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Long-term economic growth projections in the Shared Socioeconomic Pathways☆

Rob Dellink*, Jean Chateau, Elisa Lanzi, Bertrand Magné

OECD Environment Directorate, 2 rue André-Pascal, 75775 Paris, France

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ABSTRACT

Long-term economic scenarios (up to 2100) are needed as a basis to explore possible different futures for major environmental challenges, including climate change. Given the high level of uncertainty involved, such scenarios would need to span a wide range of possible growth trajectories. The recently developed storylines of the Shared Socioeconomic Pathways (SSPs) provide a basis for making such projections. This paper describes a consistent methodology to derive (per capita) GDP trend pathways on a country basis. The methodology is based on a 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 fossil fuel resources (specifically oil and gas). The paper uses this methodology to derive country-level economic growth projections for 184 countries. The paper also investigates the influence of short-term growth rate estimates on the long-term income levels in various countries. It does so by comparing long-term projections based on short-term forecasts from 2011 with the projections based on forecasts from 2013. This highlights the effects of the recent economic crisis and uncertainty in short term developments on longer term growth trends. The projections are subject to large uncertainties, 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.

1. Introduction

Future projections of the impact of international environmental policies, such as those related to climate change, are usually presented against a "business as usual" (BAU) baseline or a reference scenario. For instance, the OECD Environmental Outlook to 2050 (OECD, 2012a) describes in detail a set of socio-economic developments and the related pressures on the environment, and highlights the consequences of policy actions for key environmental themes. Greenhouse gas emissions pathways resulting from economic reference scenarios are then used for positioning mitigation actions, e.g. by defining targets in relation to baseline emission levels. However, as a wide range of possible factors can affect economic projections, it is useful to consider different possible developments.

This paper presents and compares a range of reference Gross Domestic Product (GDP) projections based on different perspectives on future socio-economic developments. The scenarios are based on the Shared Socioeconomic Pathways (SSPs). The SSP storylines have been developed by the climate change research community (Van Vuuren et al., 2014; O'Neill et al., 2014). They are part of a framework that combines the socio-economic developments defined by the SSPs with Representative greenhouse gas Concentration Pathways (RCPs) to assess future climatic changes (Moss et al., 2010; Van Vuuren et al., 2012). The economic growth projections developed here therefore represent quantitative data linked to each SSP that can be combined with other information to develop Reference (Baseline) Scenarios for climate impact assessment. These Reference Scenarios assume no climate policies; climate policy scenarios can be added to link the SSPs to the RCPs.

This paper illustrates a detailed methodology for making consistent long-term economic projections for most countries in the world, using the *ENV-Growth* model (Chateau et al., 2014a). *ENV-Growth* projects a gradual process of convergence towards a balanced growth path along the lines of an augmented Solow

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* Corresponding author. Tel.: +33 1 4524 1953; fax: +33 1 4524 1953.
E-mail address: rob.dellink@oecd.org (R. Dellink).

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growth model (Barro and Sala-i-Martin, 2004). Projections start in 2018 since the model initially mimics short-term (2012–2017) economic projections of the OECD and the International Monetary Fund (IMF), and then follows a so-called *conditional convergence* hypothesis: income levels (e.g. GDP per capita) of less developed countries will increase faster than those of more developed economies based on a catch-up effect in the key drivers of per capita economic growth. Specific attention is paid to the development of income generated from the exploitation of the natural resources crude oil and natural gas.

The methodology is applied to construct pathways of GDP and income (GDP per capita) levels for 184 individual countries, collectively representing 99.9% of global GDP in 2010, 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. 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.

It should be noted that the projections presented in this paper are not predictions of what will happen. They are meant as reference projections for quantitative modelling exercises that rely on long-term global economic baselines. For instance, Integrated Assessment Models (IAMs) need GDP projections in order to derive long-term emission and temperature projections for at least a century ahead. Having a common set of economic growth assumptions across IAMs helps understand the differences in projections of emissions. Similarly, long-term projections for agricultural sectors can benefit from reference projections on economic activity, as these influence various areas e.g. food demand. The projections are subject to large uncertainties, particularly at the country level and for later decades, and should be interpreted with sufficient care. While an internally consistent set of assumptions is used to make these projections, they 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. Further, these projections are not official OECD projections, but customised projections made by OECD specialists specifically for the SSP scenarios.

The paper is structured as follows. Section 2 describes the main elements of the SSP scenarios. Section 3 briefly introduces the *ENV-Growth* model that is used for making the economic projections. Section 4 discusses the data sources for calibrating the model and the interpretation of the different SSP storylines for the drivers of economic growth. Section 5 presents the resulting income projections for the SSP scenarios. An analysis of the implications of these projections for between-country income inequality is presented in Section 6, while Section 7 investigates the influence that forecasts of short-term growth rates play in the long-term projections and Section 8 concludes.

2. A brief introduction to SSP scenarios

Greenhouse gas emissions projections in the literature have often been based on the Special Report on Emission Scenarios (SRES) (Nakicenovic and Swart, 2000), developed by the IPCC. As time progresses, projections become outdated, and many of the assumptions underlying the SRES scenarios have been revised. For the 5th Assessment Report, the IPCC asked the international research community to develop new and updated scenarios. This has been done through a collaborative process involving modelling groups and researchers working on (i) the climate system; (ii) vulnerability impacts, and adaptation (VIA); and (iii) Integrated Assessment Modelling (IAM). A broad group of stakeholders, including governments and NGOs, reviews the scenario development process (as laid out in IPCC, 2008), providing a foundation for international credibility and acceptance.

This new scenario framework for the integrated analysis of future climate change comprises two main elements (see Moss et al., 2010; Van Vuuren et al., 2012): (i) Representative Concentration Pathways (RCPs) reflecting projections for greenhouse gas concentrations and radiative forcing, and (ii) Shared Socioeconomic Pathways (SSPs) describing different combinations of socio-economic developments and their associated levels of greenhouse gases emissions.

The SSPs combine both qualitative and quantitative information on possible future developments of emissions and their main socio-economic drivers, and include projections for population and income. They do not contain estimated impacts of climate policies and can therefore be considered as reference (or baseline) scenarios, reflecting different views on "no climate policy" developments for the 21st century. The SSPs are linked to the RCPs through the specification of a climate policy scenario. A specific SSP would lead to a certain radiative forcing level but, when combined with a specific climate policy scenario, the forcing levels would decrease to be in line with a lower RCP. Not all SSPs can be linked to all RCPs, either because the SSP without policy leads to lower forcing levels than described in the RCP (e.g. if an SSP without mitigation action leads to a radiative forcing level of 7 W/m^2, it is incompatible with RCP8.5), or because the required stringency of climate policy involved makes it infeasible to reach very low forcing levels (i.e. if the required mitigation efforts are insufficient to reduce radiative forcing to the desired level).

The different SSP storylines are described in O'Neill et al. (2014). These storylines are constructed around two axes: challenges to mitigation and challenges to adaptation, as illustrated in Fig. 1. A natural way of interpreting these axes could be to see emissions in absence of policies as index of the challenges to mitigation, and vulnerability to climate change as indicator of adaptation challenges.

In SSP1, the challenges for both adaptation and mitigation to climate change are low, as relatively rapid income growth is combined with substantially reduced reliance on natural resources. This is achieved at least in part through quick technological change and through high levels of international cooperation. Also, following KC et al. (2010) and Lutz and KC (2012), high levels of education induce lower fertility rates and

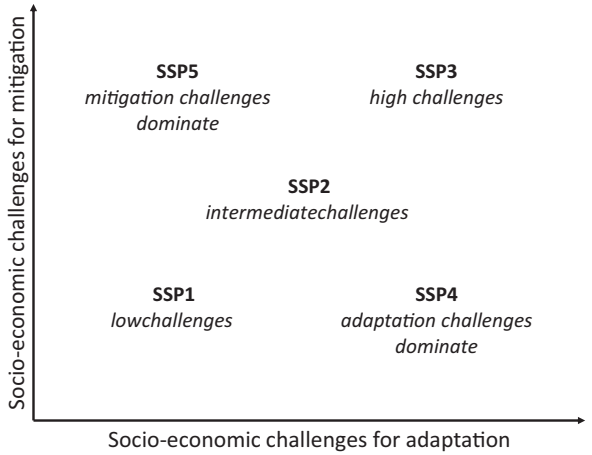

Fig. 1. Schematic representation of the SSPs.
Source: Based on O'Neill et al. (2014).

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