Chapter 2. Going for green(er) growth - what can indicators tell us?

This chapter reviews the available green growth indicators with respect to their usefulness for the potential integration in Going for Growth *in the future as well as broadly evaluates country scores and progress on them. The chapter also flags the key measurement gaps that will be crucial in determining the scope and depth of green growth coverage in* Going for Growth. *The Annex provides additional information on the main green growth indicators that would be potential inputs to the* Going for Growth *process.*

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Main findings

- A clean and healthy environment is essential for supporting economic activity and well-being in the long-term. Practically every economic and leisure activity – as well as life itself - has broadly-defined environment as a key input and could not exist without it.
- Yet, the links between the environment and economic growth as such are complex and not very well documented.
- There exists no single broadly accepted measure of environmental performance that could be used for the *Going for Growth* exercise. However, significant progress has been made in measurement of green growth outcomes, challenges and policies, notably as part of the OECD Green Growth Indicators.
- The areas of best coverage of measurement of environmental outcomes include climate, air pollution and land use. Progress has also been made in the measurement of so-called green innovation.
- Indicators on waste, waste water treatment and water efficiency, as well as on water pollution and scarcity are less well developed, and unlikely to be suitable for systematic use in *Going for Growth* at this point. The measurement of risks also needs to be improved.
- Despite recent progress, the indicators of environmental policies are not yet well developed and of limited coverage. The ability to better measure policies is crucial for improving the empirical evidence on their impacts.
- The scope of future integration of Green Growth in *Going for Growth* will depend crucially on the progress in measurement and the empirical evidence on the links among various dimensions such as growth and well-being, the environment, and environmental policies.

Going for Growth targets long-term economic growth and well-being through the identification of structural reform priorities for OECD member and key non-member economies. The ability to sustain long-term improvements in GDP and well-being depends – among other things - on the ability to reduce negative effects (such as pollution) associated with economic activity, as well as to minimise environment-related risks and the reliance on (limited) natural capital resources as a source of growth. In this respect, the *Going for Growth* goals, described as "a policy agenda for growth to benefit all" are inherently intertwined with green growth (GG) – which adds an environmental sustainability dimension: "*fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies*." (OECD, 2011).

A combined assessment of economic, social and environmental progress and challenges underpins the effective implementation of Sustainable Development Goals. The 2017 issue of *Going for Growth* focussed on the integration of inclusiveness into the priority selection framework. One year later, the time has come for a first step in exploring the potential green growth angle of *Going for Growth* (OECD, 2017a). In this respect, measurement and indicators are a key foundation for better taking account of the environment and green growth policy reforms. This chapter reviews the available indicators with respect to their usefulness for the potential integration in *Going for Growth* in the future as well as broadly evaluates country scores and progress on them.[3] The chapter also flags the key measurement gaps that will be crucial in determining the scope and depth of green growth coverage in *Going for Growth*. The Annex provides additional information on the main GG indicators that would be potential inputs to the *Going for Growth* process.

2.1. Environment and growth (and well-being)

A clean and healthy environment is essential for supporting economic activity and well-being in the long-term. Practically every economic and leisure activity – as well as life itself - has broadly-defined environment as a key input and could not exist without it. However, the relationship between the environment and GDP growth per se is more complex. For example, looking at the contributions to GDP growth in OECD and large emerging market economies (Argentina, Brazil, Russia, India, Indonesia, China and South Africa) over the past two decades, the main source has been multifactor productivity growth, followed by capital deepening (Figure 2.1).

A framework developed at the OECD allows evaluating the sources of growth in a broader sense - adjusting growth outcomes for "bad" outputs air emissions (greenhouse gasses and air pollutants) and calculating the contribution of subsoil asset use – that is, distinguishing to what extent classically measured growth has been higher (lower) due to increased pollution or increased exploitation of natural subsoil assets.[4] Still, the adjustment for emissions is sizeably negative only for China, India, Korea, Costa Rica, Turkey and Mexico, indicating a significant part of growth in these countries was achieved at the expense of the environment. This adjustment is negligible for other countries, or even positive in countries where the pollution performance improved. In Russia, Chile, China, Israel, China and Australia a considerable share of GDP growth was owed to increased subsoil resource extraction. For most other countries, underground mineral resources did not play a driving role in GDP growth.

The relationship between the environment and growth is much more complex and multidimensional than can be captured by this environmentally-adjusted multifactor productivity (EAMFP) concept. The EAMFP is severely limited by the breadth of the environmental areas covered: a handful of key air pollutant emissions, carbon dioxide and a selection of extractable resources. Still, even if the environment may not have stood out as a key driver of macroeconomic growth in the past, it is essential for maintaining production and incomes, and some broad linking themes can be identified:

- *The sustainability of growth (and well-being)*. Economic activity, consumption and lifestyles rely on exhaustible resources and limited capacity of the environment to absorb the unwanted by-products of production and consumption (so-called sink functions). Many of the key relationships are highly non-linear, the thresholds and bottlenecks are imprecise, location- and time-specific, or simply not well known. Still, surpassing certain levels of degradation will lead to high costs in terms of physical and psychological health damages, or by engaging productive resources in necessary clean-up, remediation or adaptation.
- *Environmentally-related risks to future growth paths*. Such risks have similar detrimental effects to growth and well-being as above, but are more a question of an increasing probability than affecting the central scenario. That is, environmental degradation can increase the risks related to large-scale, catastrophic events. A prime example is the increasing likelihood of extreme weather events associated with climate change.
- *Well-being aspects that are not necessarily linked to growth*. Many aspects of well-being, such as health, morbidity and premature mortality or the utility of

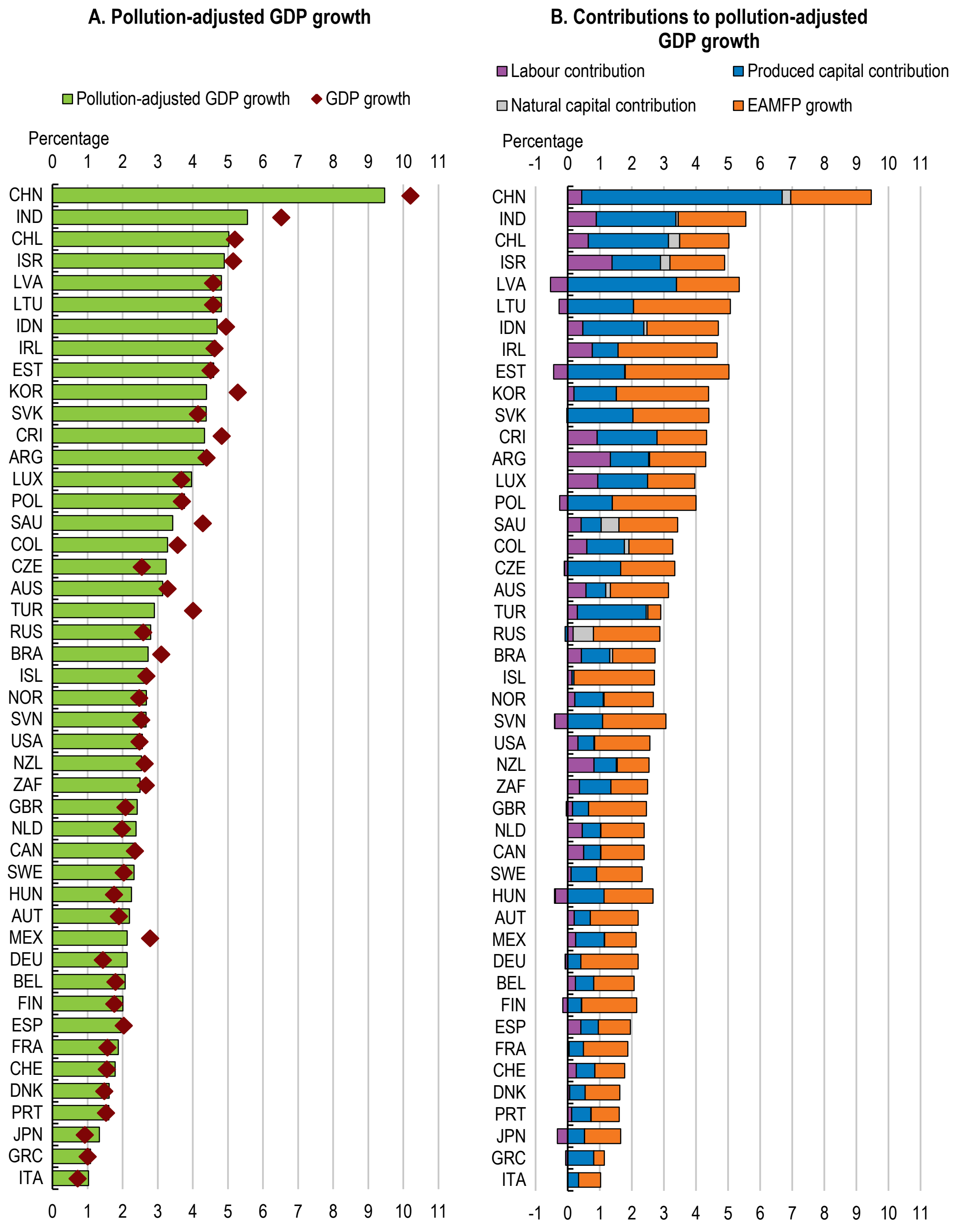
access to environmental amenities are often difficult to quantify in terms of tangible costs or GDP.

- *Public goods and cross-border effects*. An additional complication is that damages and risks do not always fall on the country responsible for generating them, for example, as in the case of global externalities related to climate change or cross-border pollution. In this respect, the constraints may come from international commitments rather than actual domestic damages and risks.
- *Social inclusion and the distribution of effects*. Even if many environment-related developments and risks are limited on average (or at the macro level), they may have significant impacts on parts of the society (in particular those vulnerable), the local economy and specific sectors.

Tracking progress on greening growth effectively means tracking the sustainability of growth and well-being improvements, the contribution to meeting global environmental challenges and the ability to keep potential risks in check. Our ability to do so remains limited but has advanced sufficiently to allow a first step of the integration into *Going for Growth*.

Figure 2.1. The sources of growth: accounting for the environment[1]

Total economy, long-term average growth rates, circa 1991-2013



1. EAMFP stands for environmentally-adjusted multi factor productivity. The coverage of environmental services remains partial, currently limited to subsoil assets on the input side ("natural capital") and air emissions as undesirable output. In panel B, negative values mean that the contribution of natural capital (effectively subsoil asset extraction) to output growth has been decreasing.

Source: OECD (2017), Green Growth Indicators 2017.

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2.2. Green growth – measuring performance and progress

There is no universal way of measuring performance and progress on green growth, primarily because of the elusiveness and multidimensionality of the green growth concept with respect to the available relevant indicators (Box 2.1). So-called green growth indicators – indicators measuring challenges and progress related to green growth – span a wide set of environmental, economic, social indicators as well as indicators that combine two or more of these dimensions. Such a set is potentially inexhaustible. In practice, it is only possible to synthesise the key dimensions of green growth, those where some consensus on their priority means data has been developed and collected. The OECD's Environment and Statistics Directorates have proposed a framework to approach the measurement of green growth (green growth indicators; OECD, 2011). This approach has been explored and adapted by countries to track their own progress, as well as updated by the OECD for cross-country monitoring (OECD, 2017b). It has also served as a reference point in joint work of four leading international organisations in the area of green growth (GGKP, 2014; Narloch et al. 2016).

The OECD's green growth indicators are conceived around a production function concept. They focus on the sustainability of "inputs" – such as the natural asset base and sink functions of the environment - and the delivery of "outputs" - the socio-economic conditions and the so-called environmental quality of life: environmental services and amenities related to health and well-being. The ability to turn "inputs" into "outputs" is covered by indicators of productivity and efficiency. Finally, these are supplemented by indicators of policies, efforts and opportunities. In each category, work is ongoing to improve or develop actual indicators and their coverage to allow cross-country comparisons. Importantly, the indicator sets are focussed on a country-level, aiming at national policy makers and the policy tools they have at hand.[5]

Box 2.1. Aggregate green growth metrics

There exists no single broadly accepted measure of environmental performance that could be used for the *Going for Growth* exercise. Attempts to measure environmental performance and sustainability have taken various forms, most commonly variations of "green" GDP (GDP adjusted for environmental degradation) and composite aggregates of diverse indicators of sustainability. Examples include the Yale Environmental Performance Index, UNEPs Green Economy Progress Index, FEEM's Sustainability Index, World Bank's Adjusted Net Savings and Total wealth including produced and natural capital, etc. (for a review see Narloch et al. 2016). All these indicators stumble over the fact of aggregating indicators on diverse phenomena and effects which are not very well measured for a start and on which no straightforward aggregation exists, as for most of them, no market prices can be observed. The weights are based either on arbitrary judgements or on various valuation attempts, but generally are rather controversial. Other important weaknesses include the selection of criteria to be (or not to be) included, inadequate dealing with intertemporal (and distributional) effects and trade-offs, and the pure challenge of measurement of many of the issues.

2.2.1. Environmental performance – assets and productivity

In the absence of a straightforward metric to compare the differing aspects of green growth performance can be assessed on individual dimensions. Cross-country indicators seem most developed for measuring progress on reducing greenhouse gas emissions related to combatting climate change and the global future costs and risks associated with it, and on air pollution. The coverage and usefulness is best for OECD and major emerging market economies (EMEs) covered in *Going for Growth*. In other areas, such as waste, water abstraction and pollution, and biodiversity, indicators are less well developed, though notable progress has recently been made on land cover. In general, across many environmental domains the measurement of flows tends to be better developed than the measurement of quantity and quality of stocks.

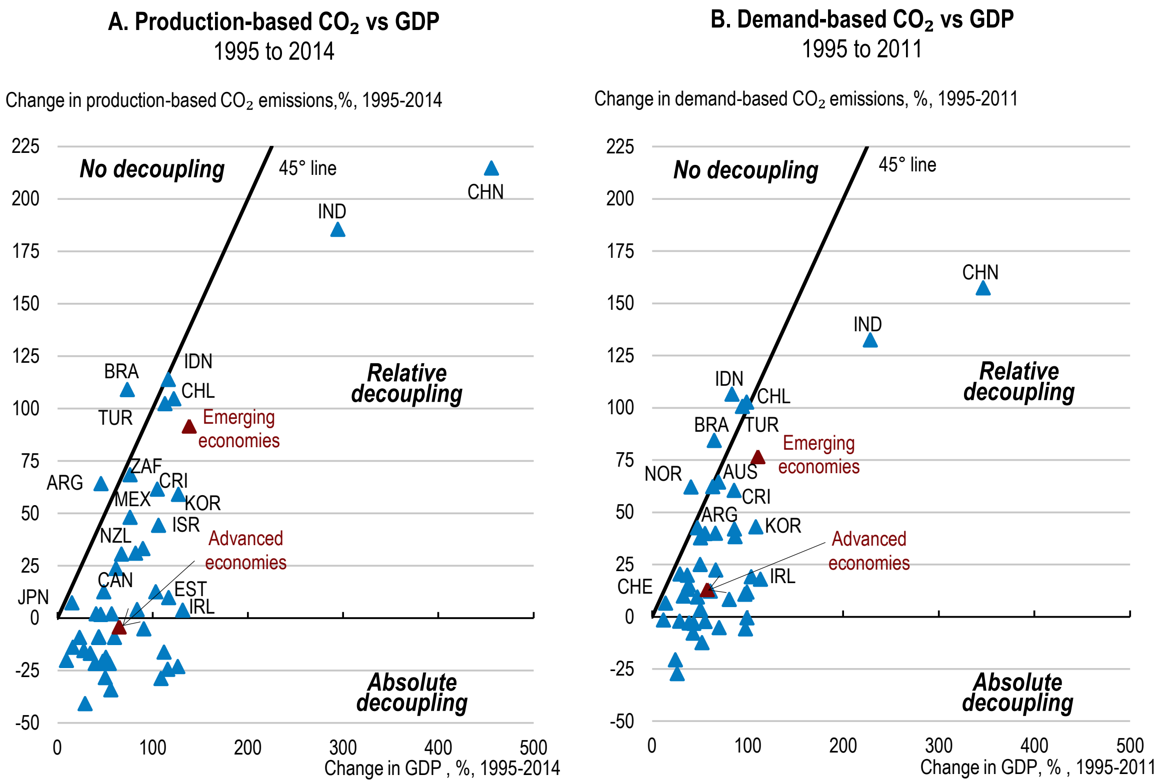
Climate change: greenhouse gas emissions

Globally, greenhouse gas (GHG) emissions[6] have continued on an upward trend throughout the 2000s, increasing by around 40% since 1990.[7] They grew less rapidly than world GDP, which roughly doubled in the same time period. In the OECD, absolute emissions peaked around 2005, and are now back to the level of the mid-1990s. Only a handful of countries did not observe falls by 2014.

More recent estimates are available for CO_2 emissions from fuel combustion, with indications that they have remained flat over 2014-16 and possibly even peaked globally (IEA, 2017). Most OECD countries and large emerging market economies have seen their GDP growth exceed emissions growth since the mid-1990s (Figure 2.2, relative decoupling). Moreover, in half of OECD countries, Russia and Lithuania, emissions have shrunk over this period, despite economic growth (Figure 2.2, absolute decoupling).

At the same time, only 12 OECD countries actually decreased the carbon emissions of their consumption basket, indicating that in other countries the fall in domestic emissions was offset by an increase in emissions embodied in imports consumed. In a few cases, such consumption-related emissions showed no decoupling at all: Norway, Indonesia, Turkey, Chile, Saudi Arabia, Brazil and Mexico.

Figure 2.2. Most countries have increased GDP faster than CO_2 emissions[1]



1. Production-based emissions account for the emissions directly "generated" by domestic production. Demand-based indicators account for emissions "used" or "generated" by domestic final demand (the "footprint" approach). They include environmental flows that are embodied in imports, and deduct the environmental flows embodied in exports. The resulting indicators provide insights into the net (direct and indirect) environmental flows resulting from household and government consumption and investment (final domestic demand). Advanced economies refer to OECD countries plus Lithuania and excluding Chile, Mexico and Turkey. Emerging economies refer to Argentina, Brazil, Chile, China, Colombia, Costa Rica, India, Indonesia, Mexico, the Russian Federation, South Africa and Turkey.
Source: OECD (2017), Green Growth Indicators 2017.

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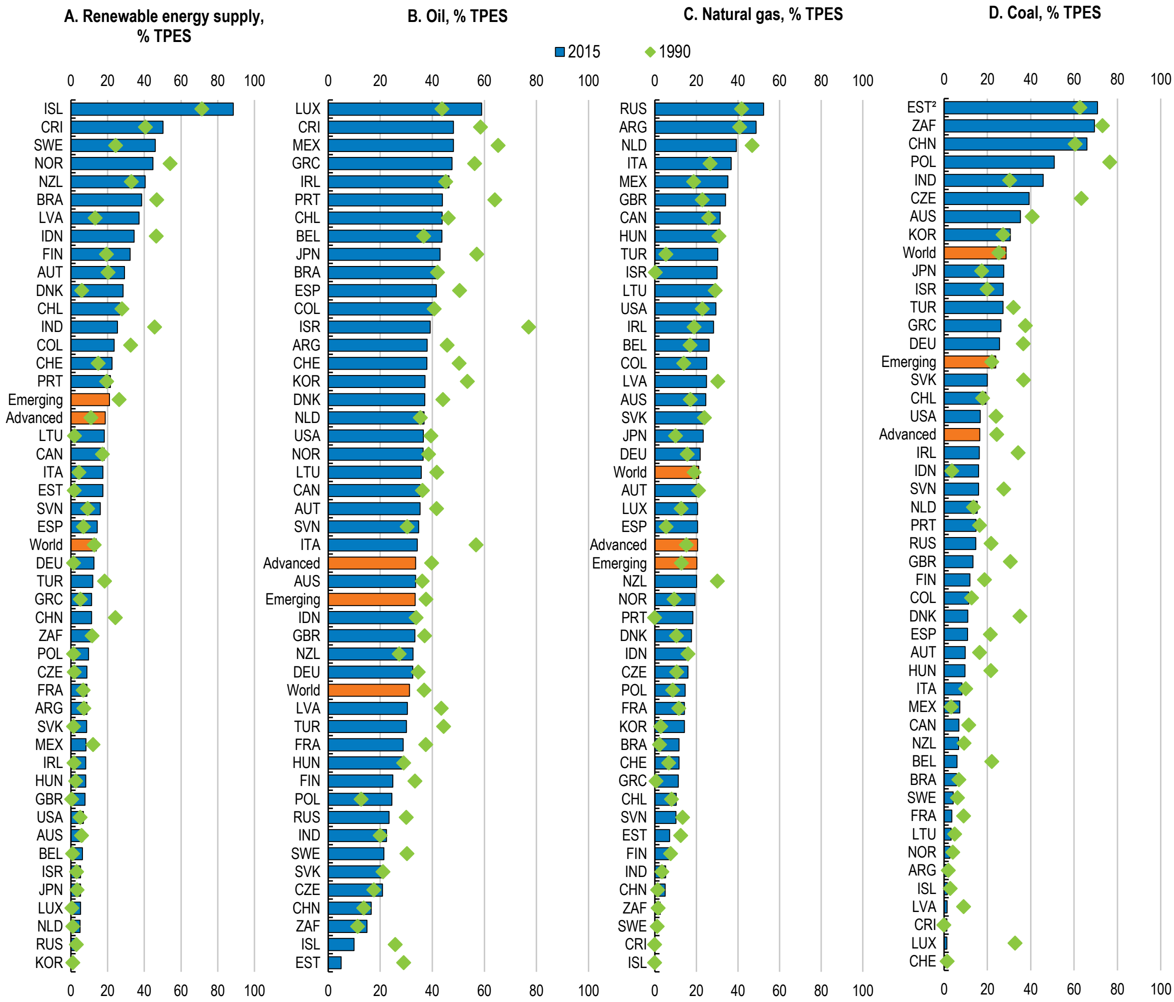
Trends in so-called carbon productivity (or the inverse, carbon intensity) reflect jointly: shifts in the industrial structure (e.g. to less energy intensive services), in energy efficiency and in the energy supply mix. Total energy consumption continued to increase in most countries, though more slowly than GDP. While the energy supply mix has been undergoing some changes in the recent years, the share of renewables somewhat increased in the advanced economies, while it fell in most emerging market economies where the supply of coal held up strongly (Figure 2.3).

Figure 2.3. Energy supply remains dominated by fossil fuels

Contributions to total primary energy supply (TPES),[1] 1990-2015



1. Total primary energy supply (TPES) is defined as energy production plus energy imports, minus energy exports, minus international bunkers, then plus or minus stock changes. Advanced economies refer to OECD countries plus Lithuania and excluding Chile, Mexico and Turkey. Emerging economies refer to Argentina, Brazil, Chile, China, Colombia, Costa Rica, India, Indonesia, Mexico, the Russian Federation, South Africa and Turkey.

2. Coal includes oil shale for Estonia

Source: OECD (2017), Green Growth Indicators 2017.

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Performance on GHG emissions, their structure and sources can guide abatement policy priorities in reform areas such as taxes, infrastructure investment or innovation. Since effects of climate change bear no direct relation to domestic emissions, the link to domestic economic growth can be made via performance with respect to potential targets – carbon budgets established domestically or committed to in international accords (such as the Paris Agreement of 2015). While in practice national commitments may be vague and difficult to compare, the idea would generally be that the further a country is from a target (such as, zero emissions by a given year), the higher the need for mitigation policy action. At the same time, an adaptation dimension can be taken into consideration, even if climate risk indicators seem somewhat less well developed.[8] Ideally such indicators would address the importance of adaptation policy action, for instance in infrastructure investment or land use planning. At the moment, examples of risks indicators include the share of population living in areas prone to flooding (e.g. for example measured as below 5 meters of elevation; CIESIN, 2013) and the costs and occurrences of extreme weather events, etc.

Air pollution

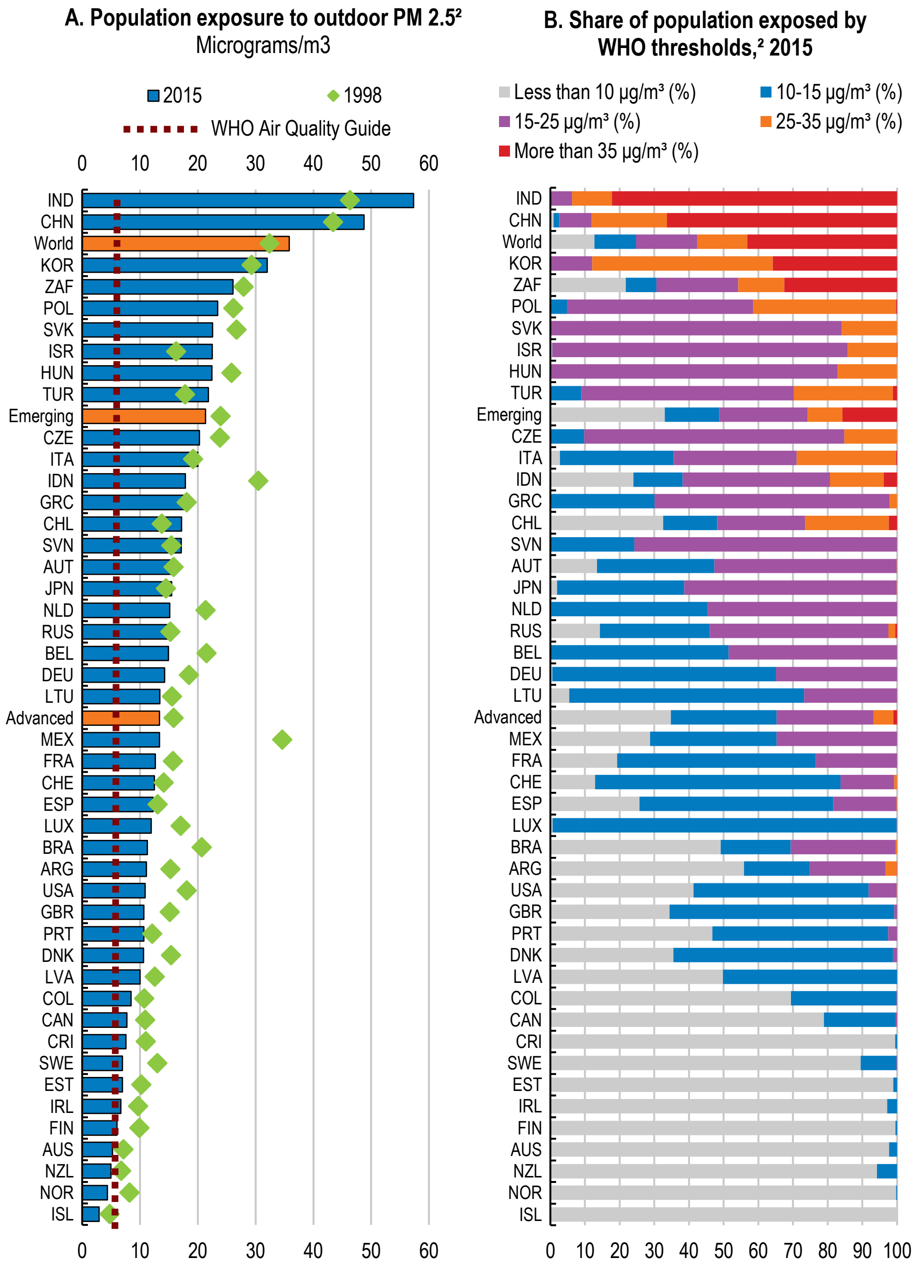
Air pollution is often labelled as the single biggest environment-related health risk across the globe (WHO, 2014). According to estimates, each year roughly 4 million people die prematurely due to air pollution, the leading environmentally related cause of death (OECD, 2016a). Fine particulate matter ($PM_{2.5}$) undermines populations' well-being through exposure-related increases of risks of heart disease, stroke and respiratory diseases and infections (WHO, 2016; Burnett et al. 2015). Adverse health impacts imply lower productivity, absenteeism and higher medical bills. With no additional policy reaction, by 2060 the impacts of outdoor air pollution are projected to reach 1.5 % of GDP in market impacts, lowering GDP by the equivalent amount. However, air pollution has much higher costs than pure GDP as the overall welfare costs are expected to be much higher. Pollution-related premature deaths are expected to continue increasing to 6-9 million people annually by 2060 (simulated premature deaths attributed to particulate matter and ozone; OECD, 2016a). The effects are estimated to total an equivalent of 9-12 % of GDP when considering non-market effects such as premature deaths, pain and suffering.[9]

A price tag for air pollution may be telling to a broader audience but the cost estimates are typically based on strong assumptions about underlying elements such as how one values an extra year of life. Hence to facilitate monitoring progress, two more direct sets of indicators of air pollution – concentrations and emissions - can be identified and used in combination.

Indicators focusing on concentrations and population exposure can show the gravity of the problem more directly. Different types of pollutants will have different effects, and effects are likely to be non-linear. Green growth indicators include population exposure to fine particles ($PM_{2.5}$) with broad country and time coverage (Figure 2.4). The situation seems worst in the most heavily populated large emerging market economies, but a number of OECD countries are also performing poorly. At the same time, the largest improvements since 1998 were observed in Indonesia, Mexico, Brazil, the United States and Denmark. The exposure to air pollution by ozone measured in EU countries has shown little improvement and NO_2 concentrations in many European cities exceed established limits (OECD, 2016a).

Figure 2.4. Population exposure to air pollution[1]

Average population exposure and share of population exposed by WHO thresholds, PM 2.5



1. The estimates of chronic outdoor exposure to PM2.5 (from both anthropogenic and natural sources) are derived from satellite observations, chemical transport models and ground monitoring stations. They are measured in micrograms per cubic metre. Population exposure to air pollution is calculated by weighting concentrations with populations in each cell of the underlying gridded data.

2. Advanced economies refer to OECD countries plus Lithuania and excluding Chile, Mexico and Turkey. Emerging economies refer to Argentina, Brazil, Chile, China, Colombia, Costa Rica, India, Indonesia, Mexico, the Russian Federation, South Africa and Turkey.

Source: OECD (2017), Green Growth Indicators 2017.

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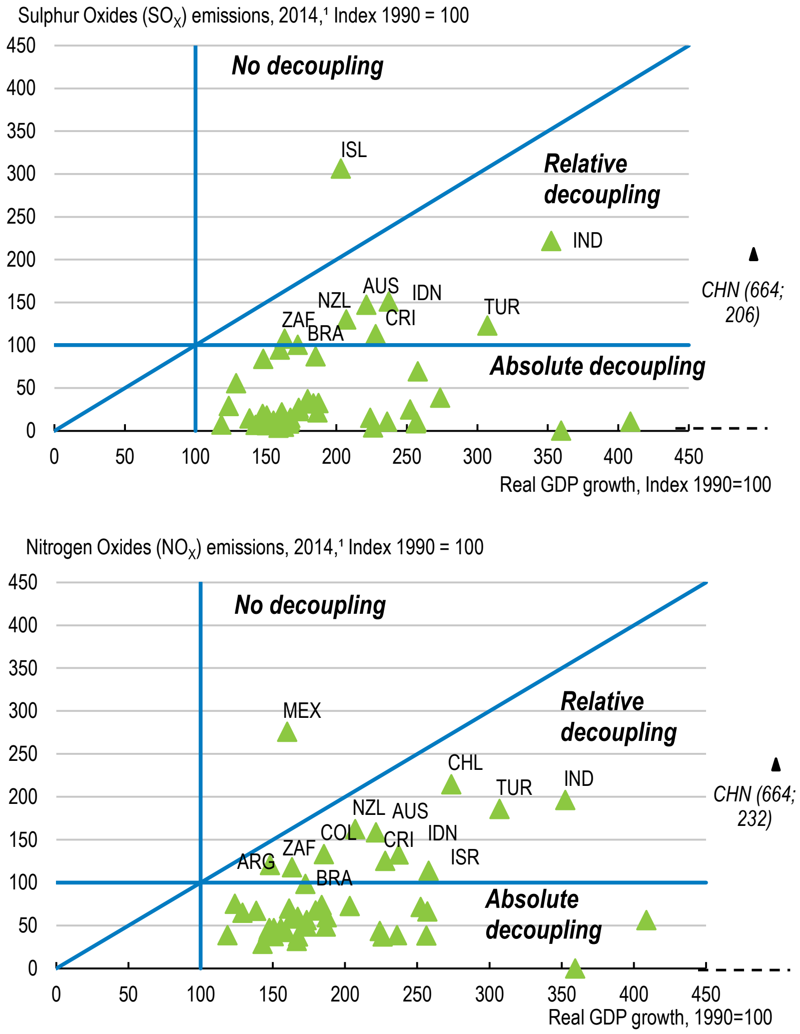
Concentrations are a result of both man-made and natural sources (e.g. due to mineral dust or salt spray), both domestic and possibly foreign (cross-border), as well as the geophysical characteristics of the location (e.g. weather, urban structure). The impacts on health will further depend on the physical distribution of populations as well as the over-time nature of pollution (e.g. long-term vs. peak exposure). Hence, from the policy makers' point of view it is useful to also look at domestic (local) emissions, which can be more directly targeted with mitigation policies than concentrations.

Emissions of harmful air pollutants have seen a sharp decrease since 1990 in the OECD as a whole (Figure 2.5). The data is less well developed than for greenhouse gasses, with good coverage for most OECD (up to 2014) and EU countries, and shorter series for non-OECD, ending in 2010 or before (EDGAR). Progress in reducing these emissions has been most significant in the EU, with emissions well below 1990s levels on all pollutants. Emissions have increased in Canada (PM_{10}), Australia (NOx, SOx), Iceland (SOx, CO, NMVOCs), New Zealand and Turkey (practically all pollutants), Chile and Mexico (NOx). Interestingly, these tend to be the countries with the highest emission intensities. As for large emerging market economies and other non-OECD countries, only relative decoupling has been observed 1990-2010, with emissions increasing albeit more slowly than GDP.

Figure 2.5. Evolution of emissions of selected air pollutants

Selected countries, relative to 1990



1. Data refer to 2009 for Argentina, Brazil, Chile, China, Colombia, Costa Rica, India, Indonesia, Mexico, South Africa; 2011 for Israel; 2012 for the Russian Federation.
Source: OECD, Air and Climate and Economic Outlook Databases.

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Land cover, land use and biodiversity

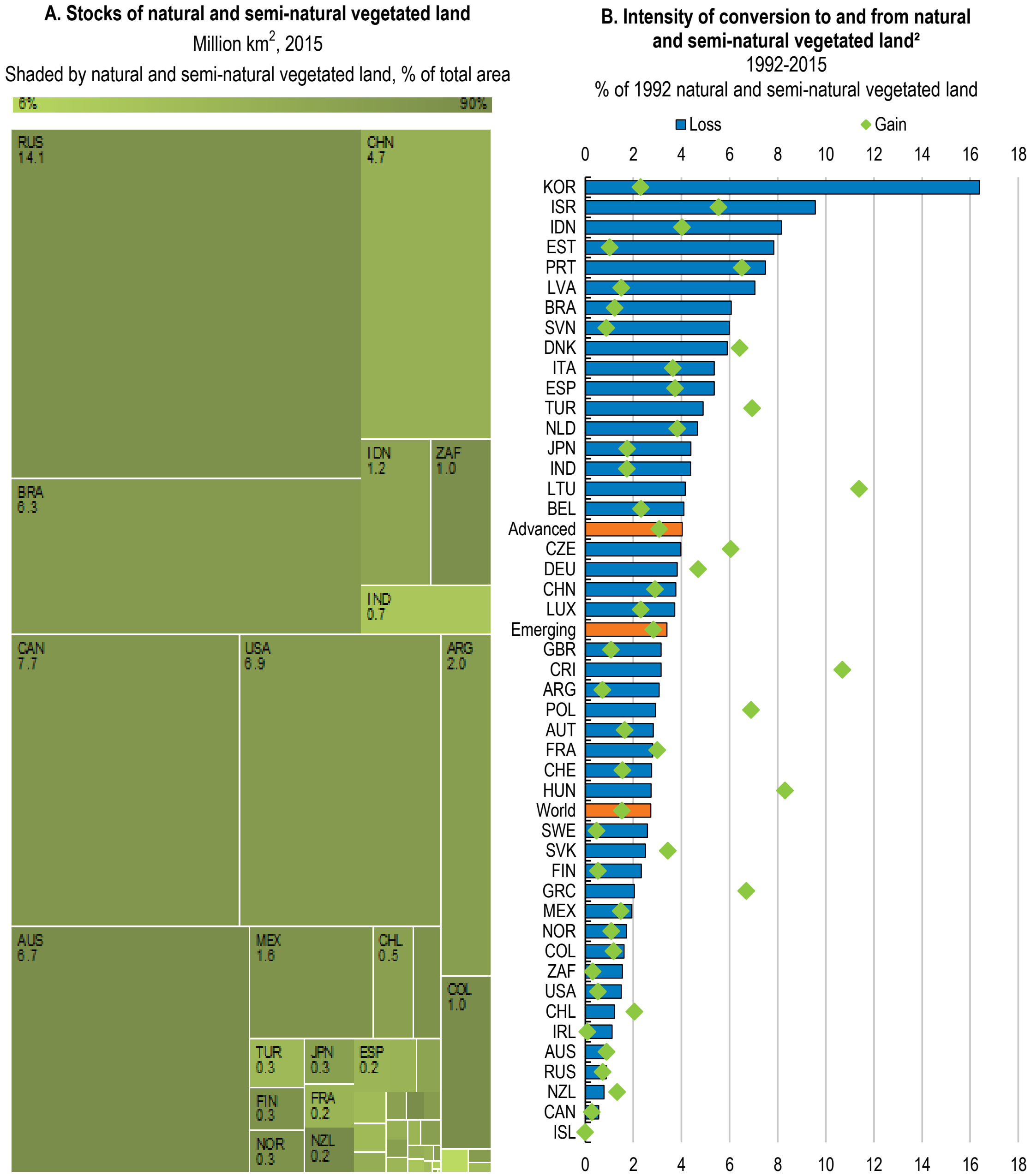
In the case of land cover, forest resources or biodiversity, the relationship with growth and well-being is particularly complex and often not very well established. Valuation methods used to attribute economic value to such resources are highly imperfect and trade-offs may be inevitable, in particular in the short term. For example, forest resources may be assessed by the value of timber – a very narrow approach, which does not take into account their role for biodiversity, air quality or erosion. The measured direct contribution of forestry and logging to GDP is hence modest in advanced economies – typically below 0.5% of GDP - with the exception of some countries with large forest endowments (and low population density) such as Finland, Latvia, New Zealand, Sweden, Estonia, Chile and Canada – but even there forestry contributes well below 2% of GDP. At the same time, the GDP contribution of down-stream industries involved wood-based manufacturing is several times higher. Data for emerging economies is of poorer coverage, but in the large emerging market economies the export contribution of forest products is also small.

Land cover changes are used as an indication of pressures on the natural environment, among them, on biodiversity. In fact, land cover change is the leading contributor to (non-marine) biodiversity loss (CBD, 2010). In light of this, the OECD has recently moved the frontier on indicators of land cover changes and conversions (OECD, 2017d). The new set is based on satellite images and has broad coverage – OECD and G20 countries (as well as regions) – and is designed for tracking land cover changes and conversions over a longer time horizon, starting in the 1990s.

Globally, some 2.7% of natural and semi-natural land has been lost since 1992,[10] with the largest losses in Brazil, China, Russia, the United States and Indonesia – i.e. among the largest and most populated, but also most biodiverse countries (OECD, 2017d). OECD countries have lost on average 1.4% of natural land, with a wide dispersion ranging from 0% to 16% (Figure 2.6). Land use cover changes generally follow a standard path related to development - the conversion of natural land to cropland, and some of it eventually to urban (or built-up) land. Among advanced economies three quarters of natural land lost was lost to cropland. In emerging market economies, the figure was significantly higher. About 2% of total cropland was converted to urban land globally, though the individual country figures did not seem closely related to demographic pressures.

Figure 2.6. Losses in natural and semi-natural land[1]

Selected countries, relative to 1992



1. World figures refer to the area within political boundaries (excluding seas, oceans and Antarctica).
2. Advanced economies refer to OECD countries plus Lithuania and excluding Chile, Mexico and Turkey. Emerging economies refer to Argentina, Brazil, Chile, China, Colombia, Costa Rica, India, Indonesia, Mexico, the Russian Federation, South Africa and Turkey.

Source: *Land cover change and conversions: Methodology and results for OECD and G20 countries*, forthcoming.

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Other indicators of environmental performance

Indicators on waste, waste water treatment and water efficiency, as well as on water pollution and scarcity are less well developed, and unlikely to be suitable for systematic use in *Going for Growth* at this point. Waste data suffer from comparability problems, and good available data tends to focus on municipal waste only. Water abstraction is partly determined by geographical and metrological conditions and is rarely available with information on the post-abstraction use – which can be important from the environmental point of view. Water quality is relatively well covered by the European Environmental Agency, the US Environmental Protection Agency, but comparable data across countries are not available. The case is even weaker for discharges of pollution into water. The specific case of water pollution-related indicators specific to agriculture - nutrient balances (relative to agricultural land surface), that is the difference in nutrients inputs leaving farms (mainly as manure and fertilisers) relative to nutrients necessary for crop and forage – are available for most EU and OECD countries for the past two decades. In general, while pure national averages on water scarcity or quality may not be very telling, such data can be presented with more emphasis on outliers, e.g. with shares of agricultural activities in area subject to water scarcity risks, share of water bodies with substandard pollution levels, etc.

Environment-related indicators linked closely to development – such as access to clean, safe water, sanitation or a reliable electricity source can be important for emerging market economies. Poor performance on such categories implies poor health and life quality and exclusion for many and can be a bottleneck for growth and well-being improvements. Such data is available annually over a longer time period.

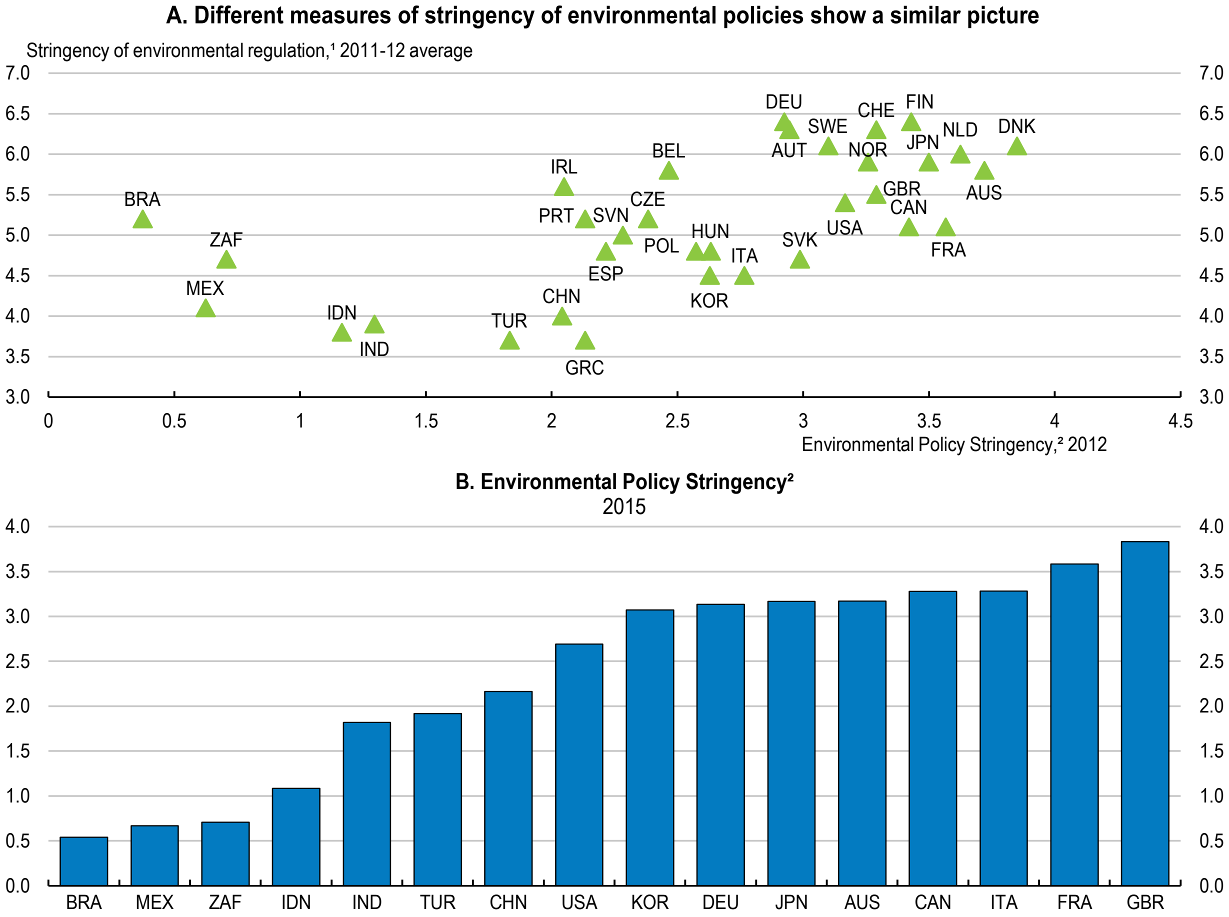
Finally, sets of aggregate indicators on natural asset bases – such as natural resource indexes and related non-energy material consumption and productivity - are designed to show the reliance on and the exhaustibility of non-renewable resources (primarily underground minerals). However, at the current stage, their usefulness for *Going for Growth* is disputable. Firstly, the estimates of natural asset stocks have proven unreliable – for example due to new discoveries or varying levels of accessibility of such resources (both across countries and time, due to technological changes). Secondly, mineral resources are internationally tradeable (and to a various extent recyclable); hence the reliance on them as inputs for growth is not obviously linked to domestic stocks. Thirdly, the aggregation methods are often problematic or at the least not well established – e.g., for material productivity, materials of various values are generally aggregated by weight. As for reliance on mining and exporting such resources as a source of growth, EAMFP growth provides a general, even if crude, indication.

2.2.2. Indicators of efforts, opportunities and policies

Green growth indicators also cover a set of indicators related to environmental policies, efforts and opportunities. The overall idea is to compare country policy stances (and intermediate outcomes, such as innovation) – in order to assess efforts in preserving a clean environment. However, the challenge of measuring and comparing environmental policies comes in as a key factor limiting the development of such indicators.

Indicators most closely related to policy focus on the stringency of the environmental policy signal. The indicators available include direct measures – OECD's Environmental Policy Stringency (EPS; Botta and Kozluk, 2014) and the perceived stringency of policies, based on responses to the World Economic Forum's (WEF) Executive Opinion Survey. The former focuses on the policy imposed "costs" of polluting – for example a more stringent policy is associated with a higher tax on emissions or tighter pollution standards. The EPS is a *de jure* measure, available for most OECD countries and large emerging market economies since the 1990s till 2015. It is a broad proxy, but currently limited largely to a selection of climate and air pollution policies.[11] The WEF's survey-based measure attempts at overall de facto stringency evaluation (as well as the evaluation of actual enforcement) by asking company managers. It covers practically all countries (Figure 2.7). Both approaches have significant limitations, but can give an indication of the overall stringency of environmental policies in countries.

Figure 2.7. Different proxies of environmental policy stringency



1. Index of 1-7 from least to most restrictive environmental regulations.
2. The OECD Environmental Policy Stringency Index (EPS) is a country-specific and internationally-comparable measure of the stringency of environmental policy. Stringency is defined as the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behaviour. The index ranges from 0 (not stringent) to 6 (highest degree of stringency).

Source: World Economic Forum and OECD, Environmental Policy Database.

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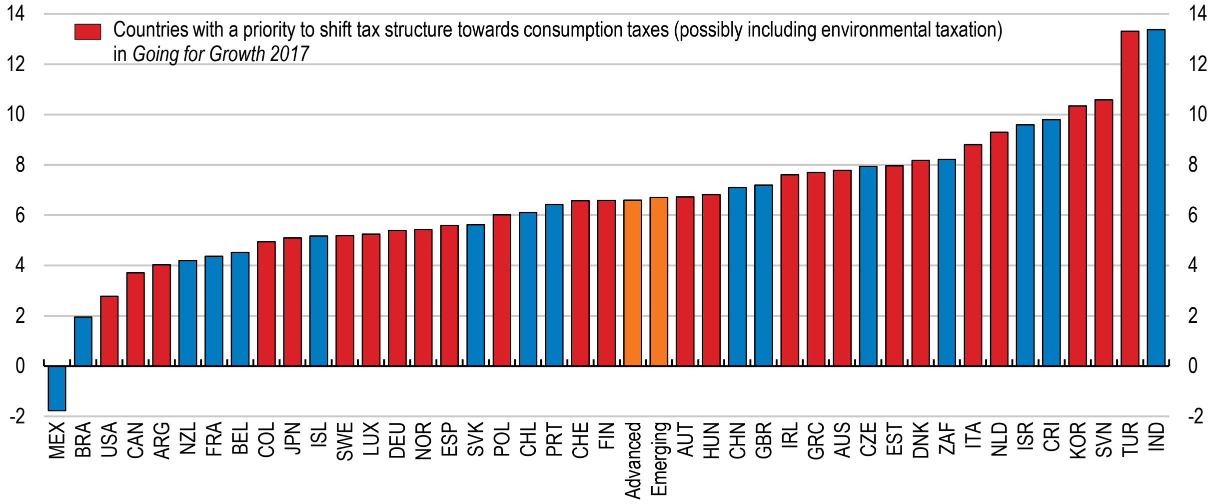
On top of this, the OECD also collects data on environmentally-related tax revenues – often used to indicate the potential for generating revenues, though this needs to be treated cautiously, as in principle high environmental tax revenues could not only indicate stringent environmental (pricing) policies, but equally well, large environmental issues.[12] In practice, the majority of revenues comes from energy taxation, with motor-vehicle taxation as the second item. Notably, many of these taxes are levied primarily for revenue, rather than environmental purposes.The country coverage of the indicators is gradually increasing beyond the OECD and large emerging market economies (Figure 2.8). More generally, environmentally related tax revenues tend to be below 4 per cent of GDP. They are often argued to have potential to substitute revenues from direct taxes, if the environmental damage associated with the production and consumption of goods and services is more systematically priced. Importantly, if as environmental taxes are increased they also serve their function – i.e. incentivise firms and households to decouple activity from the environment – the tax base should be shrinking over time.

Indicators and proxies more specific to climate policies include OECD’s effective carbon prices (OECD, 2016b) – which attempt to show the effective pricing of carbon contents of different fuels (and uses) attributable to taxes and trading schemes in each country. The country coverage is similar as with tax revenues, but time series are not yet available. Final user energy prices are also sometimes used as a proxy for the stringency of climate policies (Sato et al. 2015). Important policy related datasets concern fossil fuel subsidies (OECD Inventory of Support Measures for Fossil Fuels) and producer subsidies to agriculture (OECD, 2017c) - as both fossil fuel combustion and intensive agriculture have direct links to environmental challenges.

Notably, some of the tax-related policy indicators already serve for identification for pro-growth priorities in *Going for Growth*. Many countries with a priority to shift the tax structure to consumption (or specifically environmental) taxes raise a rather low share of revenues from environmental taxation (Figure 2.8). At the same time, countries with a priority to reduce tax expenditures or broaden the tax base tend to have intermediate levels of such exemptions supporting fossil fuels (Figure 2.9).

Figure 2.8. Large variations in share of revenues from environmentally-related taxation among countries with a *Going for Growth* priority to shift the tax structure[1]

Percentage of total tax revenue, 2014



1. Advanced economies refer to OECD countries plus Lithuania and excluding Chile, Mexico and Turkey. Emerging economies refer to Argentina, Brazil, Chile, China, Colombia, Costa Rica, India, Indonesia, Mexico, the Russian Federation, South Africa and Turkey. Data refer to 2013 for Australia, Brazil, Colombia, Japan, Mexico, the Netherlands, Poland; 2000 for Greece.
Source: OECD, Environmental Policy Database.

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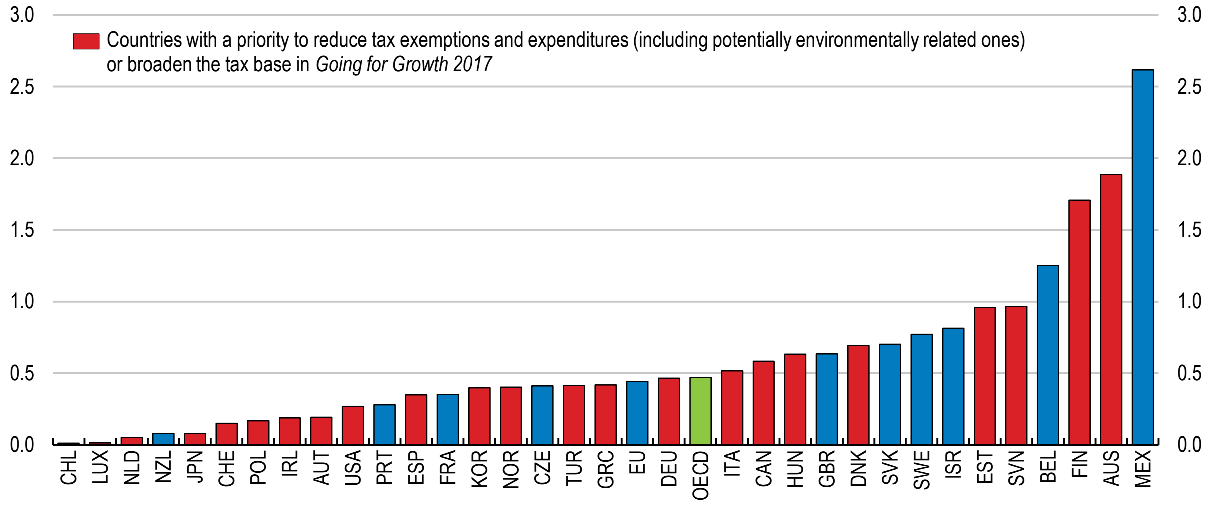
Figure 2.9. Fossil fuel subsidies versus recommendations to reduce tax expenditures

Percentage of total tax revenue, 2014



Source: OECD, Green Growth Database.

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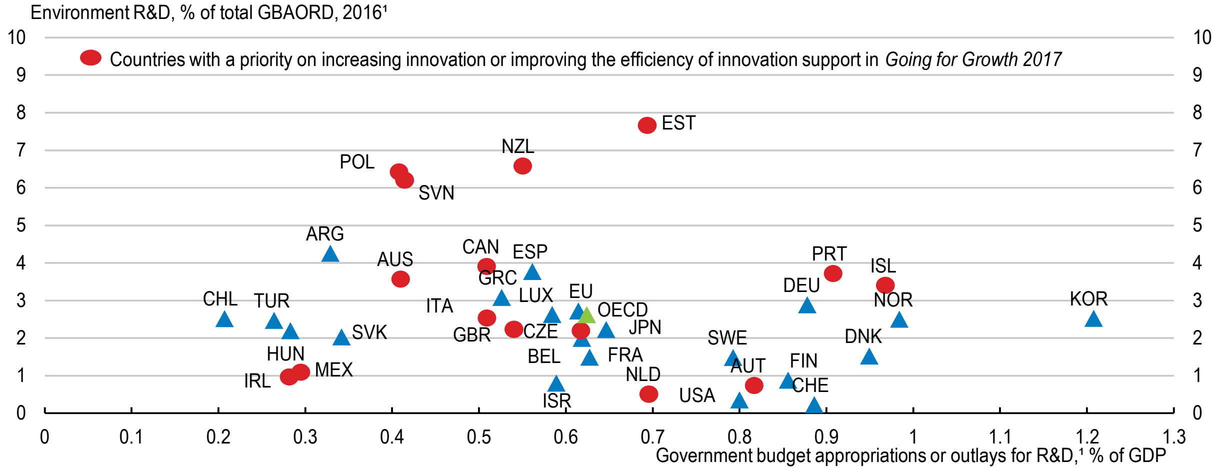
"Green" innovation

Indicators of "green" innovation constitute an attempt to capture the "intermediate" step of the green growth transformation – the development of new, more environmentally friendly ways of producing and consuming. Innovation is a necessary condition for green growth – it is the means of reducing the negative effects of growth and well-being on the environment and hence increasing their long-term sustainability and resilience. Innovation-related indicators are either input-based such as R&D spending or output-based, such as data derived from patent counts (Figure 2.10 and Figure 2.11). While well accepted proxies, neither is perfect – the link between innovation spending and actual technological progress is complex and only a fraction of innovations are patented and patentable. Neither takes into account actual adoption. Additional challenges arise from the problem of distinguishing which technologies are actually relevant for progress on green growth – done commonly by reviewing technological classifications of R&D spending areas and of patents and their descriptions (Hascic and Migoto, 2015). OECD data relies primarily on technology classifications, with specific technologies labelled as relevant for the environment. Patent data cannot directly answer the question of which of the innovations or inventions are actually important, but they have key advantages: wide availability (across time and countries) and their quantitative nature.

Overall, while government support to R&D labelled as energy- and environment-related has generally kept up or increased in most OECD countries throughout 2000s, patenting in so-called green technologies seems to have slowed globally relative to a surge in the earlier 2000s. The vast majority of green inventions originate in the advanced economies, particularly in large economies with high overall R&D spending and often stringent environmental policy signals - such as the United States, Japan, Germany, Korea and France. Denmark, while a smaller contributor in absolute terms, leads in terms of share of green patents. The large emerging market economies, in particular China and India, have noted rapid increase though still contribute less in absolute value relative to their size.

Figure 2.10. Government R&D expenditure relevant for green growth



1. GBAORD refers to Government budget appropriations or outlays for R&D. The last available year is 2017 for Austria and the Netherlands; 2015 for Belgium, Chile, Spain, Estonia, the United Kingdom, Greece, Hungary, Ireland, Israel, Italy, Korea, Poland, Slovenia, Sweden, Turkey and the Russian Federation; 2014 for Switzerland and Iceland; 2013 for Canada; 2012 for Argentina.

Source: OECD, Innovation in Environment-related technologies Database; OECD, Science, Technology and Patents Database and OECD, Economic Outlook Database.

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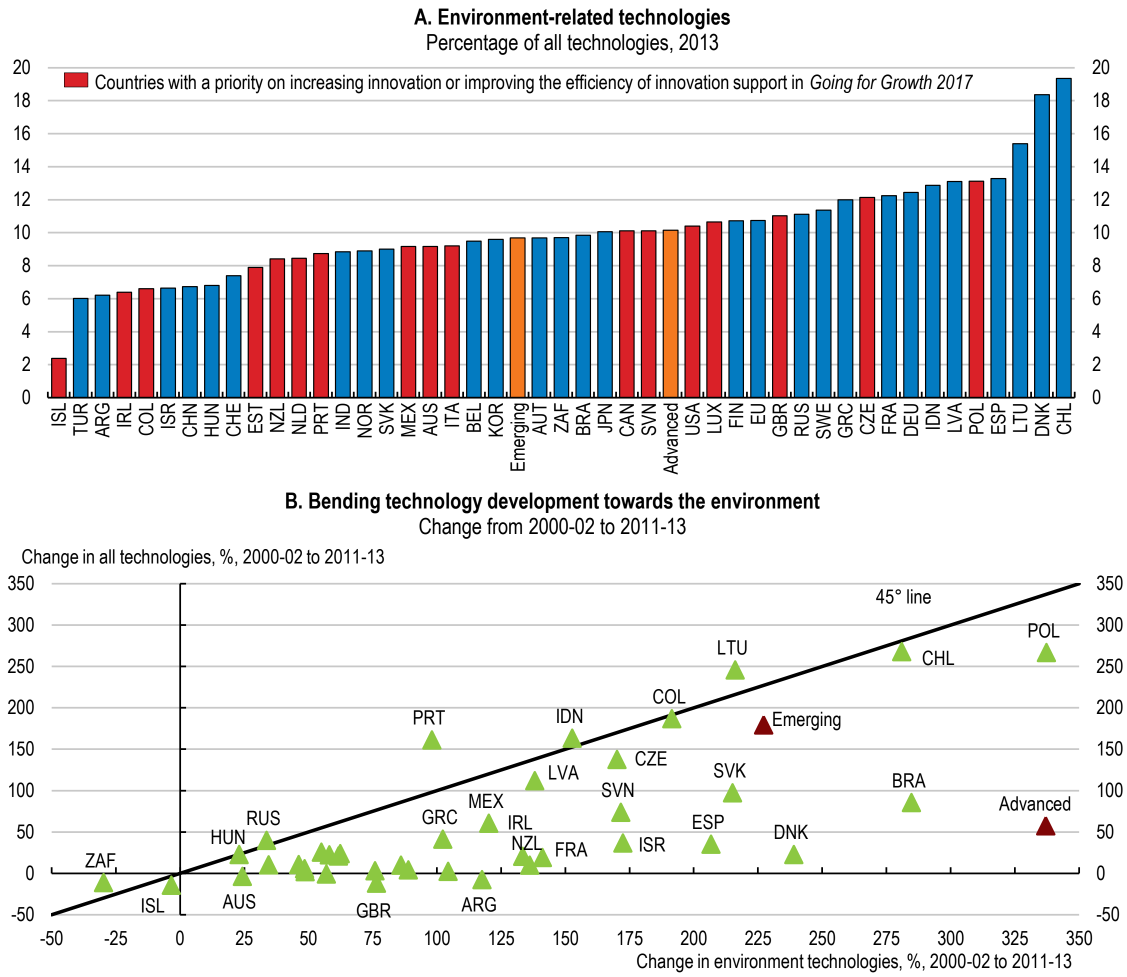
Figure 2.11. Share of patenting in so-called environmental technologies[1]



1. Advanced economies refer to OECD countries plus Lithuania and excluding Chile, Mexico and Turkey. Emerging economies refer to Argentina, Brazil, Chile, China, Colombia, Costa Rica, India, Indonesia, Mexico, the Russian Federation, South Africa and Turkey.

Source: OECD, Innovation in Environment-related technologies Database and OECD (2017), Green Growth Indicators 2017.

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2.3. Gaps in green growth measurement - what would we like to measure (better)?

The recent progress on green growth indicators allows a first step in the direction of integrating green growth into *Going for Growth*. A detailed proposal for such an integration is underway, but the process will inevitably be gradual and cautious – proceeding as work on green growth indicators progresses. Information on some of the key indicators is summarised in Annex Table 2.A.1. Several milestones would improve the potential for such integration:

Indicators:

- The coverage and timeliness of many green growth indicators needs to be improved. The fact that in key environmental areas long-term trend developments are more important than short term fluctuations is not per se problematic for *Going for Growth* which also focuses on the medium to longer run. However, to better detect progress or turning points, more up-to-date information may be desirable, e.g. for exposures and risks, GHGs or some of the policy variables. More generally coverage of a broader set of countries and intermediate years will always be welcome.
- New dimensions and improvements (e.g. on comparability) of existing indicators such as water pollution and scarcity, waste, biodiversity and ecosystems and in particular on policies would be desirable.

Concepts:

- Improved treatment of global goods (climate, oceans, biodiversity) and their incorporation in national objectives. As such targets are often outside of the direct responsibility of domestic policy makers, incorporation into *Going for Growth* could benefit from developing indicators such as the distance from a countries ambition, e.g. measured by long-term international commitments (e.g. carbon budgets that could be based on COP 21).
- Improved coverage of local or regional environmental issues and of risks that are not a central scenario. As such, these may be less evidently linked to overall growth and well-being, especially in large countries, but their importance may be better covered in moving towards indicators of population (or economy) exposures to risks (GDP at risk, population living in areas with higher health risks, agricultural production in areas at risk of flooding or water scarcity, etc.)
- Better measurement of how country environmental policies compare – in terms of stringency and other aspects of design (flexibility, stability, growth-friendliness).

Empirical evidence:

- Stronger empirical evidence linking: (i) environmental damage to economic growth and well-being (both direct and via increased risks); (ii) environmental policies to economic, well-being and environmental outcomes; (iii) economic policies and outcomes to pressures on the environment; over various time horizons would allow more directly targeting the *Going for Growth* objective of strong, sustainable growth and more concrete formulation of policy recommendations.
- Translating this evidence into better indicators of risks, costs of environmental damage and using it e.g. to inform weighting in the construction of aggregate indicators.

Endnotes

3. A key input into this chapter is the OECD work on Green Growth Indicators, led by the Environment Directorate in co-operation with the Statistics Directorate (OECD, 2017b; http://oe.cd/ggi).

4. Detailed information on the OECD's Environmentally Adjusted Multi-factor Productivity (EAMFP) measure can be found in Cardenas Rodriguez et al. (2016) and Brandt et al. (2014).

5. In some cases, more disaggregated data, e.g. at regional or city level are available.

6. Excluding land use, land use change and forestry (LULUCF).

7. The latest world observation is 2012. For OECD and large EMEs, the latest data is 2014.

8. There is work planned in 2018-19 at the OECD on developing indicators in this area.

9. The OECD (2016a) work provides a global outlook to 2060 for the major impacts of increased air pollution on human health and agriculture: numbers of premature deaths, cases of illness and loss of agricultural yields. It uses a detailed general equilibrium modelling framework, the OECD's ENV-Linkages model, to calculate regional and global economic costs related to those impacts that can be linked to markets, such as changes in health care expenditures, labour productivity, and agricultural production. Non-market impacts, such as the premature deaths and the costs of pain and suffering from illness, are derived using estimates of willingness-to-pay (WTP) based on direct valuation studies. The welfare costs of the premature deaths caused by air pollution are calculated using the value of a statistical life (VSL).

10. Natural and semi-natural land is used to define land covered by natural or semi-natural vegetation with limited anthropogenic footprint.

11. The OECD collects a large number of details on existing policies in the Database on Policy Instruments for Environment (PINE) http://www2.oecd.org/ecoinst/queries/. In particular, the EPS makes use of this data.

12. OECD defines environmentally related taxes as any taxes (or other pricing instruments, such as tradeable permits) levied on environmentally relevant tax-bases, such as emissions to air or water, energy sources and energy sources, motor vehicles, waste, etc.

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Annex 2.A. List of selected available green growth indicators and coverage

Annex Table 2.A.1. Selected green growth indicators with potential for inclusion in *Going for Growth*

Indicator area	Coverage and availability	Relevance for *Going for Growth* pro-growth priority areas and recommendations	Remarks
Performance: Climate change			
GHG emissions (total economy)	GHGs: model based estimates are global. Actual data – primarily for developed countries. Updates frequent, but coverage worse for LULUCF. CO_2 from combustion: global coverage, annual updates, up to date.	Taxation, infrastructure, land use, agriculture and transport (emissions by sector)	CO_2 is available in both emissions linked to "production" and "consumption". Often used in relation to output variables ("carbon productivity"). Performance can be assessed w.r.t. the assumed target of reducing emissions to zero eventually. Various supporting indicators (e.g. on energy mix) are available.
Carbon budgets	At the moment not well developed.	Taxation, infrastructure, land use, agriculture and transport (emissions by sector)	Important but unlikely useful at this stage.
Adaptation and risks	Poor and often out of date, particularly in the case of exposures and risks. Work planned in the OECD Environment Directorate 2018-19.	Taxation, infrastructure, land use, agriculture and transport (emissions by sector)	Important but unlikely useful at this stage.
Performance: Air pollution			
Air pollution concentrations (and exposure)	Global coverage of at least two decades for PM. Coverage much poorer for other pollutants – mainly selected cities in developed countries.	Infrastructure/public transport, road pricing, zoning/land regulations	Includes the contribution of natural factors.
Air pollution emissions	Inventory data available by source for 6 main categories of pollutants for OECD countries (up to date and historical).	Infrastructure/public transport, road pricing, zoning/land regulations, taxation	Not necessarily linked to environmental outcomes.

Indicator area	Coverage and availability	Relevance for *Going for Growth* pro-growth priority areas and recommendations	Remarks
	Model-based estimates for totals (on main categories) available for a longer time period globally (up to 2012). Should improve with forthcoming global emission accounts.		
Performance: Natural assets and land use			
Land cover and land cover changes	Global, since 1990s	Zoning, land regulation, Infrastructure/public transport, road pricing	Focus on quantity (not quality) of land cover types. Also available at regional levels.
Land cover conversions	Global, since 1990s	Zoning, land regulation, Infrastructure/public transport, road pricing	Focus on quantity (not quality) of land cover types. Also available at regional levels.
Nitrogen and Phosphorus balances	Primarily OECD, since the 1980s or 1990s	Agricultural subsidies	Not necessarily straightforward to interpret and link directly with policies.
(Intermediate) Performance: Innovation and infrastructure			
"Green" Patents	Global, annual	Innovation policies, taxation (directed technological change)	General limitations of patent data.
Government support to "green" R&D	Limited to energy categories. OECD countries, history available through lags in updating.	Innovation policies, taxation (directed technological change)	Based on general government expenditures in a limited set of categories.
Access to clean water, sanitation, electricity	Available globally, up to date and with history.	Infrastructure, Inclusiveness	Primarily relevant for EMEs.
Policies			
Environmentally related taxation	OECD + selected large EMEs + selected others. Updated annually since 1994.	Tax structure and tax base (exemptions), transport policies	Allows the identification of the structure of taxes, which can be relevant for the formulation of the recommendation. The motivation for the individual taxes is not necessarily environmental (e.g. excise taxes).
Fossil fuel subsidies	OECD and selected large EMEs (OECD). Key EMEs (IEA). Updated since 2000s.	Fossil fuels subsidies, Taxation (broadening tax base)	OECD methodology is based on actual inventories of measures. IEA methodology is based on the gap between domestic

Indicator area	Coverage and availability	Relevance for *Going for Growth* pro-growth priority areas and recommendations	Remarks
			price and global prices.
Producer support to agriculture	OECD. Updated since 1990s. Forthcoming OECD work on harmful fisheries subsidies.	Agricultural subsidies	Disaggregates between producer and consumer support. Total sums, with EU treated as one entity. Can include subsidies for improving environmental performance.
Environmental policy stringency (OECD)	Since 1990s. Most OECD + selected large EMEs. Last update 2012 or 2015 (G20).	General, rule of law, taxation	Very general composite proxy based primarily on air and climate policies.
WEF stringency of environmental policies	Global, annual, since 2000s.	General, rule of law	Problematic over-time comparison, update availability not always clear. Some potential sampling issues.
Indicators of burdens on entry and competition due to env. policies (BEEP)	2013 only, update planned in 2018. OECD countries + ZAF, HRV.	Barriers to entry and competition, administrative burdens on firms, product market regulation	Limited amount of issues covered, primarily on the design aspects of environmental policies.
Others			
EAMFP	OECD and G20, annual since 1990s	General	Multi factor productivity growth adjusted for selected air pollutants, CO_2 and key mineral resources.