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A NEW APPROACH TO MEASURING GREEN GDP: A CROSS-COUNTRY ANALYSIS

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Abstract. While the gross national/domestic product (GNP/GDP) index is a highly reliable indicator that reflects economic performance of a country, it still largely ignores the depreciation of assets, non-market economy and especially the damages to the environment caused by growth. Environmental sustainability of economic growth has come to be recognized as one of the most important pillars of sustainable growth and development. In order to tackle many challenges of the so-called green growth and sustainable development we try to build a new/alternative Green GDP indicator that should give us a clearer perspective of the consequences of economic progress by offering a new approach in quantifying the cost of ecological and environmental degradation. The indicator reviews economic growth through the environmental prism without speculating on how economic and social trends will evolve and how these developments will guide policy making in the years to come. We are well conscious that this indicator cannot ideally reflect the genuine status and improvement of national output, however, we see it as an attempt to encourage further discussions on the green growth in a diverse range of developing and developed countries. The results reveal a necessity for a new synergy between economic and environmental concepts, hence this study should be seen as an opportunity, not an obstacle for equitable and sustainable growth/development prospects.

Keywords: Green GDP, sustainable economic growth, environment and development

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JEL Classification: E01, O10, Q56

1. Introduction

A frequently asked question lately is whether the traditional measures of a country's level of economic activity and progress, such as gross domestic product (GDP) or gross national product (GNP), fail to account for the environmental issues. There is a general consensus that these indicators, (especially) according to the concepts of sustainable development and green growth, appear to be poor measurements. Some of the common critiques state that these standard measures do not take into account non-valued aspects of income distribution, the depreciation

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of assets, the non-market economy and the environmental issues of pollution, ecological degradation and resource depletion. Thus, the GDP, for example, tells us nothing about sustainability and/or equitability of growth and development. It is even worse when we use it as a measure of comparison between countries, since many countries achieve their growth by means detrimental to their environment. *Ditto*, it also becomes a question of ethics. Many would agree that GDP is a bad measure simply because it is an incomplete indicator. However, we have to be objective as well and state that standard measures such as GDP do have an enormous impact on policy goals and regulations, public and academic discourse as well the media since it is a powerful accountability mechanism (Boyd, 2009) that is objective, scientific and rule-driven, politically and institutionally independent and allows us to observe a complex economic system on an aggregate and disaggregate level. Motivated by these questions, throughout history, numerous scholars have tried to evaluate economic growth by proposing alternative measures that would incorporate different aspects of well-being, but none of the proposed indicators have yet captured enough range to dethrone the GDP measure. There are plenty of reasons why this is so, and some of these will be addressed in this paper. However, due to heterogeneous public attitude/opinions, many forms of ecological and environmental groups, an increased attention in the media, the relevance of economic costs of natural resource depletion and pollution, damages to the future growth and development perspectives, a relatively new measure of growth imposed itself as a relevant factor in measuring welfare and well-being i.e. the so-called Green GDP. Green GDP is an alternative indicator of economic growth that incorporates environmental consequences of that growth by including the depletion of natural resources and degradation of the environment. Namely, as the economic growth improves quality of life to a certain point, it usually has a negative effect beyond this point due to the 'threshold effect'. When this point is crossed, further economic growth can deteriorate the quality of life due to the costs associated with an increasing income inequality, loss of leisure time and natural resource depletion. These deficiencies could be detected by using alternative methods of national accounting or by calculating the Green GDP indicator (Vaghefi, Siwar and Aziz, 2015).

The goal of this study is to present the calculation of an environmentally adjusted GDP measure on the cross-country base in order to shed some more light on the relevance of green growth and sustainable development. Hence, we try to build an alternative Green GDP indicator that can give a clearer perspective on the consequences of economic progress by offering a new approach in quantifying the cost of ecological and environmental degradation. Not only will it evaluate the real costs of environmental damage, but it will also process some opportunity costs. We are well aware that this kind of indicator and the result itself cannot ideally reflect the genuine status and improvement of national output across the countries, however, we see it as an attempt to encourage further discussions on the green growth syntagm in a diverse range of countries, institutions, media and academic circles. The general conclusion is that economic growth is largely influenced by environmental factors; therefore, a new synergy between economic and environmental concepts should be achieved in order to make more accurate assessments of true national progress and well-being in the future.

All the data used in the study are on a country level for the year 2014. A sample of 44 countries includes developing countries and developed countries. In that manner, the sample covers some major countries of the world (European Union (EU) countries and its potential members, part of the OECD countries and some selected ones, China being the most eclectic example). Data are collected from Eurostat and World Development Indicators (WDI) database of the World Bank. All the data are thoroughly checked in order to achieve robustness, integrity and compatibility of the results across countries.

The remainder of the paper is organized as follows. Section 2 surveys the theoretical background of the Green GDP concept and offers a short review of the empirical literature. Section 3 contemplates on the challenges and future perspective of the topic. Section 4 gives a full perspective to the analytical part by describing used methodology and data together with the results of the analysis. Section 5 offers some concluding remarks.

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2. Theoretical background and literature review

This section presents a short introduction to the development of the concept of Green GDP with introspection into some practical issues, and in addition offers an empirical background on related studies.

2.1. Development of the Green GDP

Since its introduction in 1937[*], GDP has been used to measure flows of output and income through the economy; therefore, it became a basis for decision making and economic policy evaluation. However, as we can tell from the way it is being calculated (in any of the three calculating approaches standardized by the System of National Accounts – SNA), traditional GDP answers the questions related to its structure and fluctuations, thereby ignoring many relevant factors that enrich the qualitative aspects of well-being such as human, social and natural components of capital that societies depend upon. It also does not take into account the unobservable part of the economy, i.e. the unofficial economy. As early as 1950s, some scholars began to question the conformity of this indicator as a gauge of progress. Many subsequently pointed out that such a measure can give a highly misleading impression of economic growth – growth sustainability – human development. We must, however, stress that regardless of these shortcomings, the GDP is and will still be a relevant indicator of the economic health of a country, as well as a gauge of a country's standard of living.

The first imperfection is that the GDP indicator does not measure the sustainability of economic growth, for a country can achieve a temporary high GDP by over-exploiting its natural resources (Rauch and Chi, 2010). It can also fail to register economic costs of non-market activities such as crime and unemployment. Generally, GDP can be a misleading economic indicator if we place a disproportionate importance to it because it often reflects the material and static positions, rather than signalling what is wrong in the economy. Namely, a high proportion of household consumption does not always reveal its true source or its impact on savings, trade perspectives, asset bubble etc. Therefore, it can be misleading in terms of macroeconomic management. Some scholars also believe that the GDP does a poor job capturing innovation, because innovation is not necessarily limited or even related to tangible items that the GDP traditionally measures well (Samuelson and Nordhaus, 2014). A second imperfection arises from its limitations; since the GDP does not scale the sustainability of growth (it does not detect the distribution of income, household production and/or the loss of leisure time, volunteering, costs of environment degradation, social and public health costs that are in direct relation to economic activity and etc.), it is *de facto* a bad measure of social welfare. There is a bulk of indicators nowadays that are trying to resolve these issues, for example Green GDP, Index of Sustainable Economic Welfare (ISEW), Human Development Index (HDI), Genuine Progress Indicator (GPI), Adjusted Net Saving (ANS) and an array of environmental asset accounts often related to the 'green' national accounting. The third imperfection can be derived from the previous two. Considering all of the above, the GDP is also a bad measure for international comparison of countries' life standard. Thus, the GDP should be used only for comparison of the productivity (i.e. economic growth) of various countries and not for the comparison of a global well-being.

To be in line with the topic of the paper, at the same time contemplating what has previously been stated, we will focus next on the argumentation of the part human-social-natural component in the assessment of such an important indicator. As a tool for assessing the real impact of economic growth and, ultimately, for estimating the

[*] The GDP took over 300 years to develop, however, it was introduced as a standard United Nations (UN) measure for the first time in 1956, with major revisions following in 1968 and 1993 (Rauch and Chi, 2010). Means of calculating GDP have evolved continually so as to keep up with evolving measurements of economic activity (for example new forms of intangible assets, changes in industrial activity, statistical requirements, etc.).

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sustainability of an economy, some form of environmental accounting is essential (Li and Lang, 2010). There are many technical problems and challenges in producing an aggregated environmental cost account, such as a Green GDP. The 1970s was the era in which awareness of social – environmental accounting began to take its root, but it was only, as Samuelson and Nordhaus (2014) state, on the experimental base, for issues such as sustainability and environmental awareness found no place in business practice or within government policy focus. The idea of Green GDP arose in the early 1990s in response to the imperfections of traditional GDP measure to account for specific types of (environmental) economic costs which influence human well-being. Basically, inspired by various international conferences in the early 1990s, such as the UN Conference on Environment and Development in Rio de Janeiro (1992), and the World Commission on Environment and Development (1993), the concept of sustainable social and economic development was introduced and has received global attention (Li and Lang, 2010).

Ultimately, this way of thinking led to the first international framework for environmental (green) accounting prepared by the UN System of Environmental-Economic Accounting (SEEA). By amending the SNA in 1993, the UN *de facto* paved the way for the development of the Green GDP concept[†]. As of 2012 we have the SEEA – Central Framework, the first international statistical standard for environmental-economic accounting which became a multipurpose conceptual framework for understanding the interaction between the economy and the environment, and for describing stocks and changes in stocks of environmental assets (Abdul Rahim and Noraida, 2015).

Green GDP is today known as a general concept that refers to a wide array of adjusted GDP measures that are corrected for social and environmental costs (for some of these commodities are not traditionally presented in monetary units). In that manner, Green GDP is just an alternative way for the quantification and measurement of the monetary impact of social and environmental damage caused by a country's economic growth. The most common approach to measuring the Green GDP is to deduct social and environmental costs (for example natural resources depletion and pollution damage) from the standard GDP measure. There is an interesting way to explain the (conceptual) purpose of this indicator. If we consider that by adding social features/human capital and environmental features/natural capital to a standard measure of the volume of output, we are in fact relating it to the deterioration in social or environmental capital and reducing it by the amount of capital thus consumed. Some say that we could look the other way around, too. So that any improvement in social and/or environmental capital constitutes in itself a form of output and can, therefore, be added to standard GDP measure. Sustainability criteria are becoming increasingly important for industries, organizations and economies (Zavadskas *et al*., 2016; Tvaronavičienė, Černevičiūtė, 2015) as well as energy security issues (Tvaronavičienė *et al*., 2015; Tvaronavičienė, Černevičiūtė, 2015; Strielkowski *et al*., 2016). Shadow economy is another important aspect to be considered when measuring GDP (Bejaković, 2015; Gasparėnienė et al., 2016).

2.2. Practical issues

Green GDP should not be confused with various social and environmental accounting systems, as a large number of these carry issues and problems related to valuation and calculation. As Alfsen et al. (2006) said, a Green GDP will also in many contexts do more to obscure problems than resolve them, however, from its inceptions, this indicator has become a significant factor in the development and implementation of different sustainable

[†] Green GDP was first introduced in 1993 as the concept Environmentally Adjusted Domestic Product (EDP) or Eco Domestic Product in the interim version of Integrated Environmental and Economic Accounting.

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strategies in the world. It is important to mention that there is no universally accepted approach to environmental accounting, as we will see in the next section. In the next few lines we will present some practical issues that revolve around the Green GDP.

The first issue relates to the conceptual scope of the indicator. Following the SEEA standards (from 2003), we can derive four basic approaches to environmental accounting that are relevant for the coverage of Green GDP (see Hecht, 2012). The first approach is focused on measuring the relationships between the environment and the economy in both directions, as the key motivation is to determine how closely economic activity is linked to material inputs and pollution outputs. The second approach is based on measuring environmental economic activities as it tries to measure the expenditures on environmental protection and also the impact of economic policies through taxes and subsidies on the reduction of environmental damages. The third approach, called environmental asset accounts approach, collects data on the levels of various types of natural capital and offers different ways of calculating. The last, and probably the most important approach (that can be easily related to the Green GDP concept), is based on the adjustment of existing accounting measures to account for natural capital degradation, seeking to monetize the damage associated with the depletion of natural resources and environmental quality degradation, as well as to identify the so-called defensive expenditures made in response to, or in order to avoid, environmental damages. On the other hand, Veklych and Shlapak (2013) present three methodological approaches to the environmentally adjusted domestic product calculation; (1) includes the consideration of the reduction of natural capital; (2) takes into account the environmental degradation due to the accumulation of pollutants and waste, as they have an effect on both economic activity and natural capital; (3) supposes further deduction of the costs spent on combating environmental degradation because defensive expenditures should be displayed in these adjusted accounts depending on their impact on natural capital. There is no general agreement on how Green GDP should be estimated and we find no consensus either on whether there should be a uniform measure.

The second issue is related to the process of gauging the indicator. In this part, we will mention the stages of development of the Green GDP, as presented by Rauch and Chi (2010). They state that the process of developing the Green GDP can be roughly defined by three stages: (1) environmental accounting, (2) valuation, and (3) metric calculation. Environmental accounting, as the bedrock of the process, should quantify in physical units the amount of pollution, waste and other physical quantities from the environment. Valuation is a part in which monetary values are assigned to these physical quantities by applying various valuation techniques. And consequently, with the assignment of value, the environmentally and if possible, socially adjusted GDP measure, such as Green GDP, can be estimated.

There are many methodological challenges and problems that arise from the calculation, as those seeing little contribution of the Green GDP indicator would argue that the traditional GDP indicator already provides the best account of the progress of an economy, revising the system of national account and therefore, making the Green GDP unwarranted unless a solid imperative can be put forward (Li and Lang, 2010). Few countries tried to establish their own environmental accounting (China, Australia, Norway, Germany, France, and etc.) with only China being capable of fostering detailed analyses of the Green GDP to some extent. Many countries, such as Germany, even opposed the official use of this concept because if it is not statistically correct, it can lead to controversial decisions about the value of environmental assets and the real value of national output. More on this topic can be found in the next section. Now we will focus on empirical evidence.

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2.3. Literature review

The number of both theoretical and empirical papers on the Green GDP topic is not very astonishing. As we can see from the above-mentioned complexities that evolve around the Green GDP, we can expect that the empirical part would be rather intriguing, too. This is true, mainly because empirical studies approach the matter from different standpoints that consider different lines of inquiry. In order to mitigate the empirical stroll, in this short review of the literature we will present only papers that are conceptually related to the scope of our study, i.e. how to calculate (more accurately) the Green GDP measure.

An interesting theoretical discussion is provided by Boyd (2006) in his paper on non-market benefits of nature where he evaluated two positions of the SEEA related to the measurement of benefits that arise from environmental public goods. Though the focus of this paper was the measurement of services, Boyd suggested that asset valuation is utterly possible. And that even though SEEA is too pessimistic about the economists' ability to account for ecological public goods, adequate moves can be taken immediately in order to assess what is socially valuable about the common property resource. Another engaging paper was that of Rauch and Chi (2010) who explored the challenges inherent in Green GDP implementation. Their analysis of the implementation of such framework has led to the proposal of specific recommendations that could increase the robustness of sustainability accounting systems. Their appeal is seen through the title of the paper 'The Plight of Green GDP in China and the conclusion that though China aborted initial attempts, it can yet revive its development of Green GDP and/or environmental accounting. They concluded that for the sake of China and the global community, they hope that abandoning the nationwide implementation and use of Green GDP can be a step forward that will provide efforts upon more accurate and comprehensive environmental data collection and accounting as well as additional environmental valuation research. A great evaluation of the GDP *vs*. Green GDP dilemma was provided by Samuelson and Nordhaus (2014) who concluded that the traditional GDP indicator was never intended to be an all-encompassing proxy for human well-being, for it is a partial measure, one that primarily focuses on a society's material standard of living and how it changes over time. For that, the concept of GDP will retain its value. However, because standards for data collection already exist, countries' environmental performance can be evaluated and compared if they comply with a better understanding of environmental and resource use trends, Green GDP being the one indicator that could help achieve that. For a deeper systematization of the early contributions to this topic, theoretical as well as empirical, see Qi, Xu and Coggins (2001). Let us evaluate now some of the empirical studies.

The already mentioned Veklych and Shlapak (2013) calculated the Green GDP and environmentally adjusted net domestic product for Ukraine (for the period 2001-2010) by taking into account the depletion of natural capital, environmental degradation due to atmospheric pollution and governmental expenditures on environmental protection. The general conclusion was that the economic growth of Ukraine is significantly dependent on natural capital and has substantial environmental drawbacks. Abdul Rahim and Noraida (2015) tried to examine the short-run and long-run causal relationship between the Green GDP, traditional GDP, CO_2 emissions, trade openness and urbanization for Malaysia (for the period of 1971- 2010) by applying auto-regressive distributed lag (ARDL) bounds testing approach. Apart from that, this study also examined the forecasted values of Green GDP and traditional GDP from 2011 to 2050. The forecasted values have revealed that the traditional GDP could grow at higher rates in comparison to the Green GDP until both achieve equal values in the year 2045. Surprisingly, from that year onwards, the Green GDP outweighs the traditional GDP. In that way the authors suggested that Malaysia is serious in implementing its green policies, so that in the long-run, the outcome of the vision can be in fact realized. In a different type of study, Wang (2011) tested the effects of openness to international trade at Chinese provincial level, by applying Comparable Green GDP data from 31 provinces and regions to a variant of the Solow-growth model. The main finding was that there seems to exist a non-linear relationship between the

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Green GDP and openness, measured both by volume of trade and foreign direct investment, at provincial level. This result coincides with the finding of Talberth and Bohara (2006) at national level.

The most interesting paper for our study is that of Qi, Xu and Coggins (2001) because it is the only comprehensive and extensive research of the Green GDP on a cross-country base. The authors calculated the value of environmental damage as a percentage of GDP and Green GDP for a sample of 103 developed countries and developing countries (for the period 1980-1997). On behalf of environmental damages, they concluded that the values of environmental externalities per unit of GDP in the world increased in the period 1980-1983. It implies that the environmental quality has been sacrificed on some scale to GDP growth in this period. Yet, the world's environmental externalities for producing one unit of GDP have declined steadily since 1992. On the other hand, they calculated the Green GDP indicator by country in selected years (1980, 1992, and 1997) concluding that the growth of GDP and Green GDP coincided in almost all countries, though the growth rates were on some different scales, in regard to developing countries *vs.* developed countries. The authors finally concluded that most of the countries have not worsened their environmental quality to get the gains of GDP, even if we consider the countries that are in their early development stages. Since the results (in regard to the period observed) of this study are now older than 20 years, it will be interesting to see what the results would be today. The answer will be provided by our study.

3. Green GDP; future perspective

The Green GDP indicator has become a measure of awareness by which public and policy makers are trying to enforce a new, 'environmentally attributed' policy orientation. While the Green GDP accounting is not yet a widely accepted concept, for it is methodologically complex and (socio-economically speaking) a complicated and questionable system, the improvement in theories and methods is still speeding up. As part of the movement towards a new sustainable model of growth and development, many governments have been trying to evaluate, and some of them to establish, Green GDP as one of the key indicators in the assessment of national progress (see Alfsen et al., 2006). Norway has a long history of grasping with sustainable development questions. After ambiguous attempts, pointed towards the development of natural resources and environmental accounts, Norway is today focused on hybrid accounts and indicators. As they see a need for environmental accounts and not just environmental statistics, improvements are visible in the development of adequate environmental accounting framework that would be useful to policy makers. At Statistics Canada, environmental accounts models (asset accounts, energy use, gas emissions, etc.) are updated on a regular basis. The German Federal Statistics office has implemented a number of SEEA modules on energy and air emission, physical input-output tables, land accounts, sectoral reporting modules, etc. India established survey methodologies to follow different areas of environmental accounting (waste and wastewater accounts, estimation of the annual cost of environmental degradation, etc.). Other countries that are involved in environmental accounting developments are Australia, Belgium, Denmark, Finland, France, Indonesia, Italy, Japan, Netherlands, New Zealand and Sweden (but there are other countries that are speeding up the process too). The Chinese experience with environmental accounting and Green GDP was fruitful. The most engaging project in the world came to an abrupt end as China's government structure for environmental management, the degree of additional data collection required, and the lack of consistent rules for environmental valuation contributed to the failure of the use of Green GDP indicator in China (Rauch and Chi, 2010).

The reasons for such a limited and generally unsuccessful story regarding the Green GDP concept could be found in its weaknesses. Though Green GDP calculations can raise awareness for sustainable concerns, as Jiang (2007) points out well, the Green GDP (again, in general) faces expected problems when addressing environmental damage in monetary terms; due to estimation problems and data availability, this indicator cannot consider all

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damage (depletion costs for mines, water, air, forest, wildlife, etc.) to the ecosystem. Hence, social and economic issues (such as the cost of congestion) are also not taken into account. Next, calculations often tend to neglect the overlap between the categories of damage that may exist and could lead to underestimation of the true cost of environmental damage and resource depletion. On the other hand, Green GDP also fails to account for the potential benefits of the soaring development of an economy that, though causing a rapid growth of exploitation of natural resources, may likewise cause an efficient utilization of natural resources, a competition in investment and thus a rapid economic growth. Countries on higher levels of development tend to have more concern for the environment, ecosystems, high life expectancy, greater health care and all those issues that the Green GDP cannot evaluate and accurately measure. From a standpoint of short-term assessment, the accounting of a complete – comprehensive indicator is impossible (Jinnan, Hongqiang and Fang, 2004), however in the medium to long-term, monitoring of economic progress will require both an indicator of total growth (that can be observed through traditional GDP) and an indicator of how a country's real comprehensive wealth, that includes natural, social and human capital, is changing (could be evaluated through the Green GDP).

As we can conclude, Green GDP is a term much used, but only seldom precisely defined (Alfsen et al., 2006). There are many directions in which the development of the Green GDP indicator can go, as a single or even a set of indicators, nevertheless many authors agree that the future perspective of a greener accounting should be built on several features. These are (Li and Lang, 2010; Rauch and Chi, 2010; Jinnan, Hongqiang and Fang, 2004): improving the communication between the policy makers, academia and professionals for the development of new theories and methods, stimulating public interest and policy debates, developing accurate and robust environmental accounting systems on a world basis or on a country level, accelerating the construction of such systems, strengthening international cooperation on Green GDP accounting, utilizing the knowledge resource to develop more reliable and standardized valuation techniques, and improving data transparency. But, as we already mentioned, the goal of this study is to review economic growth through alternative environmental prism without speculating on how economic and social trends will evolve and how these developments will guide policy making in the years to come. Hence, the focus of the next section is the construction of a new quantitative indicator representing alternative Green GDP measure that will help us in comparing sustainable economic growth between a range of countries.

4. Methodological issues and the results

This section consists of three parts, each a conceptual continuation of the previous. First, we will clarify some methodological issues, then evaluate the dataset and in the end, interpret the results.

4.1. Methodology

In order to derive an alternative approach to the Green GDP measurement, we considered both quantitative and qualitative features that a stable and comprehensive indicator, on a cross-country scale, should possess. So as to keep the common Green GDP accounting framework (a quantitative position), we used a general methodological algorithm that is suitable for the assessment of and comparison between different countries, as well as other surveys. Therefore, the Green GDP indicator is calculated as a traditional GDP indicator minus the cost of natural resource consumption minus the costs of environmental depletion. To secure a high degree of objectivity, the indicator is calculated based on the data that are compiled from officially recognized international sources, such as the World Bank. Additionally, the indicator is presented as a growth rate, which is convenient for the comparison to the traditional GDP measure and a numerical analogy between the countries. On the other hand, we have also considered the importance of economic dimensions that are not sufficiently reflected in the traditional GDP measure, or even in different 'green growth' approaches. Namely, our methodology (a qualitative position) integrates supplementary information by distinguishing the real costs of environmental damage and opportunity

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costs (that can be easily calculated) of a lost turnover. In that manner, we are in fact addressing certain aspects of social costs.

The goal is to create a single (monetary measurable) indicator, similar to the Green GDP concept that is comprehensible to the general public and can be easily related to the traditional GDP data. Our methodology offers a flexible framework that can be extended to incorporate additional aspects over time, reflecting growing data availability and new political, social and economic concerns, and comparability across nations and/or regions.

Drawbacks of this methodology are mainly related to the usual problems when assessing environmental damage in monetary terms. Some methods of assigning monetary values show a certain degree of arbitrariness, and the data availability and reliability is still a challenge for many countries, especially developing countries, as the required data can suffer from incomplete coverage, measurement errors and biases. At the same time, it can be criticised for not having appropriate consideration of other aspects of human and social, or even natural aspects (for example environmental protection expenditure) of development. However, we see it as an attempt that can still provide a good example for constructing and developing a new indicator that can attract widespread public attention.
Thus, a general scheme of calculation is Green GDP = GDP – (CO_2 emissions in kt *x* total CDM in average prices for kt) – (t of waste *x* 74 kWh of electrical energy *x* price for 1 kWh of electrical energy) – (GNI/100 *x* natural resources depletion % of GNI); or expressed simplified as:

$$Green\ GDP = GDP - (KtCO_2 \times PCDM) - (Twaste \times 74kWh \times Pelect) - (\frac{GNI}{100} \times \%\, NRD) \quad (1)$$

where the first deduction presents the costs of CO_2 pollution (as CO_2 emissions times carbon market price), second the opportunity costs of one tonne of waste that could be used in the production of electrical energy), and a third is the adjusted savings of natural resource depletion as a percentage of the gross national income per country.

4.2. Data

Data for a sample of 44 countries, that includes both developing and developed countries, has been collected from Eurostat and World Development Indicators (WDI) [‡]database of the World Bank (with some specific indices from other sources; see Appendix). The sample covers 44 countries of the world (EU countries and potential members, part of the OECD countries and some selected countries plus two specific regions EU-28 total and Euro area total) for the year 2014. Data (un)availability is a major obstacle in achieving more extensive research on a cross-country base for most of the data on, for example CO_2 emissions (biennially published by WDI) or tonnes of waste (published by Eurostat every five years), is published irregularly. In such manner, this is a rather static indicator, but with a possibility of publication in regular terms. Nonetheless, in order to achieve adequate robustness and integrity as well as compatibility of the Green GDP indicator across countries, all the data are

[‡] WDI is the primary World Bank collection of development indicators, compiled from officially recognized international sources. It presents the most current and accurate global development data available, and includes national, regional and global estimates.

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thoroughly checked, compiled and verified. Finally, both traditional GDP indicator and derived Green GDP are measured in current U.S. dollars (USD).

GDP (in PPP) was obtained as the sum of gross value added by all resident producers in one economy plus any product taxes minus any subsidies not included in the value of the products. It has been calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources (WDI, 2017)[§]. Carbon dioxide emissions (CO_2)[**] are expressed as kilotonnes and were obtained from the same source. Total CDM in average prices for kilotonne, is a carbon market price[††]. Total (commercial and industrial) waste is presented in tonnes and data were partially collected from the Eurostat[‡‡] and from the World Bank database. In order to evaluate opportunity costs related to waste problems, knowing that the amount of waste nations produce annually is huge, we introduced a waste-to-energy conversion principle. Hence, kilowatts of energy in one tonne of waste present an amount of electrical energy that can be obtained from a waste[§§]. The price for 1 kilowatt-hour is calculated as a mean of commercial and industrial price for each country[***]. Gross national income[†††] or GNI (in current U.S. dollars) is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad (WDI, 2017). Finally, variable adjusted savings of natural resource depletion (NRD), as a percentage of the GNI per country, presents natural resource depletion as a sum of net forest depletion, energy depletion, and mineral depletion[‡‡‡].

[§] Dollars for the GDP are converted from domestic currencies using single year official exchange rates.
[**] Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.
[††] The average volume-weighted price for CDM in 2006 was around USD 11.07 per tonne CO_2 (Capoor and Ambrosi, 2007). Price in 2006 was then transformed into a price in 2014 by adjusting it with the cumulative rate of inflation, so we obtained a total price of USD 12.64 per tonne CO_2.
[‡‡] On the basis of the Regulation on waste statistics (EC) No. 2150/2002, amended by Commission Regulation (EU) No. 849/2010, data on the generation and treatment of waste is collected from the EU Member States. The information on waste treatment is divided in five treatment types (recovery, incineration with energy recovery, other incineration, disposal on land and land treatment) and in waste categories. All values are measured in tonnes of waste and in kg per capita, based on the annual average of the population (Eurostat, 2017).
[§§] Based on the researches made by the Australian Energy Regulator; Department of Environment of Australia (2015), and some others (Waste to energy in Denmark, 2006), depending on the type of waste (our calculation uses an average waste i.e. waste composite), we came to the conclusion that a tonne of waste translates into 74 kilowatt-hours per tonne of electrical energy.
[***] Prices were given in Euros so we had to transform them to U.S. dollars (Eurostat, 2017).
[†††] Formerly gross national product (GNP).
[‡‡‡] Net forest depletion is unit resource rents times the excess of roundwood harvest over natural growth. Energy depletion is the ratio of the value of the stock of energy resources to the remaining reserve lifetime (capped at 25 years). It covers coal, crude oil, and natural gas. Mineral depletion is the ratio of the value of the stock of mineral resources to the remaining reserve lifetime (capped at 25 years). It covers tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate (WDI, 2017).

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4.3. The results

Here we present a detailed overview of the differences between the traditional GDP annual growth rates and calculated Green GDP annual growth rates for the year 2014[§§§] for the observed countries (see *Table 1*). So as to ensure robustness within the comparison, we will also evaluate different categorizations of countries, for example, developed countries vs. developing countries, ex-communist countries, the Euro area countries vs. EU-28 countries, etc.

In 2014, the growth rates of GDP (see also *Graph 1*) for the whole sample were ranging from -6.99% (Australia) to 10.79% (Iceland), whereas the values of environmentally corrected GDP i.e. Green GDP were ranging from -14.83% (Chile) to 9.94% (Iceland). Average GDP growth for all the countries was 1.92%, however, we have negative values for Green GDP growth of -0.06%, meaning that we have a difference of almost 2%. This implies that growth in these countries in 2014 was not satisfactory in terms of economic development. The most satisfactory results, hence the smallest difference (<0.60%) between the GDP and Green GDP growth was found in Belgium (0.51%), Germany (0.57%), Ireland (0.35%), Spain (0.46%), France (0.39%), Italy (0.45%), Luxemburg (0.40%), Austria (0.47%), Portugal (0.49%), Japan (0.46%), Israel (0.51%) and Switzerland (0.18%). On the other hand, the worst results, in terms of differences (>5.00%), were found in Bulgaria (5.08%), Norway (5.20%), Macedonia (6.42%), Albania (9.60%), Serbia (6.77%), Chile (8.21%) and Mexico (5.79%).

Next, we can categorize countries into three standard groups[****]: developed countries (Belgium, Denmark, Germany, Ireland, Greece, Spain, France, Italy, Cyprus, Luxemburg, Malta, Netherlands, Austria, Portugal, Finland, Sweden, UK, Iceland, Norway, USA, Australia, Japan, Israel, Switzerland (24)), developing countries (Bulgaria, Czech Rep., Estonia, Croatia, Latvia, Lithuania, Hungary, Poland, Romania, Slovenia, Slovakia, Montenegro, Serbia, Turkey, Moldova, Chile, China, Mexico (18)) and underdeveloped countries (Macedonia, Albania (2)). The sample was randomly selected, however, the results will show their integrity when compared to other similar groupings. The average GDP growth and Green GDP growth for the developed countries was 1.85% and 0.92% (difference 0.93%), then 1.78% and -1.15% (difference 2.93%) for the developing countries, and 4.03% and -3.98% (difference 8.01%) for the underdeveloped countries. This implies that environmental quality and the process of economic development grows with the development stages or, on the other hand, that the countries on the lower development stages tend to go in favour of higher (current) growth rates against sustainable human-social-natural growth and development. A direct argument for such a statement could be found when observing the results for the EU countries. Namely, the average GDP growth and Green GDP growth for the EU-28 was 3.16% and 2.56% (difference of only 0.60%), and 1.93% and 1.30% (difference of only 0.63%) for the Euro area countries. We can conclude that the most satisfactory countries, by the standard of sustainable development (seen through the smallest difference in GDP *vs.* Green GDP growth), are in fact coming from one of the most developed areas in the world, the EU. Further systematization will help us in confirming some of the previous results.

[§§§] The change in 2014 for Green GDP reflects the change in growth rates of GDP in 2014 compared to 2013.
[****] Such categorization is made purely for comparison purposes, and is in no way made to be in contrariety to the initial systematization (in 4.2.) on developed countries and developing countries.

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Table 1. GDP growth rates *vs.* Green GDP growth rates (year 2014)

Country	% GDP	% Green GDP	Country	% GDP	% Green GDP
Belgium	2.24	1.73	Slovenia	3.86	2.75
Bulgaria	1.75	-3.33	Slovakia	2.32	1.03
Czech Rep.	-0.76	-1.63	Finland	0.92	0.14
Denmark	2.12	1.09	Sweden	-0.85	-1.49
Germany	3.38	2.81	UK	10.27	9.43
Estonia	4.52	1.54	Iceland	10.79	9.94
Ireland	7.10	6.76	Norway	-4.67	-9.86
Greece	-1.58	-2.52	Montenegro	2.76	1.72
Spain	0.88	0.42	Macedonia	4.63	-1.79
France	1.09	0.70	Albania	3.43	-6.16
Croatia	-1.10	-4.08	Serbia	-2.88	-9.65
Italy	0.91	0.45	Turkey	-2.97	-4.13
Cyprus	-3.10	-3.71	Moldova	-0.03	-1.80
Latvia	3.52	1.64	EU-28	3.16	2.56
Lithuania	4.18	3.03	Euro area	1.93	1.30
Luxemburg	4.98	4.58	USA	4.20	3.10
Hungary	3.43	2.42	Australia	-6.99	-10.54
Malta	5.43	4.80	Japan	-6.37	-6.83
Netherlands	1.49	0.67	Chile	-6.62	-14.83
Austria	2.36	1.90	China	9.11	5.53
Poland	4.00	1.74	Israel	5.27	4.76
Portugal	1.79	1.30	Mexico	2.87	-2.93
Romania	4.15	0.26	Switzerland	2.61	2.43

Source: Authors' calculation

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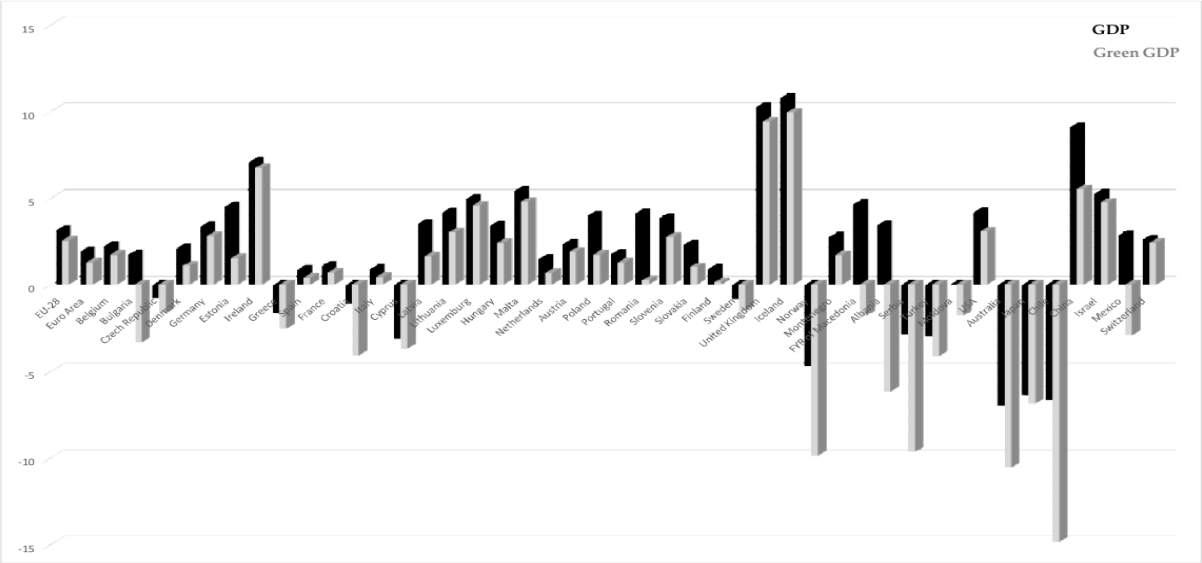

Graph 1. GDP (%) vs. Green GDP (%) in 2014

Source: Authors' calculation

Let us evaluate developed countries first. If we observe developed countries (in total) as those represented as 'High income OECD members' (as determined by the World Bank), we notice that the difference between the average GDP growth (1.87%) and Green GDP growth (0.52%) is 1.35%. When we take into account so-called 'IMF advanced economies' (according to the International Monetary Fund) we find the difference between the two indicators (2.06% against 1.01%) of 1.05%. If we eventually take into consideration the 'HDI top 25 countries' (ranked by the United Nations), there is a difference between the average GDP growth rate (2.31%) and the Green GDP growth (1.27%) of 1.04%. This is consistent with the previous, as the average values of the differences in the developed countries are below the average of the sample (1.98%). It suggests that the environmental quality tends to improve as the economy grows towards higher income levels. As Qi, Xu and Coggins (2001) put it well, such a conclusion could indicate the existence of the inverted U-curve i.e. environmental Kuznets curve on high income levels.

As for the developing countries, we notice significant differences. In the analysis of former socialist countries (Czech Rep., Bulgaria, Estonia, Croatia, Latvia, Lithuania, Hungary, Poland, Romania, Slovenia, Slovakia, Montenegro, Macedonia, Serbia and Moldova (15)) we find a huge difference between the average growth of GDP (2.29%) and the average Green GDP growth (-0.41%) of 2.70%. This difference (3.67%) gets even bigger when we focus on the ex-Yugoslavia countries (Croatia, Slovenia, Montenegro, Macedonia and Serbia), with the average GDP growth of 1.46% and a negative Green GDP growth of -2.21%. When Albania is considered, the huge difference between the indicators (3.43% against -6.16) gets to an enormous 9.59%. All the values for these countries are above the sample average, suggesting that their annual Green GDP growth rates are actually unsatisfactory.

Overall, we find that the growth rates of GDP and the growth rates of Green GDP in 2014, differ significantly in almost all countries, equally between the countries in the same grouping and in between different categories of countries. We may conclude that in most of the countries, environmental quality has been sacrificed to achieve

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higher growth rates and higher benefits of standard economic features. Finally, we have to be very careful in the interpretation, manipulation and usage of these results for they correspond to a specific period and are part of a static analysis.

Beyond conclusion

We see this paper as a step forward for a growing academic platform on 'green economy topics', a step pointed towards improving, amending, evolving and promoting further development of green growth measurements and indicators. By stating that there is a need for a new synergy between economic and environmental concepts so that more accurate assessments of true national progress and well-being in the future could be made, we are in fact raising many questions such as: Why do we need to measure Green GDP? How to measure it? Should we forecast green growth? Who are the potential users of the Green GDP indicator? How to make it an accounting rule? There is no strict answer(s) to these questions, but a pragmatic epilogue in a question form: if a century ago, a GDP indicator was a kind of anathema, yet it became the most important economic measure of economic progress; why should we not put our intellectual capacity into the development of a new indicator, that could one day become (at least) an equally important measure of a broader aspect i.e. socio-economic progress. The objective of this study was to evaluate economic growth through an alternative environmental prism without speculating on how economic and social trends will evolve and how these developments will guide economic policies in the future. Therefore, we have offered an alternative approach in quantifying the Green GDP indicator that could be used for a comparison of sustainable economic growth on a cross-country base. First, so far, no systematic attempt has been made for measuring Green GDP on a global scale or on the European level (with few exceptions). Second, by promoting an alternative indicator of socio-economic progress we are addressing a wide audience: academic circles, public groups, national policy makers but also policy analysts in important international organizations. The structural similarity to the traditional GDP measure could offer the opportunity to create public perception/awareness, thus linking it to concrete policy agendas. And third, due to its methodological limitations and interpretation scantiness, Green GDP cannot replace the traditional GDP measure, nor will it substitute other measures of sustainable development, but should be seen as an attempt in contemplating an unavoidable feature of economic progress - sustainability.

In deriving this alternative Green GDP measure, we considered both quantitative (common methodological algorithm) and qualitative (opportunity costs) features. The major distinction from other approaches is visible in this qualitative attribution. Our methodology, from a qualitative position, integrates supplementary information by distinguishing the real costs of environmental damage and opportunity costs of a lost turnover. Additionally, our methodology offers a flexible framework that can be extended to incorporate additional aspects over time (growing data availability, new international concerns, and comparability across nations and/or regions). This brings us to two major shortcomings of the study that we as authors would like to emphasize. The first is data availability and the scope (providing rather static analysis) of the research. Second is the partiality of some conclusions (resulting from *rule-of thumb* scaling and generalization). Both can impose a certain narrowness in economic reasoning (since we cannot comprehend a larger picture within a specific time domain); however, we find this argument as an incentive for further research that could include different (but analogous) set of data and broader time horizons.

Results suggest that the growth rates of GDP and the growth rates of Green GDP in the year 2014, differed significantly in almost all countries, equally between the countries in the same groupings and in between different categories of countries. We noticed that the difference between the average GDP growth and Green GDP growth, in the developed countries, is roughly 1%. This difference is even higher, when developing nations are considered. It stands around 3%. If we focus on undeveloped countries, this difference becomes enormous. Interestingly, the average GDP growth and Green GDP growth for the EU-28 was 3.16% and 2.56% (difference

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of only 0.60%), and 1.93% and 1.30% (difference of only 0.63%) for the Euro area countries. Generally, the lowest difference between these two indicators was found within developed European countries, Israel and Japan, and the highest for developing nations such as Albania, Bulgaria, Serbia, Chile and Mexico. The regularly emphasized example for the (obvious) lack of environmental awareness is China, however we found a relatively coherent result, similar to other developing nations. Finally, we conclude by stating that most of the countries' environmental quality in 2014 was sacrificed to achieve higher growth rates and higher benefits of standard economic features.

In the end, we hope that we gave a small contribution to the comprehension of methodological, as well as theoretical, vagueness within the Green GDP measurement. Our approach and deductions made above are just our opinion and could/should be subject to revision in the future.

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Appendix

Variable	Description	Source
GDP	Obtained as the sum of gross value added by all resident producers in one economy plus any product taxes minus any subsidies not included in the value of the products. It has been calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. (in PPP)	WDI (2017)
CO_2	Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring (expressed as kilotonnes).	WDI (2017)
CDM	The average volume-weighted price for carbon (in PPP)	Capoor and Ambrosi (2007)

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Twaste	Total (commercial and industrial) waste (expressed in tonnes).	WDI (2017) and Eurostat (2017)
74 kWh	Kilowatts of energy in one tonne of waste present an amount of electrical energy that can be obtained from a waste.	Australian Energy Regulator (2015), Waste to energy in Denmark (2006)
Pelect	Price for 1 kilowatt-hour is calculated as a mean of commercial and industrial price for each country. (in PPP)	Eurostat (2017)
GNI	Gross national income is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. (in PPP)	WDI (2017)
NRD	Adjusted savings of natural resource depletion as a percentage of the GNI per country, presents natural resource depletion as a sum of net forest depletion, energy depletion, and mineral depletion.	WDI (2017)

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