Achieving sustainable development:
Investment and macroeconomic challenges
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"You are probably reading this on a piece of an ex-tree. Felled by a petrol-guzzling chainsaw, it was carted to a paper mill in a diesel-powered truck. Or perhaps these sentences are on a tablet, with plastic components that started life as crude oil, and metal smelted with coke produced from the tar sands of Canada. Either way the words are probably lit with electricity from coal-fired power station. Maybe you are even sipping wine, grown with fertiliser made using natural gas, in a glass created in an oil-fired furnace… Weaning ourselves off this stuff is not going to be easy." LePage 2014.

1. Introduction

There is an emerging consensus holding that sustainable development requires the implementation of policies to pursue, simultaneously, development goals in various domains. Sustainable development requires the adoption of strategies to expand people's choices in developed and developing countries, to protect the environment, and to preserve peace and security (United Nations, 2012). Notwithstanding the multiple dimensions of sustainability, its attainment hinges upon the capacity of civilization to avert a rise in world's temperature that could trigger events of catastrophic consequences. Key to the goal of averting undue increases in the world's temperature is the transformation of the energy system away from its heavy reliance on fossil fuels and towards alternative sources, notably renewables.[1] Transforming the world energy system calls for strong leadership, carefully designed policies, behavioural changes, and large investments in developed and developing countries. While it is difficult to come up with an exact estimate of the additional

[1] The views expressed in this chapter are those of the authors and do not represent the views of the organization where they work.

investment required to build a global sustainable energy system, an often cited estimate hovers around 0.7 trillion dollars per year between 2011 and 2030; this is around one percent of the world's GDP.[2]

Achieving energy sustainability at the cost of one percent of the world's GDP in additional investments would not be especially burdensome. In reality, however, the investment effort required to secure sustainable energy systems will be several times that figure. Along with a change in energy supply, additional investments will need to be made to adapt existing devices to the new sources of energy. Changing the energy matrix will not only require investments in dams; solar panels; wind mills; nuclear, hydrogen and other energy sources. It will also need investments to adapt car engines, boilers for heating systems, compressors, and a large number of other appliances to the new sources of energy (see GEA 2012, Grubler et.al. 2012, Yeager et.al., 2012). Moreover, changing the energy matrix will also require additional investments to foster innovation, diffusion and adaptation to specific national and regional conditions, particularly in developing countries. Beyond these investments in the energy system, governments will have to bear the costs of introducing new regulations and incentives to promote changes in consumption habits and the spreading of cleaner energy technologies across industries and services. Once account is taken of investments in all these areas, estimates about the volume of resources required to support the transformation of energy systems towards sustainability could be as high as 3 percent of global GDP and even run into double digit figures (GEA, 2012). Not all these investments however, are additional outlays. These estimates include investments that would have to be made in a business as usual scenario and would still be needed in a new sustainability framework. Bringing them into consideration allows for a better sense of the overall size of investments required going forward.

The adoption of sustainable development paths extends beyond the energy system even if broadly conceived. Sustainable development requires the adoption of transformative policies in the economic, social and environmental dimensions of development. How countries undertake desired transformative changes depends on a variety of factors, but it importantly hinges on their level of development. Developed countries will have to manage the technological transition of the energy matrix and the introduction of sustainable consumption and waste management in a context where their energy policies will be mainly concerned with maintaining and renovating their energy infrastructure still within a mostly fossil-fuel base. Developing countries will confront the more demanding challenge of simultaneously building their basic infrastructure to support a more competitive economic structure, supporting faster economic growth, providing all their citizens with access to modern energy, extending their social infrastructure, deepening human development, advancing technological capabilities, and making the transition towards sustainable consumption and production. The challenge of articulating policies in all these domains is significant.

The transformation of the energy system and the achievement of inclusive development throughout the world represent a global challenge that nevertheless calls for different efforts across nations. The mapping of the global sustainable investments by regions and countries results in varying investment estimates depending on the current reliance of countries on fossil fuels, their resource endowments and their level of development. Measured as a percentage of GDP, the amount of resources that developing countries currently allocate to energy represents a significantly bigger economic effort, compared to that of developed countries. Several regions will need to undertake investments representing several percent points of GDP.

The achievement of other economic and human development goals magnifies the challenges, particularly for developing countries. The Millennium Declaration set the task of achieving a number of goals, the Millennium Development Goals (MDGs). These have inspired and influenced policies in developing countries in varying degrees. They provide a useful framework for assessing the magnitude of effort needed to make progress in human development. In the context of these goals, estimates of the additional public spending countries have to allocate above a business-as-usual path to achieve the MDG targets in education, health, and water and sanitation range from a fraction of one percent of GDP to several percent points of GDP, depending on country conditions.

This chapter attempts to offer a broad discussion of sustainable development drawing from two inter-linked strains of work to estimate the investment needed for sustainable development in the areas of energy, infrastructure and human development. Section 2 looks at the role of policy and technological options in determining the size of energy investments needed by regions of the world. The next section analyses policy options to expand public investment to attain infrastructure, including energy, and human development targets. The analysis in this section draws upon results generated by an economy–wide framework designed to assess human development policies, a tool well suited to analyse the impact of policies that have widespread consequences in the economy. Section 4 provides concluding remarks.

2. Policy, technology and energy investments for sustainability

This section focuses on the energy investment challenge for sustainable development. Drawing from the results of the Global Energy Assessment systems dynamic modelling (GEA, 2012), hereafter GEA, it draws a picture of the order of magnitude of the investment effort that will be needed globally and regionally, to achieve energy sustainability. The discussion highlights inter-regional differences and underscores the importance of policy decisions in determining the size of additional investment requirements.

Unsustainable energy trends

Energy investments early in this century represent about 2 percent of global GDP. The GEA exercise includes projections of the energy system that assume no change in the policies and technologies available in 2005 through the rest of the century. Thus, the demand for energy services would be basically met through an extension of current energy supply technology and availability of fossil fuels. The demand for energy is assumed to increase in tandem with a 2 percent annual economic growth in the global economy, mainly driven by developing countries, and continued population growth to reach a plateau of 9 billion people in the second half of the century. This scenario is identified as the *counterfactual scenario* or *path scenario* in the GEA narrative. It is a useful point of reference to illustrate the problems derived from a continuation of current policies and in the absence of additional invests in alternative technologies. This counterfactual scenario results in unsustainable increases in greenhouse gas (GHG) emissions. But, to the extent that it is based on current technology, this is and "inexpensive" route to meet the growing world energy demand; in this *path scenario* global energy investments decrease from 1.9 percent of global GDP in 2005 to 1.7 percent of GDP in 2050.

Given the differences in development, economic specialization and population size, it is only expected that investment requirements vary widely across countries. In 2005 they vary across regions from 0.7 percent of GDP (Pacific Asia OECD) to 11.6 percent of GDP (Former Soviet Union countries). In between, the Western European Union would require an investment equivalent to 0.8 percent of GDP, the North America region would have to invest 1.3 percent of GDP, Central and South America and the South Asia regions would need about 2.2 percent of GDP, and Sub-Sahara Africa would require additional investments in the order of 4.4 percent of GDP. Even if countries are grouped in two large categories, differences are significant: 1.4 percent of GDP for developed countries and 3.8 percent of GDP for developing countries.[3] Differences in the estimates for energy investments will continue well into century, as income and population continue to grow rapidly in the developing world. But differences will tend to narrow down as population growth rates in developing countries slow-down.

Energy investment requirements in this unsustainable path will have different rates of grow across regions. Changes will reflect the convergence in the pace of economic growth and population dynamics, as well as the effects of economic specialization and the availability of energy sources. The main change is a notorious decline in energy investments in the Former Soviet Union group of countries, the countries in North Africa and the Middle East and in the Sub-Sahara Africa region. Investments in other regions will not change much (few tenths of a percentage point of GDP).

Pathways to energy sustainability

The continuation of current policies has been widely recognized as unsustainable, incapable of slowing the rise in world temperature enough to reduce the probability of facing disastrous consequences for millions of people.[4] While halting the increase in global temperature is an imperative that cannot be stressed enough, it is also true that success in controlling the increase in temperature is not enough to bring sustainability to the development process. A more comprehensive framework that encompasses the economic, social and environmental dimensions of development will be needed to bring a simultaneous improvement in living conditions and sustainable use of natural resources (United Nations, 2012). Echoing this vision the GEA exercise asks what kind of policies, technologies, and investments need to take place to transform the current energy configuration into a sustainable energy system; i.e., one that keeps the increase in temperature within safe limits, promotes growth, protects the environment, and deepens social inclusion. The task is daunting; keeping it manageable and maintaining the focus on energy, the

GEA proposes a fourfold definition of sustainability. An energy system is deemed sustainable if it meets the following criteria: (a) attains almost universal access to electricity and clean cooking fuels by 2030; (b) ensures that the majority of the world's population live in areas that meet the air quality guidelines of the World Health Organization; (c) limits CO2 concentrations to levels compatible with average temperature increases of less than 2° C; and d) limits energy trade while increasing the diversity and resilience of the energy supply within each country. [5]

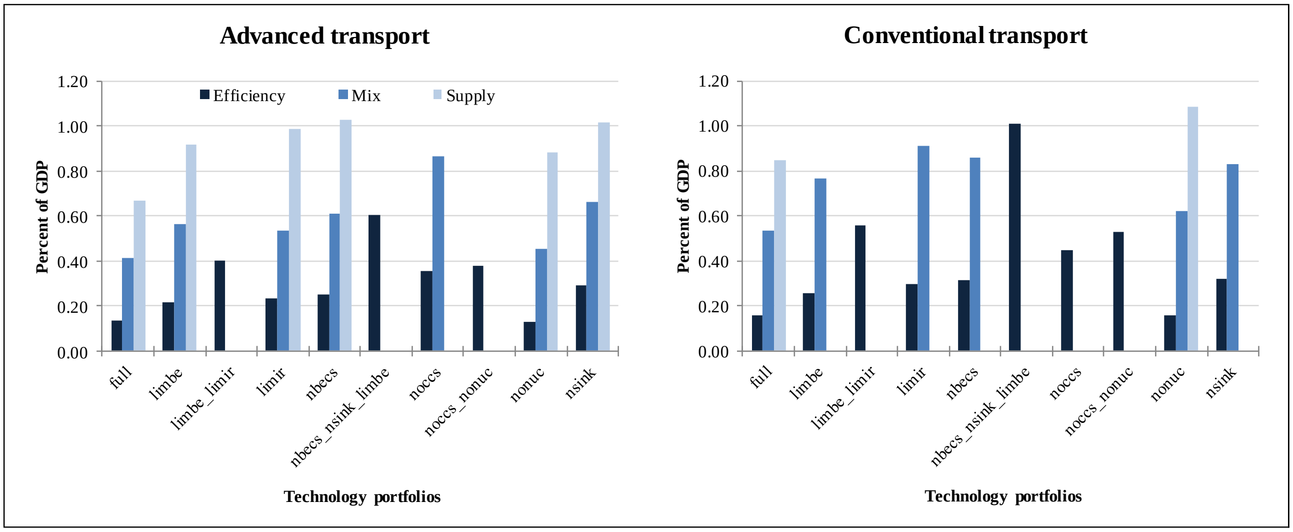
The GEA organises the discussion about the kind of policies, technologies and investments that would meet this four-fold definition of sustainability. It defines three types of policies, two modalities of transport characterised by the type of fuel they use, and ten technology portfolios. The combination of these policies and conditions results in 60 energy scenarios or paths. The three energy policy paths that combine supply and demand policies to ensure that supply meets final energy demand are the following.[6] The **supply path** emphasises policies to meet the increasing demand for energy in the world by scaling-up all supply-side options. It assumes a trend in energy intensity similar to the historical long-term pattern. In this case a large up-scaling of R&D and large investments in new infrastructure and fuels will be needed, including in hydrogen and electricity for transportation (see GEA, 2012, p. 73). The **efficiency path** emphasises demand energy policies. It simulates a doubling improvement in the long-term historical pace of energy intensity. This path assumes the implementation of policies to ensure a fast adoption of best-available technology throughout the energy system in order to enhance recycling, improve life-cycle product design, and extensive retrofitting of existing plants, among other measures. It is worth noting that while supply and efficiency paths feature similar volumes of renewable energy, the share of renewables in efficiency paths is significantly higher because energy demand is much lower. The third policy path, the **mix path,** combines features of the first two alternatives. Each of these policy paths branches out into two transportation modalities: one assuming continued reliance on conventional technologies and fuels (mainly liquid); the other adopting advanced technologies and fuels (hydrogen and electricity). From each of the six policy-transport paths, the analysis branches out into ten technology portfolios defined by different technology combinations, one of them characterized by access to all technologies, the full portfolio, while the other nine feature limited or null access to alternative technologies, including renewables, bioenergy, nuclear, carbon sinks, carbon sequestration, and bioenergy carbon sequestration.[7]

These policies, including the promotion of R&D and the diffusion of technology and innovation, define different technology options and various prices and costs of the energy system. The various options are run through the use of two systems dynamic models.[8] The majority of scenarios meet the sustainability criteria. A quick glance at successful scenarios provides a useful approximation to the role of policies, transport modalities and technologies in shaping sustainable development paths. On the whole, the sustainability test underscores the widely held view that the adoption of energy efficiency policies is a powerful driver towards sustainability. All efficiency policy scenarios meet the sustainability criteria. Efficiency policy paths assume a decline of energy intensity that is twice as large as the historical pace so far; it further assumes that incentives, regulations and technological innovations will be in place in such a way that there will be a significant reduction in the use of energy to satisfy future demand for energy services. This finding shows that as long as the growth in the demand for energy is met through improved efficiency, the world can afford the use of all energy supply side technologies available.

A different picture emerges from supply policy paths that are not accompanied by improved efficiency on the demand side. Less than half of the paths meet the sustainability criteria. Furthermore, the ability to meet sustainability critically depends on the development of technologies that support the use of hydrogen and electricity for transport services. The majority of supply paths meeting the sustainability criteria feature advanced transport modes fuelled by hydrogen and electricity. As expected, the mix policy paths offer intermediate possibilities and a little over half of them succeed in meeting the sustainability criteria.[9]

The combination of policies, technologies and transport modes not only determines the feasibility of reaching sustainability, it will also influence the size of required investments. Different scenarios yield world energy investment requirements in the range of 1.5 to 2.9 percent of GDP between 2020 and 2050. That is, sustainable paths open the opportunity to reduce energy investments, if the right policies are chosen, although they can also be more costly when compared with the 1.7 percent of GDP investment of the counterfactual scenario.[10] Several patterns emerge within the wide range of investment needs in energy sustainable paths. Efficiency paths will generally require lower investments than mix paths and supply policies. Sustainable paths featuring advanced transport modes will call for additional investments when compared to paths based on conventional transport modes, albeit differences in this case are small (Figure 1). The role of technology is more nuanced. The two smallest investment requirements, after taking into account policy and transport mode, correspond to the option where the full technology portfolio is available and the portfolio excluding nuclear energy, as nuclear usually necessitates large investments over a number of years. Portfolios that exclude—or make limited use—of two or more technologies have the highest investment requirements. The different combinations of policy, technology and modes of transportation entertained in the scenarios built by the study of GEA, confirm the idea that sustainability is affordable.

Figure 1: Global additional energy investments in sustainable energy paths, 2011-2050 (Annual average as percent of GDP)

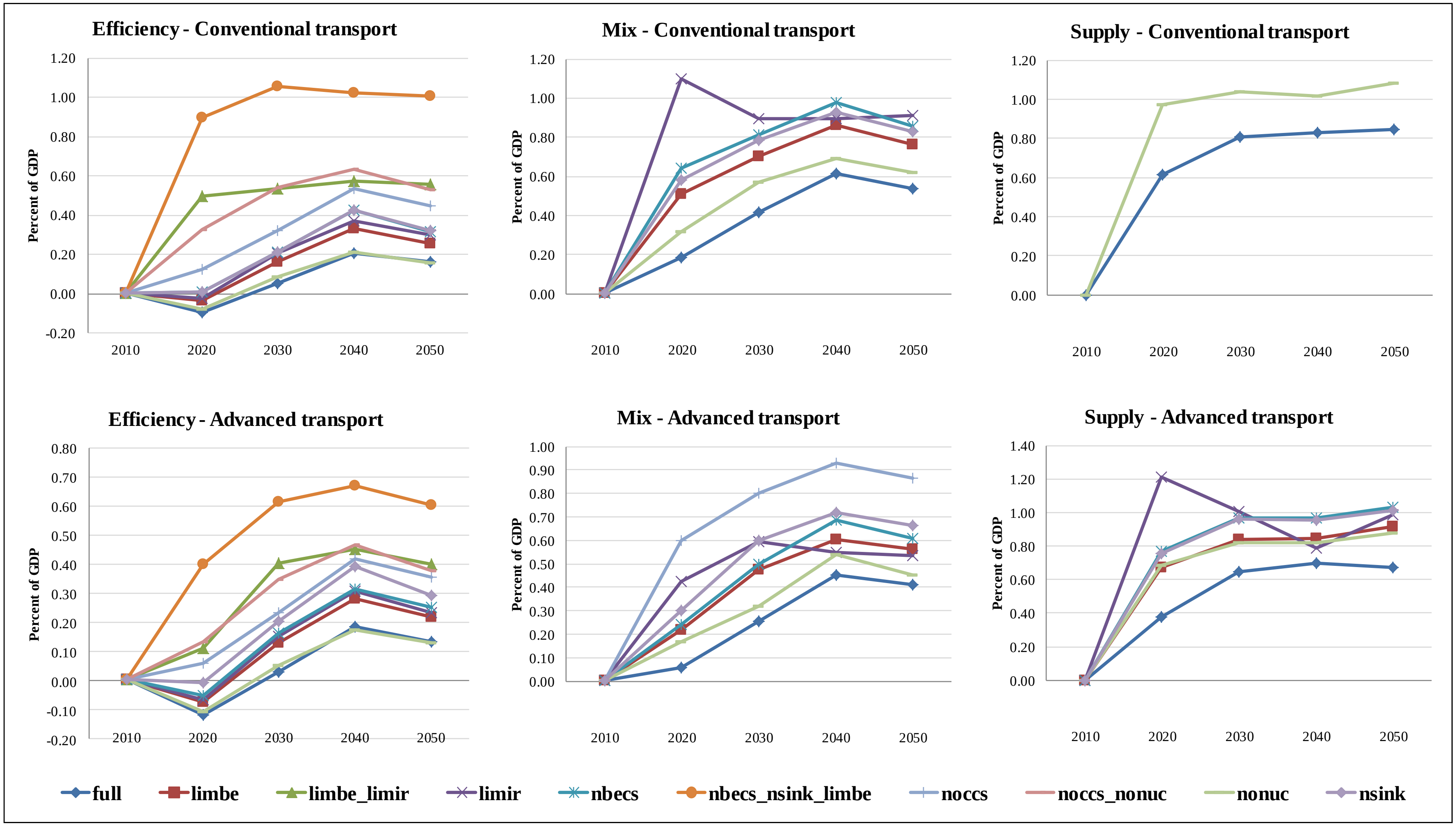


Source: Authors' construction based on GEA database (http://www.globalenergyassessment.org).
Note: Plots represent the difference between world total energy investment in sustainable paths and world total energy investment in the counterfactual scenario (keeping 2005 policies and technologies unchanged) over gross domestic product estimated at market prices. GDP is the same in all scenarios. In this and in subsequent figures the technology portfolios are defined as follows:

full:	No carbon (dioxide) capture and storage
limbe:	No nuclear and no carbon (dioxide) capture and storage
limbe_limir:	Full portfolio (all options)
limir:	Limited biomass and renewables
nbecs:	No nuclear
nbecs_nsink_limbe:	Limited renewables
noccs:	No bio-energy carbon capture and storage
noccs_nonuc:	Limited biomass
nonuc:	No sinks
nsink:	Limited biomass, no bio-energy carbon capture and storage, no sinks

The GEA exercise also confirms the widely held view that sustainability needs substantial frontloading of investments. Additional global energy investments needed to support sustainable paths will generally increase rapidly during the first 30 years, both in absolute terms and in relation to GDP. But even in these early years, the adoption of the right policies can reduce the "cost" of sustainable paths to affordable levels. Simulation results suggest that if the right policies are adopted, the additional investment requirement to achieve energy sustainability would not be larger than few tenths of one percent of global GDP (Figure 2). Moreover, in a few specific cases, sustainable paths would actually claim fewer investments in energy than those projected under the counterfactual scenario. On the contrary, supply policies that place the emphasis on fossil fuels will require an investment envelope equivalent to about one percent point of GDP, which represents an increase of about 50 percent over current trends in energy investment. [11]

Figure 2: Global additional energy investments in sustainable energy paths, 2010-2050 (Annual average as percent of GDP)

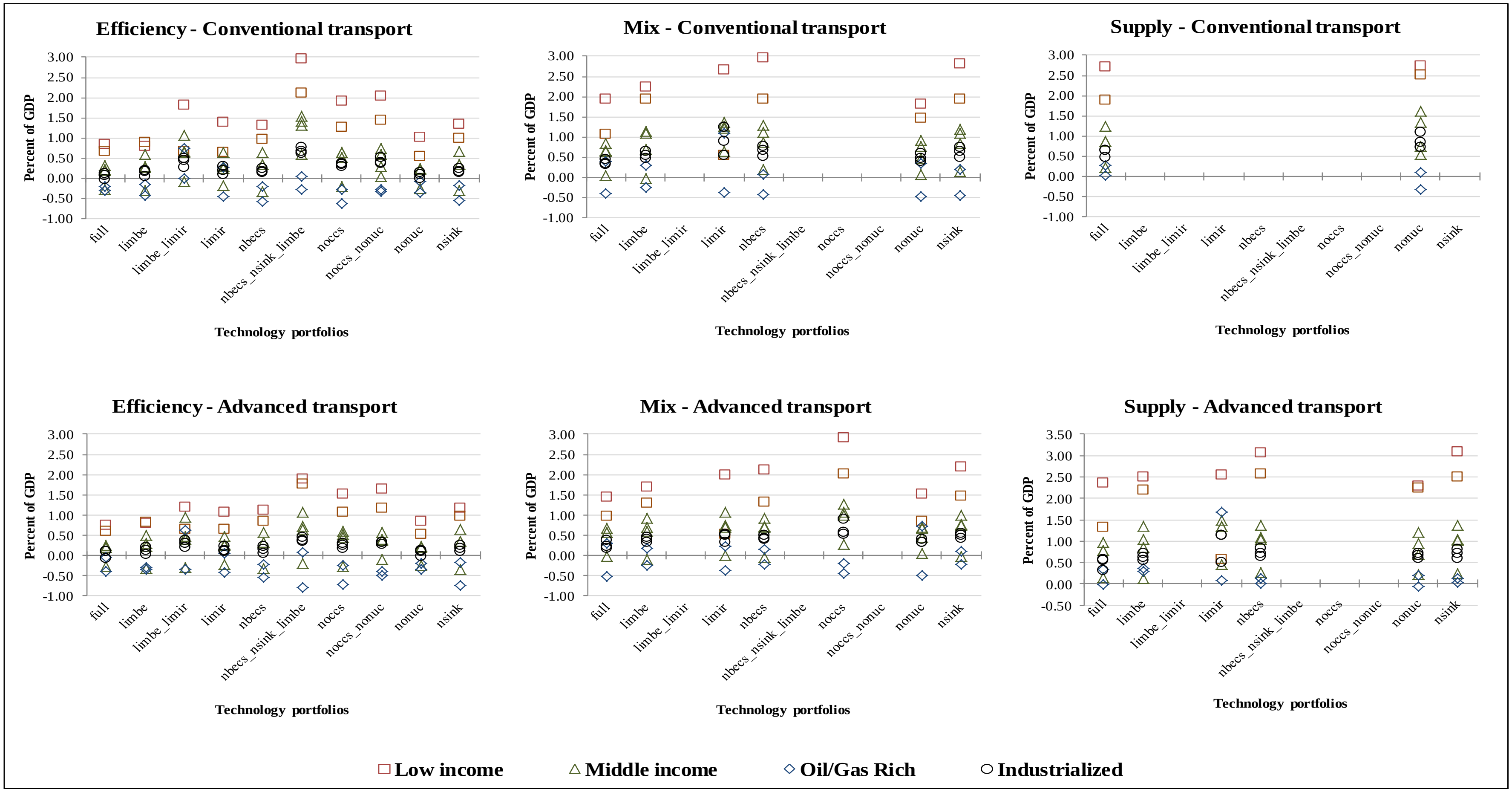


Source: Authors' construction based on GEA database (http://www.globalenergyassessment.org).
Note: Plots represent the difference between world total energy investment in sustainable paths and world total energy investment in the counterfactual scenario (keeping 2005 policies and technologies unchanged) over gross domestic product estimated at market prices. GDP is the same in all scenarios. Technology portfolios are defined in Figure 1.

Regional perspective of sustainable investments

As in current trend patterns, energy investments for sustainable development are higher in developing countries when compared to developed. In general, not only developing countries need to commit a larger proportion of their GDP to energy investments to fulfil their sustainable development aspirations, as illustrated by the counterfactual scenario, but the transition to sustainable energy paths also tends to command a stronger investment effort. Breaking estimates down to 11 regions shows that sustainable energy investments tend to be high in low income regions, moderate in middle income regions, and low in industrialized regions (Figure 3). Results support the view that on top of traditional development support, developing countries and particularly low income countries will need additional resources to pursue policies to build a sustainable energy system. Detailed results also confirm that the adoption of efficiency policies will contribute to reduce the size of sustainability investments across regions. Moreover, in a number of countries investments in energy may be lower than in a business as usual scenario, particularly in early decades. This is the case in countries grouped as Former Soviet Union (MEU) and those in the Middle East and North Africa (MEU). Lower investment requirements in these regions result from the fall in the demand for fossil fuels in other countries that are using more renewable and non-fossil energy.

Figure 3: Additional energy investment is sustainable paths by country group, 2011-2050 (Annual average as percent of GDP)



Source: Authors' construction based on GEA database (http://www.globalenergyassessment.org).

Note: Each column of points in plots includes 11 observations corresponding to the regional disaggregation of the model. Each panel represents a different combination of policies and choice of technology; for example, investment requirements of a scenario that uses conventional technology but improves energy efficiency are shown in the efficiency/conventional panel. Points represent the difference between total energy investment in sustainable paths and total energy investment in the counterfactual scenario (keeping 2005 policies and technologies unchanged). Gross domestic product is the same in all scenarios and is estimated at market prices. Technology portfolios are defined in Figure 1. Regions are classified in four groups: Low Income: AFR and SAS; Middle Income: CPA, EEU, PAS and LAM; Oil/Gas Rich: MEA and FSU; Industrialized: NAM, WEU and PAO.

To gain insights on how policies, level of development, and the frontloading of investments interact, we discuss results in five regions: Sub-Sahara Africa (AFR), South Asia (SAS), Central and South America (LAM), North America (NAM) and Western European Union (WEU). Sustainability investments in Sub-Sahara Africa, the region with the lowest income, record the largest additional sustainability investments, followed by South Asia, the second region with the lowest income. The notable increases in energy investment in the Sub-Saharan Africa region up to 2030 are consistent with the breath of actions needed for reaching almost universal access to modern energy in a region with large energy deficits and low population density.[12] For this region additional energy investments for sustainability can escalate to well above 3 percent of GDP as early as 2020. Results also suggest that in low income regions, notably Sub-Saharan Africa, investments for sustainable energy will vary significantly depending on the technology portfolio adopted. These insights suggest that these countries will require international support to afford the frontloading of large investment requirements and to gain access to the most appropriate technological options at low cost. The two high income regions show low investment requirements across policies and over time, fluctuating between zero and one percent of GDP. However, under some supply policy paths the North American region might require investments well above 4 percent of GDP, signalling the importance of adopting energy efficiency policies in this region. Sustainable investments in Central and South America are comparable to those of high income regions and in some instances are actually negative. This is explained by the strong fossil-fuel export positions of some countries in the region, but also by the region's intensive use of hydro-energy and proportionally small use of coal.

Figure 4: Additional energy investment in sustainable paths by region, 2010-2050 (Annual average as percent of GDP)

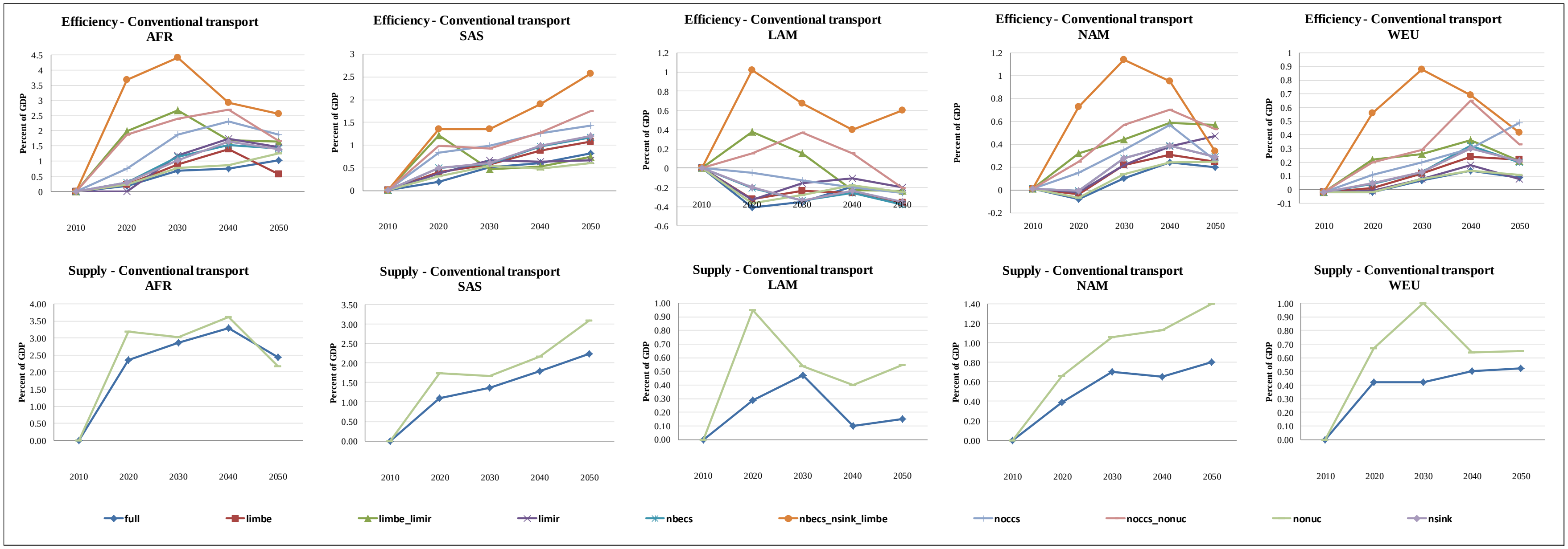
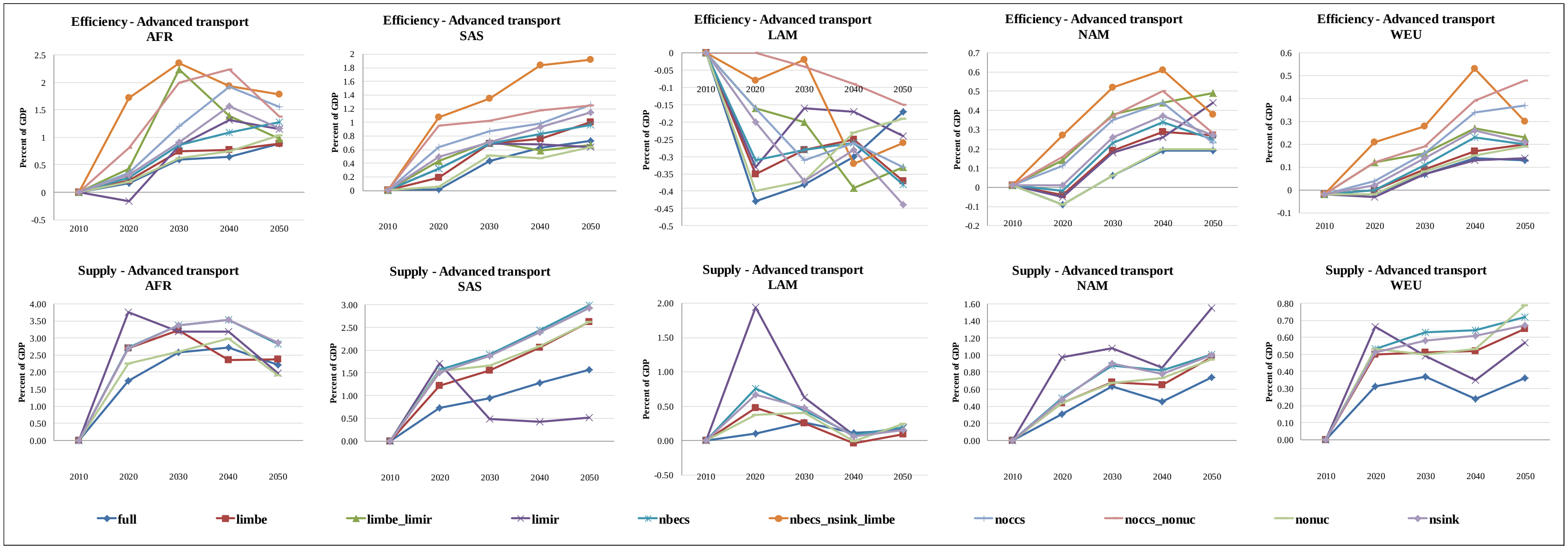


Figure 4: (continued)



Source: Authors' construction based on GEA database (http://www.globalenergyassessment.org).
Note: Each panel represents a different combination of policies and choice of technology by region; for example, investment requirements of a scenario that uses a supply policy path with conventional technology in Sub-Sahara Africa are shown in the supply-conventional/AFR panel. Plots show the difference between total energy investment in sustainable paths and total energy investment in the counterfactual scenario (keeping 2005 policies and technologies unchanged). Gross domestic product is the same in all scenarios and is estimated at market prices. Technology portfolios are defined in Figure 1. For simplicity, mix policy sustainable paths are omitted.

Focusing on energy efficiency

Investments to make efficient use of energy are very important for sustainability. Paths with strong efficiency policies expand the technology options and reduce the size of needed investments, as observed above. Efficiency investments include, among others, outlays to enhance recycling, improve life-cycle product design, and expand retrofitting of existing plants. Arguably, the technological advantage of developed countries in this type of investments is particularly strong. It is thus of particular interest to compare how these investments play out in GEA simulated sustainable paths. To simplify the discussion, we limit attention to sustainable paths assuming access to the full portfolio of technologies. For sustainable development, the accent is placed on efficiency, thus, between 2010 and 2040, investments to improve energy efficiency in the world would be twice as large when compared with supply paths.[13] Investments by region suggest that efficiency investments will be relatively higher in lower income regions. In the Sub-Sahara Africa region, for example, demand-side efficient energy investments alone might add-up to 1.0 percent of GDP. In Central and South and North America, efficiency investments might be slightly lower, clearly less than one percent of GDP. Notably, investments in the Western European Union are significantly low (few tenths of a percentage point of GDP), reflecting the relatively high energy efficiency already achieved in the region.[14] These results underscore the importance of international cooperation in ensuring that countries with less resources and technological capacities have access to the best technological options to build their own sustainable paths.

In recent years investments in renewable technologies have increased rapidly; yet, investment levels still fall short of what might be needed to achieve sustainability (IPCC, 2011; IEA, 2014a). It is interesting to look at the effect that limited access to renewable energy technologies would have on required investment to reach sustainability. The GEA simulations indicate that the needed additional investment for sustainability will be higher in Sub-Sahara Africa, and in Central South and North America when we assume there is limited access to renewables, particularly in early years.[15] Investment requirements are similar, yet smaller, in the South Asia and Western European Union regions. The financial and technology implications of these findings point again to the need to strengthen international cooperation to ensure low income regions have a fair chance to build a sustainable energy system. Even if there are leapfrogging opportunities to speed up the transition towards sustainable development, developing countries and particularly low income countries will still need to scale up energy investments. The successful adoption of sustainable development policies will thus require adequate financial resources to support investments. Even when financial requirements are not large on a global scale, they do represent a significant effort in the context of developing countries.

3. Public policies for development

The discussion so far points to the need to undertake significant investments to set energy systems in a sustainable path in developing countries. These investments are well above the sizeable energy investments needed for growth and development, already amounting to several percentage points of GDP in some regions. Such large investments will have to come through a unified effort from private and public sources. But given current market uncertainties and the strong inertia to continue businesses as usual, public policies will need to lead the way towards sustainability. Governments will need to allocate large resources to transform the energy system and achieve other economic and social development aspirations simultaneously. They will need to design a coherent strategy to jump-start the private-public investments needed for sustainability. This raises a number of questions. First, how can governments finance those sizeable investments, at least initially until private investors see potential and are ready to join efforts? There is an additional policy challenge in generating crowding-in effects that could lead to virtuous cycles of investment and growth within a sustainable pathway (United Nations, 2009). While asserting the general feasibility of using public funds to jump-start transformative energy investments is a very important step, not all countries have the same potential to create virtuous cycles of public-private investments. Most likely, there will be a significant variation across countries in terms of the size of investments that can be handled without disturbing macroeconomic balances. The second question then is: what are the macroeconomic trade-offs and synergies that such additional investments could bring about? Stepping up public investment immediately poses the question of how to finance them; all potential funding sources involve costs that need to be closely scrutinized, including their impact on private investment and consumption, on the cost of public debt, and on exchange rates.

Additional investment effort and macroeconomic trade-offs

The experience of policies aiming to achieve the MDGs provides a useful reference to answer the questions above. The MDGs were formulated to pursue social development, one of the three pillars of sustainable development. But human development investments, particularly in education and health, are also known to bear fruit in terms of increased productivity and economic growth—the other pillar of sustainable development. Several studies have analysed the economy-wide effects of stepping up public spending to achieve the MDGs. The range of investments varies significantly across countries, reflecting different initial conditions and efficiency of public social spending. These observations are supported by country studies documented in Sánchez and Vos (2013) for 9 countries in Africa, Asia and the Middle East, and Sánchez et al. (2010) for 18 Latin American and Caribbean countries. These studies estimate that additional public spending requirements to meet a number of MDG targets related to primary education, health, and water and sanitation. Additional investments range from less than one percent of GDP to a high 10 percent of GDP.[16]

The same studies suggest that, in response to public spending, there are a series of macroeconomic, labour, sectorial, poverty and distributional effects whose size and direction depend on country conditions. For example, in some cases GDP growth declines while in others it actually benefits. But even in countries where GDP is stimulated, the competitiveness of the economy over the long term could be undermined by changes in the real exchange rate induced by an increase in the demand for non-tradables. These studies also underscore the importance of adequately choosing the funding sources to finance an increase in government expenditures. In general, findings suggest that external sources have a better impact on the economy when compared to domestic sources. Within domestic sources, tapping into taxes generally brings about less adverse trade-offs than domestic borrowing. Among external sources foreign grants are preferable over debt, as there is no debt servicing involved, although due to absorptive capacity limitations both types of foreign exchange inflows may result in a real exchange rate appreciation with potential to undermine competitiveness. While negative impacts are generally small, investing in human development might also have undesired income distribution effects. This is particularly true in the context of small developing countries where such investments generally increase the demand for skilled workers (e.g., teachers, nurses and doctors, engineers) with a corresponding increase in their incomes as these workers tend to be in limited supply. Rather than an argument against increasing investments in human development such findings highlight the need to recognize and properly account for inescapable trade-offs when designing and implementing sustainable development policies.

Tax and spend

In their quest to mobilize additional resources for sustainable development, policymakers may eventually need to consider resorting to fiscal revenue. Reliance on foreign resources to finance long-term investments may not be a feasible option for many developing countries in view of debt sustainability considerations, unless foreign aid commitments by international donors are effectively delivered. Furthermore, even if foreign aid inflows increased significantly, they have been unpredictable and may be difficult to absorb without unfavourable macroeconomic consequences. Access to these inflows may also come with unfavourable conditionality and their administration is often costly thus diminishing the amount of resources effectively available for investment. Against this backdrop, countries will eventually have to rely on domestic resource mobilization. Even in low income countries, social service delivery and poverty reduction programmes are largely financed through domestic resource mobilization. Domestic borrowing is unlikely to become a significant financing source for development; most developing countries have shallow capital markets and severe constrains in domestic savings. By contrast, most developing countries still have scope to increase tax revenues as tax burdens tend to be low due to the prevalence of a large (informal) economy which remains untaxed. Even within the formal sector, tax collection is ineffective in some countries and there is room to reduce tax evasion and loopholes.[17]

There is already experience with policies that raise fiscal revenue at the same time that they help re-orient the economy towards a sustainable path.[18] A tax imposed on activities according to their carbon emissions –explicitly as carbon tax or implicitly as tax on gasoline, diesel, and energy—is a potentially important tool for sustainability. Several developed countries, notably in the Nordic region, have used this instrument over several years; more recently, some developing countries have also introduced it. A notable example is Costa Rica, who introduced a tax as early as 1997 and has maintained it since then. A tax on carbon emissions fulfils two objectives. First, it helps to raise revenues to fund low-emission programmes or, more generally, sustainable development policies. Second, it helps to correct prices and internalize some of the environmental costs of fossil fuels. In practice, however, carbon taxes have been set at such low levels that the price correction benefits have been small, leaving the revenue collection to fund sustainable policies as their most important contribution. Carbon taxes generate revenues that range from few tenths to one percent of GDP in different countries.

In spite of the appealing features of a carbon tax, however, the impact of this policy instrument needs to be carefully evaluated. The imposition of the carbon tax itself and the allocation of revenue to specific investments affects the economy as a whole, triggering a number of macroeconomic effects and trade-offs. Assessing the desirability and feasibility of these policies is very important for sustainable development. Full assessment of these effects requires the use of an economy-wide framework which allows for a simultaneous view of the impact of policy shocks into economic growth, budget issues, sector impacts, employment outcomes, and consumption consequences. A brief summary of these types of effects follows.

Assessment of economy-wide effects

The impact of imposing an implicit carbon tax is evaluated in this section using the economy-wide framework known as *Maquette* for MDG Simulations (MAMS). This model belongs to the family of dynamic-recursive computable general equilibrium (CGE) models. The choice of this particular model rests on the fact that, in addition to being a fully-fletched dynamic CGE model, it incorporates a module that specifies a number of human development indicators (see Lofgren et al., 2013). Its application involves, inter alia, detailed (country specific) microeconomic analyses of the determinants of human development indicators and the drivers of productivity growth, including the stock of public infrastructure and the existence of highly educated workers.

Our analysis is based on the application of MAMS in three developing countries—Bolivia, Costa Rica and Uganda—representative of the variety of conditions prevailing across developing countries.[19] While these countries share as a common feature their reliance on oil imports for production, the degree by which they are affected by an increase in oil prices (for example, one that is triggered by a carbon tax) will be different. Not only their degree of dependence on oil imports is different but Bolivia and Costa Rica can more easily substitute oil with other sources of (more sustainable) energy.[20]

A baseline scenario was generated for each of the three countries in order to formulate a benchmark against which different policy scenarios would be compared. This reference scenario replicates actual economic performance under policies implemented around 2005 - 2013, including spending and tax policies. This performance is subsequently projected until 2030—a reasonably long timeline for a dynamic-recursive economy-wide model analysis. Because the baseline assumes no external shock derails the economy and public spending policies, human development indicators show marked improvement under the scenario constructed.

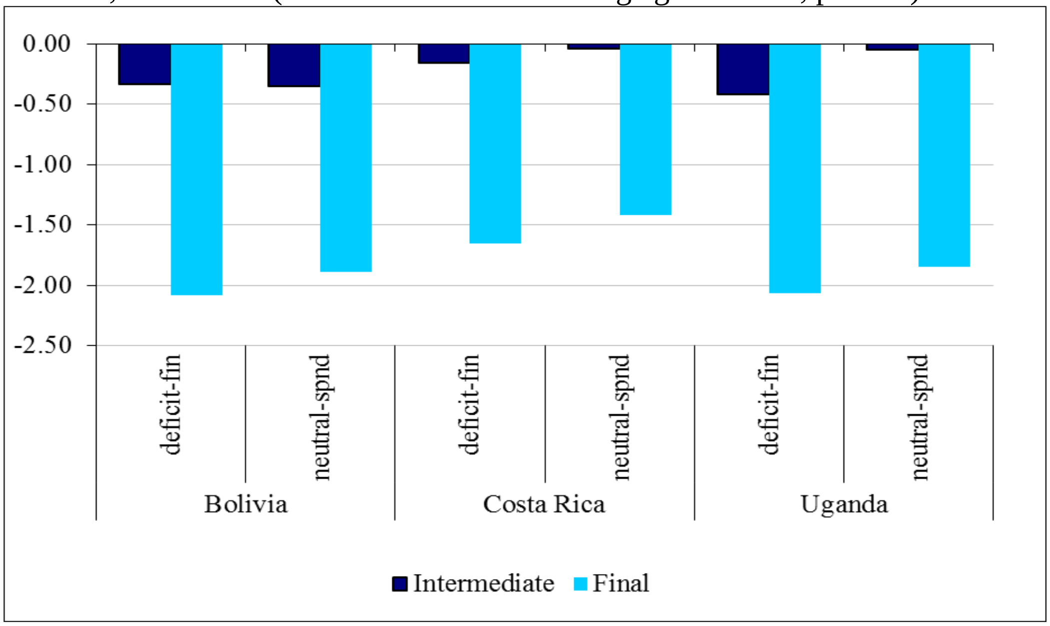
A total of 6 policy scenarios were generated and compared with the baseline. The common feature of these policy scenarios is that in all of them tax revenues in the period 2016-2030 are 2 percent of GDP higher than in the baseline. This difference in tax revenues is driven by a simulated increase in taxes on imports and domestic consumption of fuel oil, which rise gradually over time to make the simulated policy more realistic. The magnitude of change in tax revenues is similar to the additional investment needed to transform the energy system according to some of the GEA sustainable paths noted in the previous section. Each policy scenario is different with regard to the way in which the newly collected revenue is used or spent. In the first policy scenario, for example, the new revenue is used for budget deficit financing (deficit-fin). In all other policy simulations, the deficit is left unchanged while the new revenue is fully used to increase public expenditures in three different ways: (i) preserving the expenditure structure of the baseline scenario (neutral-spnd); (ii) stepping up new public infrastructure (i.e., roads, bridges and electricity networks) (infra-inv); and, (iii) raising current and capital expenditures for education (educ-spnd). Two additional variations of the third option were generated whereby expenditures are allocated to primary education only (educp-spnd) or tertiary education only (educt-spnd). The public infrastructure scenario, in particular, underscores the goal of enhancing growth and development, while the third option underscores the importance of education (in different modalities) for human development. Spending in primary education is essential to enrol more boys and girls in the formal school system at the right age with important consequences for poverty reduction and increased productivity in labour intensive sectors, particularly in the medium- to long-run. Alternatively, increasing spending in tertiary education can help improve the international competitiveness of the country and its capacity to accelerate adaptation and eventually development of new technology to enhance productivity and economic growth.

There are several studies that assess the introduction of policy options to neutralize the impact of a carbon tax on consumers' welfare, on international competitiveness or to neutralize negative impacts on employment.[21] The focus of the exercise presented here is different. Our aim is to evaluate ways in which carbon taxes can make a contribution to financing human development in particular and sustainable development in general. The discussion focuses on the effects of investing in human development and economic infrastructure.[22]

Macroeconomic effects

Imposing a tax on oil leads to an increase in its domestic price in a context where this product is imported in all three countries. As a result, there is a reduction in fuel consumption among business and households—that is essentially reflected as a reduction in total private consumption. Taxing fuel consumption has a stronger effect on final consumption when compared to the use of oil as an intermediate good, suggesting producers have more opportunities to substitute oil for non-oil sources. These changes are apparent in Figure 5, represented by the difference in the average growth of oil consumption (final and intermediate) between the first two policy shocks and the baseline scenario. The changes are much larger in Uganda, confirming that substitution towards non-oil sources are more restricted in that country when compared to Bolivia and Costa Rica. On the whole, the results confirm the view that imposing a tax on fuel has the desired effect of reducing its consumption, which will likely contribute to curb emissions of greenhouse gases and pollutants.

Figure 5: Change in real consumption of oil in the two first policy scenarios relative to baseline scenario, 2016-2030 (difference in annual average growth rate, percent)

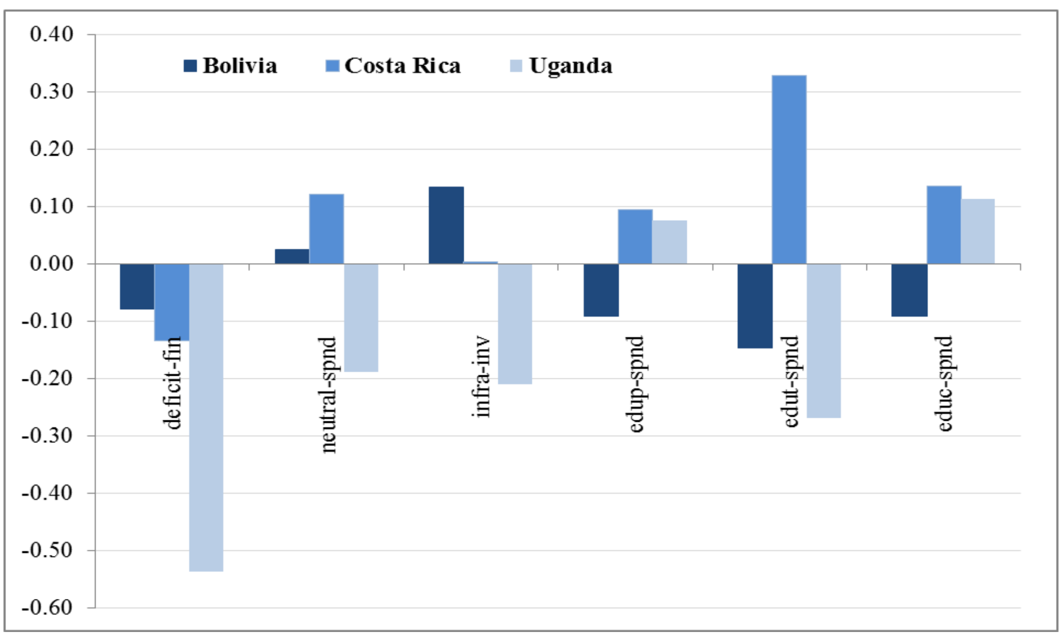


Source: Authors, based on application of MAMS with data for Bolivia, Costa Rica and Uganda.

Note: the first two policy scenarios refer to allocating revenues to reduce the budget deficit (**deficit-fin**) or fully spend all new revenue across the board while preserving the expenditure structure of the baseline scenario (**neutral-spnd**).

While the simulated policy achieves the goal of discouraging the consumption of oil, it is also important to consider its economy-wide effects. When there is no accompanying hike in spending (as in scenario deficit-fin) the policy induces a fall in the growth rate of GDP in all three countries, well in conformity with the expected consequences of running an austere fiscal policy. The cuts are small for Bolivia and Costa Rica but large for Uganda, where they amount to half of a percent point in the average growth rate of GDP (Figure 6). In contrast, the introduction of the tax in a neutral budget policy context results in an increase of the growth rate of GDP in Bolivia and Costa Rica, but not in Uganda. As noted above, the impact on oil consumption is largest in Uganda, and it is not fully offset by the increase in public spending across all sectors.

Figure 6: Changes in real GDP growth in selected policy scenarios with respect to the baseline scenario, 2016-2030 (difference in annual average growth rate, percent)



Source: Authors, based on application of MAMS with data for Bolivia, Costa Rica and Uganda.

Note: policy scenarios refer to alternative ways of spending the newly raised fuel-tax revenue as follows: to reduce the budget deficit (**deficit-fin**); to proportionally increase public expenditure preserving the baseline structure (**neutral-spnd**); to step up public infrastructure (i.e., roads, bridges and electricity networks) (**infra-inv**); and to proportionally expand current and capital expenditures in education proportionally across all levels (**educp-spnd**), only in the primary level (**educp-spnd**) or only in the tertiary level (**educt-spnd**).

The specific use of the newly raised revenue is a critical determinant of the impact on growth. One could initially expect that investing in infrastructure will have the strongest positive effects on GDP, on the presumption that building and improving roads, bridges and electricity networks improve productivity and reduce businesses costs and consumer prices. Beyond this, it is difficult to say with some certainty which of the other spending scenarios will have the next strongest effect on growth. One could argue that spending on education should have a strong impact on growth. However, education spending tends to have a long lag before today's improvements in education enhance productivity in the future. Furthermore, the impact of increased investments in education depends on the capacity of countries to fully absorb the human capital they built over time.[23] In addition, the question of what level of education bears the highest payoffs (whether primary, secondary or tertiary) is not easy to assess *a priori*; countries' contexts matter.

Results for Bolivia indicate that channelling resources for public infrastructure has the strongest positive impact on GDP growth (see Figure 6). The allocation of additional tax-revenues to a simple proportional expansion in spending across the board has the next strongest positive effect on GDP growth. Contrary to expectations, channelling resources to education, particularly to the tertiary level, actually depresses growth. This result suggests that the Bolivian economy is constrained to fully absorb an educated labour force, especially when all spending is channelled to higher education. Furthermore, skilled teachers and other qualified workers are in limited supply hence demanding them more leads to increasing wages rather than an increase in employment. The resulting increase in labour income and subsequent private spending cannot fully offset the initial reduction of oil consumption, thus the contraction in economic growth.

In the case of Costa Rica, where completion rates in both primary and secondary education are already high for developing country standards, investing the oil-tax revenue on tertiary education (educt-spnd) has the strongest positive impact on GDP—compared with all other simulations. Spending in lower levels of education also results in gains on GDP growth. Contrary to expectations, the use of newly added taxes to fund infrastructure investments results in a negligible increase in the rate of growth of GDP. Infrastructure in Costa Rica is in better shape than in the other two countries, which means that additional investments will have, *ceteris paribus*, low returns. There are potential areas of infrastructure that require upgrading (e.g., roads, bridges, ports), but attending these would necessitate a much larger effort than that simulated here.

The use of the new oil-tax revenues for infrastructure building in Uganda does not fully conform to the expected result. Investing in infrastructure only partially offsets the initial negative effect of the tax on GDP growth. A similar result is obtained when spending is scaled up in tertiary education. There are explanations for these counterintuitive results. First of all, the infrastructure sector associated to construction in Uganda is weakly linked, forward and backward, with other sectors of the economy. Therefore, investing two extra percentage points of GDP in infrastructure does not boost capital accumulation in a significant way. In the case of Uganda, productivity and economic growth are more responsive to investments in other type of infrastructure, such as irrigation in agriculture.[24] In the case of investing in tertiary education, Uganda faces similar constrains than those discussed above for Bolivia. A limited supply of skilled teachers and other qualified workers and the limitations to fully absorb better-educated workers actually lead to unemployment. As a result, the initial reduction in private consumption affecting GDP growth cannot be offset. In comparison, spending on primary and secondary education in Uganda does not face such strong labour constraints. The expansion of public expenditures in primary education or in both primary and secondary education show a small but significant increase in GDP growth.

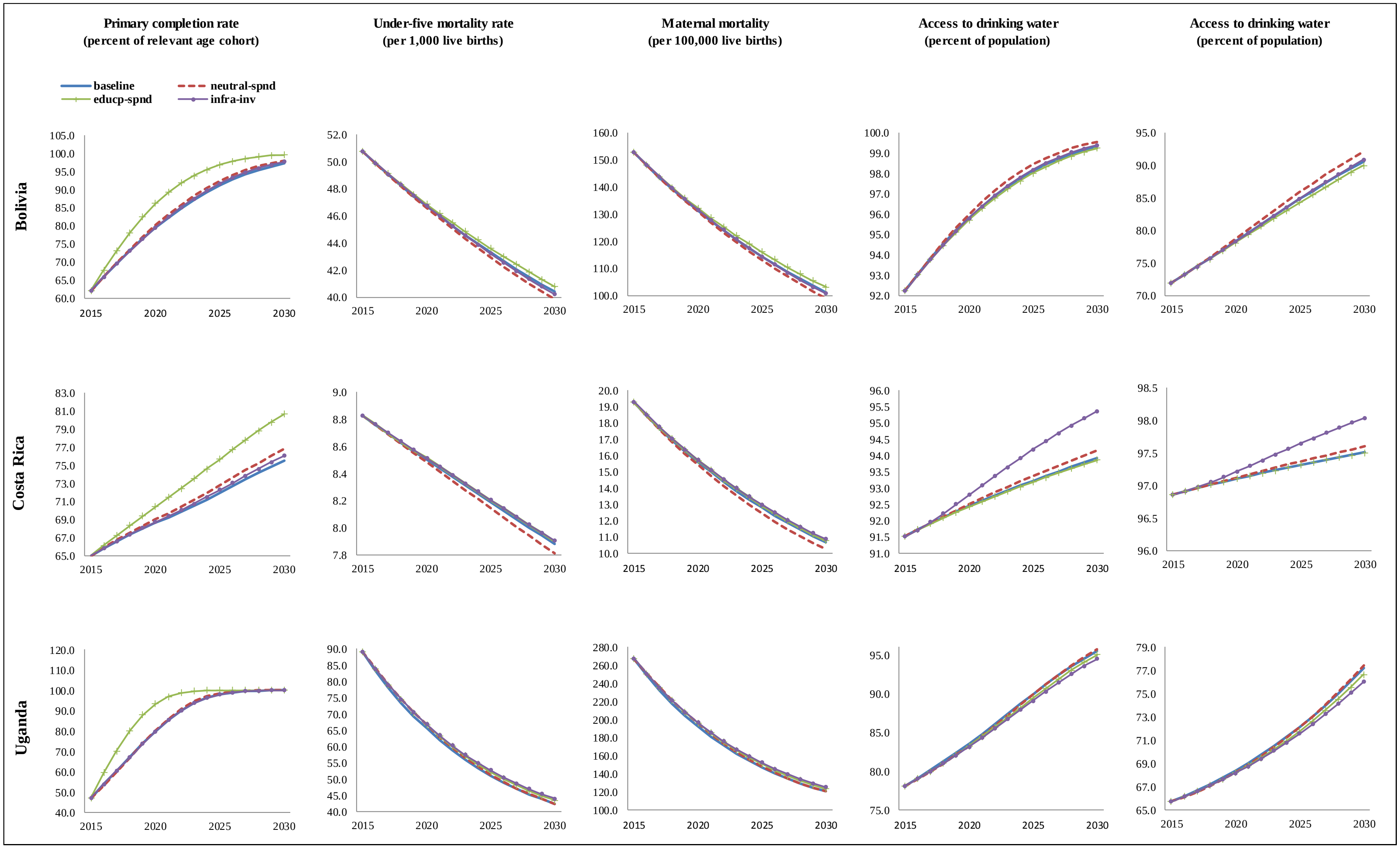
Impact on human development

Assessing the impact of policies that raise public revenues to finance social sectors and/or infrastructure extends beyond macroeconomic variables. The modelling framework allows us to probe into the impact of policy options on a number of human development indicators. Improvements in these indicators depend on various factors, including the performance of the economy, household income, public spending in health and education, and the extension of public infrastructure.

Because in the first policy scenario of fiscal austerity the economy performs worst compared with the baseline situation, human development indicators show a modest deterioration (not shown here). On the contrary, using the newly generated tax revenue to spend in one or more public sectors offsets the potential adverse impact of the oil tax on human development. In the budget neutral scenario, the additional revenue (2 percent of GDP) is proportionally allocated across all government sectors. In this case, all human development indicators improve relative to the baseline in the three countries (Figure 7). Only in the case of Uganda mortality rates do not show a clear improvement because these indicators are less responsive to total expenditures in the presence of service inefficiency. The primary completion rate increases relative to all other scenarios in all three countries, in the scenario directing the new added tax revenue fully to primary education—but also, to a lower extent, when resources are allocated to the education sector as a whole (not shown in Figure 7). Non-education indicators essentially continue to perform as in the fiscal austerity scenario or improve somewhat.[25]

These results suggest that allocating newly added public revenues to social sectors can improve human development and can also accelerate growth, as in the case of Costa Rica; or can improve human development even if it causes some loss in economic growth, as in the cases of Bolivia and Uganda. Stepping up service delivery in education only does not fully offset the adverse effects of the oil tax on non-education social indicators, even if the economy as a whole grows faster than before. The sectoral allocation of resources therefore determines the wins and losses of the tax policy.

Figure 7: Human development indicators in the baseline and selected policy scenarios, 2015-2030



Source: Authors, based on application of MAMS with data for Bolivia, Costa Rica and Uganda.

But there are also synergies to take advantage of, even if the newly generated revenue is not primarily spent in social sectors. In all cases, for instance, allocating the additional revenue to public infrastructure improves all social indicators, although only mildly in most cases—the exception is Costa Rica where the gains in the coverage of drinking water and sanitation is fairly large (Figure 7). This result is because improving public infrastructure (such as roads, bridges and electricity networks) facilitates access to and functioning of education centres, clinics, hospitals, and so on. Human development indicators are then expected to show improvements, although these improvements can vary from country to country and from indicator to indicator. The response of human development indicators to stepping up of public infrastructure is in fact nil in some cases. For example, mortality rates in Costa Rica and Uganda and access to drinking water and basic sanitation in Uganda cannot match their baseline values. This calls for a careful evaluation of alternative policy options and the variety of impact they induce, when investing in infrastructure and the social sectors. Each particular context may generate very different results. On the whole, it is safe to say that human development indicators can be enhanced by an expansive yet responsible macroeconomic fiscal policy that increases investment in infrastructure or combines this intervention with additional social spending.

Trade-offs

In spite of the synergies described above the results of different spending scenarios suggests that win-win situations with simultaneous positive impacts in GDP growth and human development are difficult to find (see Figures 6 and 7). Decision makers often confront difficult trade-offs when defining policies and strategies for sustainable development.

Examples of such trade-offs, in our results include the following. Bolivia and Costa Rica find a win-win scenario in the policy of proportionally scaling up spending across all government sectors. In this case, GDP growth and human development indicators level off above their baseline levels. Bolivia also has a similar win-win situation if it allocates the oil tax to the expansion of public infrastructure. However, there is still a decision to be made between faster human development progress at the cost of slower economic growth (as in the balanced budget scenario) versus faster GDP growth and slower human development progress (as in the infrastructure scenario).

For Costa Rica, aside from the balanced budget expansion, all other scenarios involve trade-offs.[26] According to our results, if the government channels the oil tax to primary education, primary completion rates and the pace of economic growth will improve, but at the cost of slowing down progress in maternal mortality rates. If, instead, oil taxes are devoted to tertiary education, economic growth and net enrolment to higher education will accelerate, but primary completion and mortality rates will not gain much (not shown in Figure 7).

The exercise suggests that none of the scenarios simulated result in a win-win situation for Uganda. All the scenarios involve difficult trade-offs. For example, the decision to allocate oil taxes to expand the budget proportionally helps to improve all human development indicators but at the cost of a slowdown in economic growth. Similarly, the allocation of oil taxes to primary education improves GDP growth and primary completion, but it does so at the cost of slowing-down progress in sanitation, drinking water and mortality rates.

4. Concluding remarks

Sustainable development urgently needs policies and investments that can truly generate transformative change in all countries. This chapter reviewed estimates of the energy and human development investments required for sustainable development, in an effort to highlight the interplay between policy choices and their impact on economic performance and human development. The realm of choices reviewed is wide, even if brief. The chapter looked at the effects of supply and demand energy policies on required energy investments for sustainability. It discussed the impact of policy choices on the type of fuels used in transport systems, and the choice of technology, including the promotion of R&D and technology diffusion. It also looked at the economic and social inclusion effects of policies that step up public investment in all or in a few specific areas, including investment in infrastructure and education.

The analysis of the energy policy choices suggests that energy investments will need to increase significantly in many cases if we are to succeed in transforming the energy system along the needs of sustainable development. In a good number of potential sustainable paths, energy investments might need to increase by one percent of GDP, which nearly amounts to a 50 percent hike relative to current trends. But the evidence reviewed also suggests that the world can be spared such a strong effort. Sustainable paths featuring strong efficiency policies and appropriate technology portfolios demonstrate that sustainable energy is affordable, for additional energy investments will be in the order of tenths of one percent of GDP; moreover, some sustainable paths may even allow for “savings” in the form of reductions in investments in energy.

Results analysed in the chapter reinforce the view that sustainable development necessitates a scaling-up of international cooperation to finance investment and facilitate the transfer of technology, particularly in low-income countries. Improving the capacity of countries to innovate and accelerate technology diffusion will be essential for the transition to clean energy. The evidence reviewed suggests that sustainable energy investments tend to be higher among low income countries and lower in developed countries. It also suggests sustainable investments in low-income countries, notably in Sub-Saharan Africa, require easier access to technology and rapidly increasing investments in energy, especially in the area of energy efficiency.

The analysis focusing on the implementation of public policies in three developing countries (Bolivia, Costa Rica and Uganda) supports the view that there is scope to scale-up public investment to accelerate sustainable development in its three key dimensions (economic, social and environmental), but the effectiveness of these policies varies from one country to another. The analysis suggests that increasing public investment in the order of 2 percent of GDP do not pose serious macroeconomic problems, at least in the three countries analysed. However, important trade-offs in the form of, for example, improving human development indicators at the cost of GDP growth or vice-versa, needs to be considered. Raising revenue to finance public investment is always a sensitive matter. The chapter looks at raising public revenue by imposing an implicit carbon tax, which is one form of revenue generation that has the added benefit of signalling a policy shift towards sustainable development by increasing the price of fossil fuels. The analysis of this revenue collection experiment in the three countries produces encouraging results, in the sense that this policy tool discourages fuel consumption without much disruption in the economy. The impact of the overall sustainable development policy intervention, however, will critically depend on the way increased public expenditures are allocated across sectors. From the analysis in this chapter, it is clear that there is no standard results; allocating revenues for a simple expansion of the budget as opposed to fully investing the additional resources in infrastructure or in education, results in changes in economic growth and other economic variables that are country specific. In some countries the strongest (positive or negative) impact on economic growth comes from the simple expansion of the budget, in others, it is explained by increased investments in infrastructure, or more spending in primary or in tertiary education. Specific country conditions will determine the final outcome. Moreover, the same public spending policies can generate varying effects on human development indicators such as primary completion rates, maternal and infant mortality rates, access to drinking water and sanitation. It is important to note that only in a few cases, simulations rendered win-win situations; that is to say, cases in which economic growth and human development improve in unison. In the majority of cases, choices have to be made between economic growth and performance in one or two human development indicators.

The overall message of the chapter is that a major transformation towards sustainable development is feasible but it poses two important challenges. First of all, investments in energy and human development will have to be scaled up, and in some country contexts the amount of resources needed to provide modern energy to people are significant. Secondly, in stepping up such efforts, policymakers will have to stay within a coherent policy framework that requires careful evaluation of the trade-offs and synergies that multiple policy pathways generate in concrete country contexts.

Endnotes:

[1] See, for example, IEA (2014a and 2014b)), OECD (2011a 2011b, 2012a, 2012b) United Nations (2009, 2011, 2013), UNDP (2011), UNEP (2010a, 2010b, 2011, 2012, 2013), and World Bank (2010, 2012a, 2012b).
[2] See World Economic Forum (2013), United Nations (2013), UNTT (2014), and Zepeda and Alarcon (2014).
[3] Such disparity in investment roughly corresponds to the large discrepancies in access to energy. In 2005, energy access ranged from above 200 GJ of final energy per capita in the North America region to little more than 20 GJ per capita in Sub-Sahara Africa. See `http://www.globalenergyassessment.org/`
[4] See, for example, AR5, IPCC (2013).
[5] See Riahi,et al. (2012, pp. 1214-16) and Riahi, McCollum and Krey (2012, p. 15).
[6] Supply policies are those aiming to ensure that there is enough energy to satisfy the demand for final energy. Demand policies are those seeking to make a more efficient use of energy so that the same energy services can be met with a lower quantity of final energy.
[7] See Riahi, McCollum and Krey (2012 p. 15).
[8] The simulations are carried using the IMAGE and MESSAGE models and assuming the same GDP and population projections than the counterfactual scenario (i.e., GDP grows at an annual average rate of 2 percent and population reaches a plateau of 9 billion people around the middle of the century). These simulations, as most climate change modelling exercises, do not take into account the effect of climate change on economic growth or energy investments.
[9] The number of sustainable paths by branching is as follows. Total: 41 out of 60. Efficiency: all 20. Supply: 6 and 2 for advanced and conventional transport, respectively. Mix: 7 and 5 for advanced and conventional transport, respectively. Note the special case of nuclear technology, whose phasing out is consistent with sustainability under all combinations of policy and transport mode. See Riahi et al. (2012a, pp. 1212-20).
[10] See IEA (2014a) for alternative estimates of energy investments in sustainable scenarios. See also OECD (2012a) and UNEP (2011).
[11] To simplify the discussion, we present the investment needed to bring the energy system towards sustainability as the difference between the total energy investment in sustainable paths and that of the counterfactual scenario.
[12] See Riahi et.al. (2012 pp. 1269-1267) and IEA 2014a for more detailed discussion of energy in Africa.
[13] Between 2020 and 2050 efficiency investments represent on average about 25 percent of total energy investments. Demand side or efficiency investments range between 0.7 to 1 percent of GDP in efficiency paths and around 0.4 percent of GDP in supply paths. See GEA database in http://www.globalenergyassessment.org/
[14] Efficiency investments will, of course, be higher in efficiency policy paths but, as has been noted, total investment will be lower under efficiency policies. Interestingly, however, the adoption of an advanced transport mode tends to reduce needed efficiency energy investments.
[15] See corresponding results in GEA database http://www.globalenergyassessment.org/
[16] The estimates of additional public spending are in most cases based on the assumption that countries target the MDGs as agreed internationally, with few exceptions of adaptation of these goals to countries' contexts. Accordingly, they do not necessarily represent the investment needed in a reasonably conceived local development programme. Nevertheless, these MDG estimates adequately illustrate the significant investment effort that might be needed to pursue sustainable development.
[17] According to World Bank data for the most recent year available, tax revenues as a percentage of GDP represented 17.0 in 2007 in Bolivia, 13.6 in 2012 in Costa Rica, and 13.0 in 2012 in Uganda. These are the three developing countries on which the scenario analysis of this section focuses. See http://databank.worldbank.org/data/views/variableSelection/selectvariables.aspx?source=world-development-indicators
[18] See, for example, Alton et al (2012); Bjertnaes (2011); Bjertnaes and Fehn (2008); Blackman et all (2010); Devarajan et al (2011); Fuentes (2012); Gale et.al. (2013); Gonzalez (2012); Griffiths et.al. (2012); IMF (2013); Jaafar Al-Amin and Siwar (2008); OECD (2013); Parry et.al. (2012); Ploeg, van der and Withagen (2011), Kosonen and Nicodeme (2010); Kruptnick and Parry (2012); Loisael (2009); Resnick et.al. (2012); Sumner et.al. (2009); Yusuf and Ramayandi (2008); Wiwanwiwat and Asafu-Adjaye (2013).
[19] The model was applied using, for each country, a dataset primarily consisting of a Social Accounting Matrix (SAM), which essentially provides the accounting framework of MAMS. In addition, the dataset also includes data related to the MDGs, the labour market and a set of elasticities defining behaviour in production, trade, consumption and human development indicator functions. As for the later, country-specific logistic models were estimated, econometrically, to identify the influence of supply and demand factors on various outcomes, including those related to education, health, and coverage of safe water and sanitation. The findings of these empirical analyses have been used to calibrate MAMS.

[20] According to the International Energy Agency http://www.iea.org/statistics/topics/energybalances/, in 2012 Bolivia's volume of oil products imported was less than the volume of crude oil produced in the country (in thousand tonnes of oil equivalent, ktoe). Moreover, the lion share of energy production is taken by natural gas. In Costa Rica, the total supply of energy relies on oil imports but, on the other hand, the other half is generated using renewable sources (i.e., hydropower, geothermal, and biofuels). Uganda, on the other hand, relies heavily on imports of oil products to generate electricity and primary biomass energy.

[21] See references in note 18.

[22] The level of disaggregation required to distinguish between energy and non-energy outlays within the infrastructure investment aggregate was not available at the time of elaborating this chapter.

[23] Sánchez and Cicowiez (2014) simulate a number of scenarios in which public social spending is scaled up to meet human development targets by 2015 but analyse its impact beyond 2015. The analysis is applied to four developing countries, including Bolivia, Costa Rica and Uganda. The results show that GDP could experience an additional percentage point growth of 0.2-1.0 between 2016 and 2030, with important employment repercussions, owing to the delayed impact of human development investments. The other key finding is that such economic gains are not larger in magnitude precisely because the economy's structure does not adjust commensurately to absorb the increased stock of better-educated workers. The supply of the most highly skillful workers increases to a point where the economy is no longer capable to absorb it. Such demand side constraints are likely to push down the skill premium, thus providing a disincentive to invest in education with adverse repercussions for education goals.

[24] A scenario analysis similar to that presented here shows that investing 2 additional percentage points of GDP in Uganda's agriculture infrastructure, mostly in irrigation systems, would bring about productivity gains that significantly contribute to agricultural output without expanding land use, while enhancing food security and even spurring export capacity (see United Nations, 2013, Box IV.2).

[25] In other experimental scenarios, not shown in this chapter for simplicity, the newly collected tax revenues were fully allocated to the health sector. In this case, child and maternal mortality rates fell remarkably whereas the primary completion rate improved slightly in most of the cases, although in a few cases it essentially remained at the baseline levels.

[26] But even here there might be decision to be made between achieving small additional progress in all growth and human development indicators and focusing on accelerating the pace in one particular human development indicator.

References

Alton, Theresa, and others (2012). *The Economic Implications of Introducing Carbon Taxes in South Africa*. *UNU-WIDER Working Paper*, No. 2012/46. Helsinki: United Nations University-World Institute for Development Economics Research.

Bjertnaes Geir H. (2011). Avoiding adverse employment effects from electricity taxation in Norway: What does it cost? Energy Policy 39, 4766-4773.

Bjertnaes Geir H. and taran Fehn (2008). Energy taxation in a small, open economy: Social efficiency gains versus industrial concerns. Energy Economics 30, 2050-2071.

Blackman, Allen, Rebecca Osakwe and Francisco Alpizar (2010). "Fuel tax incidence in developing countries: The case of Costa Rica" Energy Policy, 38, pp 2208-2215.

Devarajan, Shantayanan, and others (2011). Tax policy to reduce carbon emissions in a distorted economy: illustrations from a South Africa CGE model. *B.E. Journal of Economic Analysis and Policy*, vol. 11, No. 1. Available from http://www.bepress.com/bejeap/vol11/iss1/art13.

Fuentes, Juan Alberto (2012). "Hacia pactos fiscales en America Latina: entre la reciprocidad y la confrontación". In Barcena, Alicia and Narcis Serra, eds (2012). Reforma Fisccal en America Latina: ¿Que fiscalidad para que desarrollo? CEPAL and CIDOB, Santiago de Chile and Barcelona.

Gale, William G., Samuel Brown and Fernando Saltiel (2013), Carbon Taxes as Part of the Fiscal Solution, Brookings Paper (March), http://www.brookings.edu/research/papers/2013/03/12-carbon-tax-gale

GEA (2012). Global Energy Assessment – Toward a Sustainable Future, Cambridge University Press, Cambridge UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Luxemburg, Austria.

Gonzalez, Fidel (2012). Distributional effects of carbon taxes: the case of Mexico. *Energy Economics*, vol. 34, No. 6, pp. 2102-2115. doi: 10.1016/j.eneco.2012.03.007.

Griffiths, Charles, Elizabeth Kopits, Alex Marten, Chris Moore, Steve Newbold, and Ann Wolverton (2012). The Social Cost of Carbon: Valuing Carbon Reductions in Policy Analysis. In Parry, Ian W.H., Ruud de Mooji, and Michael Keen eds. (2012). Fiscal Policy to Mitigate Climate Change. IMF. Washington DC.

Grubler, Arnulf, Francisco Aguayo, Kelly Gallagher, Marko Hekkert, Kejun Jiang, Lynn Mytelka, Lena Neij, Gregory Nemet, Charlie Wilson (2012). In GEA (2012) *op cit*.

IEA (2014a), World Energy Investment Outlook: Special Report. OECD/IEA. Paris.

IEA (2014b), Capturing the Multiple Benefits of Energy Efficiency, IEA. Paris.

IMF (2013). Energy Subsidy Reform: Lessons and Implications. IMF, Washington DC.

Jaafar, Abdul Hamid, Abul Al-Amin and Chamhuri Siwar (2008). A CGE analysis of the economic impact of output-specific carbon tax on the Malaysian economy. MPRA Paper, 10210. Munich Personal RePEc Archive. Available from http://mpra.ub.uni-muenchen.de/10210/.

Parry, Ian W.H., Ruud de Mooji, and Michael Keen eds. (2012). Fiscal Policy to Mitigate Climate Change. IMF. Washington DC.

IPCC (2011). IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S.

Schlömer, C. von Stechow (eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1075 pp.39999
IPCC (2013). Summary for Policymakers. In: Climate Chnge 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
Kosonen, Katri and Nicodeme, Gaetan (2010) The Role of Fiscal Instruments in Environmental Policy. In Claudia Dias Soares, Janet E. Milne, Hope Ashiabor, Larry Kreiser, and Kurt Deketelaere (2010). Critical Issues in Environmental Taxation: volume VIII. Oxford University Press. Oxford, New York.
Kruptnick, Alan and Ian Parry (2012). What is the Best Policy Instrument for Reducing CO2 Emissions? In Parry, Ian W.H., Ruud de Mooji, and Michael Keen eds. (2012). Fiscal Policy to Mitigate Climate Change. IMF. Washington DC.
Le Page, Michael (2014), "What would a world without fossil fuels look like?" New Scientist 2991, pp. 34-39.
Lofgren, Hans, Martin Cicowiez and Carolina Díaz-Bonilla (2013). MAMS – A Computable General Equilibrium Model for Developing Country Strategy Analysis. In: Peter B. Dixon and Dale W. Jorgenson (eds), Handbook of Computable General Equilibrium Modeling, Amsterdam, North-Holland.
Loisael, Rodica (2009). Environmental climate instruments in Romania: Acomparative approach using dynamic CGE modelling. Energy Policy 37, 2190-2204.
Organization for Economic Cooperation and Development (2011a). Tools for delivering on green growth. Prepared for the OECD Meeting of the Council at Ministerial Level, 25-26 May 2011, Paris.
________ (2011b). *Towards Green Growth*. Paris.
________ (2012a). Environmental Outlook to 2050: The Consequences of Inaction. Paris. doi: http://dx.doi.org/10.1787/9789264122246-en.
________ (2012b). *Development Co-operation Report 2012: Lessons in Linking Sustainability and Development*. Paris. Available from http://dx.doi. org/10.1787/dcr-2012-en.
________ (2013). Climate and Carbon: Aligning Prices and Policies. Environment Policy Papers
Ploeg, van der Frederick, and Cees Withagen (2011). Optimal carbon tax with a dirty backstop: oil, coal, or renewables? CESifo Working Paper, No. 3334. Munich, Germany: CESifo Group.
Resnick, Danielle, Finn Tarp and James Thurlow (2012). *The Political Economy of Green-Growth: Illustrations from Southern Africa*. *UNU-WIDER Working Paper*, No. 2012/11. Helsinki: United Nations University-World Institute for Development Economics Research.
Riahi, K., F. Dentener, D. Gielen, A. Grubler, J. Jewell, Z. Klimont, V. Krey, D. McCollum, S. Pachauri, S. Rao, B. van Ruijven, D. P. van Vuuren, and C. Wilson (2012). Energy Pathways for Sustainable Development. In GEA (2012) *op cit*:
Riahi, K., D. McCollum and V. Krey (2012). The Next Energy Transition: Transformative Pathways, Choices and Opportunities. IIASA, Laxenburg, Austria.
Sánchez, M. V., Vos, R., Ganuza, E., Lofgren, E., & Díaz-Bonilla, C. (Eds.). (2010). Public Policies for Human Development. Feasible Financing Strategies for Achieving MDGs in Latin America and the Caribbean, London: Palgrave Macmillan.
Sánchez, Marco. V., and Vos, Rob (Eds.). (2013). Financing Human Development in Africa, Asia and the Middle East, New York, NY: Bloomsbury in association with the United Nations.
Sánchez, Marco V., and Martín Cicowiez (2014). Trade-offs and Payoffs of Investing in Human Development, World Development 62, pp. 14-29 (forthcoming).
Sumner, Jenny, Lori Bird and Hillary Smith (2009). Carbon taxes: a review of experience and policy design considerations. Technical report NREL/TP-6A2-47312.
United Nations (2009). Promoting Development, Saving the Planet 2009: Sustainable Development Challenges. New York: Department of Economic and Social Affairs
____________ (2011). World Economic and Social Survey 2011: The Great Green Technological Transformation. New York: Department of Economic and Social Affairs.____________ (2012), Realizing the Future We Want. New York: UN Task Team on the Post-2015 Development Agenda report to the Secretary General.
____________ (2013). World Economic and Social Survey 2013: Sustainable Development Challenges. New York: Department of Economic and Social Affairs.

United Nations Development Programme (2011). *Human Development Report, 2011: Sustainability and Equity- A Better Future for All*, United Kingdom: Palgrave Macmillan.

United Nations Environment Programme (2010a). Green economy report: a preview. Châtelaine, Switzerland.

________ (2010b). Driving a green economy through public finance and fiscal policy reform. Working paper v. 1.0. Geneva.

________ (2011). Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. Nairobi. Available from www.unep.org/greeneconomy.

________ (2012). GEO5: Global Environment Outlook - Environment for the Future We Want. Nairobi. Available from http://www.unep.org/geo/pdfs/geo5/GEO5_report_full_en.pdf.

________ (2013). The Emissions Gap Report 2012: A UNEP Synthesis Report. Nairobi. November.

United Nations Task Team (2014), “Financing for sustainable development: Review, United Nations Task Team, Working Group on Sustainable Development Financing of global investment requirement estimates, UNDESA, New York

Wiwanwiwat, Suthin and John Asafu-Adjaye (2013). Is there a role for biofuels in promoting energy self-sufficiency and security? A CGE analysis of biofuel policy in Thailand. Energy Policy 2013, pp. 543-555.

World Bank (2010a). World Development Report 2010: Development and Climate Change. Washington, D.C.

________ (2012a). Turn down the heat: why a 4ºC warmer world must be avoided. Report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. Washington, D.C. November.

________ (2012b). *Inclusive Green Growth: The Pathway to Sustainable Development*. Washington, D.C.

World Economic Forum (2013). The Green Investment Report: The Ways and Means to Unlock Private Finance for Green Growth—A Report of the Green Growth Action Alliance. Geneva.

Yeager, Kurt, Felix Dayo, Brian Fisher, Roger Fouquet, Asmerom Gilau, Hans-Holger Rogner (2012) Energy and Economy. In GEA (2012) *op cit*.

Yusuf, Arief Anshory, and Arief Ramayandi (2008). Reducing fuel subsidy or taxing carbon: comparing the two instruments from the economy, environment, and equity perspective for Indonesia. Working Paper in Economics and Development Studies, Padjadjaran University, Bandung, Indonesia.

Zepeda, Eduardo and Diana Alarcon (2014) Achieving sustainable development: the energy investment challenge. UN/DESA Policy Brief No. 43, New York.