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Updating the economic drivers in the SSPs

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Abstract

The Shared Socioeconomic Pathways (SSPs) are underpinned by projections of economic activity. This paper presents methodology and results of updated projections of GDP and per capita income using the latest demographic and economic data and the latest economic insights. To ensure consistency, the same modelling tools that were used for the original economic SSP projections presented in Dellink et al. (2017) are used.

Introduction

The Shared Socio-economic Pathways (SSPs), described in Riahi et al. (2017), are a set of scenarios describing different pathways of greenhouse gas emissions and its socioeconomic drivers. The SSPs are very widely used in quantitative assessments of climate change and climate policies. The quantification of the socioeconomic drivers, such a demographic developments and economic growth, underlying these scenarios is, however, becoming old: the original projections were made in 2013. This paper focuses on the economic dimensions: projections of GDP and per capita income in each of the SSPs.

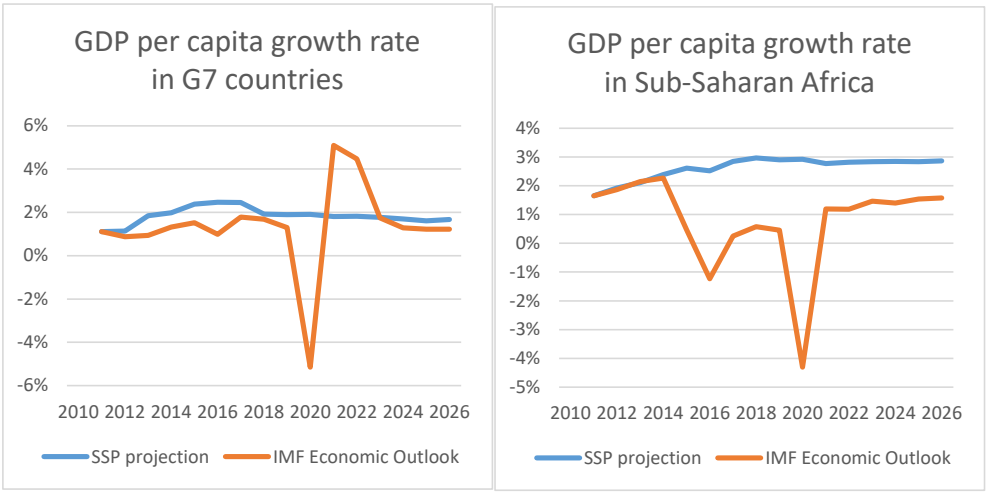
There have been significant developments since 2013 that warrant an update of these projections. In principle, one could simply replace short-term projections in the SSPs with the new forecasts of IMF and OECD. But the implications for long-term developments in the SSPs become unclear in such an approach and ad-hoc assumptions need to be made (Koch and Leimbach, 2021). For example, when updating the historical data and using the long-term growth rates from the original SSPs implies that the ranking of countries by income in 2100 can shift, which can cause inconsistencies with the underlying technology convergence assumpions. Conversely, when long-term income levels are unchanged from the original projections, the transition from the revised short-term forecasts to the unchanged long-term levels may lead to unexpected and problematic adjustment effects. Such potential inconsistencies can be prevented by redoing the original analysis but using updated data and updated information on short-term forecasts.

Four specific empirical developments stand out that also warrant not only an update of the projections to recent data, but a full re-assessment of the economic projections. First, there have been significant demographic projections, and long-term projections of population by age, gender and education level differ significantly from those made in 2013 (KC et al, 2022). Second, the last decade has seen a significant reduction in international trade as source of economic growth. In recent years, the growth of

Global Value Chains has largely stagnated. Third, resource prices have been volatile; this has caused a slump in economic growth in Sub-Saharan Africa that was not foreseen in the original projections. Figure 1 illustrates this (while simultaneously highlighting the impact of COVID-19). Fourth, and most obviously, the COVID-19 pandemic and associated government response measures, not least lockdowns, have dramatically reduced economic activity in 2020, and is still affecting economic activity in 2021 and 2022, and likely for much longer. Even if economic growth rates were to recover fully, GDP levels will be permanently lower than projected before the crisis (see Figure 2). The consequences of the Ukraine war are perhaps even more uncertain.

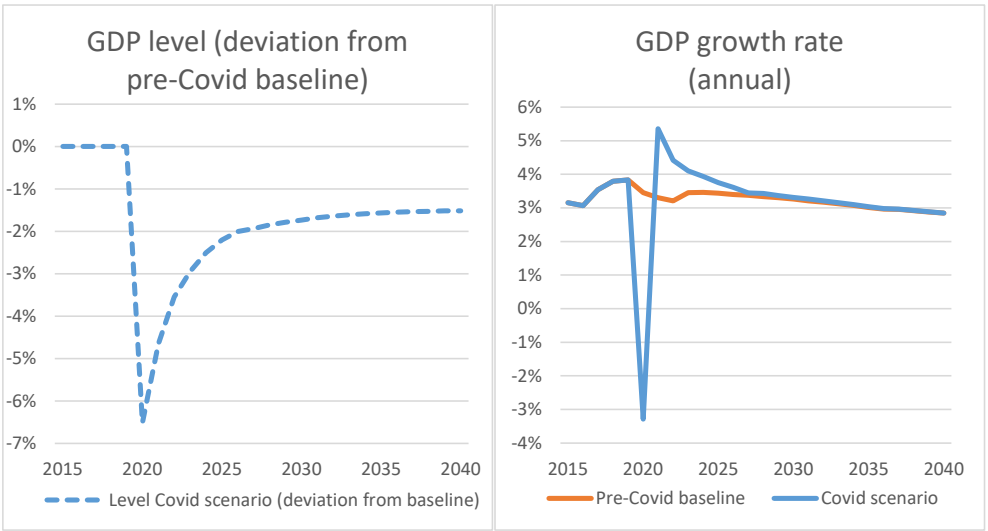
Together, these developments provide a strong reason to revisit the economic projections underlying the SSPs and provide new quantitative scenario projections for GDP. Such updated projections are the objective of this paper. The paper does NOT entail a re-interpretation of the SSP storylines. Basic assumptions on how the SSPs relate to each other, such as in which scenario income convergence is faster or slower, are left unchanged, to allow maximum compatibility with the original projections.

Figure 1. Recent trends and short-term forecasts of economic growth in selected regions



Source: Own elaboration based on Dellink et al. (2017) and IMF (2021).

Figure 2. Projected impact of COVID-19 on global GDP

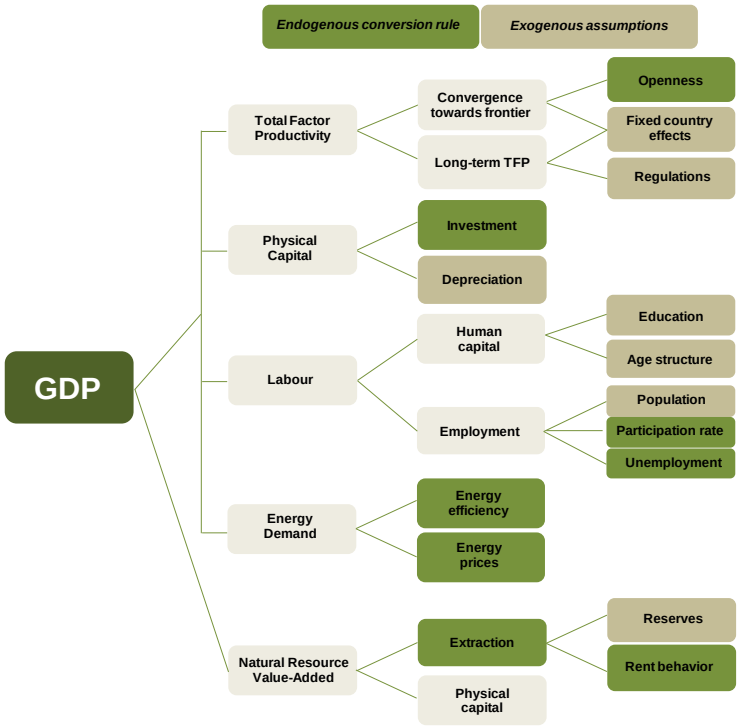


Source: Dellink et al. (2021).

Methodology

This paper uses the OECD's ENV-Growth model to make long-term projections of macroeconomic growth at country level. The same model was used for the original GDP projections as used in the SSPs, as presented in Dellink et al. (2017). The methodology is based on a conditional convergence process and places emphasis on the key drivers of economic growth in the long run: population, total factor productivity, physical capital, employment and human capital, and energy and natural resources (specifically oil and gas); see Figure 3.

Figure 3. Schematic overview of the OECD *ENV-Growth* model



Physical capital follows the standard capital accumulation formulation with a fixed depreciation rate. The investment rate per unit of GDP is assumed to slowly converge towards a balanced growth path, mimicking the *golden rule* for savings (which maximises balanced growth consumption levels, Blanchard and Fisher, 1989). Ultimately, the long-term investment rate thus depends on the structural parameters of the production function. An alternative methodology would be to endogenise the dynamics between savings/investments and current accounts as done by Fouré et al. (2012) or by Johansson et al. (2013). However, if the saving-investment relationship were fully endogenised, the capital accumulation process could not be consistent with the storylines underlying the five SSP scenarios without explicitly defining the drivers of changes in savings behaviour (which is only available for OECD countries and a selected set of emerging economies in Johansson et al., 2013). As shown in Section 2.3, this assumption has important implications for the long-term projections.

Employment follows detailed demographic trends. Total employment results from the combination of time-dependent trends in population and labour participation rates, which are specific to each age cohort and gender, and with aggregate unemployment levels.[1] The convergence process applies to participation

[1] Note that the population and education projections underlying this analysis are constructed simultaneously, see KC et al. (2012) for the original implementation of the SSPs, and KC et al. (2022) for the update.

rates by age cohorts and gender, based on various relevant variables such as ratio of dependency and education levels.[2] The country-specific structural unemployment specification used by Johansson et al fits less well with the very long time horizon of ENV-Growth. Therefore, the alternative assumption is used that unemployment levels converge very slowly to a common structural level. For most countries, this convergence process is still ongoing by the end of the century.

Human capital improvements are linked to age- and gender-specific education levels. These are converted into a human capital index using mean years of schooling as an intermediate variable, following the formulation of Hall and Jones (1999) as well as estimates from Morisson and Murtin (2010). Increases in the human capital index are reflected in the model through improvements in labour productivity.

Energy and *Natural Resources* are considered through two channels. First, value added is created by extracting and processing natural resources. The contribution to the GDP of countries that have resources is derived from country-specific resource projections, focusing on oil and gas sectors. These projections describe the interplay between oil and gas resources, together with parameters reflecting the time evolution of marginal production costs, and are used to project prices and production levels. Second, energy is used as input in production: gains in energy efficiency at the user side therefore act as a driver of economic growth (as more output can be generated by using the same energy inputs). The projection of gains in energy efficiency is based on the law of motion for autonomous energy efficiency improvements as estimated by Fouré et al. (2012), which describes a U-shaped relation between economic development and energy productivity.[3]

As in Solow (1956), the continuous improvement in *TFP* leads to more efficient production as more output can be created with the same combination of primary factors: capital and labour, and, in the case of the *ENV-Growth* model, natural resources. Specifically, the *ENV-Growth* model features additional inputs as human capital (as in Mankiw et al., 1992) and energy (as in Fouré et al., 2012).

TFP growth is assumed to be a combination of two elements: (i) countries gradually converge towards their "long-term TFP frontier" (driven by the speed of convergence); (ii) the long-term TFP frontier shifts over time. As the long term TFP frontier is country-specific, all countries will grow through both channels (which are often termed "technological catch up" and "technological pass-through", respectively). More technologically advanced countries, however, are closer to their frontier and therefore, *ceteris paribus*, grow less rapidly than countries which are less technologically advanced (i.e. whose distance to their long-term TFP frontier is longer).

Following the OECD Economics Department methodology (Johansson et al., 2013), the speed of convergence towards the frontier is influenced by fixed country effects reflecting a wide variety of country-specific factors, and an international trade openness indicator. For the latter, countries that are more open will have easier access to advanced technologies and learning. Greater country openness can thus boost domestic productivity (Leamer and Levinsohn, 1995; Edwards, 1998) via diffusion of new technologies. The amount of trade between countries is likely to increase with domestic and trading

[2] The methodology on convergence of future participation rates have been simplified compared to Johansson et al. (2013) in order to keep consistency between projections for both OECD and non-OECD countries.

[3] The logic of the U-shape relation is as follows. Commercial energy consumption is low for low-income countries and then rises rapidly with industrialisation (associated with increased incomes). As countries become richer, access to advanced technologies and further structural shifts towards the services sector imply higher energy productivity.

partners' income. Conversely, *ceteris paribus*, larger countries are likely to trade less as they have access to a larger domestic market.

Finally, the long-term frontier itself depends on a fixed country effect, a global frontier growth rate, and country-specific "market product regulation" indicators that measures the extent of regulatory barriers to market access and competition (i.e. countries that have less such barriers have more incentives to innovate and can access frontier technologies more easily).[4]

Economic growth projections are made for each of the SSP storylines. The storylines themselves are unchanged from the original SSP scenarios. The assumptions that differentiate the SSPs from each other, for instance on the speed of convergence of income across countries, or on trade openness, are also unchanged. The quantification of specific model parameters is, however, updated to reflect the latest insights, latest data and to provide a consistent set of projections across all scenarios. Furthermore, updated quantification of the demographic drivers (provided by IIASA) is used to ensure that population, education and human capital developments are fully consistent.

The SSP projections do not contain estimated impacts of climate policies and can therefore all be considered as reference (or baseline) scenarios, reflecting different views on "no climate policy" developments for the 21st century. Impacts from climate change on GDP are also excluded, to allow researchers to use their own estimates of the damages from climate change.

Data

The paper largely uses updated versions of the databases described in Dellink et al. (2017). Not least, short-term GDP forecasts from OECD (2022) and IMF (2022) are combined with demographic projections provided by KC et al. (2022). The latter are developed specifically for this update to ensure full consistency in updates of population, education and economic activity for all SSP scenarios.

The analysis further builds on long-term macroeconomic projections provided by OECD (2021). These are not used directly, but as an intermediate step to create a "business as usual" projection that functions as a reference point for the SSP-specific assumptions.

Results

The methodology is applied to construct pathways of GDP and income (GDP per capita) levels for more than 200 individual countries, collectively representing 99.9% of global GDP, plus a stylised "rest of the world" region. Trend projections are made for each of the SSP scenarios by translating SSP storylines into assumptions on the various drivers of growth. Together, this set of scenarios provides a range of future projections of GDP and income for the rest of the 21st century. The SSP scenarios do not cover the full spectrum of plausible economic projections, but they do illustrate a substantial variance in global GDP levels by the end of the century. The methodology can therefore also serve as a basis for different quantitative assessments that involve economic baselines.

As specific attention is paid to the interpretation of the differences between the different SSPs, the relative pathways of GDP and income between different SSPs are more relevant than the specific level of each individual pathway. Given that the *ENV-Growth* model focuses on long-term trends, the absolute GDP and income levels projected are also less robust than growth rates that are averaged over a longer

[4] A useful summary of the link between competition and innovation is in Aghion and Griffith (2005). Empirically, a positive effect of easing anticompetitive regulation on TFP has recently been found at the aggregate level by Johansson et al. (2013) and at the industry level by Nicoletti and Scarpetta (2003), Barone and Cingano (2011) and Bourlès et al. (2012).

time period. It should be noted that these projections are not official OECD projections, but customised projections made by OECD specialists specifically for the SSP scenarios.

[The updated projections for the SSPs will become available before the conference and will be included in the next draft of the paper. Specific attention will be paid to how the new projections differ from the original ones presented in Dellink et al (2017), and how the revisions cause differences in how the different SSP scenarios relate to each other.]

Final remarks

The projections are subject to large uncertainties, particularly at the country level and particularly for the later decades, and disregard a wide range of country-specific drivers of economic growth that are outside the narrow economic framework, such as external shocks, governance barriers and feedbacks from environmental damage. Hence, they should be interpreted with sufficient care and not be treated as predictions. Alternative scenarios will be explored for the uncertainties related to the recovery from COVID-19.

References

Aghion, P and R. Griffith (2005), "Competition and Growth. Reconciling Theory and Evidence", August 2005, MIT Press.

Barone, G. and F. Cingano (2011). "Service Regulation and Growth: Evidence from OECD Countries," *Economic Journal*, Royal Economic Society, vol. 121(555), pages 931-957, 09.

Bourlès, R., G. Cette, J. Lopez, J. Mairesse and G. Nicoletti (2010), "Do Product Market Regulations in Upstream Sectors Curb Productivity Growth?: Panel Data Evidence for OECD Countries", *OECD Economics Department Working Papers*, No. 791.

Dellink et al (2017), "Long-term economic growth projections in the Shared Socioeconomic Pathways", *Global Environmental Change* 42, pp. 200-214.

Dellink, R., et al. (2021), "The long-term implications of the COVID-19 pandemic and recovery measures on environmental pressures: A quantitative exploration", *OECD Environment Working Paper* 176, OECD Publishing, Paris, https://doi.org/10.1787/123dfd4f-en.

Edwards, S. (1998), "Openness, productivity and growth: what do we really know?", *Economic Journal*, Vol. 108, No. 447.

Fouré, J. and A. Benassy-Quéré and L. Fontagné (2012), "The Great Shift: Macroeconomic Projections for the World Economy at the 2050 Horizon", CEPII Working paper 2012-03.

Hall, R. and C. Jones (1999), "Why Do Some Countries Produce So Much More Output than Others?", *Quarterly Journal of Economics*, Vol. 114, No. 1.

IMF (2021), *World Economic Outlook*, October 2021.

Johansson, A., Y. Guillemette, F. Murtin, D. Turner, G. Nicoletti, C. de la Maissonneuve, P. Bagnoli, G. Bousqet and F. Spinella (2013) "Long-term growth scenarios", OECD Economics Department Working Papers, No 1000, OECD, Paris, doi: 10.1787/5k4ddxpr2fmr-en.

KC, S. et al. (2022), "Updated demographic projections for the SSPs", *forthcoming*.

KC, S., Barakat, B., Goujon, A., Skirbekk, V., Sanderson, W., and Lutz, W. (2010). Projection of populations by level of educational attainment, age, and sex for 120 countries for 2005-2050. Demographic Research, 22: 383-472.

Koch, J. and M. Leimbach (2022), "Update of SSP GDP projections: capturing recent changes in national accounting, PPP conversion and Covid 19 impacts", *forthcoming*.

Leamer, E. E. and J. Levinsohn (1995), "International Trade Theory: The Evidence", in: G. M. Grossman and K. Rogoff. (eds.), *Handbook of International Economics*.

Mankiw, N. G., D. Romer and D. N. Weil (1992), "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, 107, 407-437.

Morrisson, C. and F. Murtin (2010), "The Kuznets Curve of Education: A Global Perspective on Education Inequalities", CEE dp.116, London School of Economics.

Nicoletti, G. and S, Scarpetta, 2003. "Regulation, productivity, and growth : OECD evidence", Policy Research Working Paper Series 2944, The World Bank.

Riahi et al, (2017), "The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview", *Global Environmental Change* 42, pp. 153-168.

Solow, R. (1956), "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, Vol. 70, No. 1.