CASTANEDA, FUJS, HERZOG, & MAEDA

AN ANALYSIS OF COVERAGE GAPS IN ESG DATA

List of Tables

List of Figures

Introduction

This document is the continuation of the paper *Options for Improving Use of ESG data for Sovereign Bond Analysis* (World Bank 2018). Following interaction with investors in sovereign bonds that use ESG indicators in their country analyses and risk/return profiles of sovereign securities, the World Bank Group (WBG) presented a set of options for improving accessibility, quality (e.g. timeliness and regularity of publication, geographic coverage) and transparency of Emerging Markets data, in particular for ESG data. This paper aims to continue the analysis, better understand underlying data production and management issues that affect availability and provide recommendations for improving the accessibility, quality and coverage of ESG indicators.

Team

This document was written and developed by Tim Herzog, R.Andres Castaneda Aguilar, and Tony Fujs. Andrei Ilas and Hiroko Maeda contributed substantial research support.

Replicability and license

This document is fully replicable and was produced in R using the Bookdown package. All the text files, codes, underlying data, and dashboards can be found in its GitHub repository worldbank/ESG_gaps_research. The online version of this report with interactive charts is also available in Github.

1
Background

This document builds upon research first presented in the discussion paper *Options for Improving Use of ESG for Sovereign Bond Analysis* (World Bank, 2018).

Interviews with ESG data providers found that most obtain at least some and often a substantial amount of data from World Bank databases. 137 indicators were specifically identified from these interviews, of which 127 could be mapped to active databases in the World Bank's data API, enabling the authors to perform a rapid assessment of data coverage and gaps, as included in the 2018 discussion paper. The 2018 paper found that "data coverage is a significant issue in WBG data used for ESG." Looking at most recent available values (MRVs) by indicator and country, the paper found that just 41 ESG indicators (out of 127) had a value from 2017 or later (1 year old) for at least 50% of countries; 74 ESG indicators had a value from 2015 or later (3 years old) for at least 50% of countries. However, while the 2018 paper suggested a set of options for improving the availability and usefulness of ESG data, it stopped short of further investigating the reasons that might give rise to gaps in data coverage or suggesting specific strategies to address them.

The objective of this report is to pick up where the previous paper left off, and to better understand the circumstances that explain gaps in data coverage. The hope is that with a better understanding of why gaps occur and the significance of various explanatory factors, effective steps can be established to eliminate or mitigate gaps, and better understand which kinds of gaps are most relevant for ESG analysis.

The study set of ESG indicators in this report is different than the one in the 2018 report. Whereas the 2018 report excluded indicators used by providers that the Bank no longer actively maintains, this report includes those since they are relevant to the analysis. Additionally, this report includes indicators from various products introduced since the 2018 report, including the World Bank's own curated ESG dataset. Conversely, we decided to remove a subset of indicators used

by a single provider because the strong similarities among them (e.g., very similar trade or debt measures) were resulting in double-counting that could potentially skew the findings. Accordingly, this report is based on a body of 134 indicators, compared to 137 in the 2018 report.

The other major difference between the indicators in the two reports is that many of them have been updated since the 2018 report was completed. Many statistical indicators have been updated several times. Accordingly, if the 2018 analysis were re-run using the indicators from this analysis, the findings would likely be quite different, and different yet again if the analysis were run a year hence. One of the goals of this analysis is to provide a framework for thinking about data availability and coverage that is reasonably independent of the data curation cycles for the indicators under study.

1.1 What is a "Data Gap"?

The term "data gap" is somewhat ambiguous, so we should start by discussing what kinds of gaps can exist in datasets. For instance, data could be unavailable for a number of relevant economies, or there could be gaps in the time series over a relevant time period. There could also be gaps in metadata and other documentation. Data could also simply be unavailable or undefined for important concepts (such as "resilience"), necessitating the use of data proxies. While all of these are potentially relevant, the most important gaps in the context of ESG likely involve the most recently available values compared to the current time period, since ESG analysis concerns investment decisions being made today and in the near future. Accordingly, this paper defines a "data gap" as a significant difference between the current calendar year and the most recent available value(s) (MRVs) for the indicators and economies under study. Gaps in metadata or in time periods before the MRV are not a primary focus of this analysis.

1.2 How This Paper is Structured

This paper applies three separate approaches to better understand coverage gaps in ESG indicators:

1. **Coverage Analysis.** This approach provides a more detailed and visual picture of temporal gaps in the ESG indicator set, both historically and by MRV.
2. **Explanation Framework Analysis.** This approach sets out a set of reasons why data gaps might occur as a framework for classifying ESG indicators, and looking at what approaches might be used to mitigate coverage issues.

3. **Variance Analysis.** This approach looks at the temporal variance of ESG indicators to better understand the impacts of missing data for analysis. It may be possible to impute missing observations for indicators with low variance, mitigating the impact of data gaps.

The paper then concludes with a discussion section and set of recommendations based on the analysis and findings of each of these sections.

1.3 About the Data Used in This Report

The indicator database used in this report consists of 134 indicators extracted from the World Development Indicators and other World Bank Databases in October, 2019.

Table 1.1 provides a summary of the 134 indicators analyzed in this report disaggregated by pillar and origin. 44 indicators are environmental indicators, 66 are social indicators, and 24 are governance indicators. The World Bank is the primary source of 36 indicators, whereas the UN system is primary source of 66 indicators, and other organizations are the source for 32 indicators.

Table 1.1: Indicators by origin and sector

Origin	Env	Soc	Gov	Total
WBG	10	12	14	36
UN System	9	49	8	66
Other orgs	25	5	2	32
Total	44	66	24	134

Unless otherwise noted, the study period is limited to 2000-2018 since collection of 2019 data was still in its early stages at the time of compilation. 4 indicators include only projections data for the year 2050, and thus have been excluded from analysis unless otherwise noted. Another 15 indicators have been dropped or deprecated and, except as noted in the chapter on "Explanation Framework Analysis," have also been excluded, leaving 115 indicators as the primary focus of analysis.

2
Coverage Analysis

While the 2018 paper looked at coverage gaps primarily in terms of most recent available values (MRVs), in this analysis we wanted to develop a more detailed approach to identify different types of coverage gaps over a broader time span. Accordingly, we developed the heat map shown in Figure 2.1. In this chart, discrete indicators are arranged along the Y axis while time is plotted on the X axis for the 2000-2018 period. Colors indicate the number of observations (i.e., countries) for the corresponding indicator and year. Darker colors in the purple part of the spectrum indicate relatively low-density coverage, while lighter colors in the yellow part of the spectrum represent high-density coverage, up to the maximum of 217 countries. Blank areas indicate no data for that particular indicator and year.

Several patterns emerge from a visual assessment of Figure 2.1, which are not necessarily mutually exclusive, nor is a visual assessment the only approach to identifying indicator clusters. Appendix 2 includes several alternatives to and in-depth definitions of the patterns discussed in this section.

2.1 Consistently low coverage

One group of indicators is characterized by consistently low country coverage over the 2000-2018 time period. In this case we've defined "low coverage" has having values for no more than 100 countries in any given year. These indicators generally appear as steady and consistently dark horizontal lines towards the bottom of Figure 2.1.

It's important to note, however, that while total country coverage may be low for these indicators in any given year, the country composition often varies from year to year for reasons discussed in the next section. For example, "Poverty Headcount Ratio" is available for no more than 59 countries in any given year, but includes values for 135 countries across all years. By comparison, "Incidence of Malaria" is available for 99 countries in nearly all years with very little variation

Figure 2.1: Number of countries per indicator over time

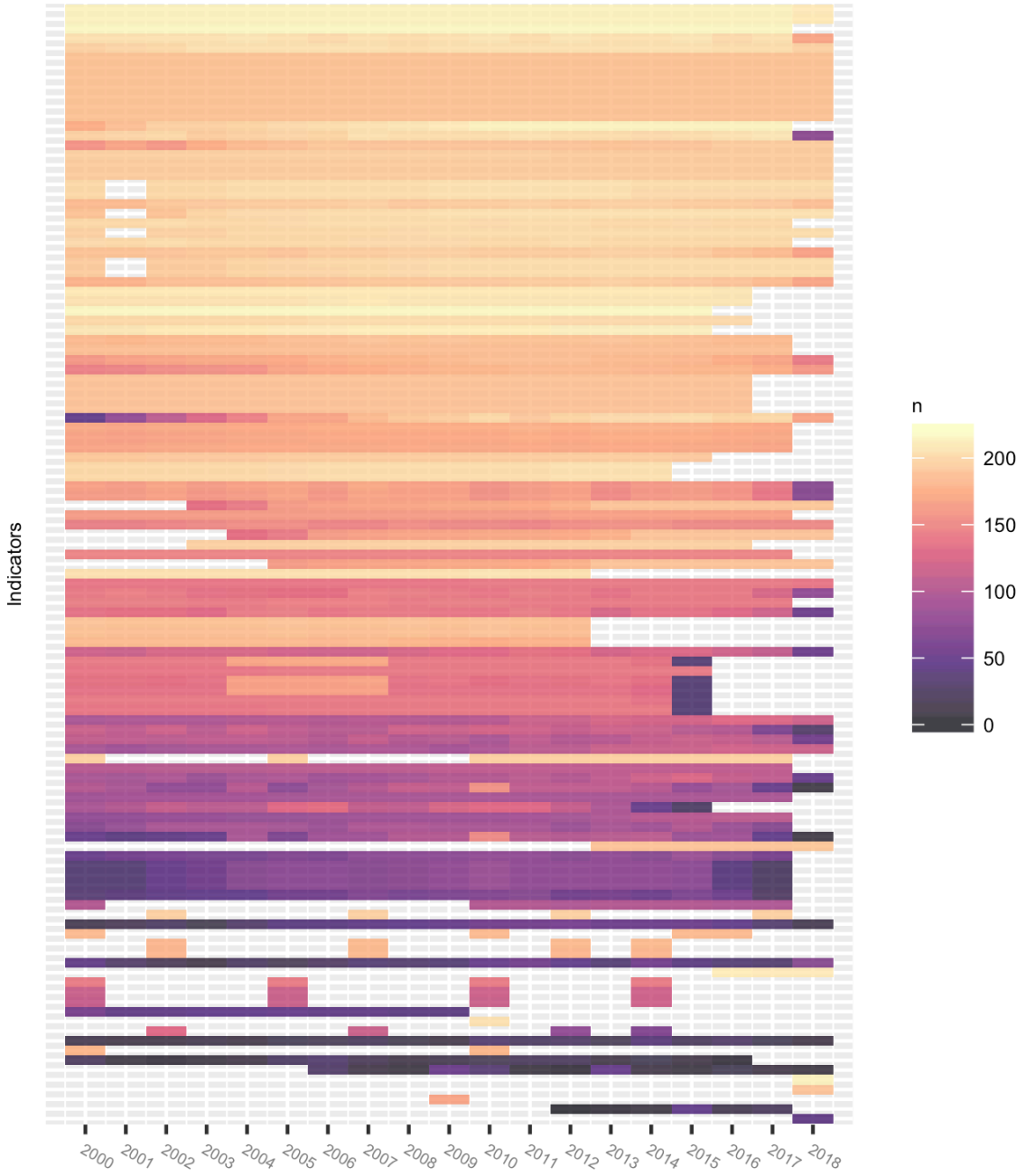


Table 2.1: Indicators with consistently low coverage

Indicator	Code	Max. Countries
Children in employment, total (% of children ages 7-14)	SL.TLF.0714.ZS	31
Unmet need for contraception (% of married women ages 15-49)	SP.UWT.TFRT	37
Retirement Age	WBL	42
Annualized average growth rate in per capita real survey mean consumption or income, total population (%)	SI.SPR.PCAP.ZG	46
Value lost due to electrical outages (% of sales for affected firms)	IC.FRM.OUTG.ZS	51
GHG net emissions/removals by LUCF (Mt of CO2 equivalent)	EN.CLC.GHGR.MT.CE	58
Poverty headcount ratio at national poverty lines (% of population)	SI.POV.NAHC	59
Technicians in R&D (per million people)	SP.POP.TECH.RD.P6	69
Literacy rate, adult total (% of people ages 15 and above)	SE.ADT.LITR.ZS	71
Income share held by lowest 20%	SI.DST.FRST.20	84
Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)	SI.POV.DDAY	84
GINI index (World Bank estimate)	SI.POV.GINI	84
Researchers in R&D (per million people)	SP.POP.SCIE.RD.P6	84
People using safely managed sanitation services (% of population)	SH.STA.SMSS.ZS	94
Research and development expenditure (% of GDP)	GB.XPD.RSDV.GD.Z	99
Incidence of malaria (per 1,000 population at risk)	SH.MLR.INCD.P3	99

in any given year. These patterns may be important for ESG analysis if it is possible to extrapolate or impute missing values from prior years; indicators whose countries vary from year-to-year (and thus have larger coverage in the aggregate) may benefit to a greater degree.

2.2 Moderate to high coverage

By contrast, most indicators include values for at least 100 countries in at least one year. 99 indicators have single-year coverage of at least 100 countries, 78 indicators cover at least 150 countries, and 27 indicators cover at least 200 countries. In Figure 2.1 these indicators range from magenta to light yellow in the middle to upper sections of the heat map.

12 indicators in this cluster include values for 2018 or later for at least 90% of countries. These indicators appear at the top-most section of Figure 2.1 and correspond to the "perfect case" classification in the next chapter.

Among the remaining indicators, year-to-year composition of coverage can vary in a manner similar to those in the "consistently low coverage" group for methodological reasons, as discussed in the next section.

2.3 Measurable improvement

A handful of indicators demonstrate significant, measureable improvement in country coverage over time. We define "measurable improvement" by regressing country coverage over time for each indicator (gap-filling for years where coverage is missing entirely). Indicators with a coefficient greater than 1 are shown in Table 2.2. In Figure 2.1 these appear as indicators that are colored dark purple or magenta on the left side of their coverage with increasingly light colors on the right side.

These and similar indicators may warrant further study to better understand the factors behind the increases in country coverage. For instance, if country coverage improved as a result of better methodologies, increased production capacity, or broader demand, they may provide a model for improving country coverage for indicators that need it.

2.4 High coverage and sudden decline

A significant group of indicators has consistent coverage through most of the time period, but with declining coverage or no coverage in recent years. In Figure 2.1 these tend to appear as "truncated" series

Table 2.2: Select indicators that improve over time

Indicator	Code
Current account balance (% of GDP)	BN.CAB.XOKA.GD.ZS
Access to electricity (% of population)	EG.ELC.ACCS.ZS
Enforcing contracts: Cost (% of claim)	ENF.CONT.COEN.COST.ZS
Outstanding international public debt securities to GDP (%)	GFDD.DM.06
Time required to start a business (days)	IC.REG.DURS
Total tax and contribution rate (% of profit)	IC.TAX.TOTL.CP.ZS
Patent applications, nonresidents	IP.PAT.NRES
Patent applications, residents	IP.PAT.RESD
Fixed broadband subscriptions (per 100 people)	IT.NET.BBND.P2
Literacy rate, adult total (% of people ages 15 and above)	SE.ADT.LITR.ZS
Proportion of seats held by women in national parliaments (%)	SG.GEN.PARL.ZS
Annualized average growth rate in per capita real survey mean consumption or income, total population (%)	SI.SPR.PCAP.ZG

with no coloring for large portions of the right side of the chart. Table 2.3 summarizes indicators by the the year of their most recent available value (MRV). As shown, over 50% of ESG indicators in the study period have no values for the most recent study year, and 13% of indicators have no values for the most recent four years or more.

Table 2.3: Indicators by Most Recent Available Year

Year of MRV	# Indicators
2018+	55
2017	25
2016	10
2015	10
<2015	15

As noted previously, MRV years are a significant factor in ESG data use, as older data is less relevant to investment decisions being made today and in the near future. Many important factors could explain the wide variance in MRV years, and this is the focus of the next chapter.

2.5 Intermittent coverage

A handful of indicators are only available for periodic years with no values available for intermediate years. These appear in Figure 2.1 as as intermittent series resembling "dashed" lines, the majority (but not all) of which are environmental indicators. Appendix 2 provides a technical description of indicators in this category.

While not the primary focus of this analysis, there are a handful of factors that could explain the coverage characteristics of this group. The most obvious explanation is that indicators may simply not be designed as time-series data. This is the most likely explanation for Retirement Age and Threatened Mammal Species, which are available for only a single year. In other cases, there may not be resources to collect data on an annual basis, even if doing so would be useful. Other indicators may measure environmental or social phenomena that change gradually so that annual data collection would not be efficient. This last possibility is material to ESG data use because it implies that older data may still be relevant if properly understood.

Table 2.4: Indicators with intermittent coverage

Indicator	Code
Droughts, floods, extreme temperatures (% of population, average 1990-2009)	EN.CLC.MDAT.ZS
Mammal species, threatened	EN.MAM.THRD.NO
Population living in areas where elevation is below 5 meters (% of total population)	EN.POP.EL5M.ZS
Annual freshwater withdrawals, total (% of internal resources)	ER.H2O.FWTL.ZS
Renewable internal freshwater resources, total (billion cubic meters)	ER.H2O.INTR.K3
Renewable internal freshwater resources per capita (cubic meters)	ER.H2O.INTR.PC
Natural capital, subsoil assets: coal (constant 2014 US$)	NW.NCA.SACO.TO
Natural capital, subsoil assets: gas (constant 2014 US$)	NW.NCA.SAGA.TO
Natural capital, subsoil assets: oil (constant 2014 US$)	NW.NCA.SAOI.TO
Cause of death, by communicable diseases and maternal, prenatal and nutrition conditions (% of total)	SH.DTH.COMM.ZS
Diabetes prevalence (% of population ages 20 to 79)	SH.STA.DIAB.ZS
Net migration	SM.POP.NETM
Retirement Age	WBL

3
Explanation Framework Analysis

The previous chapter sought to provide insights into the patterns of coverage gaps currently found in ESG data. This section seeks to provide further insight into why these gaps occur.

To better understand the nature of data gaps we consulted data management experts at the World Bank to develop a list of explanatory factors which are described below. These "explanations" are defined such that they can be used to consistently "tag" indicators to which they apply. They are particularly relevant to time series statistics. Using metadata in the World Bank API and interviews with members of the data management team, we examined each indicator through the lens of these explanations and recorded the results as dummy (i.e., yes/no) values in a metadata database. It is possible that multiple explanations apply to any given indicator.

The results of this tagging exercise were used to build a database along with other relevant metadata. The final database assembled for analysis has a total of 48 variables for 134 indicators.

The discusion below describes each of the explanations in detail. Each description includes a coverage heat map from the previous section which identifies the indicators "tagged" underneath it, showing how the explanation may impact gaps in data coverage.

3.1 Description of Explanations

Ideal Case

The World Bank API defines 217 countries and economies. Indicators that had observations for 2018 or later for at least 196 countries (90%) were considered "non gap" indicators and were not tagged with any further explanations.

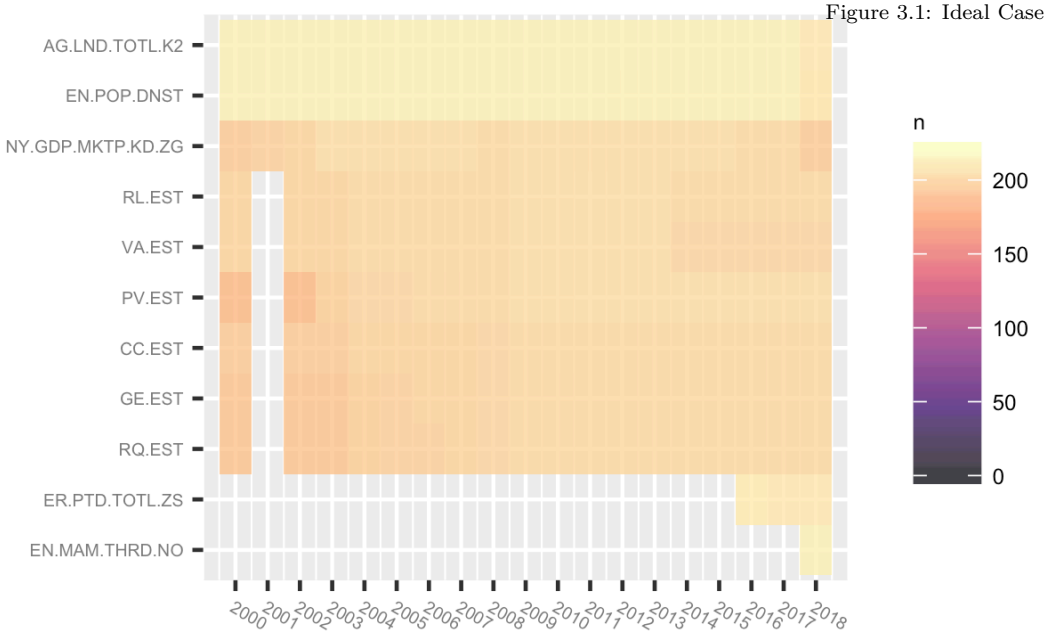


Figure 3.1: Ideal Case

Dropped or Deprecated (A)

While most major World Bank time series databases are updated on regular schedules, it is common for individual indicators and occasionally entire databases to be discontinued. This can occur if the original provider or program discontinues support for the data, or if policies, programs, or methodologies evolve such that the data are no longer relevant. In these cases, the time series is no longer updated with recent observations, and the series becomes increasingly obsolete. Deprecated indicators in the WDI are typically removed and are available only in the WDI Archives. Accordingly, it is not possible to provide a heatmap of these indicators.

Definition: the indicator only exists in a discontinued or "archived" database, including:

- WDI Archives (API source=2)
- Africa Development Indicators (API source=11)

Notes: indicators tagged with this explanation are considered inactive and remaining explanations are not considered.

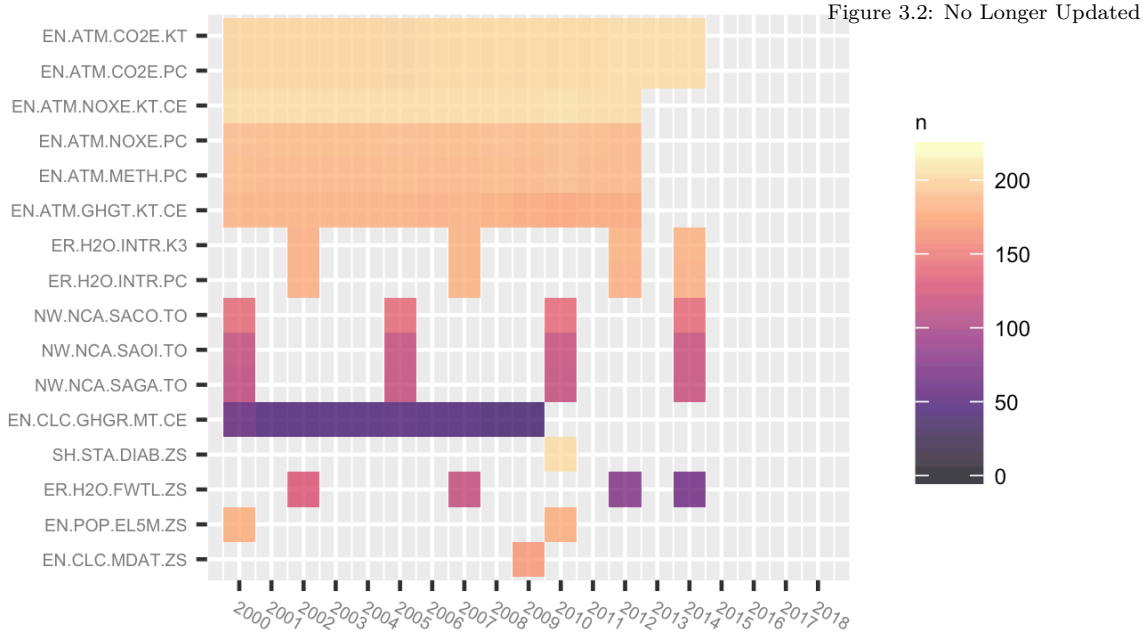
Table 3.1: Dropped or Deprecated

Indicator	Code
PM10, country level (micrograms per cubic meter)	EN.ATM.PM10.MC.M3
GEF benefits index for biodiversity (0 = no biodiversity potential to 100 = maximum)	ER.BDV.TOTL.XQ
Overall surplus/deficit, excluding current grants (current LCU)	GB.BAL.OVRX.CN
Fiscal balance, cash surplus/deficit (current US$)	GC.BAL.CASH.CD
Open Budget Index Overall Country Score	IBP.OBI.XQ
Average duration of power outages (hours)	IC.ELC.OUTG.HR
Telephone mainlines (per 1,000 people)	IT.MLT.MAIN.P3
Internet users (per 1,000 people)	IT.NET.USER.P3
Genuine savings: energy depletion (% of GDP)	NY.GEN.DNGY.GD.ZS
Gross national savings, public (current US$)	NY.GNS.PUBL.CD
Tuberculosis prevalence rate, low uncertainty bound (per 1000,000 population, WHO)	SH.TBS.PREV.LW
Labor force with secondary education (% of total)	SL.TLF.SECO.ZS
Labor force with tertiary education (% of total)	SL.TLF.TERT.ZS
Depth of the food deficit (kilocalories per person per day)	SN.ITK.DFCT
Export product concentration index	TX.CONC.IND.XQ

No Longer Updated (B)

In other cases, an indicator may remain in an active database but fall out of active maintenance. This may be the case as a precursor to Explanation A above, or it may be attributable to lapsed oversight, i.e., there is no longer a person or team responsible for the indicator (e.g., program termination, department reorganization, personnel changes). In these cases as well, the time series becomes increasingly obsolete as it is no longer updated. Some indicators that fit this definition however, may simply be subject to very long update cycles of 4-5 years or more, meaning that they may still be actively maintained.

Figure 3.2: No Longer Updated



Definition: the indicator has no observations for any country for the last four years (2015-2018)

Notes: indicators tagged with this explanation are considered inactive and remaining explanations are not considered.

Structural Lags (C)

Some indicators by their nature may be especially time consuming to produce. For instance, if an indicator relies on administrative data or other underlying raw information, it cannot be calculated until that source is published. These source dependencies may be subject to their own production schedules and timeliness issues. The effect

may be that an indicator may only be available significantly later than the time period of its observations. These delays may be compounded if multiple dependencies are involved. In Figure 3.3 indicators that embody this characteristic exhibit low or non-existent coverage on the right side of the heat map.

A different kind of structural lag manifests itself as consistent but relatively low country coverage compared to the "ideal case" scenario. For instance, an indicator may have consistent temporal coverage, but for only 85% or less of possible countries, even though the indicator may be relevant to nearly all countries. Low country coverage may be explained by resource constraints, in that data are more costly to collect in countries where capacity is limited. It may also be that certain economies (for instance, low population or island states) were considered out of scope by data producers. In Figure 3.3 indicators that embody this characteristic exhibit consistent coverage (i.e., uniformly light orange or yellow) along the horizontal axis.

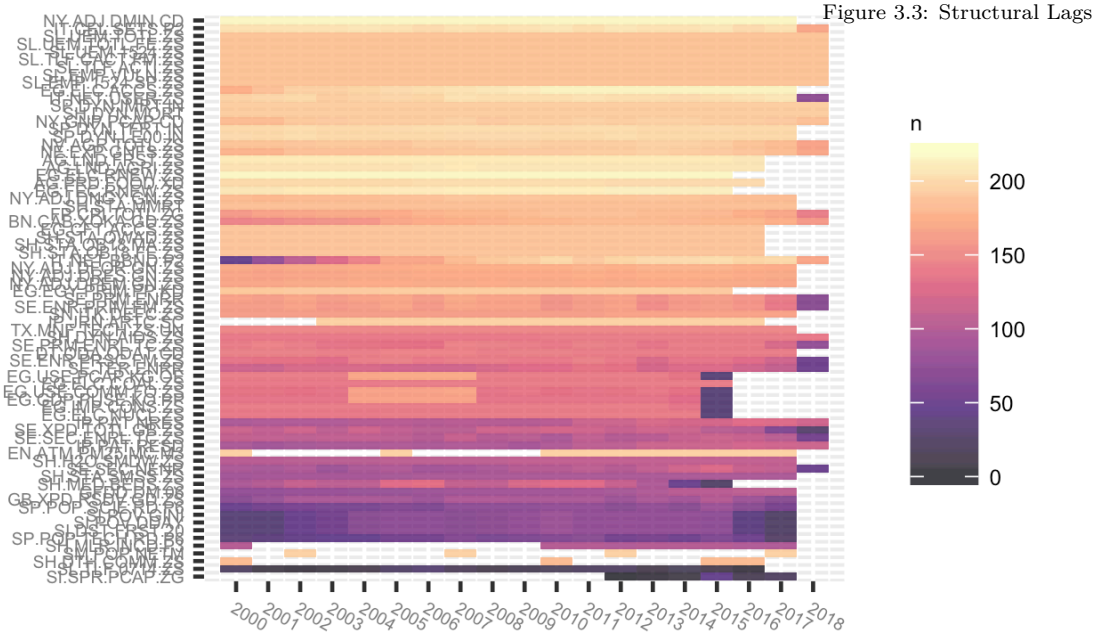


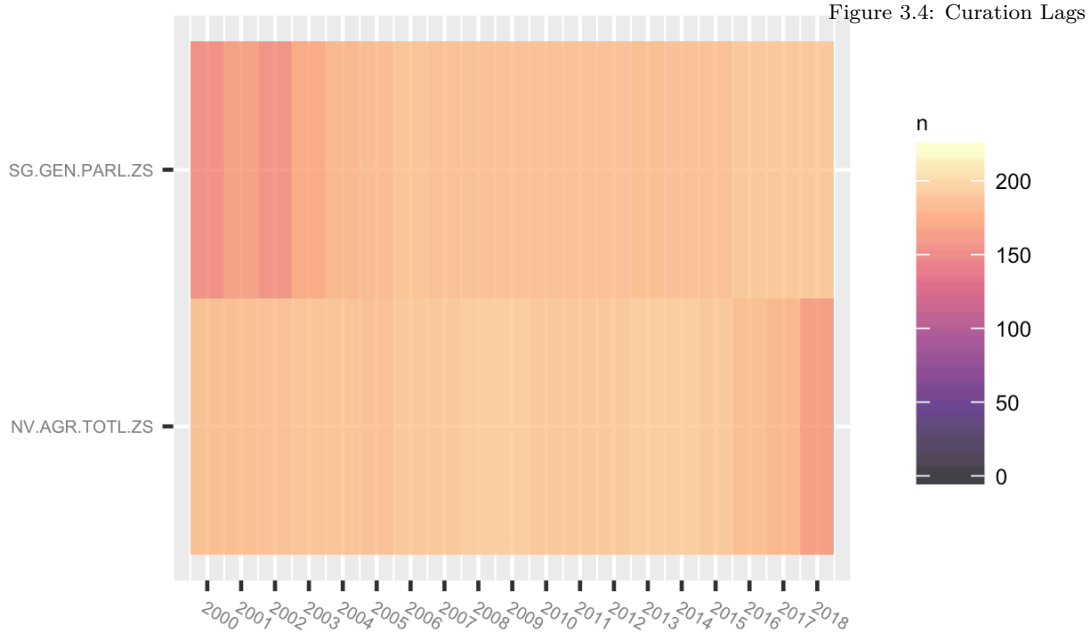
Figure 3.3: Structural Lags

Definition: classification under this explanation was made through consultations with subject matter experts.

Curation Lags (D)

In many cases the World Bank is a distributor of indicators it obtains from dozens of external parties. There is some level of "curation" overhead costs to obtain, collate, validate and finalize data from these independent sources, and this overhead may itself affect data availability compared to that of the original sources. This may be especially true where the production cycle of the original indicator varies from that of the Bank's curation team; for instance, an indicator published monthly by the original source may only be updated quarterly or annually by the World Bank.

Figure 3.4: Curation Lags



Definition: classification under this explanation was made through consultations with the data curation team.

Licensing Constraints (E)

In some cases, the World Bank distributes indicators under legal agreements that affect its availability. The most common cases are licenses that stipulate that the Bank cannot distribute the latest version of a dataset to protect that dataset's value in cases where providers sell the data commercially. Thus, while more recent data may exist, the Bank is legally prevented from distributing it for a period of time, which can result in an availability gap.

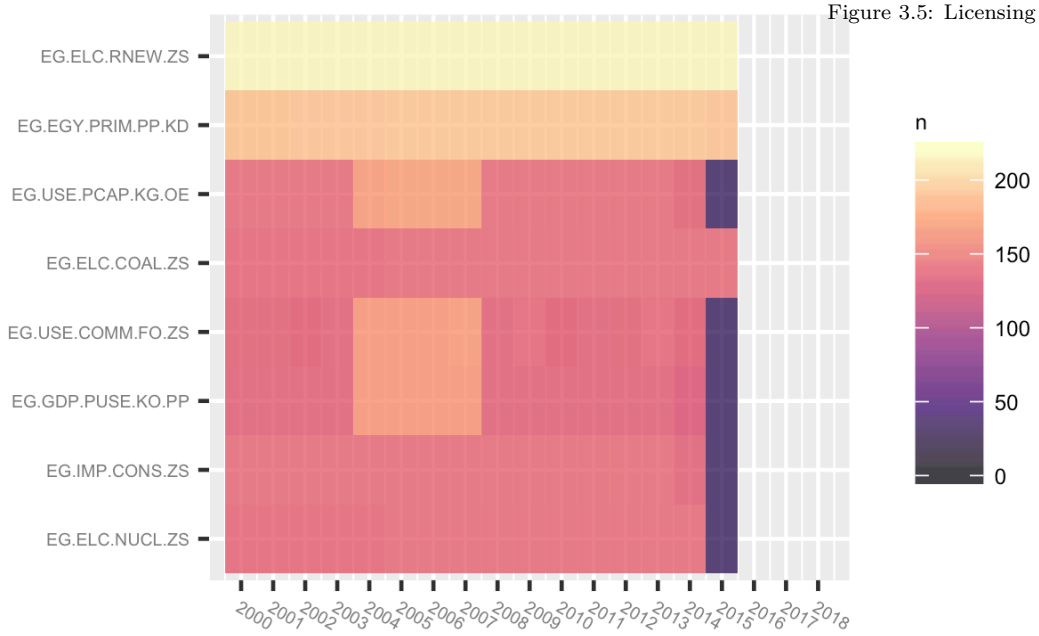


Figure 3.5: Licensing Constraints

Definition: classification under this explanation was made through consultations with the data curation team.

Survey Dependencies (F)

Some indicators are calculated from underlying microdata obtained from household-level or firm-level surveys conducted in country. The survey process constitutes a unique kind of structural lag. Surveys themselves are costly, and are frequently implemented irregularly or according to schedules that vary significantly by country. As a result, data availability may vary not only by time but by country.

Definition: classification under this explanation was made through consultations with the data curation team.

Limited Relevance (G)

Some indicators may not be relevant to or may not be interesting in the context of certain groups of economies. For example, very small economies may not have significant natural resource endowments or particular kinds of economic activity for particular indicators to be meaningful. Indicators designed to measure use of, say, forests, mineral deposits, or levels of trade may be assumed to essentially be zero or "too small to measure." In a similar vein, some indicators may not

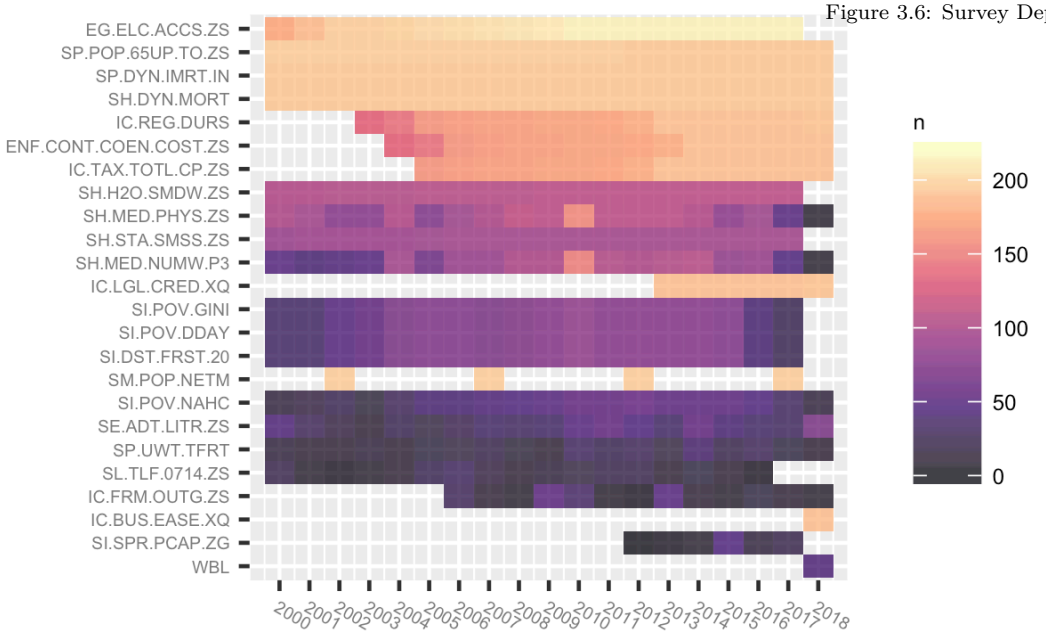


Figure 3.6: Survey Dependencies

be relevant to industrialized economies, such as prevalence of certain diseases (thought to be eradicated), literacy rates, or foreign aid.

Definition: this explanation was considered for high-income "rich" countries (using the WBG income classification) and small economies, defined as those with populations under 120,000. This population threshold represents a "natural" breakpoint at which population jumps by nearly 40 percent, clearly differentiating economies above and below it. For both "rich" and "small" economies we identified a set of indicators for which at least 80% of economies in the group had no observations at all, as this might suggest a deliberate decision on the part of data producers to exclude the group. From these results we removed indicators that we still considered potentially relevant to rich/small economies despite the lack of available data.

3.2 Findings

Figure 3.8 shows the results of the explanation framework disaggregated primarily by explanation, and secondarily by primary source (WBG and all external sources).

Overall, the "Structural Lags" explanation is by far the most dominant cause of gaps in ESG data, where it is a contributing factor for 73 of 134 indicators overall, and 40 of 67 indicators in the WBG's

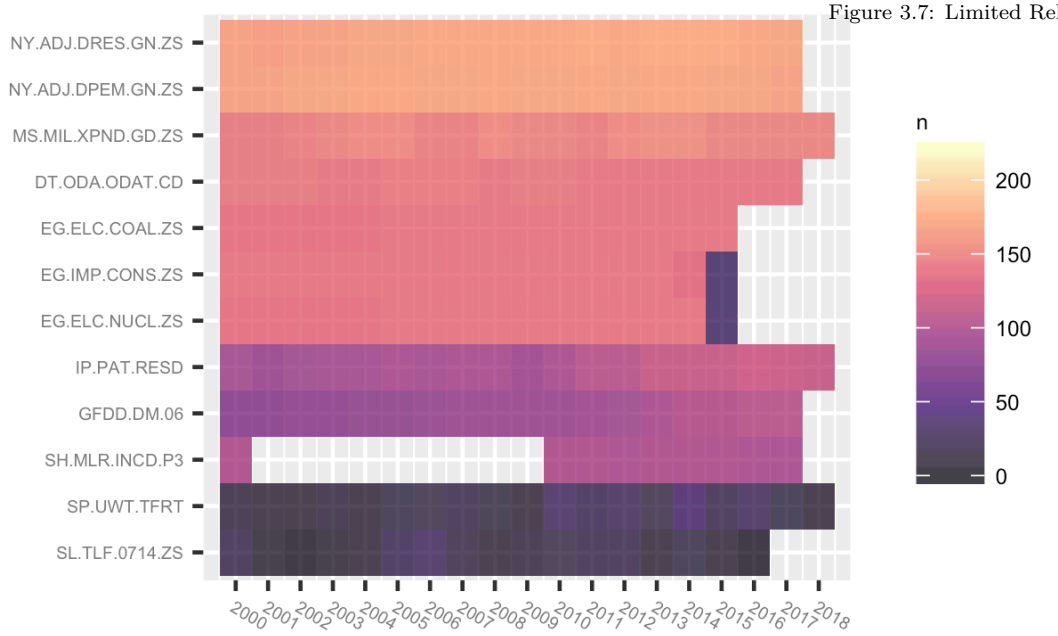


Figure 3.7: Limited Relevance

ESG dataset. This frequency likely reflects the prevalence of traditional statistical indicators currently used in ESG, many of which happen to rely on inter-agency cooperation and other intrinsically time consuming modalities to produce comparable data for all countries.

"Survey Dependencies" is the second most significant explanation, contributing to gaps for 24 of 134 indicators overall, and 15 of 67 indicators in the WBG's dataset. "No Longer Updated" is the third most significant explanation, accounting for 16 of 134 indicators overall, and 6 of 67 indicators in the WBG's dataset. "Deprecated" is close behind, accounting for 15 of 134 indicators overall, but is not a factor in the WBG's dataset.

Of the remaining factors, "Licensing" and "Limited Relevance" are the most significant, and in the WBG dataset these are equal to "No Longer Updated" in terms of prevalence. The least significant explanation in both datasets was "Curation Lags," which accounted for just 2 indicators in both datasets.

Figure 3.9 is similar to Figure 3.8 but disaggregates by explanation and sector.

This provides a slightly different perspective. Looking at the top 2 explanatory factors, indicators in the social and governance pillars are overly represented within "Structural Lags" and "Survey Dependencies," suggesting that efforts in these areas would disproportion-

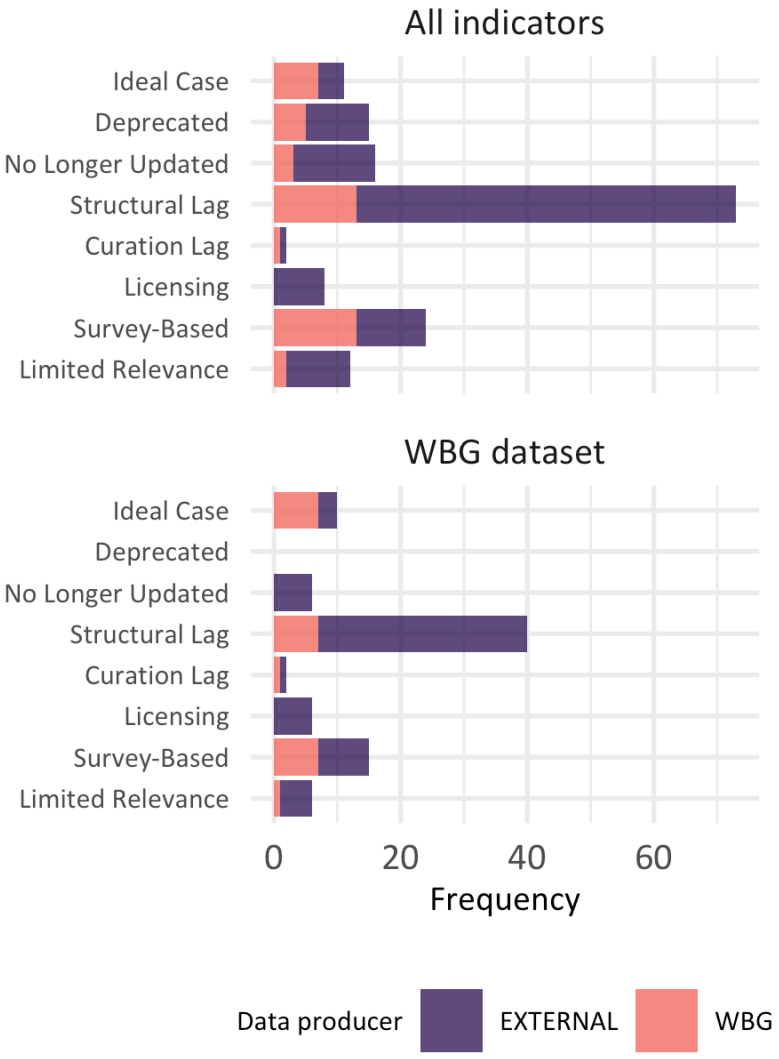


Figure 3.8: Explanations for data gaps, by source

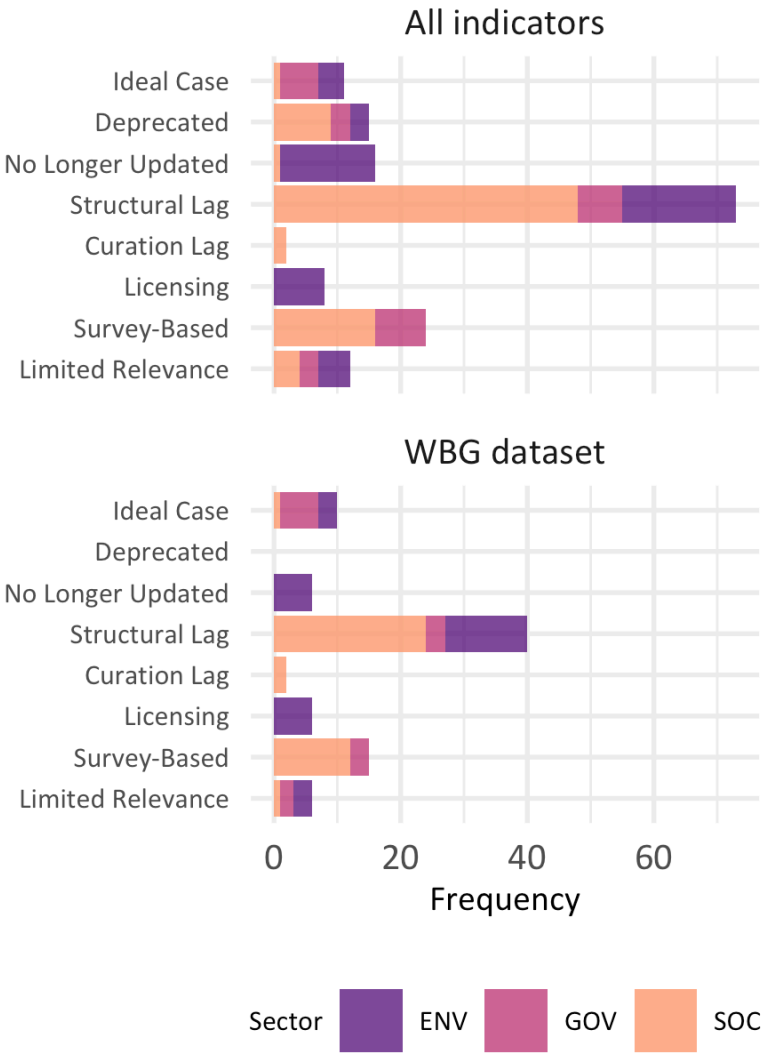


Figure 3.9: Explanations for data gaps, by sector

aately improve these pillars. By comparison, nearly all indicators in the "No Longer Updated" group belong to the environment pillar. The "Licensing" explanation also consists entirely of indicators in the environment pillar.

4
Volatility Analysis

The previous two chapters sought to provide insights into the patterns of coverage gaps found in ESG data, and the reasons why those gaps occur from a data production standpoint. This chapter starts to explore the potential for correcting certain gaps using statistical methods. For instance, missing values might (within limits) be interpolated or extrapolated from existing observations, or estimated using linear regression or other modelling techniques. While these techniques are an imperfect substitute for observed data, they may be able to play a limited role within a broader strategy for improving ESG data coverage.

Note that the scope of this paper is limited to analysis of the *potential* impact of gap filling and does not look in detail at specific techniques or tools for doing so. In all likelihood, the most appropriate approach will vary by indicator, and will depend on the definition fo the indicator, the availability of proxies and independent variables (for modelling) and other indicator-specific factors.

In general though, statistical techniques work best when indicator values move according to observable patterns, and in particular, when temporal variance is relatively low. That is, the less that an indicator varies from period to period for a particular country, the easier it is to reasonably estimate missing values. Consequently, indicator variance can be used as a proxy of the general potential to fill gaps using statistical methods, with low variance suggesting greater potential. In this analysis, we used a standard *coefficient of variation* (standard deviation divided by mean) to estimate variance for each indicator and country, and scaled all values to a 0-1 range to make values comparable across indicators.

Figure 4.1 shows the coefficients of variation (CV) for each indicator and country displayed as an interactive heat map with indicators on the vertical axis and countries on the horizontal axis. Relatively low CV values appear in light yellow, while high values appear in dark purple.

Note that indicator/country series consisting of a single year are not included in Figure 4.1 since there is no "variation" in a domain of just one observation.

Figure 4.1 is a very dense display of data, but its advantage is that it makes it easy to spot outlying instances of country/indicator combinations that are relatively volatile over time, i.e., the dark points with high CV values. These are cases where statistical techniques would be likely be especially unreliable and should be avoided. In the majority of cases, however, ESG indicators appear consistently stable over time.

Table 4.1 shows the percentile thresholds for the CV values in Figure 4.3. Figure 4.2 shows the same data in a histogram; the red line marks the median, while the blue lines mark the 5th and 95th percentiles.

Table 4.1: CV Percentiles

Percentile	CV
Min	0.000
5%	0.000
10%	0.375
25%	0.551
50%	0.688
75%	0.873
90%	1.204
95%	1.414
Max	4.243

One important feature of Table 4.1 and Figure 4.2 is the presence of a substantial number of zero values, which account for 8.2% of the total number of data points. This occurs when all observations for a country/indicator series are exactly the same value. Examples include highly stable statistics such as land area, renewable freshwater resources, and electricity mix (coal, nuclear, etc). In some countries, health indicators such as AIDS prevalence also exhibit no variation. Other cases may be greater cause for concern. For instance, the fact that the "net migration" statistics for Madagascar, Comoros, and Burkina Faso have not changed over 15 years seems dubious at first glance.

A similar-looking spike in distribution occurs around the 95th percentile. This spike is dominated by a handful of indicators that include observations for only 2-4 years, such as "Population living in areas of elevation below 5 meters," such that any variation at all results in a significant standard deviation and thus an outsized CV value.

Figure 4.3 shows the distribution of mean CV values (at the in-

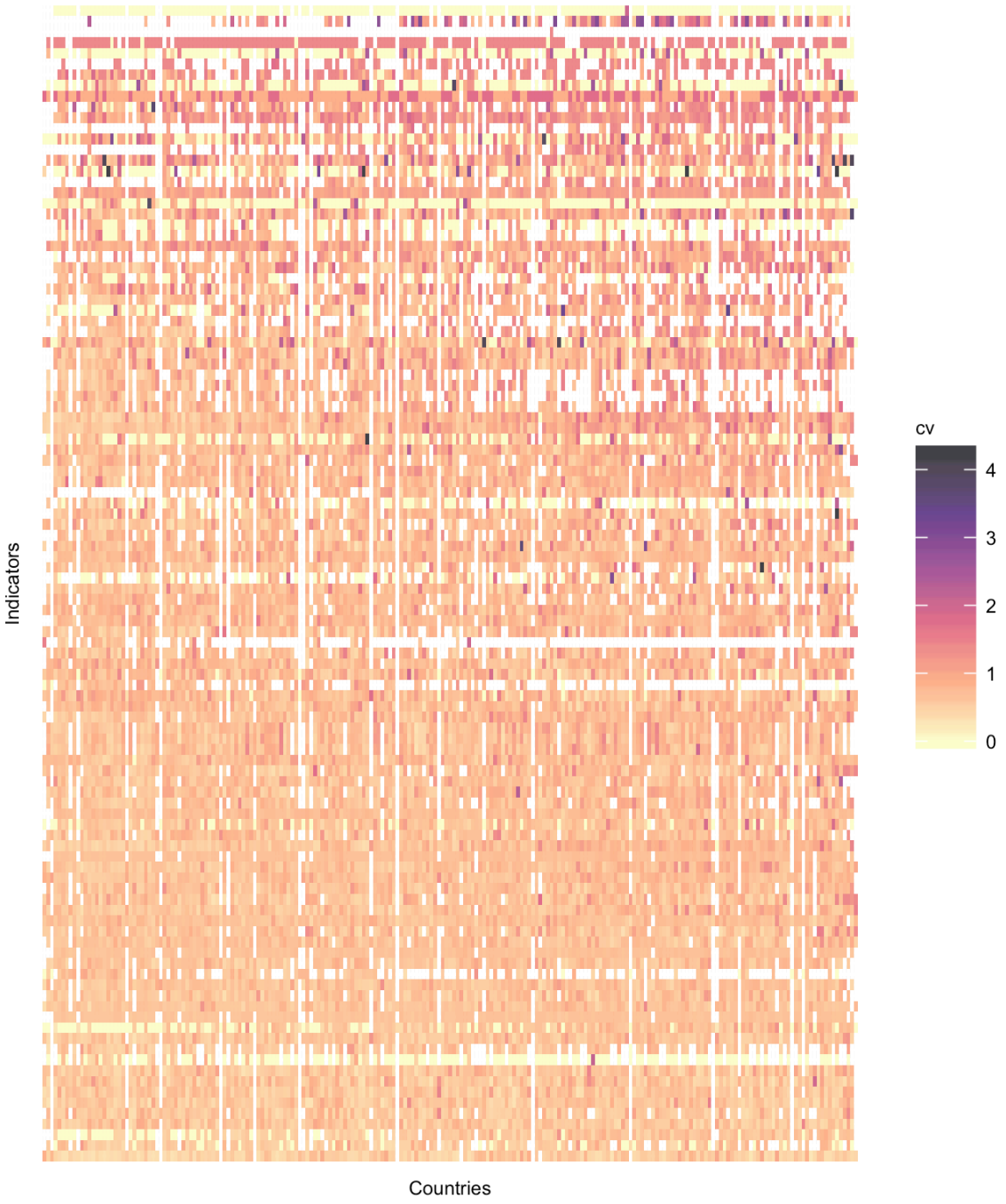
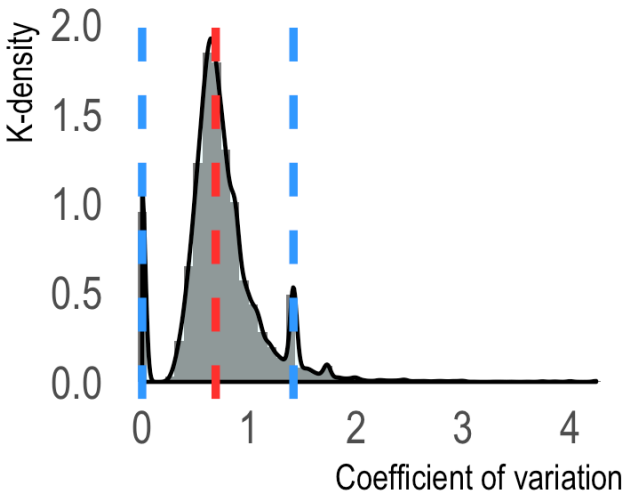


Figure 4.1: Coefficient of variation by country and indicator

Figure 4.2: Density of ESG indicator CV



dicator level) for the ESG indicator dataset. Again, the the red line marks the median, while the blue lines mark the 5th and 95th percentiles. The mean CV value may help economists assess whether gap filling is practical for a given indicator. Indicators with low mean CVs may be especially good candidates for gap filling except for the small number of countries with individually high CV values. Indicators with relatively high mean CVs may not be good candidates.

Table 4.2 shows the indicators whose mean CVs fall below the 5th percentile or above the 95th percentile:

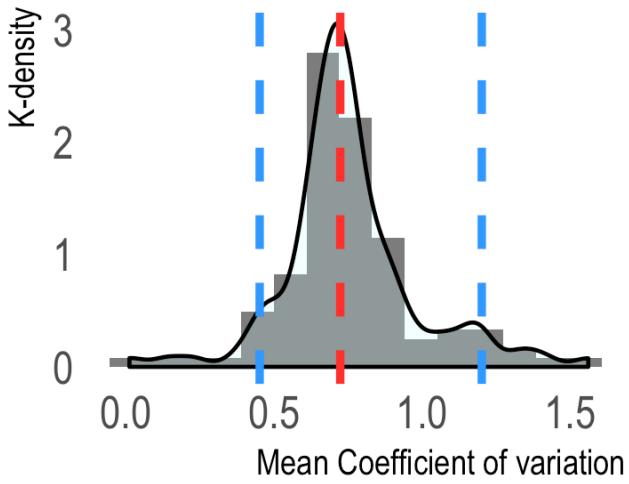
4.1 Implications for Gap Filling

While gaps in ESG data follow several patterns as described in the Coverage Analysis chapter, the most significant issue is likely indicators whose most recent value (MRV) is 2 years out of date or more, as investment decisions are made in the context of current and near future conditions. The CV analysis in this chapter and summarized in Figures 4.2 and 4.3 suggest that (normalized) indicator values fall within a fairly narrow range with few outliers, and that the majority of values are below 1.0. In several probability fields values below 1.0 are considered low-variance. While it's not clear whether this benchmark applies in the context of some or all ESG indicators, it

Table 4.2: ESG indicators with lowest and highest volatility

Low volatility (CV <= 0.45)	High volatility (CV >= 1.2)
Renewable internal freshwater resources, total (billion cubic meters)	Cause of death, by communicable diseases and maternal, prenatal and nutrition conditions (% of total)
Electricity production from nuclear sources (% of total)	Terrestrial and marine protected areas (% of total territorial area)
Land area (sq. km)	Population living in areas where elevation is below 5 meters (% of total population)
Strength of legal rights index (0=weak to 12=strong)	Value lost due to electrical outages (% of sales for affected firms)
Access to electricity (% of population)	Annualized average growth rate in per capita real survey mean consumption or income, total population (%)
Electricity production from coal sources (% of total)	Incidence of malaria (per 1,000 population at risk)

Figure 4.3: Density of mean ESG indicator CV



provides a starting point for thinking–conservatively–about the potential for using statistical methods for filling gaps in ESG data. Again, it is beyond the scope of this analysis to suggest specific gap filling techniques, but stipulating that gap filling will be more robust where indicator variance is low, we can start to think about the impacts of doing so.

For instance, in this analysis there are 217 countries and 115 indicators for a total of 24955 country/indicator pairs. 7659 country/indicator series have an MRV value of 2018 or later. So we can say that the year 2018 has coverage of *7,659 / 24,955,* or 31%. To estimate the potential for gap filling techniques, let's say that we can confidently extrapolate or estimate an additional year of data from observed values beyond the current MRV for any country/indicator series with a CV value below the 25th percentile of 0.551. Again, while we don't know exactly how the estimate would be obtained, we can assume the effect would be to increase the MRV year by 1, raising 2016 to 2017, 2017 to 2018, etc. The resulting new estimates mean that we now have 8,559 country/indicator series with at least a 2018 MRV value, which raises our coverage to *8,559 / 24,955* or 34%. One could vary the study year, CV threshold and number of years to extrapolate in various combinations, as shown in Table 4.3.

Alternatively, the tool available here provides an interactive way to

Table 4.3: Effects of selected CV thresholds and lengths of imputation on coverage in 2018

CV Threshold	Years To Extrapolate	Resulting Coverage (%)
0.551	1	35
0.688	1	39
0.873	1	43
0.873	2	50

test various combinations of assumptions and see both the aggregate impacts and the effects on individual indicators. Area under the curve (AUC) is equivalent to the percent coverage for any set of assumptions (100% being "perfect" coverage of a value for every indicator and country).

5
Discussion

Together, the findings from the three analytical approaches suggest several options that could be taken to mitigate gaps in ESG data, or deal appropriately with gaps that are unavoidable.

5.1 Discourage use of discontinued indicators

15 indicators, or 11% of the 134 studied, have been discontinued by the World Bank and are no longer maintained. They continue to be available for historical purposes, and only reside in databases that are described as "archives" in the World Bank Data Catalog. None of these indicators appear in or affect the WBG dataset. Still, it is possible that external users may not be aware that the indicators are discontinued, particularly if they are accessing them through the API and not the data catalog.

In most cases, discontinued indicators have been replaced by a more recent and more appropriate substitute (see Appendix A). It is strongly recommended that ESG users switch to more recent indicators and discontinue use of those that are no longer maintained.

5.2 Technical enhancements to existing indicators

The previous two sections explored two ways in which technical approaches could be used to improve the coverage and quality of ESG data. First, it may be possible, as suggested in the previous volatility analysis, that statistical techniques could be used to impute, extrapolate, or estimate missing values in some cases. Although discussion of specific techniques is beyond the scope of this analysis, we can use indicator volatility as a proxy to estimate the potential for these techniques.

For instance, building off the approach demonstrated by the interactive tool in the previous chapter, if one stipulates that country/indicator series with a volatility coefficient no higher than 0.65

(slightly less than the median) can be extrapolated or estimated one year forward, data coverage in 2018 would improve from 31% to 37% of potential observations for all indicators and countries. At that level the number of indicators with some level of 2018 coverage would improve from 54 to 77 out of 115 total. An additional 28 of the original 54 indicators would see improved country coverage in 2018. While the choice of median CV is somewhat arbitrary, it gives some reference for what could be accomplished through established techniques and econometiric modeling.

The second possible approach involves the "limited relevance" indicators identified in the explanations framework. These are indicators where gaps in coverage may be due to the indicator being irrelevant to certain countries, either because they are very small or very rich. As a result, it may be possible to "assume" a reasonable value for indicators that fall into this explanation. For instance, it is reasonable to assume that "Net official development assistance" for high-income countries that are missing this value is $0. Likewise, it may be reasonable to assume that "Electricity production from nuclear sources" is 0% for small island economies. The other indicators in this cluster might similarly be inferred for certain groups of countries, effectively eliminating coverage gaps with little effort or cost. Alternatively, it may be possible to drop these indicators at the analytical level for countries for which they are clearly not relevant.

While use of statistical techniques to "enhance" data may sound enticing, great care would be necessary to make clear to data users which data are "actual" compared to which are "estimated." Ideally, data users would be able to choose between an "actual" and a "estimated" dataset with full transparency and information on the implications of using estimated data. That said, "estimated" data are becoming increasingly common in the age of machine learning and artificial intelligence (e.g. weather forecasts or Zillow real estate estimates), so users may not find the concept to be especially exotic or concerning.

5.3 Consider higher frequency approaches or substitutes

The third option is to selectively improve the frequency of indicators where MRV is a significant issue, or find better sources where it not cost effective to make these improvements. The explanations analysis identified 102 indicators (76.1%) as either active but not recently updated or as likely having a "structural lag" of some sort in the production process that results in frequency gaps. However, 78 of 102 indicators are primarily produced by the UN or other outside organizations. This is an important consideration, because it means that investments to improve the frequency of *existing* indicators are really

investments in the capacity of third party providers. Alternatively, if it is determined that this is not a practical approach, then the remaining options are to build this capacity internally (which would have its own significant costs), or identify alternative and cheaper substitutes.

Theoretically, there are several approaches that could at least partially fill gaps in ESG data, including:

- **Sentiment analysis** derived from social media channels such as Twitter, Facebook, and Instagram. Within some domains, keyword and sentiment analysis could be used to detect high frequency changes in economic indicators such as employment, or conditions affecting governance or social stability. Online news sources could be analyzed in a similar fashion, leveraging services such as GDELT.
- **Mobile phone data** such as Call Detail Records (CDR)–the metadata from cell phone calls–have been used to measure changes in migration as well as response to natural disasters and other disruptive events. There are also efforts to measure changes in living conditions via cell phones. It is possible these efforts might provide higher frequency tools for measuring poverty, income inequality, and a range of socio-economic conditions.
- **Geospatial data**, especially satellite imagery and low altitude imagery from unmanned aerial vehicles (UAVs) are increasingly effective means of obtaining current, high resolution data. Satellite and drone imagery can be used to monitor ecosystems, agriculture production, soil moisture, and other environmental conditions. Night lights analysis has been suggested as a way to measure levels of economic activity, access to electricity, and impact from natural disasters.
- **Private sector sources** are sometimes used as proxies or leading indicators in certain sectors. For instance, SafeGraph recently used geolocation data from cell phones to estimate foot traffic patterns to commercial storefronts as a proxy for economic activity during the 2020 coronavirus pandemic. Data from OpenTable, a restaurant reservation service, can provide high-frequency estimates of consumer spending. Activity data from ride sharing services such as Uber and Lyft might also provide proxies for economic activity. Google search trends could provide insights into emerging issues and potential hot spots.

Further research is necessary to determine the potential of each of these technologies to provide suitable data substitutes, and which indicators they could replace. Even at this point, however, some general caveats can be made about the potential for alternative sources.

With the exception of night lights data, none of the examples listed

above has been produced at a global level or even for a critical mass of countries. While mobile phone data and sentiment analysis have been used extensively in many countries, examples of alternative data collection that targets multiple countries simultaneously are still limited. Obtaining alternative data from disparate countries comes with its own set of issues. For instance, sentiment analysis, which infers data from text, must account for language differences across countries. Data from technology platforms (such as OpenTable or Uber) are only available in countries where those platforms have achieved significant penetration, and must correct for selection bias where the user base is not representative of the broader population. Similarly, NLP techniques that rely on news sources, search queries, or social media will likely be affected by subjectivity bias and, in many cases, censorship. Furthermore, since many alternative sources have only be tested in small areas or in pilot studies, it is not clear if, when operated continuously at a global scale, they could actually produce data with higher frequency than traditional techniques.

More broadly, it is unclear whether alternative data sources would be compatible with traditional statistics, or whether they would be suitable for, say an ESG scoring framework. The indicators currently in the ESG database are designed to be producible and comparable across a large number of countries, and consistent over time. These design considerations are not necessarily true for the examples above. For instance, geospatial analysis may need to be recalibrated for local terrain, and sentiment analysis recalibrated for continually changing slang. Either adjustment could fundamentally change the definition of an indicator in a way that could confound temporal or geographic comparisons. Furthermore, most of the non-traditional methods listed above are not collected at regular, consistent intervals as statistics are. Thus, what may be cost effective and feasible for small area data production on an individual basis may not be cost effective for large area or global data production on a repeated basis.

On the other hand, geographic or temporal comparability may not be required in all use cases, depending on how the data are used. For example, high-frequency data from social media or news sources could still be useful as early warning detection systems, aside from their utility in an ESG scoring framework.

5.4 Conclusion and Next Steps

This analysis employed a range of techniques to better understand the extent and nature of gaps in ESG data, and explore options for improving data coverage. While some improvements can be made relatively easily and represent “low hanging fruit,” other options are

likely to be more expensive and entail greater risk.

An implicit premise in this analysis is that the existing set of ESG indicators, coverage gaps notwithstanding, is ideally suited for ESG analysis and decision making. Significant investments in further research and alternative data sources should be predicated on first determining if the data fit well within the anticipated ESG analytical framework. At the time of this writing, the Bank's ESG analytical framework is still under development. Accordingly, the most appropriate next step may be to further define the optimal ESG framework to more fully inform investments in data.

Similarly, the Bank's ESG data strategy is also a factor in assessing options to improve quality. If the strategy is simply to provide data in support of an analytical framework then the choice of indicators would be straight forward and defined by the framework. However, if the strategy is to provide a broad portfolio of data to support any number of frameworks (including ones that users may define) then the data effort may be similarly broad, and include a wide range of data types–including traditional statistics, geospatial data, microdata, high frequency data and so forth–to encourage innovation among ESG investors.

A
Deprecated Indicators

This appendix lists the indicators classified as “Dropped or Deprecated” in the explanation framework analysis section, along with recommended substitutions where available.

Table A.1: Recommended Substitutes for Deprecated Indicators

Deprecated ID (DB)	Deprecated Indicator	Replacement ID (DB)	Replacement Indicator
SN.ITK.DFCT (57)	Depth of the food deficit (kilocalories per person per day)	SN.ITK.DEFC.ZS (2)	Prevalence of undernourishment (% of population)
ER.BDV.TOTL.XQ (57)	GEF benefits index for biodiversity (0 = no biodiversity potential to 100 = maximum)	NA	NA
NY.GEN.DNGY.G (57)	Genuine savings: energy depletion (% of GDP)	NY.ADJ.DNGY.G (2)	Adjusted savings: energy depletion (% of GNI)
IT.NET.USER.P3 (57)	Internet users (per 1,000 people)	IT.NET.USER.ZS (2)	Individuals using the Internet (% of population)
SL.TLF.SECO.ZS (57)	Labor force with secondary education (% of total)	SL.TLF.INTM.ZS (12)	Labor force with intermediate education (% of total working-age population with intermediate education)
SL.TLF.TERT.ZS (57)	Labor force with tertiary education (% of total)	SL.TLF.ADVN.ZS (12)	Labor force with advanced education (% of total working-age population with advanced education)
EN.ATM.PM10.M((57)	PM10, country level (micrograms per cubic meter)	EN.ATM.PM25.M((2)	PM2.5 air pollution, mean annual exposure (micrograms per cubic meter)
IT.MLT.MAIN.P3 (57)	Telephone mainlines (per 1,000 people)	IT.MLT.MAIN.P2 (2)	Fixed telephone subscriptions (per 100 people)
GC.BAL.CASH.CI (11)	Fiscal balance, cash surplus/deficit (current US$)	GC.NLD.TOTL.G (2)	Net lending (+) / net borrowing (-) (% of GDP)
GB.BAL.OVRX.CN (11)	Overall surplus/deficit, excluding current grants (current LCU)	GC.REV.GOTR.ZS (2)	Grants and other revenue (% of revenue)
IC.ELC.OUTG.HR (11)	Average duration of power outages (hours)	IC.ELC.OUTG.ZS (2)	Firms experiencing electrical outages (% of firms)
TX.CONC.IND.XQ (11)	Export product concentration index	EF.EFM.UNIV.XD (70)	Universal Economic Fitness Metric
NY.GNS.PUBL.CI (11)	Gross national savings, public (current US$)	NY.GNS.ICTR.CD (2)	Gross savings (current US$)
IBP.OBI.XQ (11)	Open Budget Index Overall Country Score	IQ.CPA.FINQ.XQ (2)	CPIA quality of budgetary and financial management rating (1=low to 6=high)
SH.TBS.PREV.LW (11)	Tuberculosis prevalence rate, low uncertainty bound (per 1000,000 population, WHO)	SH.TBS.INCD (2)	Incidence of tuberculosis (per 100,000 people)

List of Databases

Database ID	Database Name
2	World Development Indicators
11	Africa Development Indicators
12	Education Statistics
57	WDI Database Archives
70	Economic Fitness 2

B
Extended Coverage Analysis

This appendix includes a range of options and definitions for classifying indicator coverage as discussed in the section on coverage analysis. Throughout our research we discussed several options for thinking about clusters of indicators, and the complete list, along with their formulas and definitions, are included here for reference. Several of these approaches have strong similarities to the ones that appear in the coverage analysis section, but with slightly different or more precise definitions that may be useful in future research.

B.1 Country Coverage

Country coverage is defined as follows,

$$C_j = \frac{1}{y_f - y_i + 1} \sum_{y=y_i}^{y_f} n_j^y \tag{B.1}$$

Basically, it is the the average of the number of countries for which there is information available in indicator j over the period $y_i - y_f$. In this case, n_j^y is the number of countries with information available for indicator j in year y. y_i and y_f refer to the initial and final years of the analysis, which at the time of this publication they are 2000 2019, respectively.

The table below is an expanded version of the table presented in section 2.1. Indicators are organized from the lowest to highest country coverage.

B.2 Improvement over time

In section 2.3 we present how some indicators have presented a remarkable improvement over time. In order to find these countries systematically and taking into account that The coverage growth in many indicators is inconsistent and fluctuating over time, we estimate

Table B.1: Average Countries per Indicator

Code	Indicator	Average of countries per year
SI.SPR.PCAP.ZG	Annualized average growth rate in per capita real survey mean consumption or income, total population (%)	15.7
SL.TLF.0714.ZS	Children in employment, total (% of children ages 7-14)	15.7
IC.FRM.OUTG.ZS	Value lost due to electrical outages (% of sales for affected firms)	19.1
SP.UWT.TFRT	Unmet need for contraception (% of married women ages 15-49)	19.7
SE.ADT.LITR.ZS	Literacy rate, adult total (% of people ages 15 and above)	36.4
SI.POV.NAHC	Poverty headcount ratio at national poverty lines (% of population)	38.8
WBL	Retirement Age	42.0
EN.CLC.GHGR.MT.CE	GHG net emissions/removals by LUCF (Mt of CO2 equivalent)	44.8
SP.POP.TECH.RD.P6	Technicians in R&D (per million people)	52.4
SI.DST.FRST.20	Income share held by lowest 20%	63.6
SI.POV.DDAY	Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)	63.6
SI.POV.GINI	GINI index (World Bank estimate)	63.6
SP.POP.SCIE.RD.P6	Researchers in R&D (per million people)	68.2
SH.MED.NUMW.P3	Nurses and midwives (per 1,000 people)	79.2
GB.XPD.RSDV.GD.ZS	Research and development expenditure (% of GDP)	89.2
GFDD.DM.06	Outstanding international public debt securities to GDP (%)	90.0
SH.MED.PHYS.ZS	Physicians (per 1,000 people)	92.2
SH.STA.SMSS.ZS	People using safely managed sanitation services (% of population)	92.8
ER.H2O.FWTL.ZS	Annual freshwater withdrawals, total (% of internal resources)	96.8
SE.SEC.NENR	School enrollment, secondary (% net)	97.8
SH.MLR.INCD.P3	Incidence of malaria (per 1,000 population at risk)	98.6
SE.SEC.ENRL.TC.ZS	Pupil-teacher ratio, secondary	98.7
IP.PAT.RESD	Patent applications, residents	102.4
SH.MED.BEDS.ZS	Hospital beds (per 1,000 people)	103.7
SE.XPD.TOTL.GB.ZS	Government expenditure on education, total (% of government expenditure)	105.2
SH.H2O.SMDW.ZS	People using safely managed drinking water services (% of population)	106.9
IP.PAT.NRES	Patent applications, nonresidents	108.8
NW.NCA.SAGA.TO	Natural capital, subsoil assets: gas (constant 2014 US$)	114.8
NW.NCA.SAOI.TO	Natural capital, subsoil assets: oil (constant 2014 US$)	116.2
SE.TER.ENRR	School enrollment, tertiary (% gross)	119.5
SE.ENR.PRSC.FM.ZS	School enrollment, primary and secondary (gross), gender parity index (GPI)	124.8
SE.PRM.ENRL.TC.ZS	Pupil-teacher ratio, primary	129.1
EG.ELC.NUCL.ZS	Electricity production from nuclear sources (% of total)	133.2
EG.IMP.CONS.ZS	Energy imports, net (% of energy use)	133.8
EG.GDP.PUSE.KO.PP	GDP per unit of energy use (PPP $ per kg of oil equivalent)	137.1
EG.USE.COMM.FO.ZS	Fossil fuel energy consumption (% of total)	137.1
SH.DYN.AIDS.ZS	Prevalence of HIV, total (% of population ages 15-49)	139.4
EG.ELC.COAL.ZS	Electricity production from coal sources (% of total)	139.9
NW.NCA.SACO.TO	Natural capital, subsoil assets: coal (constant 2014 US$)	141.0
EG.USE.PCAP.KG.OE	Energy use (kg of oil equivalent per capita)	141.1
DT.ODA.ODAT.CD	Net official development assistance received (current US$)	142.6
SE.ENR.PRIM.FM.ZS	School enrollment, primary (gross), gender parity index (GPI)	148.7
TX.MNF.TECH.ZS.UN	Medium and high-tech exports (% manufactured exports)	149.0
SE.PRM.ENRR	School enrollment, primary (% gross)	149.7
MS.MIL.XPND.GD.ZS	Military expenditure (% of GDP)	150.4
SN.ITK.DEFC.ZS	Prevalence of undernourishment (% of population)	163.7
IT.NET.BBND.P2	Fixed broadband subscriptions (per 100 people)	166.4
EN.CLC.MDAT.ZS	Droughts, floods, extreme temperatures (% of population, average 1990-2009)	168.0
BN.CAB.XOKA.GD.ZS	Current account balance (% of GDP)	170.3
NY.ADJ.DPEM.GN.ZS	Adjusted savings: particulate emission	171.8

the average *growth* in the number of countries $\hat{G}_j$ in indicator j (this is different from C_j in equation (B.1)),

$$n_j^y = \alpha + G_j y + e \tag{B.2}$$

Where n_j^y refers to number of countries with information available for indicator j in time y. As n_j^y could be zero for any y, we penalize the value of $\hat{G}_j$ by the number of years in which they have no data at all, p_j,

$$p_j = \frac{Q_j}{y_f - y_i + 1} \tag{B.3}$$

where Q_j refers to the number of years for which there is at least one country available in indicator j. y_i and y_f refer to the initial and final years as in equation (B.1).

Most indicators have improved their coverage over time, but some of them show a remarkable improvement. The table below shows the average growth of number of countries in each indicator penalized by the number of years in which they have no data at all. The higher the number in column **Avg. growth in coverage (penalized)** the more consistent the indicator has been on increasing country coverage since 2000.

B.3 Remain stable over time but with middle coverage

Stability of country coverage over time can be seen as the standard deviation of the number of countries available for each indicator in each year. The lower the standard deviation, the more stable the country coverage of the indicator is.

The country coverage of some indicators have remained relatively stable over time. Among the 7 indicators that have not changed their country coverage over the period of analysis, the average of countries covered is 187. These indicators are Employment to population ratio, ages 15-24, total (%) (modeled ILO estimate), Vulnerable employment, total (% of total employment) (modeled ILO estimate), Labor force participation rate, total (% of total population ages 15-64) (modeled ILO estimate), Ratio of female to male labor force participation rate (%) (modeled ILO estimate), Unemployment, youth total (% of total labor force ages 15-24) (modeled ILO estimate), Unemployment, female (% of female labor force) (modeled ILO estimate), and Unemployment, total (% of total labor force) (modeled ILO estimate).

The table below shows how stable each indicator is over time and the average number of countries covered in each year.

Table B.2: Average Coverage Growth Per Indicator

Code	Indicator	Avg. growth in coverage (penalized)	No. of years with data
IC.TAX.TOTL.CP.ZS	Total tax and contribution rate (% of profit)	8.218	15
ENF.CONT.COEN.COST.ZS	Enforcing contracts: Cost (% of claim)	7.983	16
IC.REG.DURS	Time required to start a business (days)	7.251	17
IC.LGL.CRED.XQ	Strength of legal rights index (0=weak to 12=strong)	4.531	7
IT.NET.BBND.P2	Fixed broadband subscriptions (per 100 people)	2.996	19
EN.ATM.PM25.MC.M3	PM2.5 air pollution, mean annual exposure (micrograms per cubic meter)	2.626	10
SH.MLR.INCD.P3	Incidence of malaria (per 1,000 population at risk)	1.491	9
SG.GEN.PARL.ZS	Proportion of seats held by women in national parliaments (%)	1.390	20
ER.PTD.TOTL.ZS	Terrestrial and marine protected areas (% of total territorial area)	1.067	3
SE.ADT.LITR.ZS	Literacy rate, adult total (% of people ages 15 and above)	0.746	19
SI.POV.NAHC	Poverty headcount ratio at national poverty lines (% of population)	0.449	19
IC.FRM.OUTG.ZS	Value lost due to electrical outages (% of sales for affected firms)	0.388	13
SH.STA.DIAB.ZS	Diabetes prevalence (% of population ages 20 to 79)	0.315	2
PV.EST	Political Stability and Absence of Violence/Terrorism: Estimate	0.290	18
SI.SPR.PCAP.ZG	Annualized average growth rate in per capita real survey mean consumption or income, total population (%)	0.252	6
SP.UWT.TFRT	Unmet need for contraception (% of married women ages 15-49)	0.240	19
RQ.EST	Regulatory Quality: Estimate	0.169	18
SH.DTH.COMM.ZS	Cause of death, by communicable diseases and maternal, prenatal and nutrition conditions (% of total)	0.165	4
GE.EST	Government Effectiveness: Estimate	0.164	18
EN.MAM.THRD.NO	Mammal species, threatened	0.137	1
IC.BUS.EASE.XQ	Ease of doing business index (1=most business-friendly regulations)	0.121	1
IP.PAT.NRES	Patent applications, nonresidents	0.105	19
CC.EST	Control of Corruption: Estimate	0.081	18
IP.PAT.RESD	Patent applications, residents	0.059	19
IP.JRN.ARTC.SC	Scientific and technical journal articles	0.042	14
WBL	Retirement Age	0.027	1
SM.POP.NETM	Net migration	0.000	4
SL.EMP.1524.SP.ZS	Employment to population ratio, ages 15-24, total (%) (modeled ILO estimate)	0.000	20
SL.EMP.VULN.ZS	Vulnerable employment, total (% of total employment) (modeled ILO estimate)	0.000	20
SL.TLF.ACTI.ZS	Labor force participation rate, total (% of total population ages 15-64) (modeled ILO estimate)	0.000	20
SL.TLF.CACT.FM.ZS	Ratio of female to male labor force participation rate (%) (modeled ILO estimate)	0.000	20
SL.UEM.1524.ZS	Unemployment, youth total (% of total labor force ages 15-24) (modeled ILO estimate)	0.000	20
SL.UEM.TOTL.FE.ZS	Unemployment, female (% of female labor force) (modeled ILO estimate)	0.000	20
SL.UEM.TOTL.ZS	Unemployment, total (% of total labor force) (modeled ILO estimate)	0.000	20
EN.CLC.MDAT.ZS	Droughts, floods, extreme temperatures (% of population, average 1990-2009)	-0.006	1
RL.EST	Rule of Law: Estimate	-0.127	18
ER.H2O.INTR.K3	Renewable internal freshwater resources, total (billion cubic meters)	-0.162	4
ER.H2O.INTR.PC	Renewable internal freshwater resources per capita (cubic meters)	-0.164	4
VA.EST	Voice and Accountability: Estimate	-0.215	18
ER.H2O.FWTL.ZS	Annual freshwater withdrawals, total (% of internal resources)	-0.235	4
EN.POP.EL5M.ZS	Population living in areas where elevation is below 5 meters (% of total population)	-0.242	2
NW.NCA.SAGA.TO	Natural capital, subsoil assets: gas (constant 2014 US$)	-0.300	4
NW.NCA.SAOI.TO	Natural capital, subsoil assets: oil (constant 2014 US$)	-0.305	4
SH.MED.NUMW.P3	Nurses and midwives (per 1,000 people)	-0.311	19

Table B.3: Indicator Stability Over Time

Code	Indicator	Avg. of countries	Standard Dev.
SL.EMP.1524.SP.ZS	Employment to population ratio, ages 15-24, total (%) (modeled ILO estimate)	187.00	0.00
SL.EMP.VULN.ZS	Vulnerable employment, total (% of total employment) (modeled ILO estimate)	187.00	0.00
SL.TLF.ACTI.ZS	Labor force participation rate, total (% of total population ages 15-64) (modeled ILO estimate)	187.00	0.00
SL.TLF.CACT.FM.ZS	Ratio of female to male labor force participation rate (%) (modeled ILO estimate)	187.00	0.00
SL.UEM.1524.ZS	Unemployment, youth total (% of total labor force ages 15-24) (modeled ILO estimate)	187.00	0.00
SL.UEM.TOTL.FE.ZS	Unemployment, female (% of female labor force) (modeled ILO estimate)	187.00	0.00
SL.UEM.TOTL.ZS	Unemployment, total (% of total labor force) (modeled ILO estimate)	187.00	0.00
SP.UWT.TFRT	Unmet need for contraception (% of married women ages 15-49)	18.70	8.72
WBL	Retirement Age	2.10	9.39
SL.TLF.0714.ZS	Children in employment, total (% of children ages 7-14)	13.35	9.49
SG.GEN.PARL.ZS	Proportion of seats held by women in national parliaments (%)	184.25	10.38
SI.SPR.PCAP.ZG	Annualized average growth rate in per capita real survey mean consumption or income, total population (%)	4.70	11.33
IC.FRM.OUTG.ZS	Value lost due to electrical outages (% of sales for affected firms)	12.40	16.05
SE.ADT.LITR.ZS	Literacy rate, adult total (% of people ages 15 and above)	34.55	16.30
SI.POV.NAHC	Poverty headcount ratio at national poverty lines (% of population)	36.90	16.90
SP.POP.TECH.RD.P6	Technicians in R&D (per million people)	47.15	19.59
SP.POP.SCIE.RD.P6	Researchers in R&D (per million people)	61.35	22.77
EN.CLC.GHGR.MT.CE	GHG net emissions/removals by LUCF (Mt of CO2 equivalent)	22.40	23.24
IP.PAT.RESD	Patent applications, residents	97.25	25.25
SE.SEC.ENRL.TC.ZS	Pupil-teacher ratio, secondary	98.65	25.99
SI.DST.FRST.20	Income share held by lowest 20%	57.20	26.55
SI.POV.DDAY	Poverty headcount ratio at $1.90 a day (2011 PPP) (% of population)	57.20	26.55
SI.POV.GINI	GINI index (World Bank estimate)	57.20	26.55
SE.SEC.NENR	School enrollment, secondary (% net)	92.95	26.75
IP.PAT.NRES	Patent applications, nonresidents	103.35	27.02
GB.XPD.RSDV.GD.ZS	Research and development expenditure (% of GDP)	80.25	28.54
SH.STA.SMSS.ZS	People using safely managed sanitation services (% of population)	83.50	28.59
GFDD.DM.06	Outstanding international public debt securities to GDP (%)	81.00	29.11
SH.DYN.AIDS.ZS	Prevalence of HIV, total (% of population ages 15-49)	132.40	31.17
SE.TER.ENRR	School enrollment, tertiary (% gross)	113.55	31.82
SE.XPD.TOTL.GB.ZS	Government expenditure on education, total (% of government expenditure)	99.95	32.08
SH.H2O.SMDW.ZS	People using safely managed drinking water services (% of population)	96.25	33.00
SE.PRM.ENRL.TC.ZS	Pupil-teacher ratio, primary	129.10	33.71
MS.MIL.XPND.GD.ZS	Military expenditure (% of GDP)	142.85	33.79
SE.ENR.PRSC.FM.ZS	School enrollment, primary and secondary (gross), gender parity index (GPI)	124.85	35.09
SH.MED.PHYS.ZS	Physicians (per 1,000 people)	87.60	35.56
SH.MED.NUMW.P3	Nurses and midwives (per 1,000 people)	75.25	37.20
EN.CLC.MDAT.ZS	Droughts, floods, extreme temperatures (% of population, average 1990-2009)	8.40	37.57
BN.CAB.XOKA.GD.ZS	Current account balance (% of GDP)	161.80	39.96
FP.CPI.TOTL.ZG	Inflation, consumer prices (annual %)	166.10	40.45
SE.ENR.PRIM.FM.ZS	School enrollment, primary (gross), gender parity index (GPI)	148.65	40.59
SE.PRM.ENRR	School enrollment, primary (% gross)	149.70	40.95
ER.H2O.FWTL.ZS	Annual freshwater withdrawals, total (% of internal resources)	19.35	41.56
IC.BUS.EASE.XQ	Ease of doing business index (1=most business-friendly regulations)	9.45	42.26
NE.EXP.GNFS.ZS	Exports of goods and services (% of GDP)	177.65	42.28
NV.AGR.TOTL.ZS	Agriculture, forestry, and fishing, value added (% of GDP)	180.05	42.82
NY.GNP.PCAP.CD	GNI per capita, Atlas method (current US$)	181.50	42.87
SH.DYN.MORT	Mortality rate, under-5 (per 1,000 live births)	183.35	43.16
SP.DYN.IMRT.IN	Mortality rate, infant (per 1,000 live births)	183.35	43.16
SP.POP.65UP.TO.ZS	Population ages 65 and above (% of total)	183.95	43.30

B.4 High coverage and sudden decline

The remarkable coverage of some indicators in the previous decade suddenly declined and has remained either null or very low since then. The table below shows the year in which the country coverage of each indicator plummeted and the number countries dropped in that year.

B.5 Intermittent and Lumpy coverage

Some indicators have *intermittent* coverage with excellent coverage in some years and no coverage at all in others. Other indicators are very *lumpy* in the sense that the number of countries covered varies up and down from year to year. Following Syntetos, Boylan, and Croston (2005) and Williams (1984), we calculated the *Average coverage interval* and the *Lumpiness* index for all indicators.

The *Average coverage interval* indicates the average number of years between successive years with country coverage. For example, if the *Avg. coverage interval* is 24, it means that in average every four years this indicator covers at least one country.

$$aci_j = \frac{Y}{Q_j} \tag{B.4}$$

Where Y is the total number of years in the period of analysis and Q_j is the number of years for which there is at least one country available in indicator j, exactly the same as in equation (B.3). The higher the *aci*, the more intervals with no information the indicator has.

The *Lumpiness* index shows how lumpy the indicator is. The higher it is, the more lumpy the country coverage is. It is calcualted as follows,

$$L = \frac{cv(n_j)^2}{aci} \tag{B.5}$$

Where $cv(n_j)$ is the coefficient of variation of the number of countries avialable over time in indicator j and *aci* is the derived in equation (B.4).

The table below tries to characterize all the indicators by their level of intermittentness and lumpiness. The *No. years covered* column shows the number of years with at least one country covered during the studied period. The *No. intervals with no data* is the number of intervals in which no country is covered. The higher this number the more intermittent the indicator is. The *Avg. coverage interval* indicates how often the indicator has information or how intermittent the information of this indicator is. The last columns contains the *Lumpiness* index.

Table B.4: Coverage Decline Per Indicator

Code	Indicator	Year	No. Countries dropped
EG.ELC.RNEW.ZS	Renewable electricity output (% of total electricity output)	2016	217
NY.ADJ.DMIN.CD	Adjusted savings: mineral depletion (current US$)	2018	216
EG.ELC.ACCS.ZS	Access to electricity (% of population)	2018	215
EN.MAM.THRD.NO	Mammal species, threatened	2019	215
EG.FEC.RNEW.ZS	Renewable energy consumption (% of total final energy consumption)	2016	213
AG.LND.TOTL.K2	Land area (sq. km)	2019	210
ER.PTD.TOTL.ZS	Terrestrial and marine protected areas (% of total territorial area)	2019	210
EN.POP.DNST	Population density (people per sq. km of land area)	2019	209
AG.LND.AGRI.ZS	Agricultural land (% of land area)	2017	208
AG.LND.FRST.ZS	Forest area (% of land area)	2017	208
EN.ATM.CO2E.KT	CO2 emissions (kt)	2015	205
PV.EST	Political Stability and Absence of Violence/Terrorism: Estimate	2019	205
SH.STA.DIAB.ZS	Diabetes prevalence (% of population ages 20 to 79)	2011	205
EN.ATM.CO2E.PC	CO2 emissions (metric tons per capita)	2015	204
EN.ATM.NOXE.KT.CE	Nitrous oxide emissions (thousand metric tons of CO2 equivalent)	2013	204
CC.EST	Control of Corruption: Estimate	2019	203
GE.EST	Government Effectiveness: Estimate	2019	203
RL.EST	Rule of Law: Estimate	2019	203
RQ.EST	Regulatory Quality: Estimate	2019	203
AG.PRD.FOOD.XD	Food production index (2004-2006 = 100)	2017	201
VA.EST	Voice and Accountability: Estimate	2019	201
SP.DYN.TFRT.IN	Fertility rate, total (births per woman)	2018	200
SP.DYN.LE00.IN	Life expectancy at birth, total (years)	2018	199
IP.JRN.ARTC.SC	Scientific and technical journal articles	2017	196
NY.GDP.MKTP.KD.ZG	GDP growth (annual %)	2019	196
EN.ATM.PM25.MC.M3	PM2.5 air pollution, mean annual exposure (micrograms per cubic meter)	2018	194
SM.POP.NETM	Net migration	2018	194
SH.DYN.MORT	Mortality rate, under-5 (per 1,000 live births)	2019	193
SP.DYN.IMRT.IN	Mortality rate, infant (per 1,000 live births)	2019	193
SP.POP.65UP.TO.ZS	Population ages 65 and above (% of total population)	2019	193
EG.EGY.PRIM.PP.KD	Energy intensity level of primary energy (MJ/$2011 PPP GDP)	2016	191
EG.CFT.ACCS.ZS	Access to clean fuels and technologies for cooking (% of population)	2017	189
IC.BUS.EASE.XQ	Ease of doing business index (1=most business-friendly regulations)	2019	189
SH.STA.OB18.FE.ZS	Prevalence of obesity, female (% of female population ages 18+)	2017	188
SH.STA.OB18.MA.ZS	Prevalence of obesity, male (% of male population ages 18+)	2017	188
SH.STA.OWAD.ZS	Prevalence of overweight (% of adults)	2017	188
EN.ATM.NOXE.PC	Nitrous oxide emissions (metric tons of CO2 equivalent per capita)	2013	186
EN.ATM.METH.PC	Methane emissions (metric tons of CO2 equivalent per capita)	2013	185
NY.GNP.PCAP.CD	GNI per capita, Atlas method (current US$)	2019	185
SH.STA.MMRT	Maternal mortality ratio (modeled estimate, per 100,000 live births)	2018	185
NY.ADJ.DNGY.GN.ZS	Adjusted savings: energy depletion (% of GNI)	2018	183
SH.DTH.COMM.ZS	Cause of death, by communicable diseases and maternal, prenatal and nutrition conditions (% of total)	2017	183
ER.H2O.INTR.K3	Renewable internal freshwater resources, total (billion cubic meters)	2015	182
ER.H2O.INTR.PC	Renewable internal freshwater resources per capita (cubic meters)	2008	182
EN.POP.EL5M.ZS	Population living in areas where elevation is below 5 meters (% of total population)	2011	179
EN.ATM.GHGT.KT.CE	Total greenhouse gas emissions (kt of CO2 equivalent)	2013	177
NY.ADJ.DFOR.GN.ZS	Adjusted savings: net forest depletion (% of GNI)	2018	173
NY.ADJ.DRES.GN.ZS	Adjusted savings: natural resources depletion (% of GNI)	2018	172
IT.CEL.SETS.P2	Mobile cellular subscriptions (per 100 people)	2019	170
NY.ADJ.DPEM.GN.ZS	Adjusted savings: particulate emission damage (% of GNI)	2018	170

Table B.5: Indicators and 'Lumpy' Coverage

Code	Indicator	No. Years covered	No. intervals with no data (intermittentness)	Avg. coverage interval	Lumpiness index
ER.H2O.FWTL.ZS	Annual freshwater withdrawals, total (% of internal resources)	4	5	5.00	0.923
ER.H2O.INTR.PC	Renewable internal freshwater resources per capita (cubic meters)	4	5	5.00	0.842
ER.H2O.INTR.K3	Renewable internal freshwater resources, total (billion cubic meters)	4	5	5.00	0.842
SM.POP.NETM	Net migration	4	5	5.00	0.842
NW.NCA.SAGA.TO	Natural capital, subsoil assets: gas (constant 2014 US$)	4	4	5.00	0.842
NW.NCA.SAOI.TO	Natural capital, subsoil assets: oil (constant 2014 US$)	4	4	5.00	0.842
NW.NCA.SACO.TO	Natural capital, subsoil assets: coal (constant 2014 US$)	4	4	5.00	0.842
SH.DTH.COMM.ZS	Cause of death, by communicable diseases and maternal, prenatal and nutrition conditions (% of total)	4	3	5.00	0.842
EN.ATM.PM25.MC.M3	PM2.5 air pollution, mean annual exposure (micrograms per cubic meter)	10	3	2.00	0.526
EN.CLC.MDAT.ZS	Droughts, floods, extreme temperatures (% of population, average 1990-2009)	1	2	20.00	1.000
IC.BUS.EASE.XQ	Ease of doing business index (1=most business-friendly regulations)	1	2	20.00	1.000
WBL	Retirement Age	1	2	20.00	1.000
EN.MAM.THRD.NO	Mammal species, threatened	1	2	20.00	1.000
SH.STA.DIAB.ZS	Diabetes prevalence (% of population ages 20 to 79)	2	2	10.00	0.948
EN.POP.EL5M.ZS	Population living in areas where elevation is below 5 meters (% of total population)	2	2	10.00	0.947
ER.PTD.TOTL.ZS	Terrestrial and marine protected areas (% of total territorial area)	3	2	6.67	0.895
SI.SPR.PCAP.ZG	Annualized average growth rate in per capita real survey mean consumption or income, total population (%)	6	2	3.33	1.744
SH.MLR.INCD.P3	Incidence of malaria (per 1,000 population at risk)	9	2	2.22	0.579
IC.FRM.OUTG.ZS	Value lost due to	13	2	1.54	1.089

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