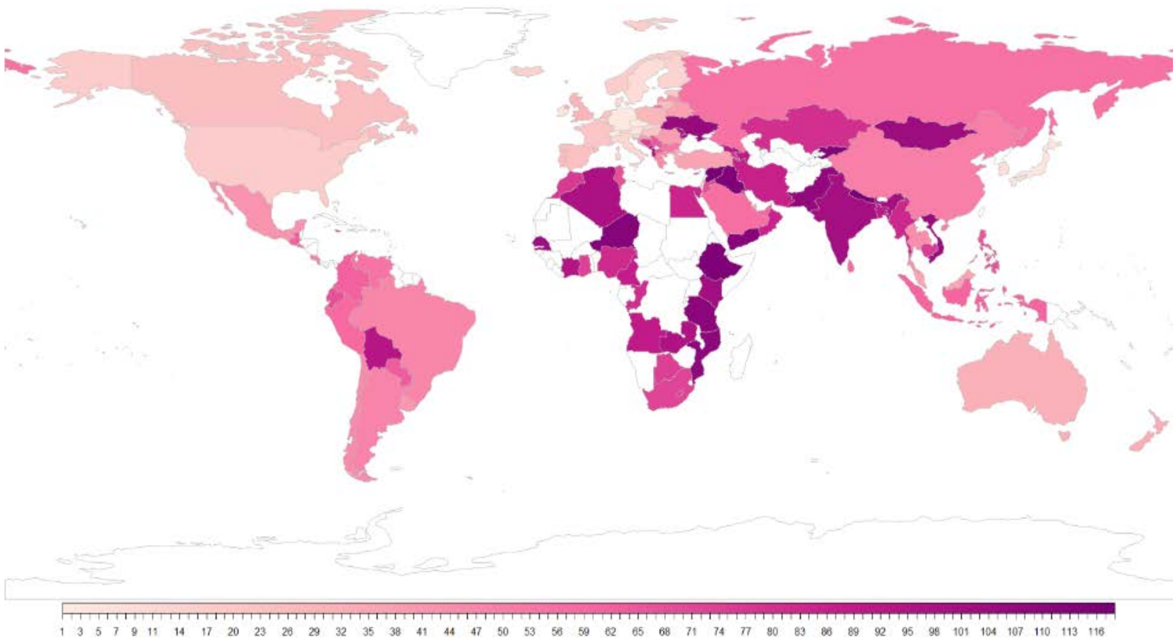


Source: INDSTAT2 rev.3 (United Nations Industrial Development Organization, 2018); World Development Indicators (The World Bank, 2018); Standardized World Income Inequality Database (2018).
Note: The median value of the sample normalizes variables.

4.2 ISIDsdg9 approach

We now turn our the attention to the ISIDsdg9 approach and only consider indicators associated with UN SDG9, i.e. approved international indicators, and focus specifically on the manufacturing sector. Based on the dataset of 118 countries in 2015, Figure 3 presents the global ranking of ISIDsdg9 with Czechia and Switzerland ranking high on the efficiency frontier (integrated efficiency score equal to 1). The performance of Czechia and Switzerland reflects low CO_2 emission intensity and a high manufacturing employment share. By reviewing the ranking of countries across regions, we find that countries in Africa and South Asia generally perform below average.

Figure 3: ISIDsdg9 ranking for 2015

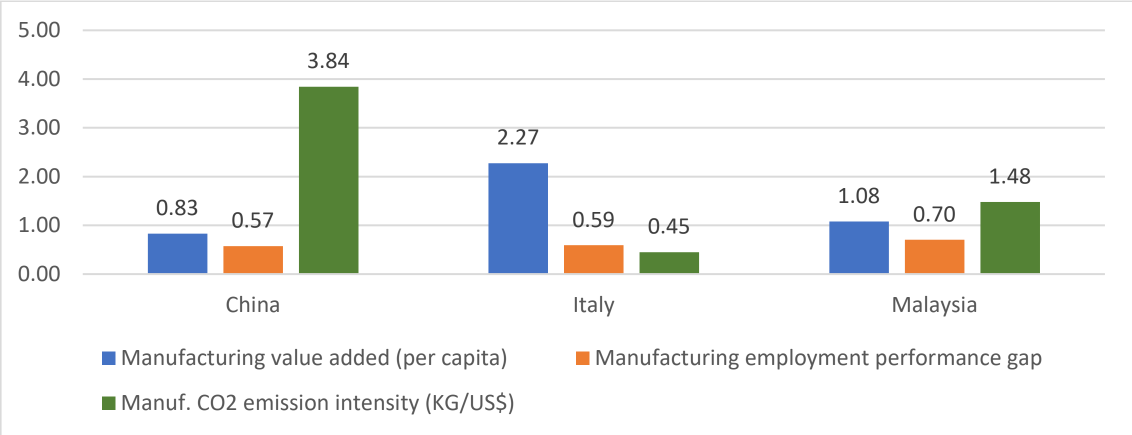


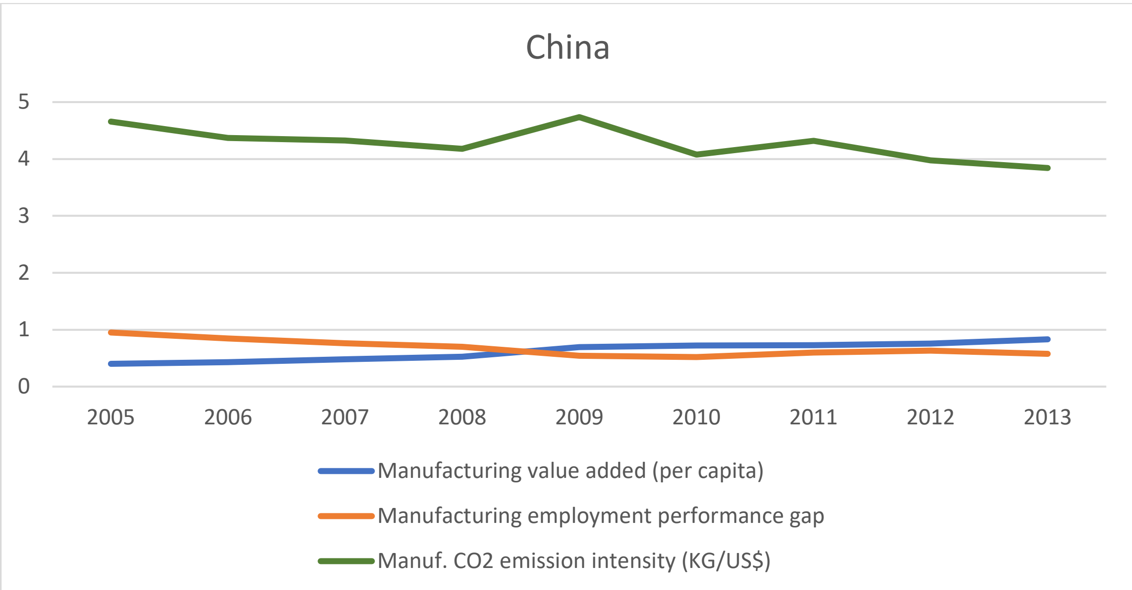
Source: Authors' elaboration based on the input-oriented DEA CCR SBM model.

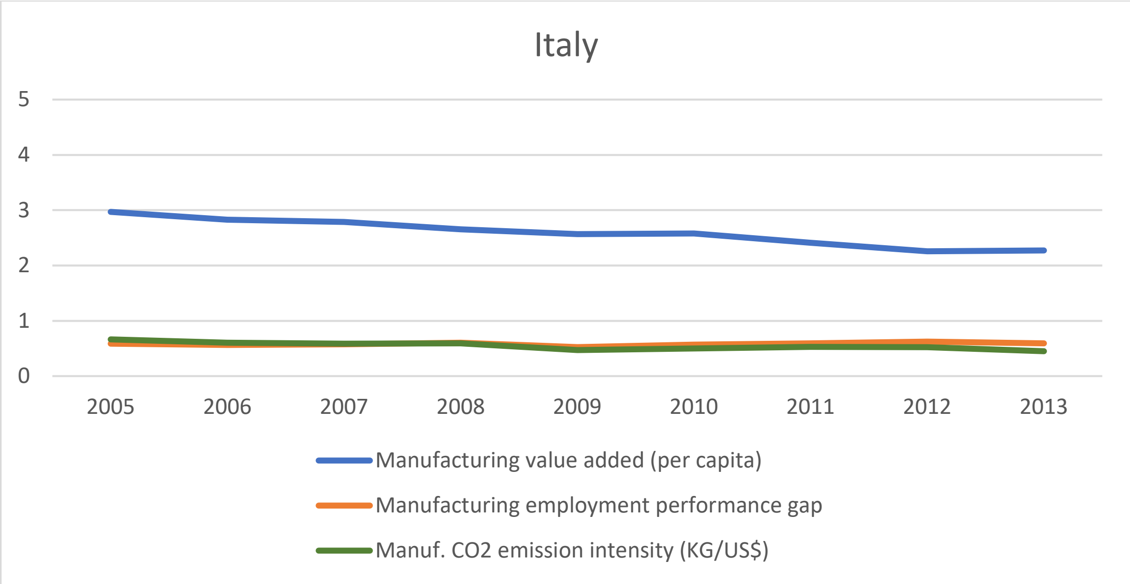
Figure 4 (upper section) shows that Italy's performance in MVA per capita (blue bar) is outstanding relative to the low level of manufacturing CO_2 emission intensity and the gap to the best performer in terms of manufacturing employment share (orange and green lines). China and Malaysia are particularly inefficient in producing MVA per capita by reducing their CO_2 emission intensity. Figure 4 (lower panel) illustrates a declining trend of Italy's efficiency score, suggesting that the coutnry's capability to generate manufacturing value added has been gradually decreasing over time with a relatively stable deveopment of both emission intensity and inequality. Italy is an example of rapid deindustrialization accelerated by the global financial crisis.

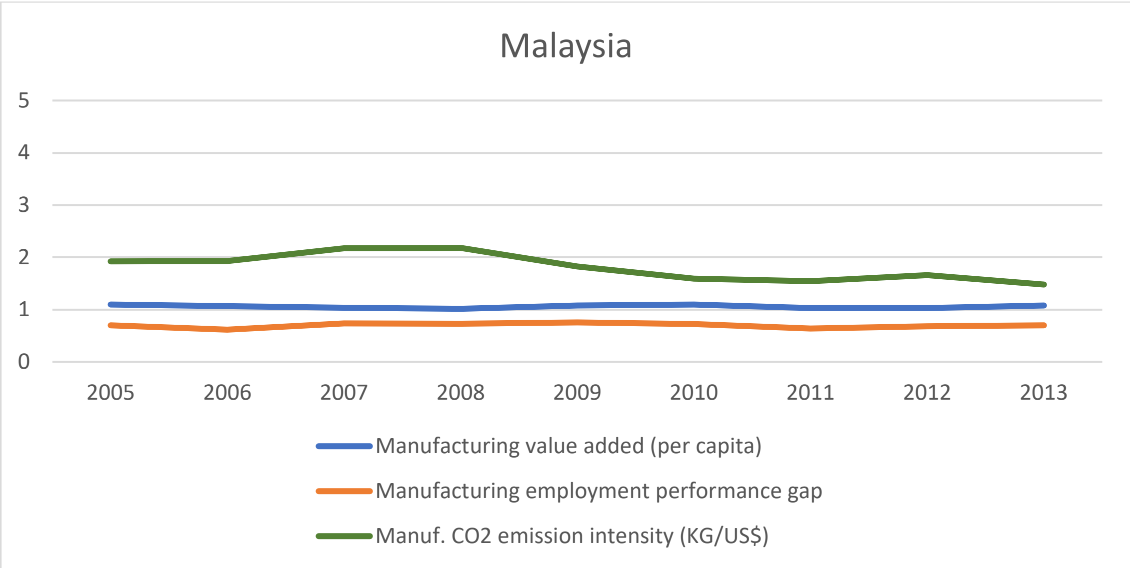
Italy has dropped one position (10th in 2015) since 2005 as a result of declining MVA performance. In many developed countries, the value of industrial-led growth for society has come into question as a result of increasing inequality. In developing countries, record decreases in poverty and growing manufacturing activities have fueled higher demand for transport and energy; these demands are now clashing with the environmental challenges the majority of developing countries are currently facing. The CO_2 intensity of China's manufacturing sector is around 3.8 times higher than the global average.

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







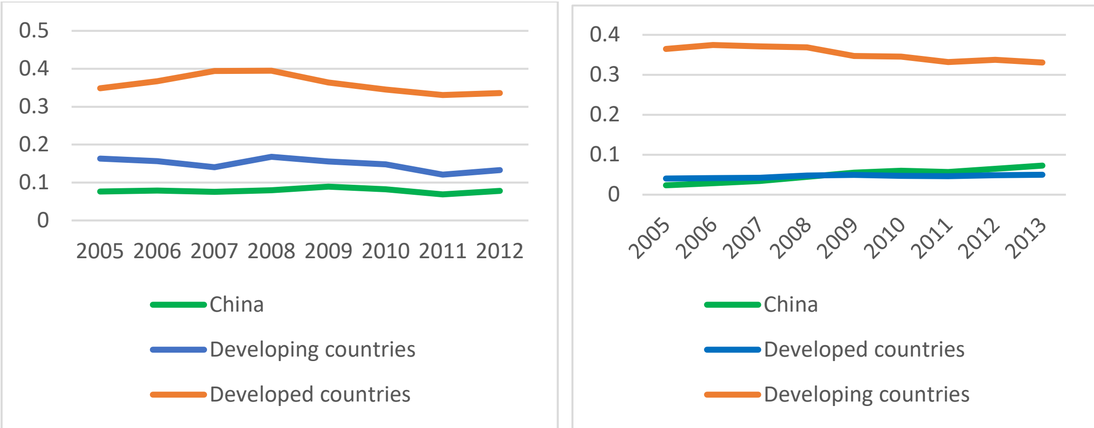


Source: INDSTAT2 rev.3 (United Nations Industrial Development Organization, 2018); World Development Indicators (The World Bank, 2018); Standardized World Income Inequality Database (Solt, 2018).
Note: The median value of the sample normalizes the variables. The assumption underlying this figure is that value added is scaled at the same level for all included countries.

The evidence presented above is supported by the average measures of the ISID and ISIDsdg9's efficiency scores for developed and developing countries. Developed countries are the most efficient according to 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 is the most inefficient region in the ISID approach, performing even lower than the average score for other developing countries. Based on the ISIDsdg9 formulation, however, 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 feature strongly in the 2030 Agenda for Sustainable Development[10]. All countries have the potential to activate ISID, and policymakers are encouraged to continue reviewing the best ISID practices and to accelerate their progress to pave the way for ISID. An urgent need has emerged for an objective and comprehensive ISID policy tool to rationalize the trade-off between the multidimensional notions of ISID and to monitor and evaluate the progress of countries towards achieving ISID.

An immediate question arises in this regard: how can this study support policymakers in formulating an effective monitoring and evaluation system 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 ISID practices. ISID benchmarking consitsts of two steps: (i) identifying the ISID best practice “role model” countries, and (ii) conducting an assessment of reduction potentials. One concern with this policy tool is that it neither prescribes which specific policy tool to use nor does it introduce a one-size-fits-all solution, as country conditions differ. Our approach, however, identifies the respective country’s role model in terms of best ISID practice and assesses the efforts required to reach that target. The actual modalities to achieve the target would require a more in-depth policy study about the specific enablers of ISID.

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

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, Sweden and Switzerland lie at the efficiency frontier (red curve). They are the most efficient countries capable of accelerating the manufacturing sector's growth and simultaneously minimize the negative externalities of carbon emission (CO_2 emission per capita) and social inequality (GINI).

We now turn to the ISIDsdg9 approach, in which we limit the externalities of ISID to the manufacturing sector. In Figure 7, we classify 118 countries based on their performance in terms of CO_2 emission intensity (CO_2 emission per value added) and the manufacturing employment gap (distance from the country with highest manufacturing employment share) by assuming that these countries achieve similar levels of manufacturing development. A general observation that holds for both the ISID and ISIDsdg9 approaches is that OECD countries are the most efficient and clustered around the origin of the diagram. As illustrated in Figures 6 and 7, developing countries are generally furthest from the efficiency frontier (red curve). According to the ISIDsdg9 approach, in 2015 (Figure 7), Czechia and Switzerland were the most efficient countries in terms of generating manufacturing value added and capable of minimizing both manufacturing CO_2 emission intensity and the gap to the best performer in share of manufacturing employment in total employment. It is worth noting that Czechia has the highest share of manufacturing employment in total employment and lies at the frontier together with Switzerland, which had the lowest carbon intensity in 2015.

We can establish a radiate line (from the origin to DMU) in Figure 6 for Malaysia, for example, to reach the target role model countries (countries on the efficiency frontier: Switzerland, Sweden and Denmark) or a comparator (on the radiate line and closer to the frontier: Italy) for ISID benchmarking. We can also identify countries' reduction potentials compared to the role model or a comparator, i.e. how these countries could achieve a 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 policy making. As discussed earlier, Czechia and Switzerland lie at the efficiency frontier and serve as role model countries for ISIDsdg9. As the ISIDsdg9 indicator considers manufacturing employment, it is expected that the model penalizes advanced countries that have been experiencing deindustrialization, for example, Australia and New Zealand, which are characterized by a low share of manufacturing employment (high gap ratio to the best performer).

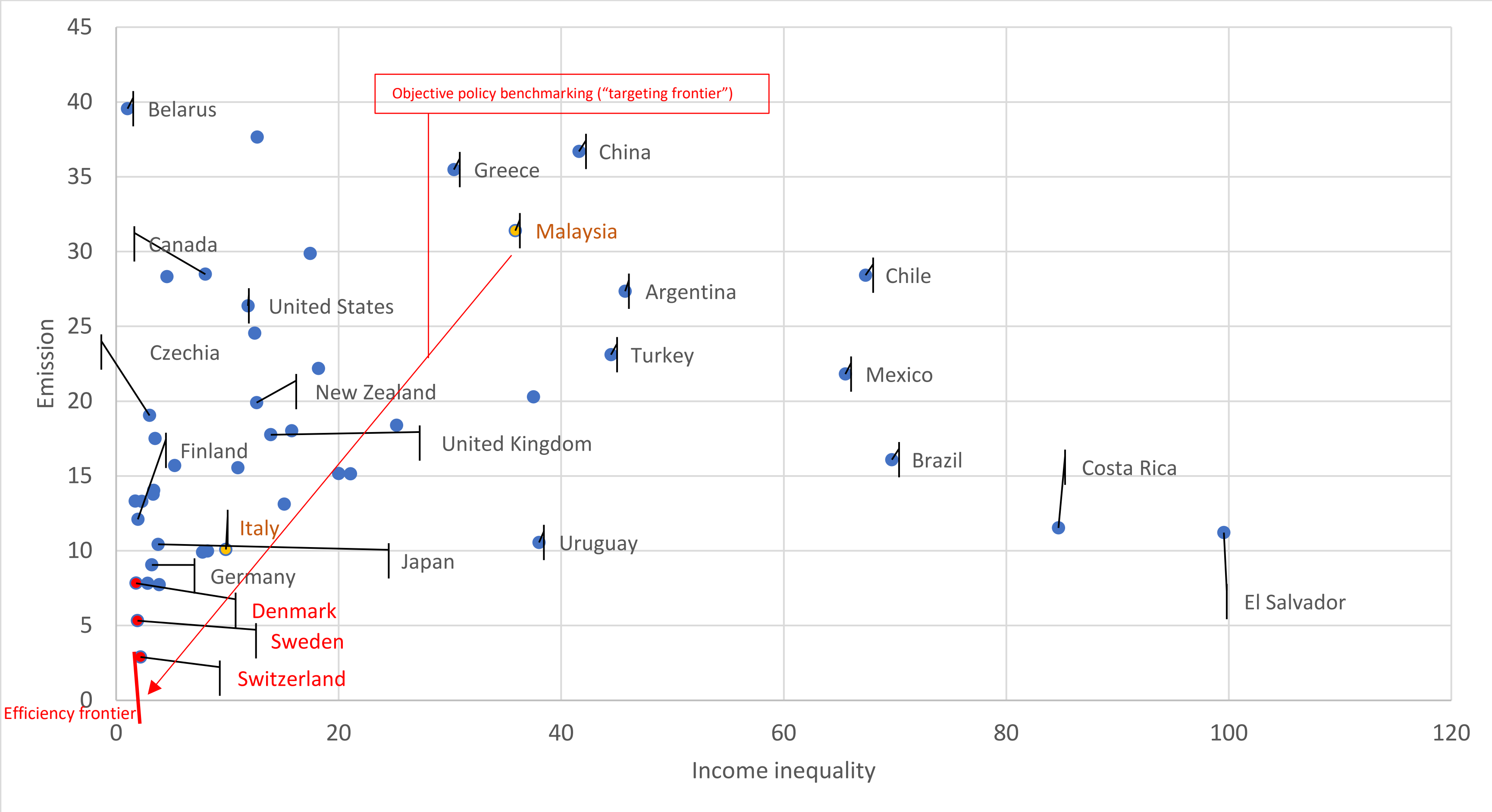
A more developed country, such as Italy, with a strong manufacturing base and relatively low CO_2 emission intensity could be a suitable comparator for Malaysia.

From a policy perspective, it is also useful to asses the trade-off between externalities caused by industrialization. Table 4 presents the indicator-specific efficiency values of nine countries. According to the input-oriented DEA-CCR-SBM model, it is possible to measure a country's reduction potential for reaching the efficiency frontier. Malaysia, for example, must reduce its CO_2 emission to 0.00085 (CO_2 emission 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, which implies an 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 its targeted manufacturing CO_2 emission intensity and manufacturing employment share in the ISIDsdg9 formulation. Based on the data in 2015, a country such as Malaysia could become efficient in terms of ISIDsdg9 by reducing its CO_2 intensity by 0.32 (CO_2 emission kt, per value added US$) and by minimizing its employment gap by around 9.5 per cent.

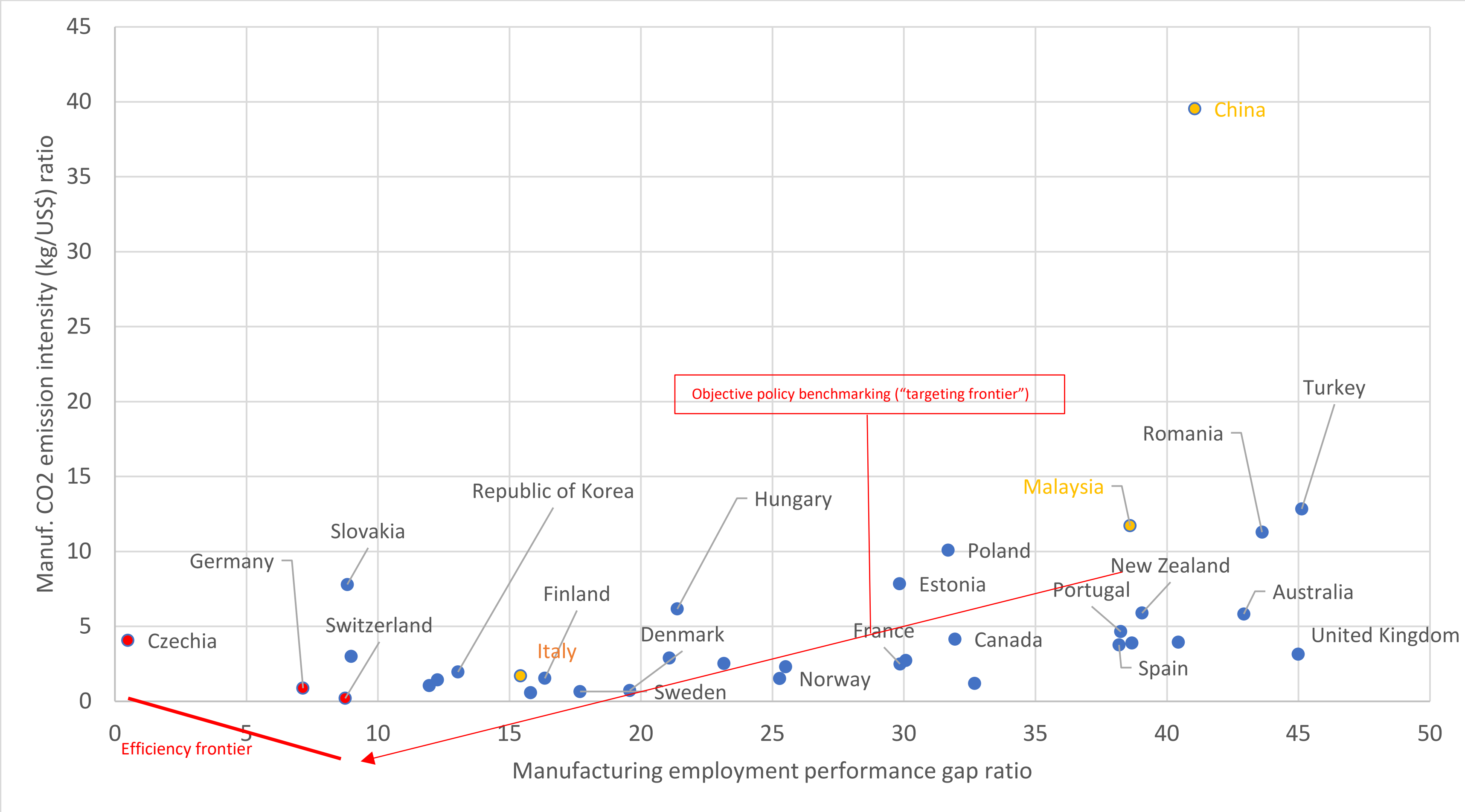
We find that for a country such as Malaysia, the binding constraint for achieving higher levels of ISID and ISIDsdg9 appears to be carbon emission. Mainstreaming ISID and ISIDsdg9 in national policies can have far-reaching impacts on communities at all levels. When environmental safeguards and social inclusiveness criteria are adequately taken into account, as mandated by ISID, industry proves to be a powerful driver of prosperity and collective wellbeing.

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 figure is that value added is scaled at the same level for all 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 figure is that value added is scaled at the same level for all included countries.

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

Country	Manufacturing value added per capita (US$)	CO_2 emission (kt) per capita	GINI (disposable income)	Ranking	Efficiency score	Targeted CO_2 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$)**	**CO_2 emission (kt) per value added (US$)**	**Manufacturing employment gap**	**Ranking**	**Efficiency score**	**Targeted CO_2 emission (after slack adjustment)**	**Targeted Manufacturing employment gap (after slack adjustment)**
Czechia	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
Republic of 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).

6 Conclusions

ISID calls for the full engagement of policymakers in industrializing countries to minimize their environmental footprint and negative social impacts. Despite the existence of a vast consensus among the international community about the significance of ISID—reflected in the approval of SDG9 on industrialization, inclusiveness and environmental sustainability—from an operational point of view, it is quite complicated to monitor and evaluate the progress of countries in ISID and to set benchmarks. Many attempts to express ISID through composite indices, including economic, environmental and social indicators, are not always very useful for policymakers and practitioners. The biggest practical problem is that composite indices assume equal weights (the economic, environmental and social indicators carry the same weight at every level of income per capita) and are characterized by perfect substitutability (the rate of substitution across indicators to maintain the same constant level of ISID over time). Data Envelopment Analysis addresses these technical problems (implying substantial difficulties in correctly interpreting ISID) by applying an optimization algorithm that calculates optimal weights, putting countries in the most favorable position in the final ranking based on their underlying economic structure. The present study has applied the Data Envelopment Analysis by using two formulations: in the first one, manufacturing value added per capita is produced by minimizing total CO_2 emissions per capita and inequality in the distribution of income. This formulation interprets ISID as industrialization achieved by minimizing the adverse externalities of industrialization on the overall economy.

The ISIDsdg9 formulation interprets ISID as industrialization achieved by minimizing detrimental environmental and social impacts in 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 research, but a general finding arising from our study is that methodologies that are able to fully capture the extent of the trade-offs between economic, indicators and negative social and environmental indicators should be used to evaluate countries' progress in achieving ISID.

Annex 1 ISID ranking of 50 countries for 2013

Case: ISID (Normal)

Year: 2013

Data: UNIDO INDSTAT, IEA, SWIID

Data: MVA per capita (US$), CO_2 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
Czechia	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
North 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$), CO_2 emission per value added (kt/US$), manufacturing employment share (gap to top performer)

Country	**Year**	**Rank**	**Theta**
Czechia	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
Republic of 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
United Kingdom	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
Viet Nam	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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