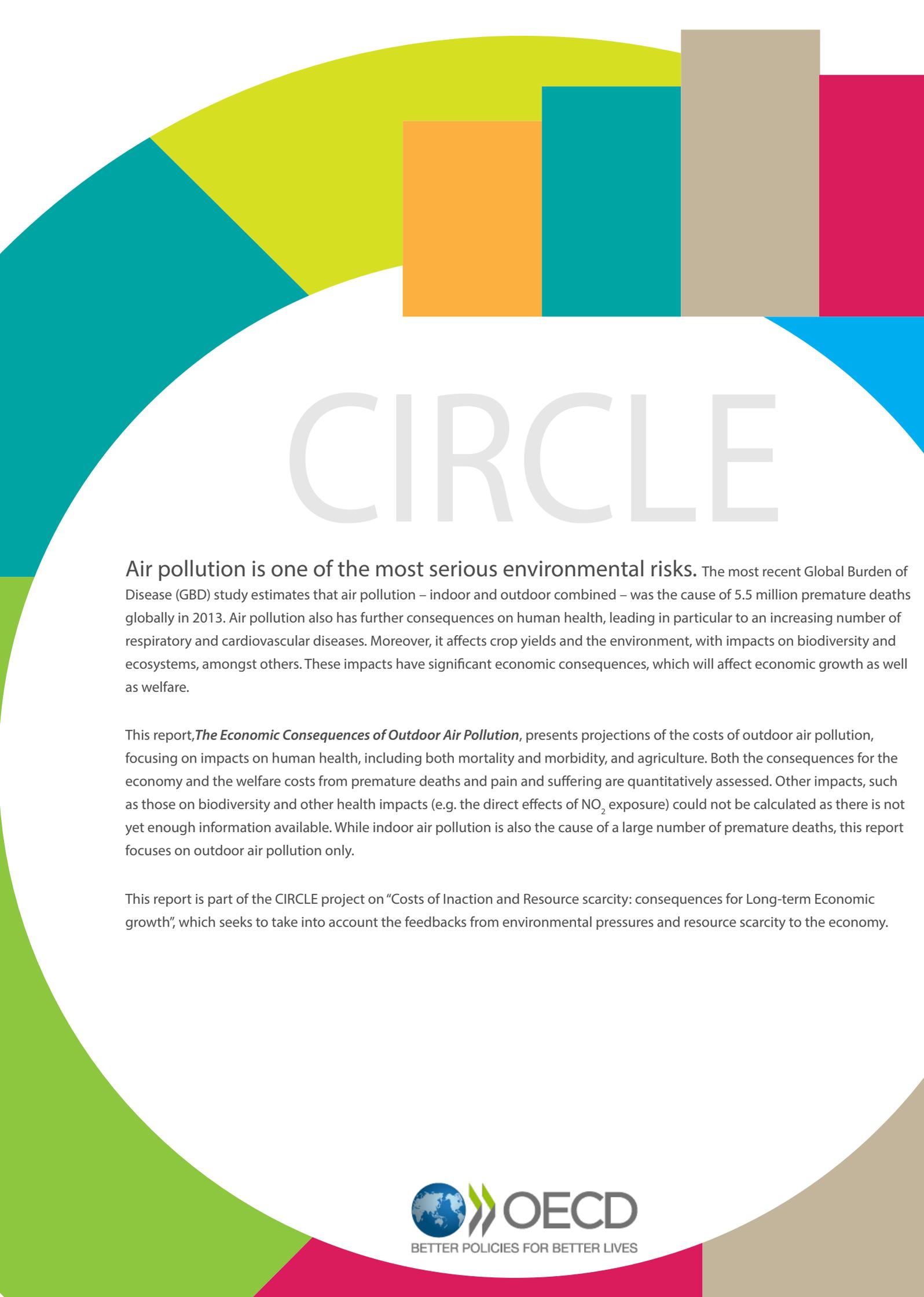


# The economic consequences of outdoor air pollution

POLICY HIGHLIGHTS



# CIRCLE

**Air pollution is one of the most serious environmental risks.** The most recent Global Burden of Disease (GBD) study estimates that air pollution – indoor and outdoor combined – was the cause of 5.5 million premature deaths globally in 2013. Air pollution also has further consequences on human health, leading in particular to an increasing number of respiratory and cardiovascular diseases. Moreover, it affects crop yields and the environment, with impacts on biodiversity and ecosystems, amongst others. These impacts have significant economic consequences, which will affect economic growth as well as welfare.

This report, *The Economic Consequences of Outdoor Air Pollution*, presents projections of the costs of outdoor air pollution, focusing on impacts on human health, including both mortality and morbidity, and agriculture. Both the consequences for the economy and the welfare costs from premature deaths and pain and suffering are quantitatively assessed. Other impacts, such as those on biodiversity and other health impacts (e.g. the direct effects of NO<sub>2</sub> exposure) could not be calculated as there is not yet enough information available. While indoor air pollution is also the cause of a large number of premature deaths, this report focuses on outdoor air pollution only.

This report is part of the CIRCLE project on “Costs of Inaction and Resource scarcity: consequences for Long-term Economic growth”, which seeks to take into account the feedbacks from environmental pressures and resource scarcity to the economy.

## THE ECONOMIC CONSEQUENCES OF OUTDOOR AIR POLLUTION

### Findings

- Air pollution already affects human health, agriculture and leads to a range of other impacts. These impacts are projected to become much more severe in the coming decades.
- In absence of additional and more stringent policies, increasing economic activity and energy demand will lead to a significant increase in global emissions of air pollutants, according to projections using the OECD's ENV-Linkages model.
- Rising emissions of air pollutants are projected to lead to higher concentrations of particulate matter (PM<sub>2.5</sub>) and ground level ozone. In several regions of the world, average concentrations of PM<sub>2.5</sub> and ozone are already well above the levels recommended by the WHO Air quality guidelines.
- The projected increase in concentrations of PM<sub>2.5</sub> and ozone will in turn lead to substantial effects on the economy. According to the calculations in this report, global air pollution-related healthcare costs are projected to increase from USD 21 billion (using constant 2010 USD and PPP exchange rates) in 2015 to USD 176 billion in 2060. By 2060, the annual number of lost working days, which affect labour productivity, are projected to reach 3.7 billion (currently around 1.2 billion) at the global level.
- The market impacts of outdoor air pollution, which include impacts on labour productivity, health expenditures and agricultural crop yields, are projected to lead to global economic costs that gradually increase to 1% of global GDP by 2060.
- The most dangerous consequences from outdoor air pollution are related to the number of premature deaths. This report projects an increase in the number of premature deaths due to outdoor air pollution from approximately 3 million people in 2010, in line with the latest Global Burden of Disease estimates, to 6-9 million annually in 2060. A large number of deaths occur in densely populated regions with high concentrations of PM<sub>2.5</sub> and ozone, especially China and India, and in regions with aging populations, such as China and Eastern Europe.
- The annual global welfare costs associated with the premature deaths from outdoor air pollution, calculated using estimates of the individual willingness-to-pay to reduce the risk of premature death, are projected to rise from USD 3 trillion in 2015 to USD 18-25 trillion in 2060. In addition, the annual global welfare costs associated with pain and suffering from illness are projected to be around USD 2.2 trillion by 2060, up from around USD 300 billion in 2015, based on results from studies valuating the willingness-to-pay to reduce health risks.
- Policies to limit air pollution emissions would lead to an improvement in air quality, reduce risks of very severe health impacts, and, if properly implemented, generate considerable climate co-benefits.
- The potential economic consequences of both the market and non-market impacts of outdoor air pollution are very significant and underscore the need for strong policy action.
- There's no one-size-fits-all recipe for reducing the impacts of air pollution. As both the sources of air pollutant emissions and the economic consequences of air pollution are very unequally distributed across different regions, policies need to be tailored to specific local circumstances. Nevertheless, the implementation of policies, such as incentivising the adoption of end-of-pipe technologies, implementing air quality standards and emission pricing, will certainly help avoid the worst impacts of outdoor air pollution.

# 1

## Modelling the economic consequences of outdoor air pollution

Modelling the economic consequences of outdoor air pollution requires several steps that link economic activity to emissions, concentrations, exposure, biophysical impacts and finally valuation of the economic costs (Figure 1).

1. The OECD's ENV-Linkages model, a computable general equilibrium (CGE) model, is used to create detailed projections of sectoral and regional economic activities from 2015 to 2060.
2. For each year, emissions of a range of air pollutants are linked in ENV-Linkages to the different economic activities, using emission coefficients derived from the GAINS model developed at the International Institute for Applied Systems Analysis (IIASA). In some cases, emissions are directly linked to the relevant element in the production process, such as the combustion of fossil fuels. In other cases, emissions are linked to the scale of activity, and thus to production volumes.
3. Emissions of air pollutants are used to calculate concentrations of particulate matter (PM<sub>2.5</sub>) and ozone with the TM5-FASST atmospheric dispersion model of the European Commission's Joint Research Centre (EC-JRC).
4. The biophysical impacts caused by the population-weighted concentrations of PM<sub>2.5</sub> and ozone, including impacts on number of lost working days, hospital admissions and agricultural productivity, are calculated using demographic projections, exposure to the pollutants and results of studies calibrating concentration-response functions.
5. The economic consequences of outdoor air pollution are calculated by attributing a monetary value to each health endpoint. For example, hospital admissions are translated into health expenditures. The macroeconomic costs of those impacts of outdoor air pollution that are linked to economic activity are then calculated using the ENV-Linkages general equilibrium model. Welfare costs related to mortality and pain and suffering from illness are calculated using results from direct valuation studies.

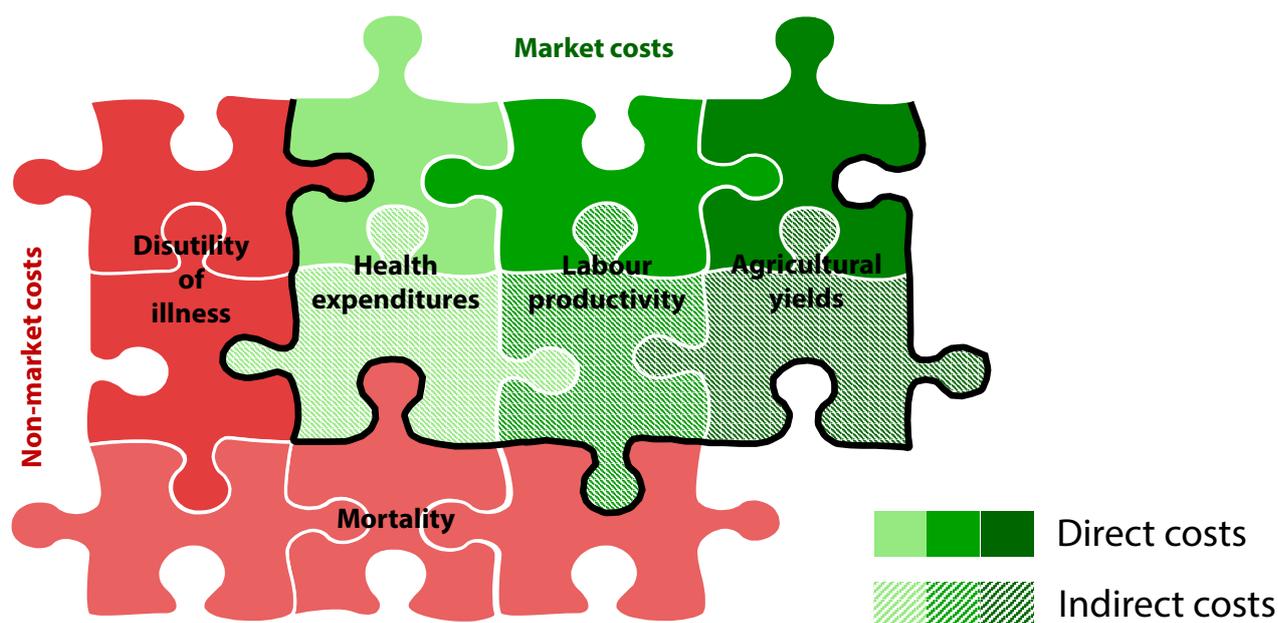
Figure 1. Steps to study the economic consequences of outdoor air pollution



The total cost of inaction on outdoor air pollution include both market and non-market costs (Figure 2). Market costs are those that are associated with biophysical impacts that directly affect economic activity as measured in the national accounts and GDP. For example, lower crop yields

affect agricultural production. Non-market costs include the monetised welfare costs of mortality (premature deaths), and of the disutility of illness (pain and suffering).

Figure 2. Cost categories considered



The market impacts, which in this study comprise additional health expenditures due to illness, labour productivity losses due to absences from work for illness, and agricultural yield losses, are included in the ENV-Linkages model to calculate the global and regional costs of outdoor air pollution on sectoral production, GDP and welfare. Thanks to the general equilibrium framework of the ENV-Linkages model, the market costs include both direct and indirect market costs. For instance, a decrease in crop yields will lead to a direct impact on agricultural output of the affected crops,

but also to indirect effects, including substitution by other crops and changes in trade patterns.

Non-market impacts cannot be easily accounted for in a general equilibrium framework as they are not linked to any specific variable in the production or utility functions of the model. The welfare costs of non-market impacts are evaluated using estimates of willingness-to-pay to reduce health risks obtained from results of existing direct valuation studies.



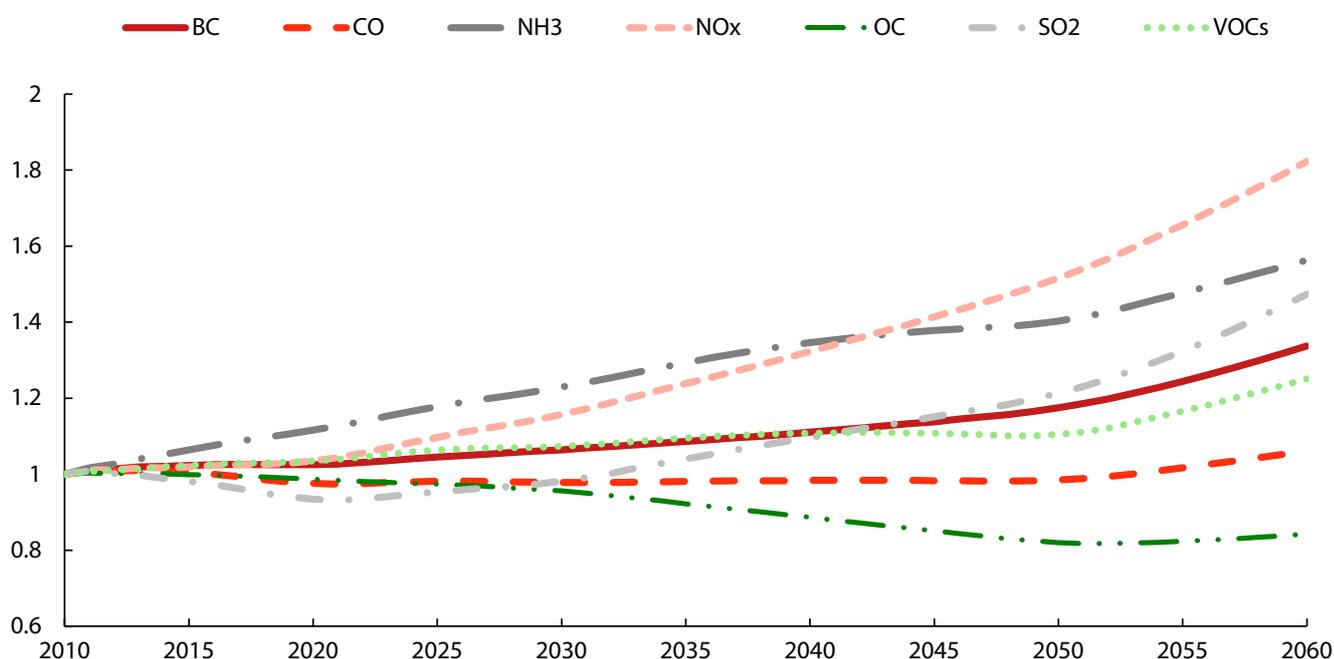
# 2 Emissions and concentrations of outdoor air pollutants

For most air pollutants, emissions are projected to increase in the coming decades (Figure 3). Rising emissions reflect the underlying baseline assumptions on economic growth: with increasing GDP and energy demand, especially in fast growing economies such as India and China, emissions of air pollutants rise, albeit at a slower pace than GDP.

In particular, emissions of nitrogen oxides (NO<sub>x</sub>) and ammonia (NH<sub>3</sub>) are projected to increase strongly. These large changes are due to the projected increase in the demand for agricultural products and energy (incl. transport and power generation). Emissions of black carbon (BC), carbon monoxide (CO), and volatile organic

compounds (VOCs) also increase. Emissions of sulphur dioxide (SO<sub>2</sub>) are projected to initially decrease but increase again after 2030. The initial decline is due to current policies that require flue gas desulphurization (primarily in the power sector) even in several developing countries, but is later offset by the continuing increase in energy demand, which eventually leads to higher emissions. The slight emission decrease for organic carbon (OC) corresponds to lower emissions from energy demand from households, which reflects technology improvements in energy efficiency, the use of cleaner fuels, and the switch from biomass in open fire to cleaner energy sources including LPG, ethanol, or enhanced cooking stoves.

Figure 3. **Emission projections over time**  
Index with respect to 2010



Source: ENV-Linkages model, based on projections of emission factors from the GAINS model.

Emissions of BC and OC directly contribute to PM<sub>2.5</sub>, while other gases such as NH<sub>3</sub>, NO<sub>x</sub>, SO<sub>2</sub> form PM<sub>2.5</sub> through chemical reactions in the atmosphere. Ozone is formed in the atmosphere

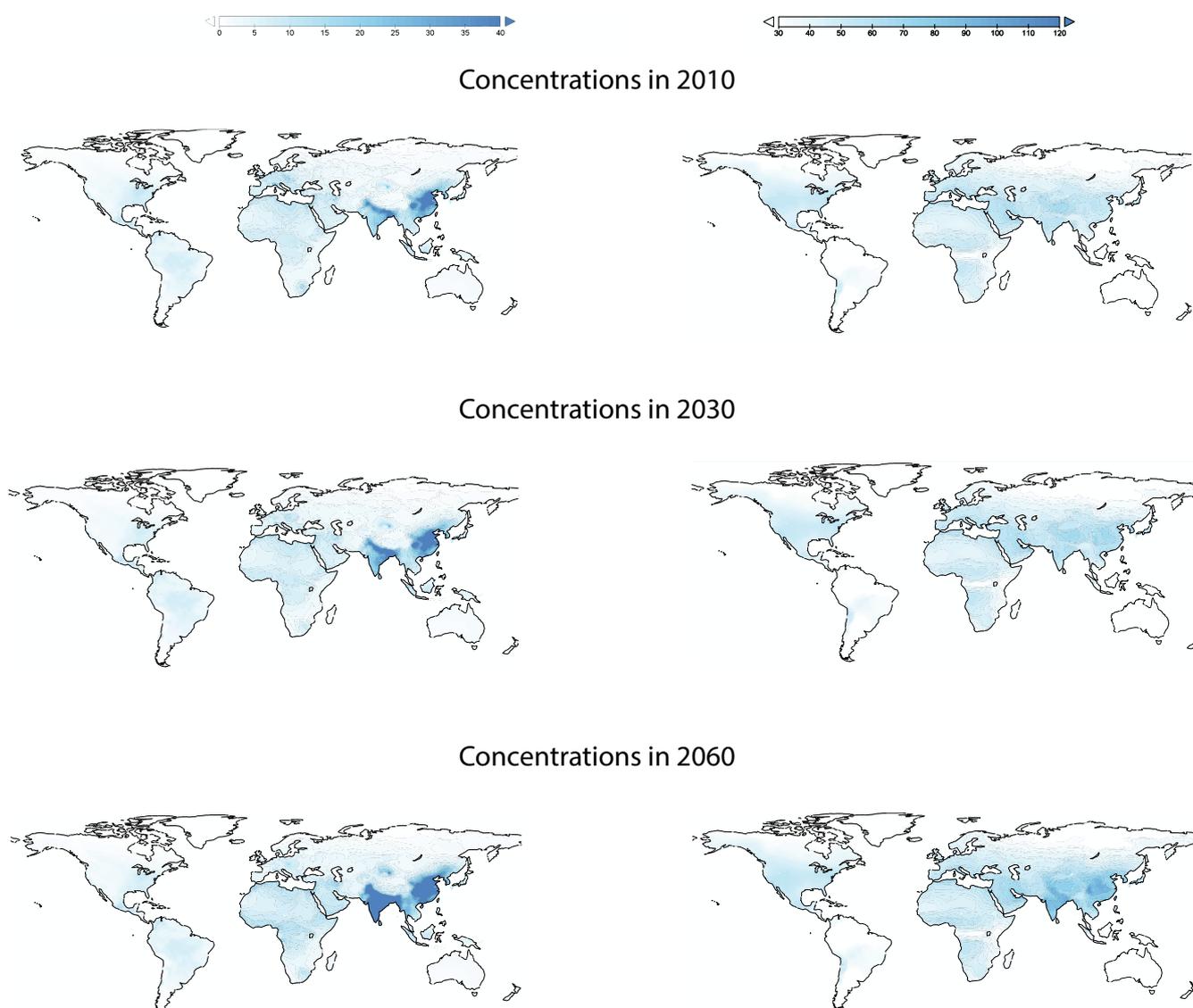
as a consequence of chemical and photochemical reactions involving gases such as NO<sub>x</sub>, VOCs and methane (CH<sub>4</sub>).

With emissions of air pollutants generally rising over time, the concentrations of PM<sub>2.5</sub> and ozone are also projected to increase in most regions (Figure 4). Several other factors, such as changing climatic conditions, also influence the concentrations. In many places, concentrations of PM<sub>2.5</sub> and ozone are already well above the levels recommended by the WHO Air quality guidelines. Population-weighted average PM<sub>2.5</sub> concentrations are already high and rapidly rising in South and East Asia, especially China and India. In large parts of North America, Europe and Africa PM<sub>2.5</sub> concentrations from anthropogenic sources are

also high but are projected to rise less quickly. Ozone concentrations are particularly high in Korea, the Middle East and the Mediterranean, but they also exceed air quality guidelines in many other OECD and non-OECD regions. These areas are the most polluted at present and remain so in the projections for the coming decades. High average population-weighted concentrations mean that in many areas – and especially in large cities – air pollution is permanently above recommended levels; furthermore, for several days per year, they may reach levels that are extremely dangerous for human health.

Figure 4. **Particulate matter and ozone concentrations**

Projected annual average anthropogenic PM<sub>2.5</sub> on left panels (µg/m<sup>3</sup>) and maximal 6-month mean of daily maximal hourly ozone on right panels (ppb)



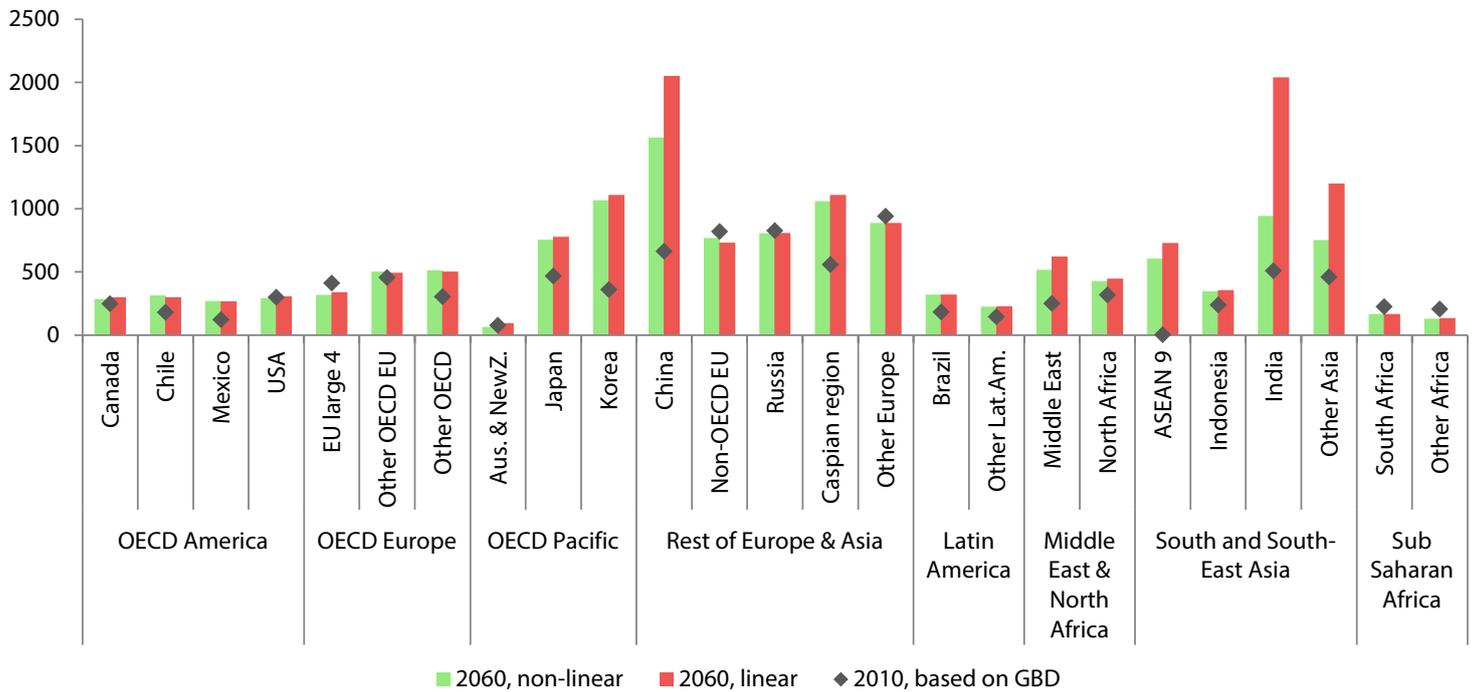
Source: TM5-FASST model, based on projections of emissions from the ENV-Linkages model.

# 3 Impacts on health and on agricultural productivity

The most worrying and striking impact of air pollution is the large number of premature deaths (Figure 5). The number of premature deaths due to outdoor air pollution is projected to increase from 3 million people globally in 2010 to a global total of 6 to 9 million people in 2060 (considering a non-linear and a linear concentration-response function respectively). This large increase is not only due to higher concentrations of PM<sub>2.5</sub> and ozone, but also to an increasing and aging population and to urbanisation, which leads to higher exposure.

The number of premature deaths is unequally distributed across the world. The highest number of deaths takes place in non-OECD economies and particularly in China and India. These regions also experience the highest increase in the number of premature deaths to 2060. A smaller increase is projected in OECD countries, with the number of premature deaths increasing from around 430 thousand people in 2010 to around 570-580 thousand in 2060, with the most significant increases projected in Japan and Korea.

Figure 5. **Premature deaths from exposure to particulate matter and ozone**  
 Projected number of deaths caused by outdoor air pollution per year per million people



The projected increasing concentrations of PM<sub>2.5</sub> and ozone will also lead to a higher number of cases of illness, which will imply more hospital admissions, health expenditures and sick or restricted activity days, which lead to labour productivity losses (Table 1).

The number of cases of bronchitis is projected to increase substantially, going from 12 to 36 million new cases per year for children aged 6 to 12, and from 3.5 to 10 million cases for adults. Children are also affected by asthma, with an increasing

number of asthma symptom days for children of age 5 to 19. These increasing cases of illness have been translated into an equivalent number of hospital admissions, which are projected to increase from 3.6 in 2010 to 11 million in 2060.

The additional cases of illness also lead to an impact on normal work activities. In 2060, lost working days at the global level are projected to be around 3.75 billion days. But there will also be an increasing number of (minor) restricted activity days.

Table 1. **Projected health impacts at global level**

	2010	2060
<b>Respiratory diseases (million number of cases)</b>		
Bronchitis in children aged 6 to 12	12	36
Chronic bronchitis (adults, cases)	4	10
<b>Asthma symptom days (million number of days)</b>		
Asthma symptom days (children aged 5 to 19)	118	360
<b>Healthcare costs (million number of admissions)</b>		
Hospital admissions	4	11
<b>Restricted activity days (million number of days)</b>		
Lost working days	1 240	3 750
Restricted activity days	4 930	14 900
Minor restricted activity days (asthma symptom days)	630	2 580

High levels of concentration of pollutants, and particularly of ozone, also reduce crop yields and thus affect agricultural productivity. According to the TM5-FASST calculations, and in line with the larger literature, crop yields are projected to be negatively affected in all regions, with big

differences between regions and crops. In many regions, wheat and oil seeds are more affected than the other crops, with high losses in several OECD countries, including Japan, Korea and the USA for oilseeds.



# 4

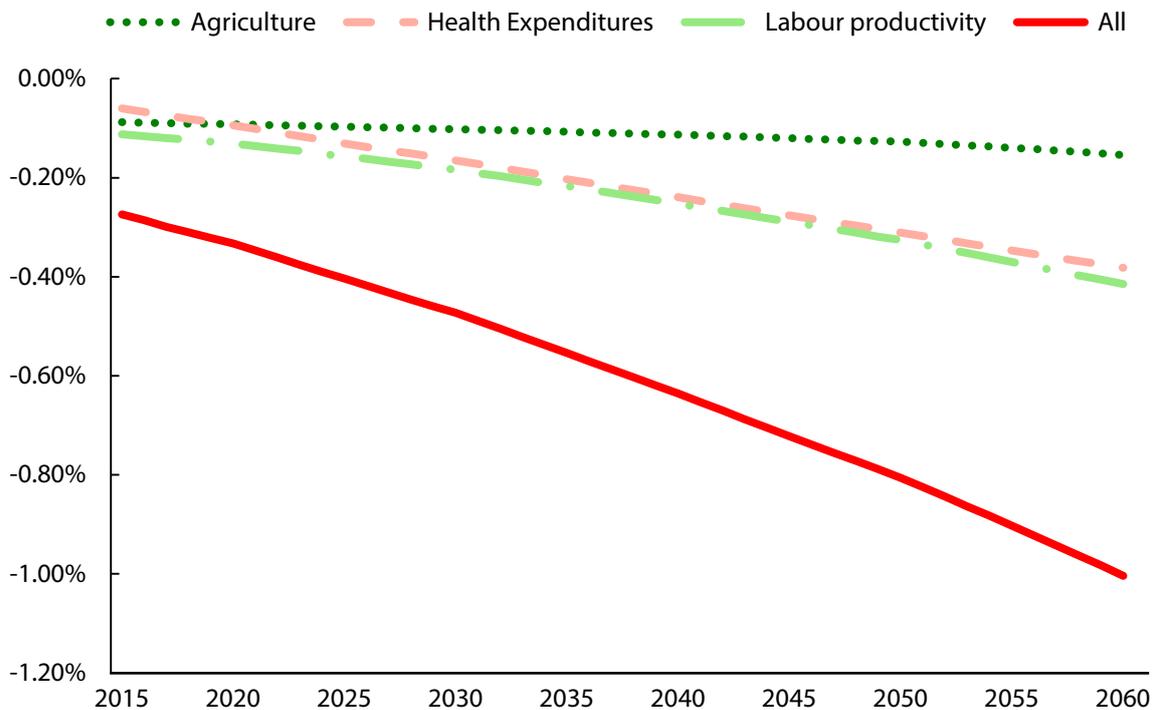
## The macroeconomic costs of outdoor air pollution

The three different market impacts of air pollution are: reduced labour productivity; increased health expenditures; and crop yield losses. They all contribute to a projection of GDP that is below the projection that excludes the pollution feedbacks on the economy (Figure 6). At the global level, the consequences of labour productivity and health expenditure impacts continue to

increase significantly relative to GDP. In contrast, agricultural impacts are relatively stable over time in percentage of GDP, i.e. in absolute terms these impacts grow more or less at the same speed as GDP. Taken together, the total annual market costs of outdoor air pollution are projected to rise from 0.3% in 2015 to 1.0% by 2060.

Figure 6. Attribution of macroeconomic consequences to selected climate change impacts, central projection

Percentage change, central projection w.r.t. no-feedback projection



Source: ENV-Linkages model.

The total market costs include both direct and indirect costs (Figure 7). The direct market costs comprise (i) the change in value added generated in all sectors from changes in labour productivity; (ii) the increased health expenditures; and (iii) the change in value added generated in agriculture from changes in crop yields. The indirect economic

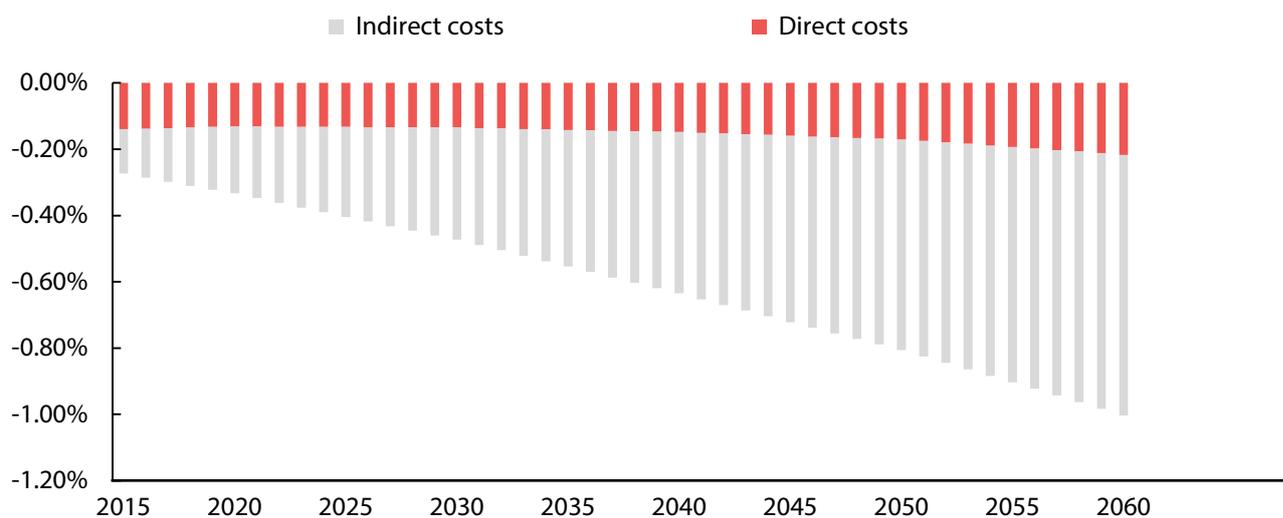
effects come from reallocation of the factors of production across the economy, changes in international trade and changes in savings, as they are induced by changes in relative prices. There is a clear difference between the direct and indirect costs: while the direct costs increase more or less at the same pace as economic activity (i.e. the costs

in percent of GDP is roughly stable), the indirect costs rapidly increase over time. Two important mechanisms play a key role: (i) any negative impact on capital accumulation has a permanent effect as

it lowers the growth rate of the economy; and (ii) as the shocks become larger over time, the cheapest adjustment options are exploited first, and further shocks need to be absorbed at higher costs.

Figure 7. **Direct versus indirect costs over time**

Percentage change, central projection w.r.t. no-feedback projection



Source: ENV-Linkages model.

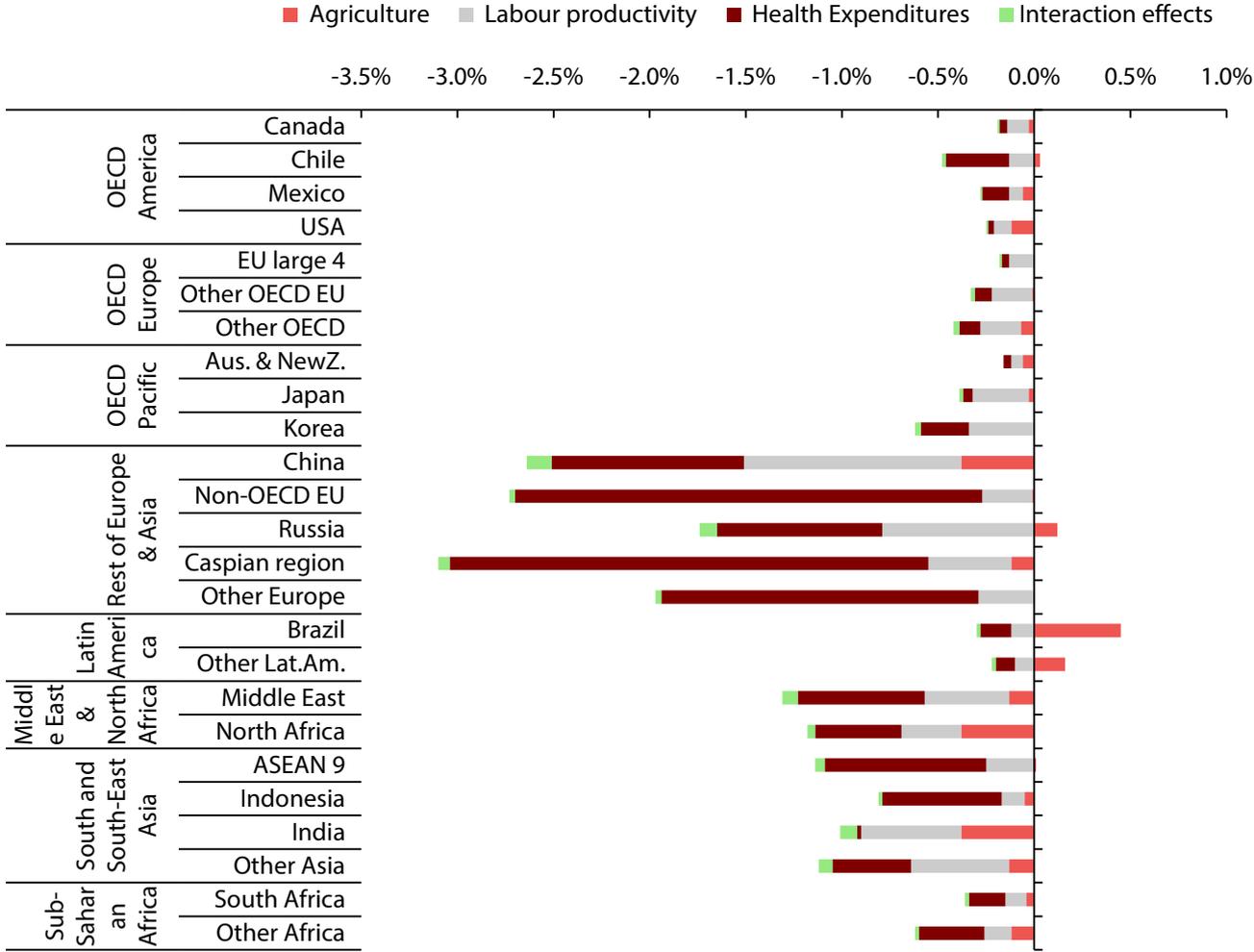
At the regional level, the projected losses are by far the largest in the Rest of Europe and Asia region, which includes China and Russia (Figure 8). Not only are the concentrations projected to be very high in this region, the impacts on labour productivity and especially health expenditures are significantly larger than in other regions. The situation is quite different in India. Projected 2060 GDP losses in India are much smaller than in China, despite both countries having projections of very high concentrations. One key difference between the two countries is the age structure of the population: India has a much younger population, while aging is projected to become a more severe problem in China. This means that the Chinese population structure in the coming decades is more vulnerable to air pollution, so that for example the additional health expenditures are higher in China than in India. Furthermore, the savings profile of India is significantly different compared with that of China (current savings and investment rates are substantially larger in China, while in the longer run the opposite is true), which imply a different response to a reduction in income or increased expenditures.

Large macroeconomic costs also occur in the Middle East and North Africa and South- and South-East Asia. North Africa is affected by all three market impact categories, while in the Asian regions, one particular impact tends to dominate (labour productivity for India, health expenditures for the ASEAN economies). The projected macroeconomic costs are smaller in the OECD regions, Africa and the Americas.

The effects of the three different impact categories cannot just be added up to calculate an overall effect of the market impacts of air pollution on economic growth as there are interaction effects that need to be taken into account. In theory, these interaction effects can be both positive and negative. In the projection with all impact categories, the overall GDP loss is larger than the sum of the three individual losses. At the global level this effect is minor (less than 0.1% of GDP in 2060), but for the most affected regions, it can increase GDP losses more significantly.

Figure 8. **Change in regional GDP from combined market impacts, central projection**

Percentage change, central projection w.r.t. no-feedback projection



Source: ENV-Linkages model.



# 5 Welfare costs of mortality and illness

It is possible to attribute a cost to non-market impacts, such as the premature deaths and the costs of pain and suffering from illness, 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). This is a long-established metric, which can be quantified by aggregating individuals' WTP to secure a marginal reduction in the risk of premature death over a given timespan. The VSL values used are calculated using a reference OECD value of 2005 USD 3 million and then using benefit transfer techniques to calculate country-specific values following OECD (2012). This is done on the basis of country-specific income adjustments, with an income elasticity of 0.8 for high-income countries, 0.9 for middle-income countries and 1 for low-income countries.

The costs at global level are projected to be close to USD 3.2 trillion in 2015 and increase to USD 18-25

trillion in 2060 (Table 2). That is a six- to eightfold increase, which is driven by the increasing number of premature deaths at global level (caused by changes in demographic and concentration trends) and by increasing VSL (following income growth especially in emerging and developing countries).

Welfare costs from premature deaths are by 2060 projected to more than double in OECD countries, going from USD 1.4 trillion in 2015 to USD 3.4- 3.5 trillion in 2060. Nevertheless, larger costs are estimated for non-OECD economies, where they amount to almost USD 1.7 trillion in 2015 and are projected to increase roughly tenfold to reach USD 15-22 trillion in 2060. That is due to the high and rising number of premature deaths in China and India, as well as the projected increase in income in these countries, which leads to higher values associated with each premature death.

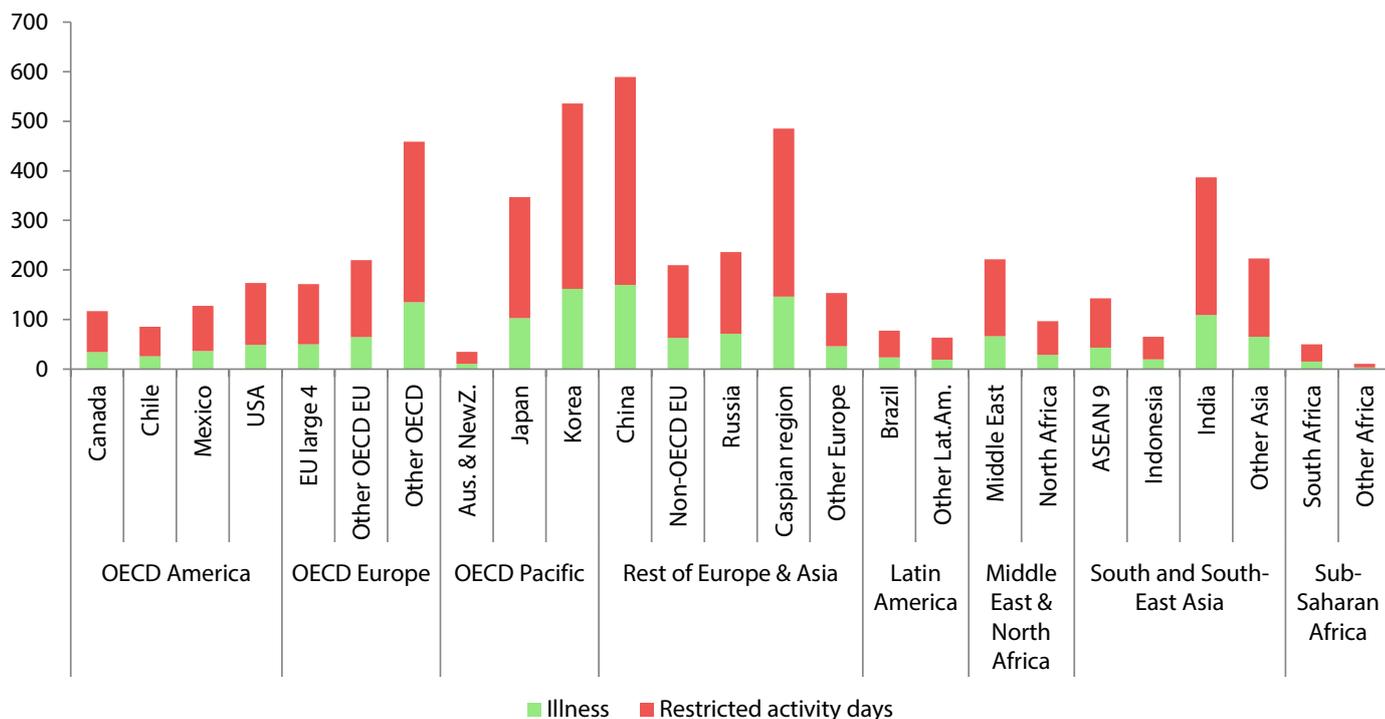
Table 2. **Welfare costs from premature deaths due to air pollution, central projection**  
Billions of USD, 2010 PPP exchange rates

	2015	2060
OECD America	440	1 100 - 1 140
OECD Europe	730	1 660 - 1 690
OECD Pacific	250	680 - 710
Rest of Europe & Asia	1 130	7 730 - 9 850
Latin America	80	470
Middle East & North Africa	110	1 030 - 1 180
South and South-East Asia	380	5 300 - 9 950
Sub-Saharan Africa	40	330 - 340
World	3 160	18 300 - 25 330
OECD	1 420	3 440 - 3 540
Non-OECD	1 740	14 860 - 21 790

Large costs can also be associated with the pain and suffering from illness (Figure 9). The per-capita welfare costs from illness, as broken down into different categories: the costs relative to restricted activity, hospital admissions, and illness. The largest welfare costs come from the restricted activity days, which cause disruptions of normal activities, followed by chronic bronchitis in adults. At the global level, welfare costs from non-market impacts of morbidity are estimated to be USD 280 billion in 2015 and USD 2.2 trillion in 2060.

The regions with the highest per capita costs are China, followed by Korea, Eastern Europe and the Caspian region. These are regions in which the number of cases of illness per capita is highest. Interestingly, Korea and China have similar results, especially for chronic bronchitis in adults. The projected number of cases of chronic bronchitis is higher in China than in Korea (almost 3 million cases in China and 260 thousand cases in Korea in 2060). However, when calculating per capita costs the size of the population matters and it is much higher in China. Further, the value attributed to a single case of adult bronchitis is lower in China than in Korea.

Figure 9. **Welfare costs from illness due to outdoor air pollution, central projection**  
(USD per capita, 2010 PPP exchange rates, 2060)





# 6 Comparing market and non-market costs

The market costs calculated in the general equilibrium model can also be expressed in terms of welfare (using the equivalent variation of income).

The annual welfare costs of the different market impacts in the OECD add up to USD 90 billion in 2015, and USD 390 billion by 2060 (Table 3). That reflects 0.3% and 0.5% of income (as measured in GDP per capita), respectively; or USD 70 and

USD 270 per capita. At the global level, the numbers are larger, both in absolute terms and as percentage of income, and rising much more rapidly over time: while in 2015 the average welfare costs of the market impacts per person are lower in non-OECD countries than in the OECD region, by 2060 they are substantially higher in non-OECD economies, reaching 1.5% of income at global level.

Table 3. Total welfare costs of air pollution, central projection

	OECD		World	
	2015	2060	2015	2060
<b>TOTAL market impacts (billions USD)</b>	90	390	330	3 300
Share of income (percentage)	0.3%	0.5%	0.6%	1.5%
Per capita (USD per capita)	70	270	50	330
<b>TOTAL non-market impacts (billions USD)</b>	1 550	3 750 - 3 850	3 440	20 540 - 27 570
Share of income (percentage)*	5%	5%	6%	9 - 12%
Per capita (USD per capita)	1 210	2 610 - 2 680	470	2 060 - 2 770

\* Welfare costs from non-market impacts are not related to expenditures and therefore not an integral part of the calculation of income; the expression of these welfare costs as share of income is therefore only for illustrative purposes.

For the OECD as a whole, the annual welfare costs related to non-market health impacts of outdoor air pollution amount to almost USD 1.6 trillion by 2015, and rise to USD 3.8-3.9 trillion in 2060, of which more than 90% stem from the welfare loss of premature deaths. At the global level, the costs are projected to be USD 3.4 billion in 2015 and are rising more rapidly, reaching USD 20.5-27.6 trillion by 2060.

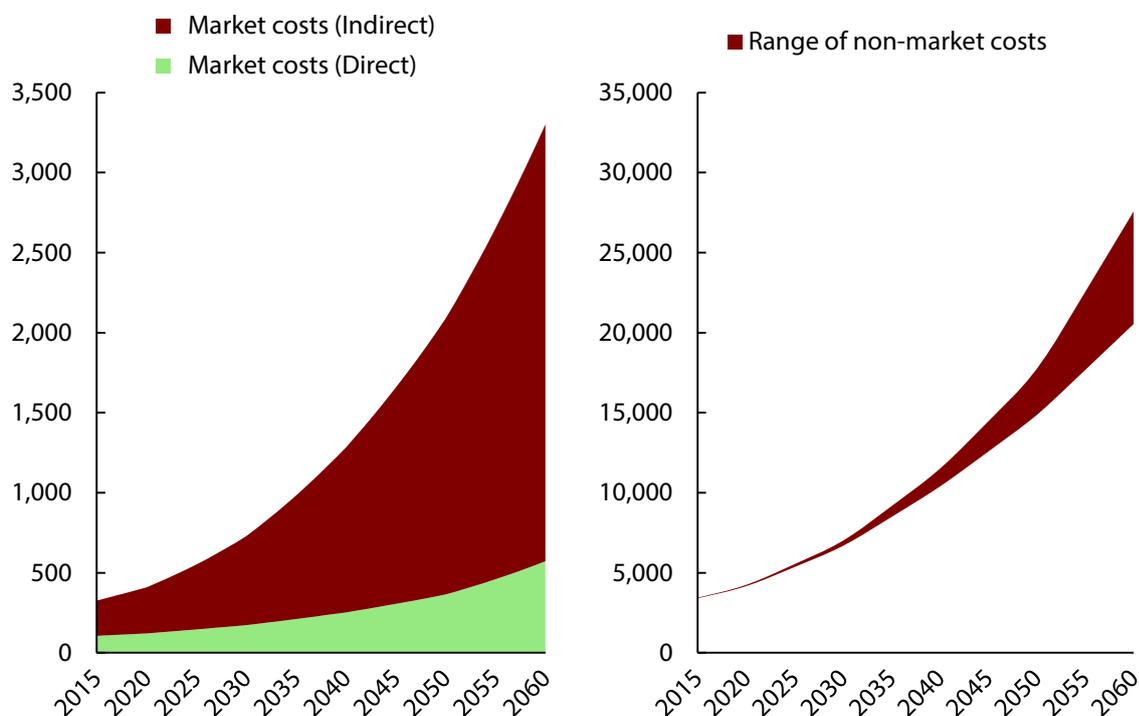
These welfare costs from non-market impacts are not related to expenditures or tradable goods; they can therefore not be directly compared with macroeconomic indicators such as GDP.

In 2015, the per-capita welfare costs of outdoor air pollution for non-market impacts are higher in OECD countries than in the emerging and developing countries: around USD 1 200 per capita for the OECD, and less than USD 500 per capita for the world. By 2060, the situation is changed, despite continued population growth in developing

countries: per capita costs in the OECD region are projected to rise modestly to USD 2 610-2 680, whereas they increase to USD 2 060-2 770 globally.

While it is clear that by far the largest cost component is the welfare loss from premature deaths, indirect economic consequences as induced by the various market impacts have an increasingly important role (Figure 10). In the short- and medium term, indirect economic repercussions tend to be of the same order of magnitude as the direct market impacts. But in the long run (2060), the induced economic consequences of air pollution will outweigh the direct effects of the various market impacts, not least due to the long-term consequences of a slowdown of economic growth. Ignoring these indirect economic consequences can lead to a significant miscalculation of the morbidity costs of air pollution.

Figure 10. Evolution of the welfare costs of air pollution over time, central projection  
Billions of USD, 2010 PPP exchange rates



# 7 Policies to reduce air pollution

The welfare gains of policies that avoid premature deaths and illness are potentially very significant. However, there is no one-size-fits-all recipe for reducing the impacts of air pollution as there are large differences among countries in terms of prevalent pollutants and sources. The implementation of policies that reduce pollution levels will certainly address and reduce the biophysical as well as the economic costs of air pollution. These can include incentivising or requiring the adoption of end-of-pipe technologies that can reduce pollution or of cleaner technologies, especially for energy combustion, as well as implementing air quality standards, automobile emission standards, fuel quality standards, and emission taxes, among others.

Human exposure to air pollution has a spatial dimension because both population density and the resulting pollutant concentrations vary over space. This creates a role for effective local policies, aiming at reducing pollution levels in highly populated areas. But even if air pollution mostly has local and regional consequences, it is also a global problem. Several pollutants and

small particles such as PM can be transported by winds and have impacts in regions and countries other than the ones where they have been emitted. Further, air quality is deteriorated in almost all major regions of the world, and international linkages between countries, not least through international trade, mean that changes in consumption patterns in one country affect emission levels in others. Global solutions are also needed to develop less polluting technologies, and a global transformation of the energy system is an essential part of any cost-effective policy response.

Further, there are strong interactions with a wide variety of other policy domains. Policies that stimulate energy efficiency reduce emissions of air pollutants and greenhouse gases. Implementing air pollution policies would lead to immediate benefits thanks to an improved air quality and even stronger benefits in the long term, with the addition of reduced impacts from climate change. But in some cases there are trade-offs between different policy objectives. A co-ordinated policy mix among different environmental issues is therefore essential.



## FOR FURTHER INFORMATION

OECD (2016), The economic consequences of outdoor air pollution, OECD Publishing, Paris.

OECD (2015), The economic consequences of climate change, OECD Publishing, Paris.

OECD (2012), OECD Environmental Outlook to 2050: the consequences of inaction, OECD Publishing, Paris.

### The economic consequences of outdoor air pollution on the web:

[www.oecd.org/environment/circle.htm](http://www.oecd.org/environment/circle.htm)

[www.oecd.org/environment/modelling.htm](http://www.oecd.org/environment/modelling.htm)

[www.oecd.org/environment/the-economic-consequences-of-outdoor-air-pollution-9789264257474-en.htm](http://www.oecd.org/environment/the-economic-consequences-of-outdoor-air-pollution-9789264257474-en.htm)

## CONTACT

*Elisa Lanzi, Policy Analyst, [elisa.lanzi@oecd.org](mailto:elisa.lanzi@oecd.org)*

*Rob Dellink, Co-ordinator Modelling and Outlooks, [rob.dellink@oecd.org](mailto:rob.dellink@oecd.org)*

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