Chapter 4

Consequences of outdoor air pollution for economic growth

This chapter presents the results of the numerical simulations with the ENV-Linkages model on the macroeconomic costs of outdoor air pollution. It first presents the results relative to each impact considered in the report, and then it illustrates results of the impacts as considered together. The focus of this chapter is on market impacts, and macroeconomic costs, but the chapter also investigates regional and sectoral consequences. The results include both direct market impacts, such as those related to changes in crop yields, and indirect impacts, such as those related to the changes in international trade flows due to the regional changes in crop yields.

4.1. Economic consequences of specific market impacts

The market impacts described in Chapter 3 are treated as inputs into the economic modelling framework, ENV-Linkages, to assess how they affect economic activity in the different sectors and regions. Each impact is linked to a specific part of the economic system: lost working days are linked to labour productivity losses, additional health expenditures are linked to increases in demand for healthcare services by both governments and households, and agricultural yield impacts are linked to reduced productivity of agricultural production. The economic consequences are then assessed for the 2015-60 period.

4.1.1. Consequences of the labour productivity impacts

The lost working days related to poor health due to air pollution have a direct effect on labour markets through a reduction of labour productivity, and thus on the contribution of labour to gross domestic product (GDP). Labour supply effects are not included in the central projection, but investigated in an alternative specification in Section 4.3. Panel A of Figure 4.1 presents the change in regional GDP (expressed as deviation from the no-feedback projection) for the year 2060, decomposed into *(i)* the direct effect on labour (the productivity shock), *(ii)* an indirect effect on labour markets (induced effects on wages and the allocation of labour across sectors), *(iii)* an induced effect on capital markets (as capital accumulation adjusts to changes in households' savings) and *(iv)* a change in other components of GDP (including the change in tax revenues and the value added generated by land and natural resources). The direct productivity shock can be labelled as the direct costs of the market impact, whereas the other components together comprise the indirect market costs.

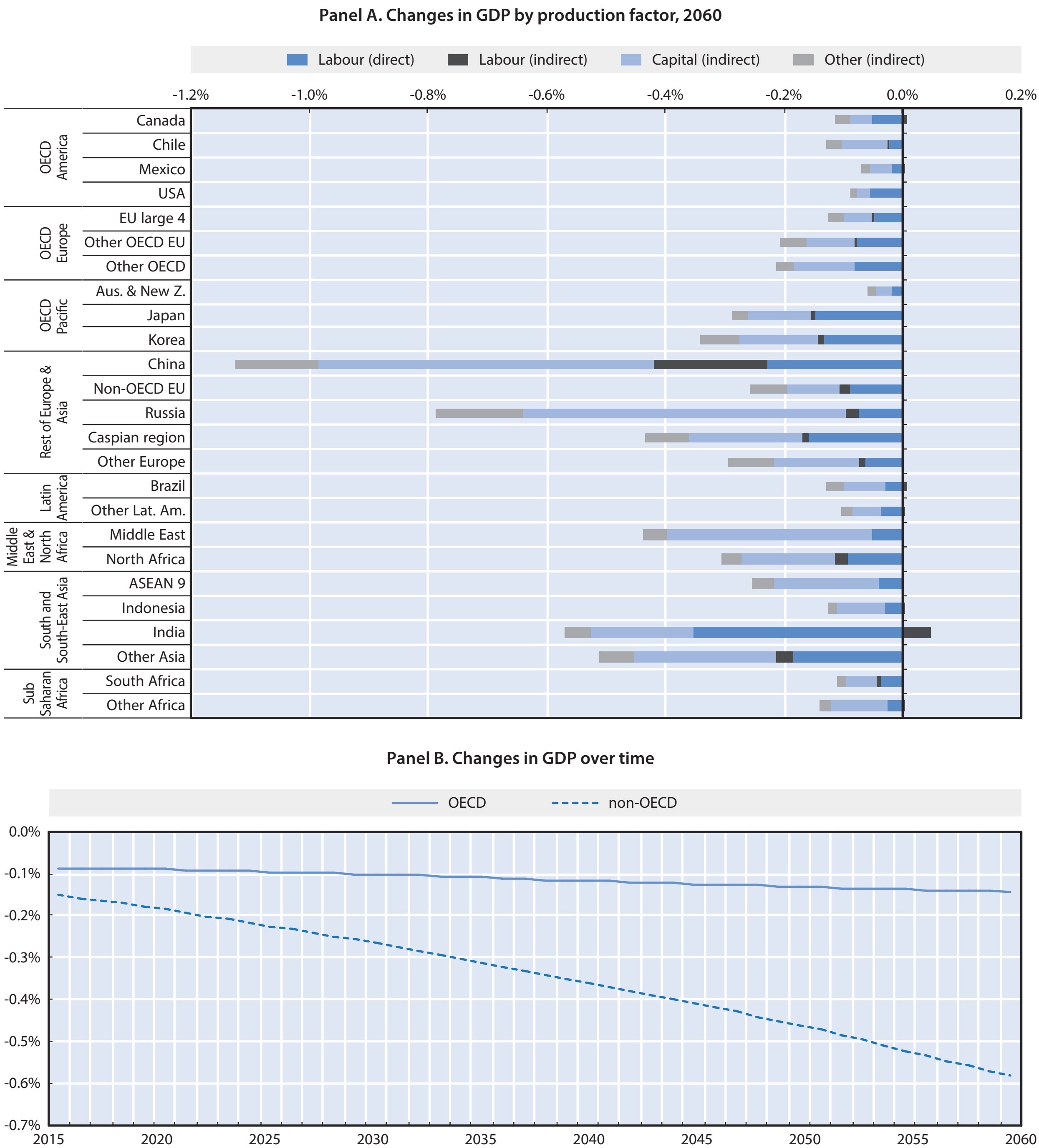
The direct effect of the labour productivity impacts is negative in all regions: air pollution lowers output per worker, and that lowers economic growth. Global GDP in 2016 is 0.1% below the projected level in the case of no feedbacks from outdoor air pollution on the economy. But this productivity shock leads to adjustments throughout the economy (components ii through iv), causing an overall GDP loss in 2060 of 0.4%. For instance, some labour will move from sectors where lower efficiency of labour can be offset by more capital use to sectors where the shock will be managed by employing more people. Demand patterns will also adjust to the changing production costs in the different sectors. But the slowdown in economic activity also induces a negative effect on the total value added generated by labour. As the productivity shock applies to all sectors of the economy, there is little room to accommodate the shock by reallocating labour between sectors. On balance, the indirect effect on labour remuneration as part of GDP is negative in most regions, but smaller than the direct effect (globally less than 0.1%, although the ratio between direct and indirect effect differs by region).[1]

For capital, the effect is negative, and becomes stronger over time. As wage income is reduced owing to the pollution impacts, households respond by reducing their expenditures, including their savings, making less capital available for investment and thus slowing down capital accumulation.[2] Therefore, the negative capital effect is especially large in regions where the income loss from the labour productivity shock is strong, e.g. the People's Republic of China (henceforth "China"), which has a total GDP loss of more than 1%. Interestingly, the capital effect is much smaller in India, even though India, like China, is also projected to be confronted with very large increases in concentrations and significant reductions in labour productivity. The key difference between the two regions is that in the current decade, the marginal propensity to save (and the capital intensity of production) is much smaller in India than in China. Hence, a reduction in income will mostly lead Indian households to reduce consumption, while in China it has a stronger effect on savings. In later decades, when savings rates in India are projected to rise, it will have benefited from the relatively small capital income loss in the first decades.

For the OECD countries, by 2060 the projected GDP losses are substantially smaller than in the big emerging economies. The strongest effects are projected to be in Japan and Korea. Especially Korea is projected to have significant ozone concentrations, almost as high as China and India. For $PM_{2.5}$ (which is dominant in the effect on labour productivity),

Figure 4.1. **Change in GDP from labour productivity impacts, central projection**

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



StatLink http://dx.doi.org/10.1787/888933357375

Source: ENV-Linkages model.

the average concentrations in Japan and Korea are, by 2060, significantly lower than in many non-OECD regions, but still higher than in other OECD countries. These higher concentrations translate into higher number of lost working days and thus a stronger labour productivity impact. But as Panel B of Figure 4.1 shows, the differences between the OECD and non-OECD regions become increasingly large in the coming decades. It is primarily the projected economic growth, and associated increases in air pollutant emissions and concentrations, that drive the larger GDP losses in later decades in non-OECD economies.

4.1.2. Consequences of the health expenditure impacts

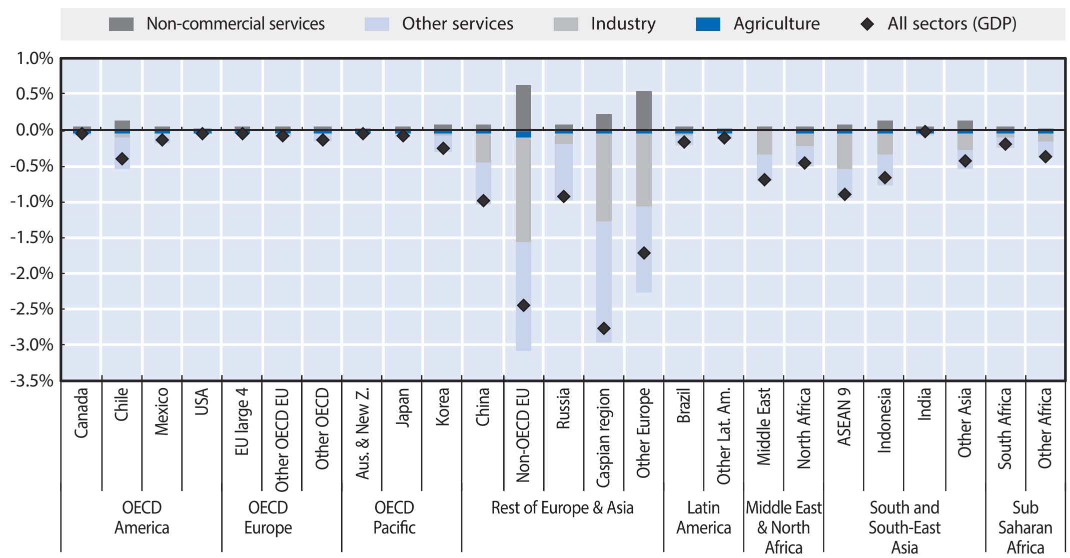
Health expenditure impacts of air pollution are in a different category from productivity shocks to agriculture or labour. They form a necessary expenditure by governments and households, i.e. an expenditure that is driven by the health impacts of outdoor air pollution rather than by a maximisation of welfare, which leads to reductions of other expenditures, i.e. they affect demand and not productivity.[3] The two possible responses to such a demand shock are to reduce spending on other goods and services (a crowding-out effect), or an increase in total expenditures (an expansion effect). As income is not unlimited, the expansion effect implies that households will limit savings and that governments will need to find a way to finance the expansion, e.g. through increased taxes. In the central projection, both mechanisms are allowed. Households will determine the least-cost mix of reduced consumption of other goods and services and reduced savings; government will not reduce the provision of other public goods and services, but finance the additional health expenditures through an increase in labour taxes (as a proxy for social security payments, following e.g. Vrontisi et al., 2016). Section 4.3 presents an alternative specification where the expansion effect is removed.

As shown in Figure 4.2, the biggest projected changes in health expenditures (and consumption of other non-commercial services, of which health is a part) are in the Rest of Europe and Asia region, which includes China, Russia, the Caspian region and most of Eastern Europe (not least Ukraine).[4] The Caspian and European regions in this group (Non-OECD EU and Other Europe) have a particularly large additional expenditure for pollution-related healthcare relative to other regions. Further, in these regions the share of health expenditures in total expenditures is lower than in OECD regions. Thus, changes related to additional health expenditures are accentuated as – for a given shock – the percentage increase in health spending is higher. Combined, this contributes to *(i)* a significant increase in the non-commercial services sector, and simultaneously *(ii)* a large reduction in consumption of other goods and services (see the corresponding bars in the Figure 4.2).

The effect on GDP follows these sectoral results. On average, the GDP loss in the Rest of Europe and Asia group equals 1.1% by 2060, against 0.4% for the world (not shown). Notably, the effects on the OECD regions is quite small, reflecting that in these economies the additional air-pollution-related health expenditures are on balance a significantly smaller share of total expenditures for both governments and households. In principle, additional expenditures for households have a tendency to lead to larger GDP losses than increased government expenditures, through the induced effect on savings and capital accumulation. Thus, although in many regions the majority of the health expenditures are borne by governments, the majority of the GDP loss can be attributed to additional household expenditures. But as the results for the Rest of Europe and Asia region shows, the minor effects from increased government expenditures only hold at the margin: as soon as the additional expenditures become non-marginal, they will also affect economic growth, not least through the increased tax burden on households that is needed to balance the government budget.[5]

Figure 4.2. **Change in value added and GDP from health expenditure impacts, central projection**

Percentage change w.r.t. no-feedback projection, 2060



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Note: The non-commercial services include health services.

Source: ENV-Linkages model.

4.1.3. Consequences of the agricultural yield impacts

The agricultural yield impacts, as discussed in Section 3.5, lead to a global reduction in the growth of agricultural output over time, i.e. agricultural production declines relative to the no-feedback projection. But given that food is a basic commodity, demand for agricultural products is not very price-elastic and overall crop production does not decline very much (-1.1% in 2060), as shown in Figure 4.3. The lower productivity of agricultural production and the associated increase in unit production costs induce both an intensification and extensification of production: in all regions, farmers aim to limit the negative consequences for production by putting more resources such as capital and fertiliser per unit of output (intensification), and – especially in regions where land is in ample supply (Africa and Latin America) – by converting more land to crop production (extensification). These responses tend to have negative environmental consequences: increased fertiliser use leads to higher emissions and can damage water quality, while conversion of land can have a negative effect on ecosystems and biodiversity, and lead to higher climate change impacts owing to land use and forestry changes. Given also the relatively small share of agriculture in total GDP, the macroeconomic costs of reduced yields as measured by percentage changes in GDP are very limited (-0.1% globally by 2060).

There are significant differences between the regions. Although increases in concentrations of ozone (the driver of the agricultural impacts) will be strongest in China and India (cf. Figure 3.7), the largest projected reductions in agricultural production are in some of the OECD regions, especially USA. The main reason for the strong projected reductions in the USA is that air pollution is already affecting production in the short run, and continues to put downward pressure on agricultural yields and output in the coming decades. In contrast, the consequences for agricultural production in China and India gradually build up over time. Furthermore, there are strong trade links in oilseeds between the USA and Latin America, especially Brazil, so that minor changes in competitiveness between Brazil and USA can translate into relatively large changes in the location of production.

Despite the negative yield impacts in all regions, some regions can increase their crop production beyond the no-feedback level. This effect is strongest in Chile, but also present in e.g. Brazil and the ASEAN economies. Relatively minor domestic yield losses, combined with large opportunities for expanding agricultural land, imply that the *relative* competitive position of these countries in the global crop market is improving vis-à-vis their main competitors. As already mentioned, these economic gains tend to go together with an increased pressure on the environment. This effect mimics similar consequences of yield losses from climate change, and is extensively discussed in OECD (2015) and OECD (2016), which dives into the analysis of how climate change affects trade flows and the revealed comparative advantage of countries.

As indicated in Figure 4.3, large changes in regional agricultural production do not necessarily imply correspondingly large changes in GDP. There are several ways in which GDP is affected by a sectoral shock such as the one on yields. First, in countries where agriculture is a relatively small part of total production, such as the USA, changes in agricultural production do not lead to very significant macroeconomic changes. Second, lower productivity of agriculture also leads to changes in production of other sectors (e.g. the food industry is confronted with higher input costs). Third, the changes in international trade patterns (and terms of trade) resulting from the different changes in agricultural conditions across countries in their agricultural sectors also affect GDP. Fourth, the induced effect of the lower productivity of the economy translates into lower income for households, and thus lower savings. This leads to lower investments and therefore a slow-down of capital accumulation that affects long-term economic growth. However, with a relatively small shock located in one specific sector this effect is limited. These mechanisms illustrate that all sectors and regions are connected to each other, and a shock to one particular part of the economy will have indirect consequences for other regions, other sectors and future time periods.

The largest macroeconomic costs can be found in China, North Africa and India. Furthermore, there are some regions where GDP impacts are negative while consequences for agricultural production are positive, as measured in Figure 4.3 by the total value added in agriculture. A complex set of interactions drives these results, the intensity of which varies between regions. A first explanation is reduced capital accumulation. The lower capital stock hurts all sectors, and especially capital-intensive industries. This is at least partially driven by the fact that these regions are more open to international trade. Hence, a shock to their agricultural system cannot be absorbed domestically, their terms-of-trade deteriorate and their total activity level is lower. Further, some of these regions respond to the agricultural shock by intensifying agricultural production, and when land is abundant, as in the case of e.g. Other Africa, these economies can also resort to extensifying, i.e. increasing agricultural land use. Since agricultural products are necessary goods, with relatively inelastic demand, these regions face negative agricultural shocks by drawing resources away from the rest of the economy. While this may hurt the overall productivity of the economy, it makes sense from the perspective of food security and the basic goods nature of food.

Figure 4.3. **Change in value added and GDP from agricultural impacts, central projection**

Percentage change w.r.t. no-feedback projection, 2060

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Source: ENV-Linkages model.

4.2. Economic consequences of the combined market impacts

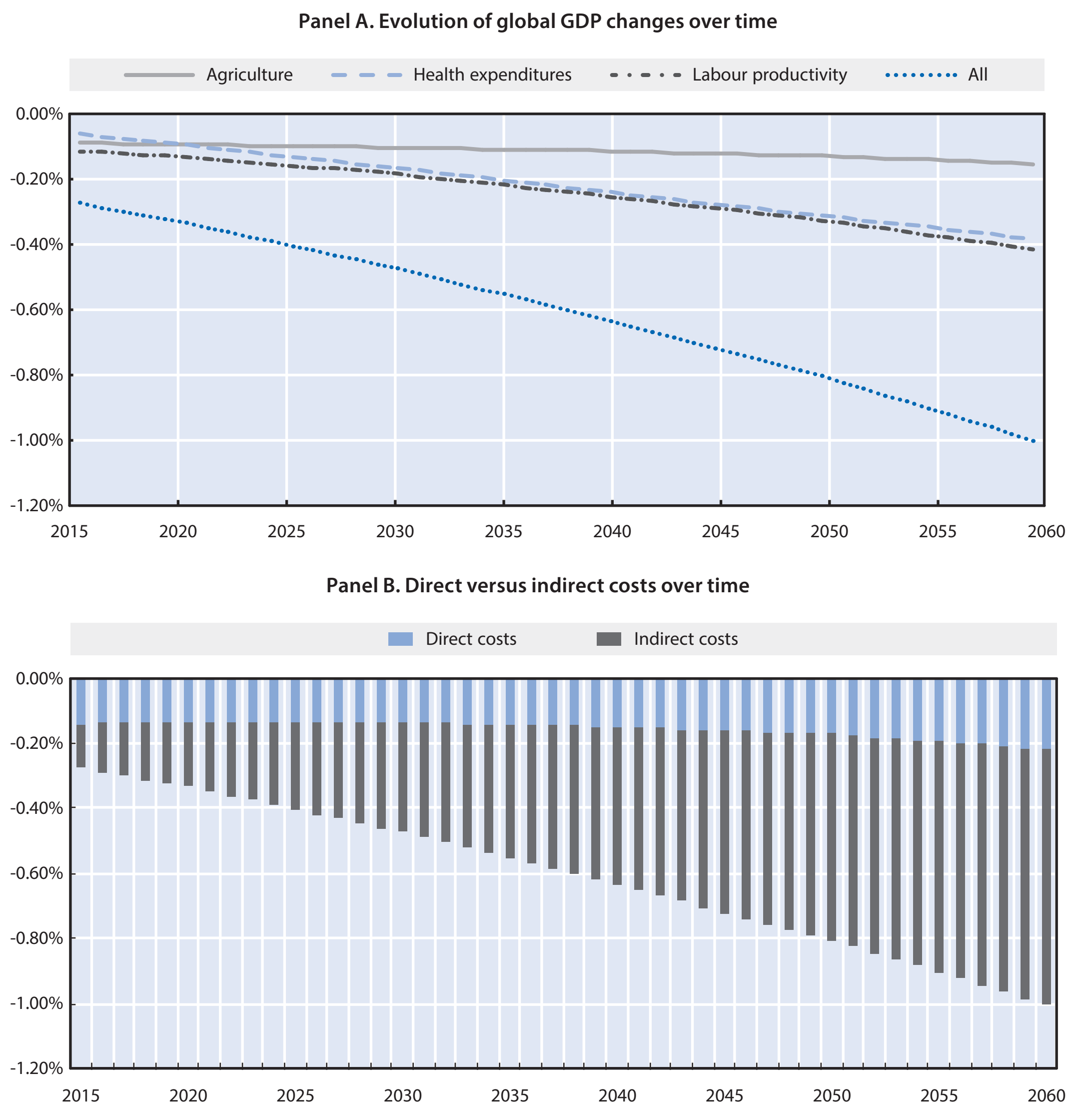
4.2.1. Macroeconomic consequences of the combined market impacts

The three different market impacts of air pollution discussed in Section 4.1 all contribute to a projection of GDP that is below the "naïve" no-feedback projection that excludes the pollution feedbacks on the economy. Panel A in Figure 4.4 summarises how these three impacts evolve over time in terms of percentage changes in global GDP levels from the no-feedback projection. 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.

Panel B of Figure 4.4 presents a different way of decomposing the total market costs of outdoor air pollution. The *direct market costs* can be calculated as the sum of the direct economic effects as implemented in the model. This comprises *(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. All these direct costs are measured without taking reallocation of economic resources into account. The *indirect economic effects* can then be deduced as the total macroeconomic costs, i.e. the change in GDP, minus the direct costs. These indirect effects come from reallocation of the factors of production across the economy and e.g. changes in savings rates, and are induced by changes in relative prices. There is a marked 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 options are exploited first, and further shocks need to be absorbed at higher costs.

Figure 4.4. **Change in global GDP from combined market impacts, central projection**

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



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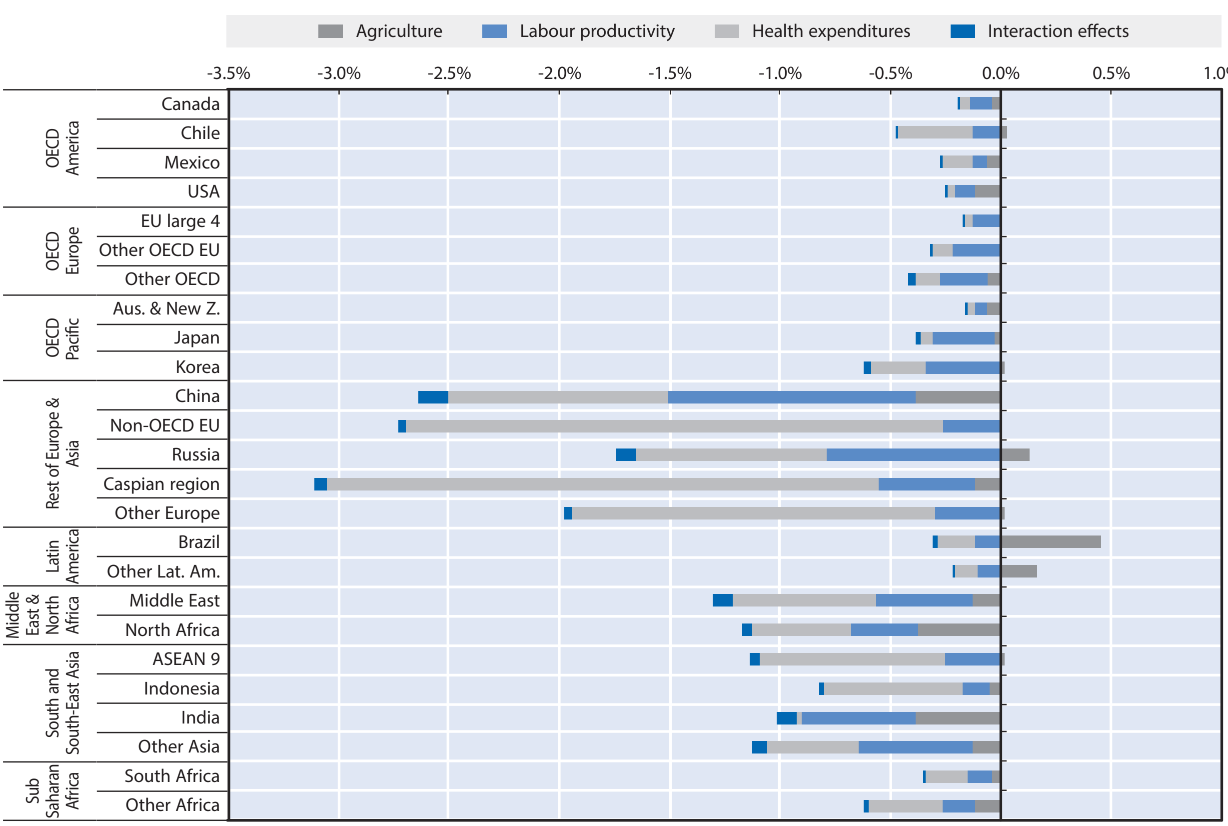
Source: ENV-Linkages model.

At the regional level, it is not surprising that the projected losses are by far the largest in the Rest of Europe and Asia region, which includes China and Russia (Figure 4.5). 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.[6] 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 (cf. Figures 3.6 and 3.7). 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, as discussed in Section 4.1, 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 take place 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.

Figure 4.5. **Change in regional GDP from combined market impacts, central projection**

Percentage change w.r.t. no-feedback projection, 2060



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Source: ENV-Linkages model.

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. On the one hand, economic consequences tend to be more than proportionally larger for larger shocks, due to the multiplier effect (i.e. that lower income leads to lower savings and thus to lower capital accumulation and lower future income). Thus, combining the different effects may worsen total GDP loss. On the other hand, by combining different shocks into the economic system, a new optimal adjustment process and reallocation of resources may lead to lower costs when combining all impacts. In the projection with all impact categories, the negative effect of having larger distortions of consumption and production possibilities dominates, and 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.

These effects on economic activity in turn affect emissions of air pollutants. In principle, one should account for these reductions and re-assess the concentration levels and impacts of air pollution until convergence is reached between all steps in the causal chain. However, the reductions in economic activity are fairly limited, and hence emissions levels as projected in the central projection with pollution feedbacks differ less than 1% at the global level from those in the no-feedback projection (and less than 4% at the regional level). Therefore, the second-order effect of lower emission projections on concentrations and impacts is very small, and can be ignored in the light of the uncertainties surrounding all calculations in this report.[7] In other words, there is no need to iterate back from the central projection to revise the no-feedback projection of economic activity and emissions (cf. Section 2.2).

4.2.2. Linking air pollution and climate change

The projected increase in air pollutant emissions also has an effect on climate change. Some air pollutants have a cooling effect (aerosols such as organic carbon), while others are relatively strong near-term climate warmers (esp. black carbon and ozone). To study the interactions between outdoor air pollution and climate change in the projections, radiative forcing have been calculated using the MAGICC6.4 model (Meinshausen et al., 2011). In the no-feedback projection, the aerosols have a direct global *cooling* effect that is projected to increase from 0.4 W/m^2 to 0.5 W/m^2 (excluding indirect effects from induced cloud albedo), while tropospheric ozone has a *warming* effect of similar magnitude. On balance, the contribution of air pollutants to climate change is therefore limited.

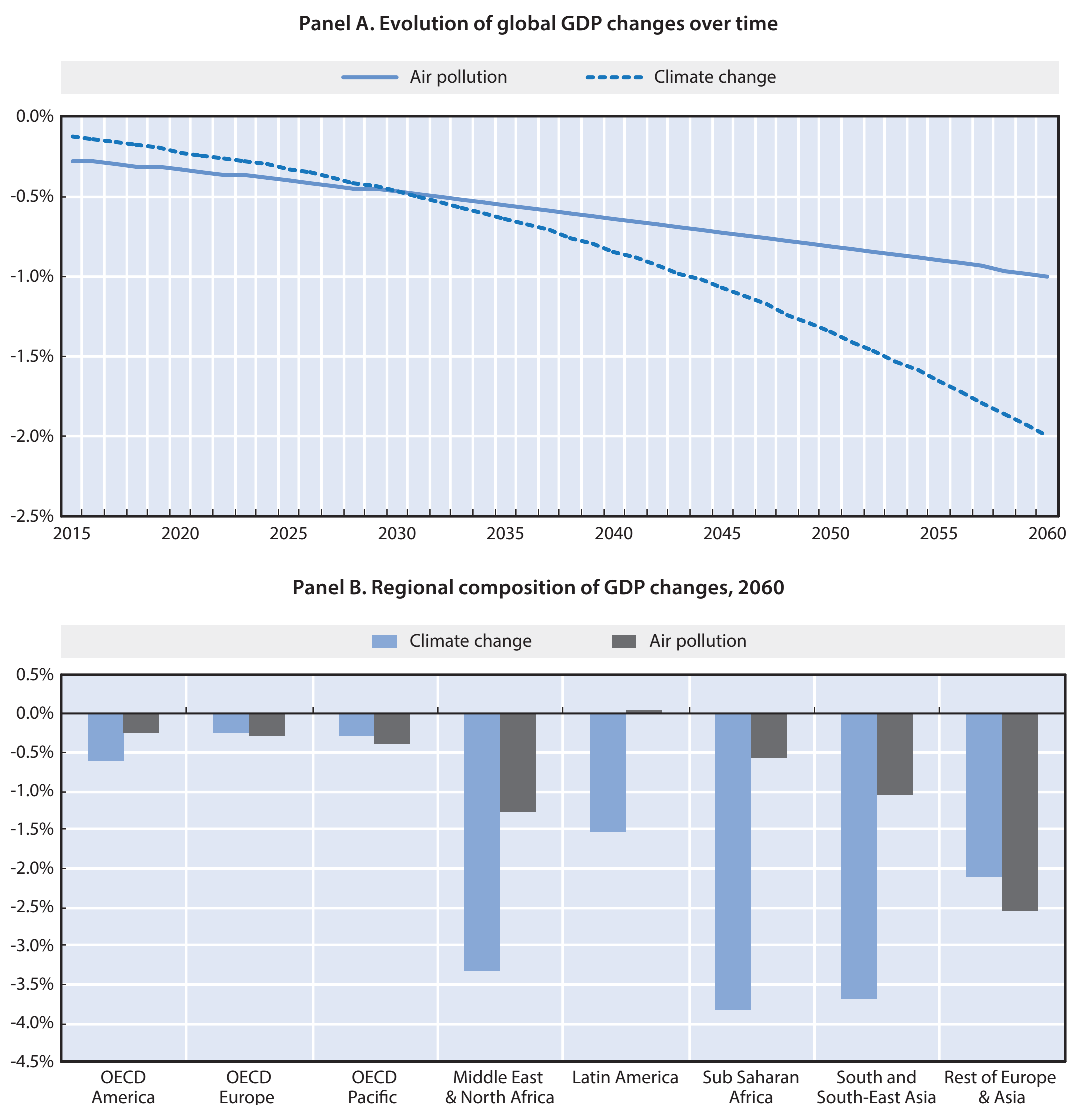
The economic feedbacks of outdoor air pollution slow down economic activity around the world, and thus lead to lower global greenhouse gas emissions. However, the effect is fairly minor: less than 1.5% for global emissions, and in all regions less than 4% for carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The resulting reduction in climate impacts is not significant. Reversely, climate damages also have very limited effects on emissions of air pollutants, ranging at the global level from a reduction by 5.5% for NH_3 to an increase of 0.5% for SO_2 according to the projections in OECD (2015).

The interaction effects between climate and air pollution damages may be stronger at the sectoral level, for instance in agriculture. There are also interaction effects on the policy side: reducing the polluting economic activities for air pollution will have significant climate co-benefits. Similarly, mitigation efforts for climate change and air pollution affect emissions of all pollutants; in some cases there are important synergies (e.g. from improvements in energy efficiency), while in other cases trade-offs dominate (e.g. air pollutant capture techniques that reduce the efficiency of power generation). These linkages should be investigated in a comprehensive, integrated manner, but such a study of the multiple benefits of policy action is beyond the scope of this report.

The report *The Economic Consequences of Climate Change* (OECD, 2015) contains a related exercise on the costs of inaction for climate change. It provides a detailed global quantitative assessment of the macroeconomic and sectoral consequences of climate change (i.e. climate damages) for a selected number of impacts: changes in crop yields, loss of land and capital due to sea level rise, changes in fisheries catches, capital damages from hurricanes, labour productivity changes and changes in healthcare expenditures from diseases and heat stress, changes in tourism flows, and changes in energy demand for cooling and heating. It uses the same baseline projection and a very similar production-function methodology.

Figure 4.6. **Outdoor air pollution and climate change impacts, central projection**

Percentage change in GDP w.r.t. no-feedback projection



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Source: ENV-Linkages model.

There is a much wider literature on the economics of climate change (see OECD, 2015, for an overview). Most directly comparable is the work at JRC-IPTS, that have used similar methodologies to assess the economic consequences of climate change (Ciscar et al., 2011, 2014) and air pollution (Vrontisi et al., 2016).

An important caveat is that, as with the assessment of the economic consequences of air pollution, some of the major consequences do not directly affect markets and could not be accounted for in the modelling framework. The main rationale for policy action on climate change does not come from the market impacts, but rather from the sizable downside risks of tipping points and very severe impacts. Nonetheless, a comparison of the market consequences of climate change and air pollution can help shed light on how these two environmental issues affect economic activity.

In the first half of this century, the order of magnitude of the projected global market costs of air pollution is similar to that of climate change (Figure 4.6). But the time profile of both sets of impacts is very different: air pollution has a stronger effect on the economy in the coming decades, while climate change damages gradually ramp up and become much more significant in the second half of the century. The downside risks of climate change also seem substantially larger, although a proper assessment of the uncertainties surrounding the air pollution damages is not possible owing to a lack of reliable information. Interestingly enough, climate change and air pollution affect the economy through some of the same main channels (labour productivity losses, agricultural yield losses and demand shocks), even if due to different biophysical impacts. But climate change is projected to have more far-reaching macroeconomic consequences and affects a wider set of economic activities, not least capital stocks, directly.

There are also important differences in the geographical distribution of the market costs. OECD (2015) concluded that for climate change even with adaptation “net economic consequences are projected to be […] especially large in Africa and Asia, where the regional economies are vulnerable to a range of different climate impacts, such as heat stress and crop yield losses”. In comparison, the economic consequences of air pollution are much more concentrated in highly populated areas like in Europe and especially in Asia. The position of China and India is also reversed: while climate change impacts are particularly threatening to India, air pollution impacts are larger in China. For geographical reasons, large parts of the OECD are also more affected by air pollution than by climate change, especially in the coming decades.

4.3. Alternative specifications of the market impacts

Applied economic models are based on a series of equations that try to reproduce characteristics of the structure and functioning of the economy. A number of assumptions are needed to set up the modelling frameworks. The modelling assumptions used to model the market impacts of outdoor air pollution reflect the state of the art in the literature (see Vrontisi et al., 2016), but they are still modelling choices and as such influence the results.

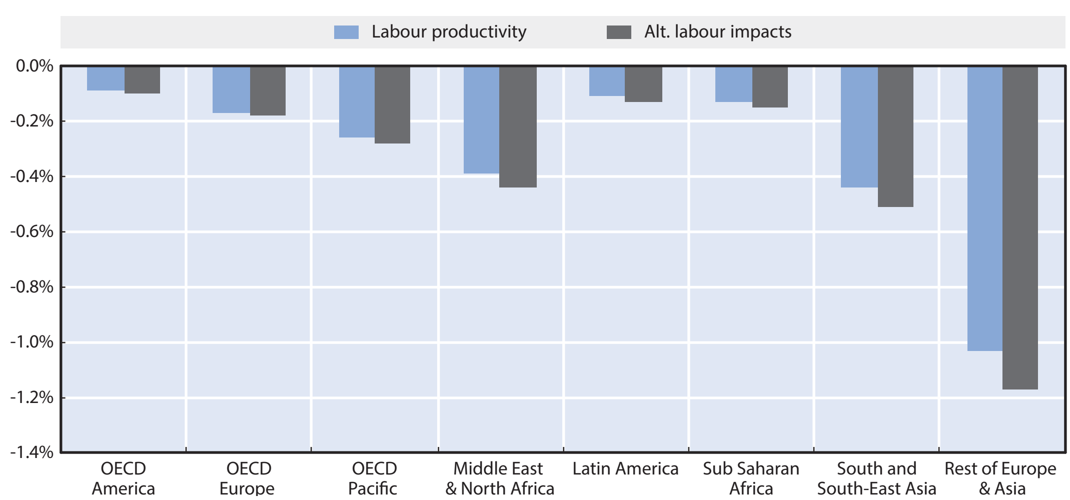
This section presents a sensitivity analysis of the results of the market impacts of outdoor air pollution to alternative specifications of the different impacts considered. For the labour market impacts, the central projection only considers the effect of lost working days on labour productivity. Section 4.3.1 presents an alternative specification in which labour supply changes due to premature deaths are also considered. The health expenditure impacts are modelled in the report assuming that households will adjust their consumption levels and that governments will increase their budget to finance the increase in health expenditures through higher taxes on labour. In the alternative specification presented in Section 4.3.2 it is assumed that households and governments will crowd out other expenditures. Finally, Section 4.3.3 presents alternative specification of the impacts of crop yield changes considering the uncertainty ranges relative to the biophysical impacts.

4.3.1. Alternative specification of labour market impacts

The analysis of labour market impacts in the central projection is only based on the direct effect of lost working days on labour productivity and the indirect effects as they emerge in the economy. As an alternative specification, an additional labour supply effect is calculated, by using the premature deaths in the working age population as a shock to labour supply. This additional effect does not aim to resemble a welfare assessment of these premature deaths, but limits itself to identifying the consequences for the economic system through reduced supply of labour. There are several indirect effects that could be taken into account (e.g. lower aggregate consumption due to the decrease in population size or demographic consequences for future generations due to lower births). The net consequence of these effects is not a priori clear and cannot be easily assessed numerically without further examination. Hence, for illustrative purposes, only the direct labour supply effect of the linear projection of premature deaths is included in this alternative specification. The key results are summarised in Figure 4.7.

Figure 4.7. **Sensitivity of market costs to alternative labour market impacts**

Percentage change in GDP w.r.t. no-feedback projection, 2060



StatLink http://dx.doi.org/10.1787/888933357436

Source: ENV-Linkages model.

While the non-market welfare consequences of premature deaths are very large, the consequences of a smaller labour supply for GDP are minor. In all regions, the consequences of the reduced labour supply are projected to be well below 0.1% of GDP in 2060. This small effect on labour supply and associated GDP losses strengthens the insights from earlier studies (e.g. OECD, 2012) that the key element in an assessment of the economic costs of premature deaths lies in the valuation of the life lost, not in its repercussions in the rest of the economy (see also the discussion in Chapter 5).[8]

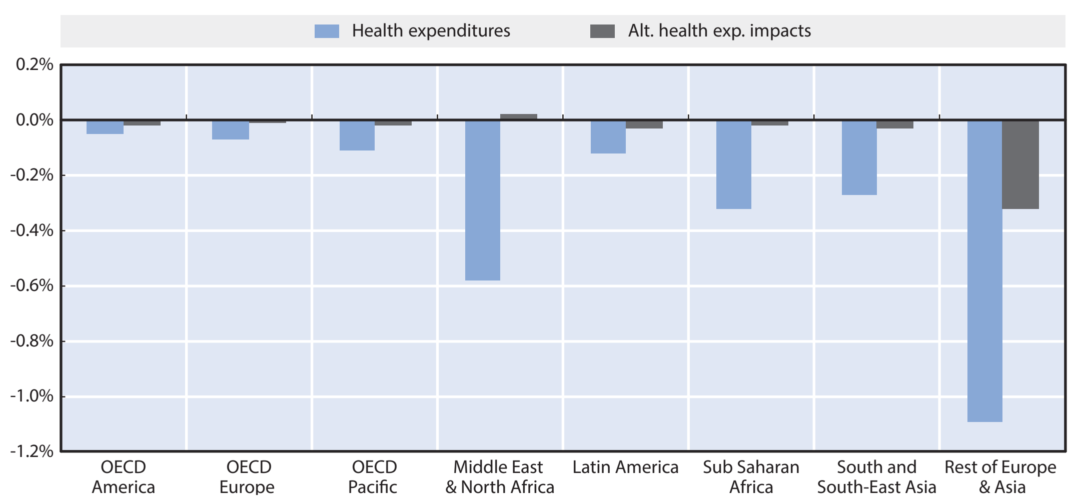
4.3.2. Alternative specification of health expenditure impacts

Modelling the response of households and governments to extra health expenditures owing to degradation in health is not straightforward. In the central projection, the assumption is made that households respond by adjusting the consumption levels of other (non-health related) expenditures as well as their savings. Governments are assumed to increase their budget to finance the increase through higher taxes on labour (reflecting the situation in some countries of increased health payments through the social security system). In the alternative specification, the assumption is made that both households and governments respond to the additional health expenditures by fully crowding out expenditures in other commodities. In this crowding out scenario households keep their savings unchanged, while governments keep their budget unchanged.

Figure 4.8 shows how the different regions are affected by the alternative assumption. When health expenditures fully crowd out other expenditures, the consequences of the air pollution impact on GDP levels tend to be significantly smaller. The reasoning is that agents shield the economy from multiplier effects that arise from reducing their savings or increasing their budget. Especially the assumption of fixing private savings to the no-feedback level implies that there is no induced slowdown of the economy through reduced investments and capital accumulation. However, these smaller consequences for GDP do not necessarily imply an improvement in well-being: additional savings come at the expense of consumption, and the government provision of non-health public goods is also reduced. The overall effect of these changes on well-being can unfortunately not be inferred from the modelling framework, which can only measure narrower indicators based on private consumption.

Figure 4.8. **Sensitivity of market costs to alternative health expenditure impacts**

Percentage change w.r.t. no-feedback projection, 2060



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Source: ENV-Linkages model.

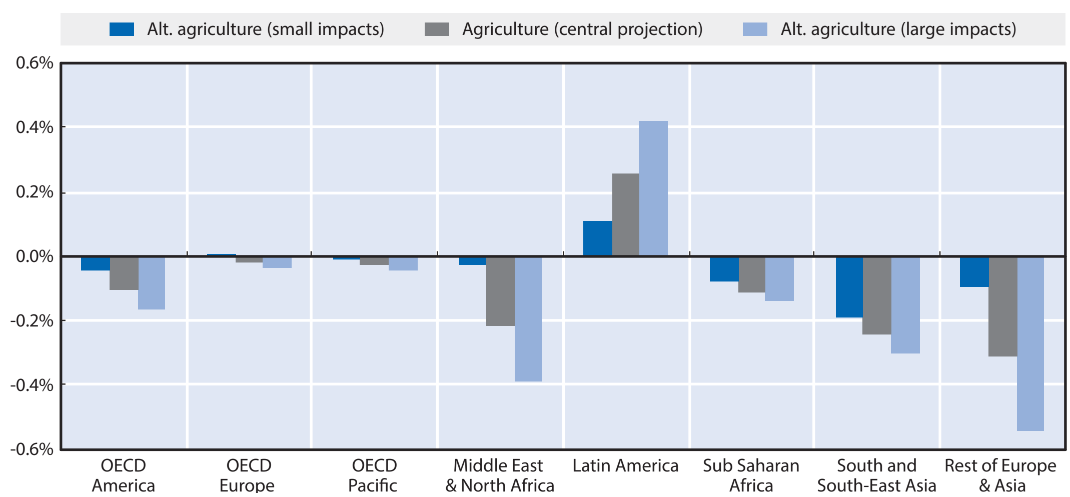
4.3.3. Alternative specification of agricultural yield impacts

The calculations of the agricultural impacts are based on the EC-JRC's TM5-FASST model. The model also provides an assessment of the plausible uncertainty range for these impacts, through the calculation of a minimum and maximum impact. These variations are driven by using different metrics for crop varieties and for ozone concentrations (see Section 2.5 and Van Dingenen et al., 2009). The amount of variation between minimum, central projection and maximum varies between crops and regions, but the minimum is roughly half the impact of the central projection, while the maximum is around 50% higher.

Figure 4.9 shows the sensitivity of the economic assessment of the agricultural impacts. The larger the impact, the larger the GDP consequences are, although there are some variations between crops and regions. This pattern extends to the positive consequences in Latin America: larger yield losses in other regions imply more opportunities to increase production in Latin America. Although the domestic negative impacts of air pollution on agricultural production are also larger, what matters more for production in this region is that the difference between its production costs and those of its competitors increase. Hence, their competitive position improves even more when the yield losses are globally larger. This does not imply that larger levels of air pollution are always beneficial for the economies of this region. Once domestic impacts become substantially negative, the negative domestic consequences will start outweighing the increased comparative advantage. Similarly, if global impacts become severe, the slow-down of global demand will also offset the competitiveness gains.

Figure 4.9. **Sensitivity of market costs to alternative agricultural impacts**

Percentage change in GDP w.r.t. no-feedback projection, 2060



StatLink http://dx.doi.org/10.1787/888933357450

Source: ENV-Linkages model.

Notes

1. The exception is India. Although the labour productivity shock is of the same order of magnitude as that in China, labour represents a significantly larger share of GDP in India. Consequently, the direct labour effect is larger. But it also implies that the reduction in the other components is smaller, and in fact the indirect labour effect turns positive, albeit small.

2. The size of these effects depends on how savings behaviour is modelled, and it does not take into account any specific action of households to change their savings when realising the change in the risk of premature death.

3. Governments could also choose to reduce the quality of the health care that is provided, but the welfare costs of such actions are presumably larger than the health expenditures included here. The costs calculated and presented here are in that sense lower bounds of the potential welfare costs.

4. In all regions, the vast majority of these additional expenditures come from illnesses related to $PM_{2.5}$ concentrations; the contribution of ozone is much smaller.

5. Note that alternative specification of the financing mechanism, e.g. by letting the government budget be balanced by adjusting income taxes or the lump-sum payments between households and government, does not significantly alter these results.

6. Note that these are projections of the costs of policy inaction and do not reflect any judgement on future policy action by China, Russia or any other country.

7. In principle, this does not exclude significant changes for specific hotspots, but the modelling framework does not allow an assessment at that level of detail.

8. However, as this report amply shows, the same does not hold for morbidity costs.

References

Ciscar. J.C. et al. (2014), "Climate impacts in Europe. The JRC PESETA II project", *JRC Scientific and Policy Reports*, No. EUR 26586EN, Publications Office of the European Union, Luxembourg. http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=7181 (last accessed on 3 May 2016).

Ciscar, J.C. et al. (2011), "Physical and economic consequences of climate change in Europe", *Proceedings of the National Academy of Science (PNAS)*, Vol. 108, pp. 2678-2683.

Meinshausen, M., S.C.B. Raper and T.M.L. Wigley (2011), "Emulating coupled atmosphere-ocean and carbon cycle models with a simpler model, MAGICC6: Part I – Model Description and Calibration", *Atmospheric Chemistry and Physics*, Vol. 11, pp. 1417-1456.

OECD (2016, forthcoming), *The international trade consequences of climate change*, COM/TAD/ENV/JWPTE(2015)63.

OECD (2015), *The Economic Consequences of Climate Change*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264235410-en.

OECD (2012), *OECD Environmental Outlook to 2050: The Consequences of Inaction*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264122246-en.

Van Dingenen, R. et al. (2009), "The global impact of ozone on agricultural crop yields under current and future air quality legislation", *Atmospheric Environment,* Vol. 43(3), pp. 604-618.

Vrontisi, Z. et al. (2016), "Economic impacts of EU clean air policies assessed in a CGE framework", *Environmental Science and Policy* 55, pp. 54-64.

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