WORKING PAPER

TOWARDS ISEW AND GPI 2.0, PART I: DEVELOPING TWO ALTERNATIVE MEASURES OF ECONOMIC WELFARE WITH DISTINCT TIME AND BOUNDARY PERSPECTIVES FOR BELGIUM.

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Towards ISEW and GPI 2.0, part I: developing two alternative measures of economic welfare with distinct time and boundary perspectives for Belgium.

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Highlights

Two welfare measures with distinct time and boundary choices are compiled in a case study for Belgium.

The first measure – the benefits and costs experienced – considers present experiences and looks within domestic borders.

As a consequence, this experiential welfare measure does not include physical capital changes, nor the ecological costs shifted in time and space.

The second measure – the benefits and costs of present activities – additionally accounts for the benefits and costs shifted in time and space.

Since the benefits and costs of present activities incorporate physical capital changes and ecological cost-shifting we believe this measure is more informative for policy-making.

Abstract

Scholars have long had difficulties when dealing with cross-time and cross-boundary issues in the ISEW and GPI. As a result, different views exist on how to account for impacts of climate change that are shifted in time and space. This study puts forward a “2.0 methodology” that deals with cross-time and cross-boundary issues in an application to Belgium as a first step to calculate economic welfare in a standardized way for the EU-15 countries. In doing so, we address time and boundary issues by calculating two welfare measures with distinct time and boundary perspectives and introduce a number of improvements to the methodology. Experiential welfare looks at welfare that is currently experienced within domestic borders, whereas the benefits and costs of present activities also include the welfare impacts that are shifted in time and space. The former construct only registers present ecological costs within borders and does not include capital changes, while the latter includes capital changes and ecological cost-shifting. We find that both welfare and GDP improved in Belgium between 1995 and 2018. Yet, we also observe an important divergence: experiential welfare per capita and the benefits and costs of present activities improved by respectively 15% and 18%, while GDP per capita grew by 30%. As we find that for Belgium substantial ecological costs are being shifted in time and space, we suggest to move forward with the latter construct as it tracks these costs in its methodological framework. Furthermore, we also propose to look beyond the aggregate welfare level and adopt a disaggregated and dashboard-like approach to evaluate economic performance in detail.

Keywords: Index of Sustainable Economic Welfare (ISEW); Genuine Progress Indicator (GPI); cost-shifting; beyond GDP; postgrowth.

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1. Introduction

Among economists it is widely acknowledged that GDP is a poor indicator to measure social welfare or social progress (Kuznets, 1934, Max-Neef, 1995; Jackson, 2004; Fleurbaey, 2009; van den Bergh, 2009; Stiglitz et al., 2009, 2018; Costanza et al., 2014; Raworth, 2017; Hoekstra, 2019; Van der Slycken, 2021). Yet paradoxically, GDP is, to date, still very influential in economics, public policy, politics and society at large (van den Bergh, 2009), making it the 'most powerful number' in the world (Fioramonti, 2013). In parallel with the theoretical and empirical criticisms of GDP as a welfare indicator, voices have been raised to adopt alternative measures to evaluate economic performance. Many alternative "Beyond GDP" indicators have been developed over the past decades that aim to measure welfare, well-being, wealth and social progress differently – see, for instance, the approaches mentioned in Dasgupta and Mäler (2000), Dasgupta (2009), van den Bergh (2009), Fleurbaey (2009), Bleys (2012), O'Neill (2012), O'Neill et al. (2018) and Hoekstra (2019).

There is a long tradition of calculating alternative measures of economic welfare. In 1972, Nordhaus and Tobin (1972) constructed a Measure of Economic Welfare, while Zolotas (1981) created the Index of the Economic Aspects of Welfare. Daly and Cobb (1989) elaborated on both efforts to develop the Index of Sustainable Economic Welfare (ISEW) – a monetary welfare indicator that accounts for the benefits and costs of economic activity. By doing so, the ISEW accounts for many of GDP's welfare deficiencies. It does so by making visible elements that remain hidden from the rather narrow GDP lens such as unpaid work, the distribution of income and ecological destruction. Over the last thirty years, welfare indicators such as the ISEW and the Genuine Progress Indicator (GPI) have been calculated for many countries and regions all over the world. Yet, to date, these measures have had little impact on policy-making because of their lack of standardization (Bleys and Whitby, 2015). Currently, Economic Welfare Measures (EWM) such as the ISEW and GPI are being updated and improved to a "2.0 methodology" (Bagstad et al., 2014; Talberth and Weisdorf, 2017).

One of the important issues that remains unresolved is the way(s) to account for cross-time and cross-boundary issues such as ecological costs and physical capital changes (Van der Slycken and Bleys, 2020). The climate change item, for instance, is treated differently in different studies: some scholars suggest to look at the present impacts of climate change within domestic borders, whereas others include future costs and costs abroad. Mostly, EWM do not register cross-boundary issues (well). Yet, scholars have pointed at the importance to account for the environmental costs that are outsourced to other regions. Furthermore, different views exist on how to account for investments and capital changes: some authors only register current consumption services flowing from capital stocks, while others also include investments or changes in capital stocks that will contribute to future consumption flows. In order to overcome the existing conceptual unclarity and methodological shortcomings, the ISEW/GPI community needs to scrutinize how to account for cross-time and cross-boundary issues in EWM before compiling any new study.[2] In a previous paper (Van der Slycken and Bleys, 2020) we already examined these issues theoretically and conceptually.

The first novelty of this paper is that we present a case study on Belgium that is the very first to calculate two separate EWMs based on different views of dealing with ecological costs and investments in line with different time and geographical boundaries as introduced in Van der Slycken and Bleys (2020). Experiential welfare or the *benefits and costs experienced* (BCE) only look at the present ecological costs that fall within domestic borders and exclude physical capital changes, while the *benefits and costs of present economic activities* (BCPA) include capital changes and also account for the ecological costs shifted in time and beyond borders. The BCPA are argued to provide policy-makers, politicians, economists, media and the broader public with more detailed welfare information as substantial ecological costs are shifted in time and space. In addition, we introduce several other methodological novelties in this article as the welfare study we present here is the first that includes: (1) the value added by the shadow economy, (2) an inequality adjustment for the diminishing marginal utility of income that is based on a sufficiency threshold, (3) a consumption footprint view for the emissions embodied in trade, and (4) the climate impacts of aviation and shipping. In doing so, we primarily develop a "2.0 methodology" for EWM that deals with the cross-time and cross-boundary issues and apply this methodology in a case study for Belgium as a first step to calculate economic welfare in a standardized way for the EU-15 countries in a follow-up paper (Van der Slycken, 2021).

Drawing on the theoretical foundations of Hicksian and Fisherian income, section 2 outlines two indicators of economic welfare with distinct time and boundary dimensions – the *benefits and costs experienced* (BCE) and the *benefits and costs of present economic activities* (BCPA). Section 3 elaborates on the methodologies used to calculate these measures, introduces a number of methodological novelties and improvements. Section 4 estimates time series of BCE and BCPA for Belgium for the period 1995-2018. The paper concludes by discussing that future EWM should account for cost-shifting in time and space in order to guarantee that policy-makers are also informed about the fact that physical capital is being consumed or that economic activities are fueling ecological breakdown.

[2] In this paper we refer to 'alternative measures of economic welfare', 'economic welfare measures' and 'indicators of economic welfare' as the overall, general category of welfare indicators that includes the ISEW, GPI and other variants such as the German National Welfare Index.

2. What are alternative indicators of economic welfare measuring?

2.1 Defining economic welfare measures

In the past, scholars have defined and interpreted welfare – as implied by the ISEW and GPI – differently (Van der Slycken and Bleys, 2020). Some believe EWM capture sustainable economic welfare or genuine progress, while others argue they allow us to track experiential welfare. We define EWM as macroeconomic monetary welfare measures that account for the benefits and costs of economic activity. They do so by valuing the contributions from unpaid work, the market, state and shadow economy as they are all different means to satisfy people's needs and wants. Furthermore, the social and ecological costs caused by the economic process are also included, since these indicators see the economy as embedded in society and in the Earth System. As a consequence, EWM are potentially capable of guiding economies and societies on a just transition toward living well within limits by providing an alternative to move beyond GDP.

2.2 Dealing with cross-time and cross boundary issues in economic welfare measures

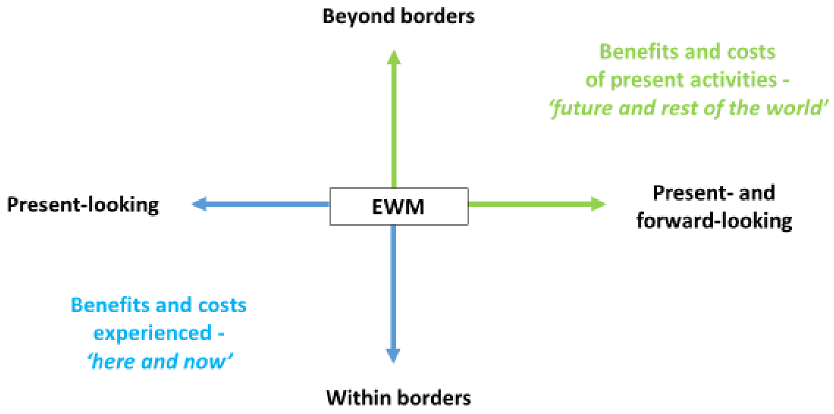
Designing EWM involves making choices on where to draw the economic system's boundaries, choices that are ideally made by relying on a theoretical or conceptual framework. It is important to scrutinize the choices made on time and boundary issues in EWM, because a recent theoretical and conceptual review found that the EWM community holds different views on how to deal with cross-time and cross-boundary issues such as ecological costs and capital changes (Van der Slycken and Bleys, 2020). Without going into detail on the theoretical foundation(s), we will summarize this review's key findings here and propose a boundary convention for the methodological choices in the remainder of this paper.

The different views the EWM community holds on dealing with cross-time and cross-boundary issues is related to the fact that EWM have a double theoretical foundation. Van der Slycken and Bleys (2020) articulated how Daly and Cobb were jointly inspired by both Hicksian and Fisherian income when creating the first ISEW. Broadly speaking, Fisher emphasizes the experiential nature of income while for Hicks capital consumption does not count as income. This theoretical duality helps to explain the different views scholars have regarding accounting for ecological costs and capital changes and their time and boundary dimensions.

Although Daly and Cobb did not explicitly link their ISEW to either Fisher or Hicks, the ISEW was ex post connected to Fisherian income by Lawn (2003). In his seminal paper, Lawn argued that the ISEW is solidly based on Irving Fisher's concepts of income and capital. According to Fisher's psychic or experiential income concept, only the current experiential consumption services that are flowing from capital stocks count as income. Based on this Fisherian concept, one can see EWM as a specific type of a cost-benefit analysis, namely as the *benefits and costs experienced* (BCE). After the establishment of this ex post theoretical Fisherian foundation, the methodology of EWM was revised – i.e. some 'Fisherisation' or 'experientisation'. First, physical capital changes were removed from EWM as accounting for capital changes is not compatible with Fisherian income. Experiential EWM should only capture current services flowing from capital stocks and thus exclude current additions to capital stocks that will lead to services experienced in future periods. Second, ecological items' boundaries were shifted: scholars aimed for maximum compatibility with Fisher's experiential concept by only including the ecological costs that are currently experienced and felt within domestic borders. Nonetheless, not all authors follow these steps as some still include capital changes and ecological costs caused beyond borders and in the future.

The 'Fisherisation' of only looking at what is experienced in the present and within domestic borders is not the only way forward, as we argued in our previous paper, since EWM can also be interpreted as the *benefits and costs of present activities* (BCPA). Following this interpretation, EWM can look at the impacts of present activities by adopting a forward-looking view that also looks beyond borders. This broad interpretation includes capital changes as these are future benefits (or costs if negative) originating from present activities. Including capital changes violates Fisher's distinction between income and capital, yet it aligns with Hicksian income, which can be approximated as the sum of consumption and capital accumulation, i.e. $C + \Delta K$ (Hicks, 1939). By deducting the depreciation of manufactured capital from the gross national product, one obtains the net national product (NNP) that is often seen as a basic version of Hicksian income. Next to this basic version of Hicksian income, there also exists an extended version of Hicksian income, i.e. green NNP, that also deducts the depletion of natural capital. This extended Hicksian income helps to explain why ecological costs are deducted in EWM. Since the ecological costs of economic activity are not necessarily *experienced*, the broader welfare interpretation should account for the ecological costs shifted in time and space – here we build on Kapp's (1950) work of seeing externalities as "cost-shifting" to the poor, future generations and the ecosystem. Fig. 1 gives an overview of the benefits and costs experienced and the benefits and costs of present activities and their different time and boundary implications.

Figure 1: Two different economic welfare measures with their distinct time and boundary dimensions.



Note: The vertical axis depicts the boundary perspective, whereas the horizontal axis reveals the time dimension. Benefits and costs experienced implies a within border perspective and takes a contemporaneous perspective on experiences: it registers what is experienced *'here and now'*. Whereas, the benefits and costs of present activities have a beyond boundary viewpoint and take a present- and forward-looking perspective by also incorporating the costs (and benefits) present activities cause to the *'future and the rest of the world'*.

Source: Van der Slycken and Bleys (2020).

2.3 Two distinct economic welfare measures

Drawing on the above, we put forward methodologies for two separate EWM that differ in their treatment of ecological costs and capital adjustments. The *benefits and costs experienced* (BCE) only include current ecological costs that are experienced within borders and exclude capital adjustments. While the *benefits and costs of present activities* (BCPA) include capital changes and also the ecological costs shifted in time and space. The component related to climate change, for instance, is captured differently in both EWM. BCE measures the damages suffered here and now, while BCPA registers the damages caused by present activities, including the damages caused to the future and the rest of the world.

Yet, both EWM have most of the welfare categories in common. The general representation of both EWM in the following equations illustrate that both EWM include the welfare contributions from unpaid work, individual and government consumption expenditures and the shadow economy, while both indicators make deductions for the welfare losses from income inequality and for a set of defensive expenditures:

$$BCE = UW + C_i + S + G_c - DIRE_p - INQ - NEC \quad (1)$$

$$BCPA = UW + C_i + S + G_c - DIRE_p - INQ - BEC + \Delta K \quad (2)$$

In Eqs. 1 and 2: UW = unpaid work, C_i = individual consumption, S = shadow economy, G_c = non-defensive collective government consumption, $DIRE_p$ = defensive, intermediate and rehabilitative private expenditures, INQ = welfare losses from income inequality, NEC = narrow ecological costs that are experienced in the present and within domestic borders, BEC = broad ecological costs, including current costs within domestic and the costs shifted in time and space, ΔK = capital adjustment. UW, C_i, S, G_c are valued positively; INQ, $DIRE_p$, NEC and BEC are deducted, whereas ΔK can be either positive or negative.

3. Methodology

In this section we will explain the valuation methods used to calculate both welfare indicators. Table 1 presents a brief overview of the methodology used. Not all items are discussed in this methodological section, yet we do want to elaborate on the items for which we introduce methodological improvements: unpaid work (Section 3.1), actual individual consumption (Section 3.2), the shadow economy (Section 3.3), the diminishing marginal utility of income (Section 3.4), climate breakdown (Section 3.5), the depletion of non-renewable energy resources (Section 3.6) and net capital growth (Section 3.7). These improvements are illustrated with data for Belgium from 1995 to 2018. A detailed explanation for all items (including data sources) can be found in Appendix A, while Appendix D provides the monetary data. In Section 4 we present the EWM results of the case study on Belgium, while a sensitivity analysis for the main methodological changes that we propose can be found in Appendix B.

Table 1: Methodological overview and additional information on two welfare interpretations.

	Items *(category)*	**Method of calculation and** ***additional information***
A	Unpaid work *(UW)*	Total hours of unpaid work x market wages *Unpaid work covers routine housework, shopping, care for household members, care for non-household members, volunteering, travel related to household activities and other unpaid work and is valued using the replacement cost method to find a market substitute.*
B	Actual individual consumption (+) *(C_i)*	B is the sum of the individual consumption expenditures by households and the individual consumption expenditures made by Non-Profit Institutions Serving Households and government.
C	Defensive, intermediate and rehabilitative private	C involves subtracting the following from B: 25% of food and alcohol expenditures, 100% of tobacco and narcotics expenditures, 100% of insurance and financial services expenditures and the cost of road accidents. The latter is

	expenditures (-) *(DIRE$_p$)*	calculated by using direct and indirect costs estimates for fatalities and injuries in road accidents. *Defensive expenditures such as insurance expenditures are deducted because they merely serve to defend oneself from the unwanted effects of other economic activities. Intermediate expenditures such as financial services are deducted too, because they are not ultimate consumption. Financial services are at best an intermediate means to final consumption but are by themselves not the ultimate end of economic activity. Rehabilitative expenses after a car accident, for instance, are undertaken to restore to previous, more healthy conditions and are deducted because they are to be seen as costs, not benefits.*
D	Cost of consumer durables (-) *(C$_i$)*	Current expenditures on durable consumer goods are subtracted.
E	Services of consumer durables (+) *(C$_i$)*	∑ previous 8 years' consumer durables expenditures x 0,2 *The services are equal to the depreciation and an imputed interest value of the stock of consumer durables.*
F	Shadow economy (+) (S*)*	F approximates the value of the shadow economy. Only 50% is included as welfare-enhancing, to exclude illegal activities and avoid double counting with actual individual consumption and unpaid work.
G	Net consumption	Actual individual consumption – defensive, intermediate and rehabilitative private expenditures – cost of consumer durables + services of consumer durables + shadow economy (B-C-D+E+F)
H	Welfare losses from income inequality (-) *(INQ)*	Inequality adjustment index x net consumption *H uses an inequality adjustment index that is based on the diminishing marginal utility of income and normalizes the correction at a sufficiency threshold.*
I	Non-defensive government expenditures (+) *(G$_c$)*	100% of government expenditures on general public services, housing and community amenities and recreation, culture and religion are included.
J	Cost of air pollution (-) *(NEC & BEC)*	J is calculated by multiplying annual emissions with cost estimates. *J compiled from a within border (i.e. production) view captures the costs related to the following pollutants PM 2,5, NOx, NH3, SO2 and NMVOC. It is assumed*

		the direct disamenity cost of air pollution in the narrow ecological costs is equal to 20% of this within border cost. In the broader perspective on air pollution, the costs of air pollution embodied in trade from the pollutants PM 2,5 fossil, PM 2,5 bio, NOx, NH3 and SO2 are added to the within border costs.
K	Ecosystem costs of nitrogen pollution (-) *(NEC & BEC)*	K is calculated by linking cost estimates to annual emissions of NO2 and NH3 and with the use of inorganic fertilizer. *The cost estimates for NO2 and NH3 only cover ecosystem costs in order to avoid double counting of health costs, which are already registered in the costs of air pollution. The ecosystem cost for reactive nitrogen measures the run-off from agricultural sources to rivers and seas. This item is included in both NEC and BEC, as it reflects current ecosystem costs within domestic borders.*
L	Cost of climate breakdown (-) (*BEC)*	L captures the damages related to climate breakdown and is calculated by multiplying a time-varying marginal social cost by the amount of greenhouse gas emissions. The emissions included are domestic emissions, CO2-emissons embodied in trade, emissions from international navigation and aviation, domestic LULUCF-emissions, the emissions related to global land use changes, and biomass emissions. *L is forward looking and looking beyond borders. It is only included in the broad ecological costs.*
M	Cost of extreme weather events (-) *(NEC)*	M is equal to the total amount of uninsured losses as insurance (subtracted as defensive expenditures) helps to 'reduce' the costs from extreme weather events. *M covers uninsured losses to approximate the damages suffered in the present from extreme weather events for the narrow ecological costs.*
N	Depletion of non-renewable energy resources (-) *(BEC)*	N is calculated by multiplying the primary energy consumption by a transition cost that is needed to replace non-renewable resources and achieve an energy efficiency target of 33% by 2030. *N is only included in the broad ecological costs. Using non-renewable energy resources means that resource stocks are being depleted. This item tries to proxy this depletion by using transition costs to replace non-renewable energy resources with a renewable substitute.*
O	Costs of use of nuclear power (-) *(BEC)*	O is calculated by multiplying the amount of nuclear electricity generated by a cost estimate from the German welfare study.

		O is forward looking and only fits in the broad ecological costs.
P	Net capital growth (+) *(ΔK)*	P is calculated by taking the difference between this year's and previous year's net capital stock. *P only fits in BCPA as net capital growth is seen as a benefit (or cost if negative) of present economic activities.*

3.1 Unpaid work

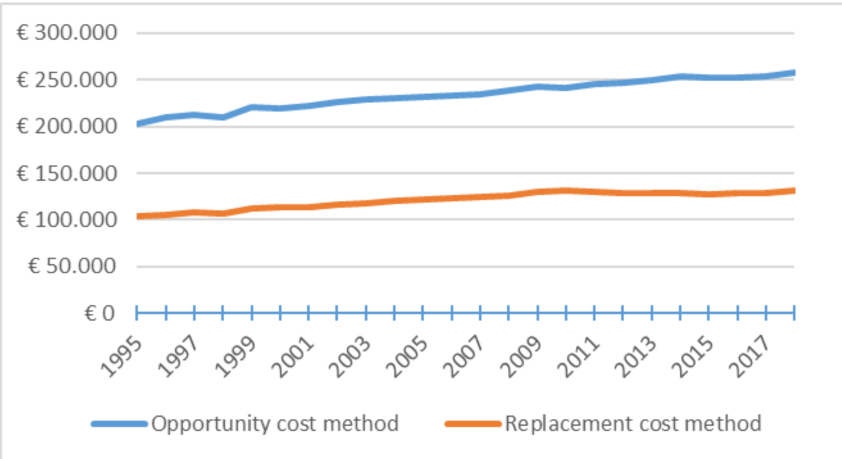
Economists have long expressed their dissatisfaction with the exclusion of unpaid household work from the System of National Accounts (see, for instance, Waring, 1999, 2003). To date, unpaid household services remain invisible, even though the production boundary of GDP has expanded over time to also include financial services and the informal sector (DeRock, 2019). In contrast to GDP, unpaid household work is included in EWM since the first attempts to measure economic welfare by Nordhaus and Tobin (1972) and Daly and Cobb (1989). EWM typically account for unpaid work as activities like cooking, cleaning or giving childcare as they are also benefits of economic activity. These activities often remain outside formal markets, although they can be commodified as market activities.

Similar to GDP, private consumption expenditures take a central place in EWM. Most EWM take final consumption expenditures as a starting point after Daly and Cobb's (1989) initial compilation. Yet, Ziegler (2007) argues that Daly and Cobb proposing an index centered around personal consumption in the appendix of a book in which they describe humans as persons-in-community is paradoxical as increasing consumption and commodification in market societies not only tends to erode social relationships, but also reduces them to merely monetary exchanges (Polanyi, 1957). Therefore, we propose to go beyond GDP by also going beyond consumption as a baseline for EWM. The consumption paradox is addressed in this paper by taking unpaid work as baseline to reveal its pivotal role in a society's welfare. Jochimsen and Knobloch (1997) argue that the "maintenance economy", consisting out of the productive and creative (reproductive) activities like ecological processes and the maintenance of physical and social relationships (i.e. "caring activities"), is a key foundation of the current industrial economic system. Proposing an indicator based on unpaid (care) work would be more consistent with seeing humans as "persons-in-community", as caring activities are about maintaining physical and social *relationships*.[3]

[3] Furthermore, unpaid work plays a significant role in a person's well-being (Nierling, 2012).

We are interested in the *output* services of unpaid work, yet, because of data availability issues time-use inputs are used to calculate this item. The time-use of unpaid work that is included in this study is broader than merely household work as it covers routine housework, shopping, care for household members, care for non-household members, volunteering, travel related to household activities and other unpaid work. Most studies value unpaid work at a replacement cost, i.e. the hourly wage to find a market substitute. However, Brown and Lazarus (2018) use the opportunity cost method, in which unpaid work is valued at average wages. In the replacement cost method, unpaid work is treated as another tradeable commodity, while the opportunity cost method rather values unpaid care work as a valuable, average economic activity as such. We will use the replacement cost method but will perform a sensitivity analysis on the results for the opportunity cost method in Appendix B. Our final replacement cost estimates can be thought of as conservative because low market wages are used, which devalues the importance of unpaid work. Moreover, it assumes the availability of a market substitute, which is not necessarily the case. Feminist economists have critiqued this low replacement cost method as anti-female and anti-care work (Berik, 2018).[4] Fig. 2 illustrates that the opportunity cost method values unpaid work almost twice as high as the replacement cost method but that the trend over time is comparable as they respectively increase by 26.6% and 25.6%.

Figure 2: The value of unpaid work using the opportunity cost and replacement cost method (million, 2010 prices).



3.2 Actual individual consumption

To this base, actual individual consumption (AIC) is added. Previous studies mostly started from household's individual consumption expenditures, which is equal to household's final consumption expenditures on individual services and goods, deducted half of the private expenditures on health

[4] The replacement cost method is anti-care and anti-feminist since Belgians, for instance, performed on average more unpaid work compared to paid work and women perform more unpaid work than paid work, in contrast to men who spend more time on paid work.

and education, and added half of the public expenditures on health and education.[5] Yet, subtracting (adding) a certain fraction of these private (public) expenditures on health and education may be seen as arbitrary. Therefore, this study measures consumption by using the amount of AIC instead of households' individual consumption expenditures.

AIC is defined as individual consumption expenditures made by households plus individual consumption expenditure by government plus individual consumption expenditures by Non-Profit Institutions Serving Households (NPISHs) (see Fig. 3). AIC is equal to what households actually consume to meet their individual needs. Using AIC has several advantages. First, it is a better measure of material well-being compared to GDP and household's individual consumption expenditures, because it captures all of the goods and services consumed by the households, irrespective of whether households pay for it themselves or benefit from it via the expenditures made by NPISHs or the government (Eurostat, 2012). Second, it fosters comparability between countries. This is needed because of country differences in who pays for health and education, for instance. In some countries individuals mostly pay for health and education expenses, whereas in other countries these services are provided to households as social transfers in kind by the government in NPISHs (Eurostat, 2012). Finally, it avoids making arbitrary decisions on the defensive fraction of health and education expenses. The defensive expenditures that we deduct from AIC to obtain the welfare category *individual consumption* are, however, determined based on a more solid rationale as explained in Appendix A.

Figure 3: From final consumption expenditure to actual final consumption.

<table>
<tr><th>Who pays</th><th>Final consumption expenditure</th><th>Actual final consumption</th><th>Who consumes</th></tr>
<tr><td>Households</td><td>Individual consumption expenditure by households</td><td rowspan="3">Actual individual consumption</td><td rowspan="3">Households individually</td></tr>
<tr><td>NPISHs</td><td>Individual consumption expenditure by NPISHs</td></tr>
<tr><td rowspan="2">General government</td><td>Individual consumption expenditure by government</td></tr>
<tr><td>Collective consumption expenditure by government</td><td>Actual collective consumption</td><td>General government (households collectively)</td></tr>
</table>

Source: Eurostat (2012).

3.3 Shadow economy

So far, while EWM made unpaid work visible, the shadow economy remained invisible although Daly and Cobb (1994) admit that they would like to include the shadow economy (excluding illegal activities) in EWM. From a welfare perspective, it is important to also account for informal market activities

5 See, for instance, the welfare measures in Daly and Cobb (1989) and Bleys (2008).

because these activities also create value in the form of consumption benefits. Including the item *shadow economy* is needed for meaningful welfare comparisons over time and between countries since the size of the shadow economy declined over time and since there are substantial differences in the size of the informal economy between countries (Kelmanson et al., 2019).

This item is estimated based on a study by Kelmanson et al. (2019), in which the size of Europe's shadow economy is estimated as a percentage of GDP. Yet, a correction is needed for double counting. Medina and Schneider (2019) illustrate that between 2009 and 2015 35.7 % Germany's shadow economy consists of legally bought material for shadow economy and do-it-yourself activities, illegal activities (smuggling etc.) and do-it-yourself activities and neighbors' help. In order to conservatively approximate the welfare contribution of the shadow economy, we have halved the size of the shadow economy, which we believe is better than taking 100% or excluding the shadow economy altogether. This can be thought of as a conservative estimate to exclude illegal activities, avoid double counting with actual individual consumption and unpaid work and exclude defensive expenditures. As the shadow economy is also treated as consumption and included in net consumption, the value of the shadow economy is also corrected for income inequality.[6]

3.4 Welfare losses from income inequality

EWM account for the welfare losses from income inequality. Daly and Cobb (1989) build on the principle of diminishing marginal utility of income to argue that a redistribution of income from a rich family to a poor family would benefit overall welfare as the reduction of the rich's utility levels would be lower than the increase in the poor's utility levels.[7] Since EWM measure consumption and not income, this adjustment can be thought of as capturing the use value of consumption by accounting for the diminishing marginal utility of *consumption.* A more equal distribution of consumption would hence also be beneficial for welfare.

Many welfare studies account for income inequality by weighing consumption expenditures via an index based on the Gini coefficient.[8] Yet, this procedure has been criticized as being ad hoc, for not making explicit the scholars' assumption on a society's aversion to inequality (Neumayer, 2000) and for lacking a clear welfare-theoretical interpretation (Dietz and Neumayer, 2006). In contrast, the

[6] Future research could investigate ways of refining this item's valuation methods, for instance by distinguishing between consumption and investment. Part of the shadow economy that is included as consumption here, but that is in fact an investment in the physical capital stock should be factored back in as a capital adjustment in BCPA in a similar was as is done with net capital growth in Section 3.7.

[7] What is more, evidence shows that more equal societies perform much better compared to unequal ones on public health, education, well-being, mental ills, violence, etc. (Wilkinson and Pickett, 2009, 2018).

[8] See, for instance, the recent studies by Kenny et al. (2019) and Held et al. (2018).

Atkinson index does take into account society's aversion to inequality, which is why weighing consumption expenditures using the Atkinson Index is the preferred procedure to account for income inequality in EWM (Neumayer, 2000; Stymne and Jackson, 2000; Dietz and Neumayer, 2006). This suggestion has been picked up by some scholars (Jackson et al., 1997; Bleys, 2008; Bleys and Van der Slycken, 2019). Recently, Talberth and Weisdorf (2017) proposed another method using an explicit correction for the diminishing marginal utility of income (DMUI). In what follows, we will first discuss the DMUI-adjustment. Afterwards we will build on Talberth and Weisdorf to present what we believe is the most appropriate way to estimate welfare losses from income inequality in EWM. Both approaches are based on the distribution of income and not on the distribution of consumption because of data availability issues. It is thus assumed that the former distribution is indicative for the latter. We will not elaborate here on the Atkinson Index. A discussion of the Atkinson Index can be found in Appendix C.

3.4.1 Talberth and Weisdorf's correction for the diminishing marginal utility of income

The adjustment based on the Atkinson Index helps EWM to take inequality into account by indicating how much lower incomes could be if they were equally distributed while keeping social welfare constant. Yet, this rationale and method is not so equipped to trace the diminishing marginal utility of income, which was the key motivation for Daly and Cobb (1989) to take inequality into account in the original ISEW. By using the income distribution to weigh consumption, Daly and Cobb (1994, p. 459) acknowledge to implicitly assume that "marginal increases in consumption by the poor are of greater value than marginal increases by the rich". Daly and Cobb deemed this was needed because "it seems likely that marginal increases in consumption bring diminishing returns to satisfaction".

Recently, Talberth and Weisdorf (2017) introduced a new correction in the GPI based on the diminishing marginal utility of income that corresponds to Daly and Cobb's (1994) reasoning. Talberth and Weisdorf make use of an iso-elastic utility function for this adjustment. The authors do so by building on Layard et al. (2008), who estimated the elasticity of marginal utility with respect to income at the individual level using subjective happiness surveys covering 50 countries and time periods between 1972 and 2005. Layard et al. argued that in normative public economics it is important to know how fast the marginal utility of income declines as income increases. This effect is captured by the elasticity, ε, of marginal utility to income. Layard et al. assume ε is constant and that utility, u, is given by:

$$u = \begin{cases} \dfrac{y^{1-\varepsilon} - 1}{1 - \varepsilon}, & \varepsilon \neq 1 \\ \log y, & \varepsilon = 1 \end{cases} \tag{3}$$

In Eq. 3 y is income. In the classical hypothesis where ε = 1, utility declines in proportion of income. Yet, Layard et al. (2008) estimate that ε is equal to 1.26, indicating that the marginal utility of income declines faster than the log of income.

Talberth and Weisdorf (2017) use the more conservative ε = 1 to calculate the inequality adjustment. Next, Talberth and Weisdorf's approach introduces an adjustment to Eq. 3. Due to the arbitrariness of the unit of income or utility, Talberth and Weisdorf have normalized utility to the median of income. This introduces a discontinuity in the utility from consumption: persons earning the median of income or less are assumed to enjoy utility equal to their consumption expenditures, however, from the median income onwards utility declines logarithmically. As a result, Talberth and Weisdorf adjust the top two income quintiles logarithmically and use the following formula to obtain the median-income normalized diminishing marginal utility of income adjustment:

$$\mathrm{DMUI}(x_{i,t}, m_t) = m_t * \ln\left(\frac{x_{i,t}}{m_t}\right) + m_t \tag{4}$$

In Eq. (4), $x_{i,t}$ is the income of household i at time t, m_t is median income at time t and ln is the natural logarithm. By taking the sum of the unadjusted incomes of the first three quintiles and the adjusted incomes from the top two quintiles, Talberth and Weisdorf obtain an adjusted income aggregate. This aggregate is divided by the total unadjusted income to obtain the fraction of consumption that remains after inequality adjustment in EWM, while 1 minus this fraction is the share of consumption expenditures that is deducted as welfare losses from income inequality. In their paper, Talberth and Weisdorf articulate that the adjustment could be normalized using other thresholds, such as the poverty threshold (or some multiple thereof), but they do not further pursue these avenues.

3.4.2 Our proposed correction for the diminishing marginal utility of income

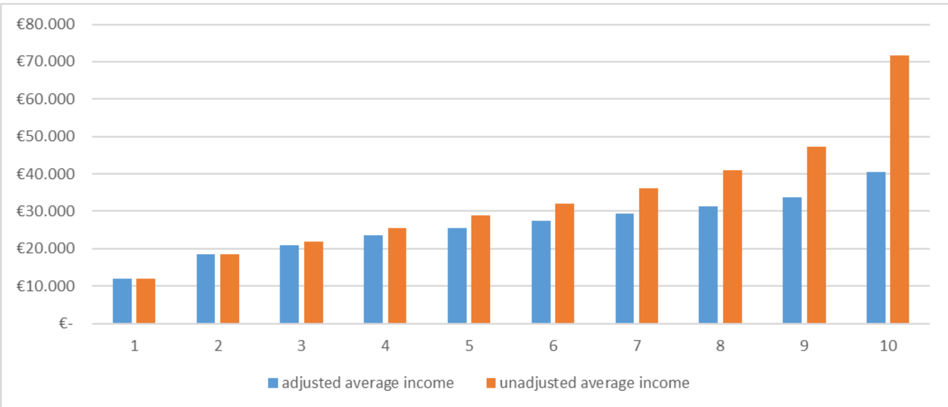
We build on Talberth and Weisdorf's approach but we suggest to normalize the data on a *sufficiency threshold*. We adjust all income deciles greater than the sufficiency threshold and call this adjustment DMUI_s. Introducing a sufficiency threshold that has a fixed absolute value (in constant prices) is a crucial requirement to properly account for the diminishing marginal utility of total income. If one would follow Talberth and Weisdorf's (2017) approach of normalizing at (median) incomes that vary (increase) over time, then this has the effect that the threshold increases as incomes rise such that the proposed adjustment fails to properly correct for the diminishing marginal utility of income.

We use a sufficiency threshold of $20,000 in 2011 prices in line with Hickel (2020) who set forth this threshold in the calculation of his Sustainable Development Index. For Belgium, the threshold is equal to €16,377.88 in 2010 prices, or 53.7% of the median income in 2010.[9] The sufficiency threshold falls for the majority of the study period (1995-2018) within the second decile. As a result, in 2010 – with the sufficiency threshold in second decile – the top eight deciles are adjusted according to Eq. (5).

$$\mathrm{DMUI}(x_{i,t}, \mathrm{s}) = \mathrm{s} * \ln\left(\frac{x_{i,t}}{s}\right) + \mathrm{s} \tag{5}$$

In Eq. (5), s is a constant sufficiency threshold and $x_{i,t}$ is the average income per decile for decile i at time t. In line with Talberth and Weisdorf (2017) we use the more conservative ε = 1 or the natural logarithm. Fig. 4 graphically illustrates how the income deciles in 2010 are adjusted using our DMUI-adjustment with sufficiency threshold. The adjustment ratio for the diminishing marginal utility, is equal to the ratio between the adjusted average incomes per decile (blue bars) and the unadjusted average incomes per decile (orange bars).

Figure 4: The adjusted and unadjusted average incomes per decile in 2010 for Belgium.



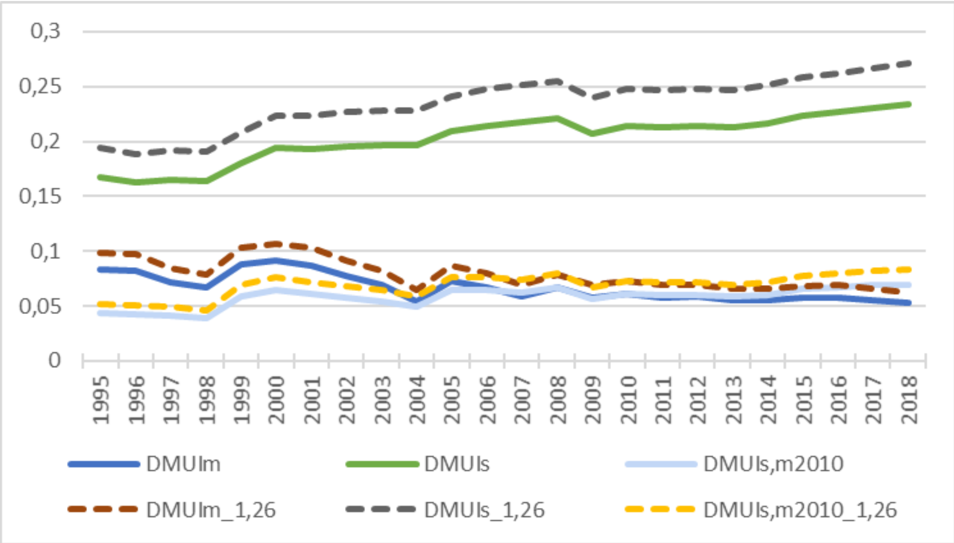
Note: For the first and second decile the 'adjusted' and unadjusted average income are equal because these deciles are not adjusted as the sufficiency threshold lies in the second decile.

Next, we will also perform a sensitivity analysis scrutinizing the impact of s and ε. First, we make use of a higher sufficiency level – i.e. a constant threshold equal to the median income in 2010 ($\mathrm{DMUI}_{s,m2010}$) of €30,485.28 (2010 prices). Next, we will verify the effect of a higher elasticity of marginal utility to income with ε = 1.26. Finally, in order to investigate the impact of working with a fixed threshold instead of a time-varying one, we will compare our method with the DMUI_m-approach that normalizes

[9] Due to data availability issues, we approximated the median income as the mean of the fifth and sixth income decile.

at the median income level in each year and adjusts the top five income deciles. Fig. 5 illustrates that the evolution of $DMUI_s$, $DMUI_{s,m2010}$ and $DMUI_m$ and of their variants with ε = 1.26.

Figure 5: The adjustment for the diminishing marginal utility given various parameter choices for Belgium.



First, using a fixed versus time-varying threshold results in a different trend over time. The time-varying $DMUI_m$ declines during the considered time period by 37.4%, while $DMUI_s$ and $DMUI_{s,m2010}$ increase by respectively 40.4% and 59.8%. Second, the absolute value of a fixed threshold also impacts the DMUI-adjustment. $DMUI_s$ involves a higher adjustment as on average 20.3% is deducted versus only an average reduction of 5.8% for the higher sufficiency threshold in $DMUI_{s,m2010}$. Third, as expected, using a higher elasticity of ε = 1.26 results in higher proportions of consumption that are deducted. The trends over time are very similar to when the lower elasticity ε = 1 was used – in this case, $DMUI_{m\_1.26}$ declines during the considered time period by 36.6%, while $DMUI_{s\_1.26}$ and $DMUI_{s,m2010\_1.26}$ increase by respectively 39.7% and 59.5%. Finally, it may be concluded that using a fixed threshold to normalize the data captures the diminishing marginal utility of income as total income grows best – this is illustrated by the upward sloping curves for $DMUI_s$ and $DMUI_{s,m2010}$ versus $DMUI_m$ and the curves based on the Atkinson Index in Appendix C.

In our calculation of BCE and BCPA, we use the $DMUI_s$-adjustment with the lower threshold (s = €16,377.88) and the low elasticity (ε = 1). We use a constant sufficiency threshold in EWM because it is essential to account for the diminishing marginal utility of income (and consumption). We believe that our approach captures the DMUI-effect better compared to the approaches by Talberth and Weisdorf and the (adjusted) Atkinson Index. In the sensitivity analysis in Appendix B, we will compare the welfare results from our $DMUI_s$-adjustment with the other methodological and parameter choices for the (adjusted) Atkinson Index and DMUI-adjustments.

The DMUI-approaches make use of the distribution of incomes, but it does only do so to measure the diminishing marginal utility of income. The DMUI-corrections do, however, not incorporate a correction for societies' aversion for income inequality as the corrections based on the Atkinson Index do. It is left for future research to determine whether EWM aim to capture societies' aversion for income inequality in addition to the DMUI-correction. Nonetheless, since the DMUI-adjustment also builds on the distribution of income, we continue to label this item *welfare losses from income inequality*.

3.5 Costs of climate breakdown

This item, previously referred to as the 'costs of climate change', has been modified significantly over the years – see O'Mahony et al. (2018) for an overview.[10] Most studies valued this item by linking the emissions related to the domestic consumption of fossil fuels with a social cost of carbon (SCC). Since this SCC measures the damages per metric ton of CO_2 emissions due to associated climate change (Ackerman and Stanton, 2012), most studies thus measure the total climate damages caused by the emissions originating from current economic activity. Nevertheless, in line with EWM's Fisherisation (see Section 2.2), scholars are still discussing how to properly account for 'climate change'. Bagstad et al. (2014) suggested to leave out this item and use substitutes linked more directly to climate change impacts (e.g. the costs of natural disasters and water scarcity), whereas O'Mahony et al. (2018) stipulated the need for a separate approach to distinguish between the future global impact costs related to current domestic emission activities and the current national impacts stemming from past global emissions.

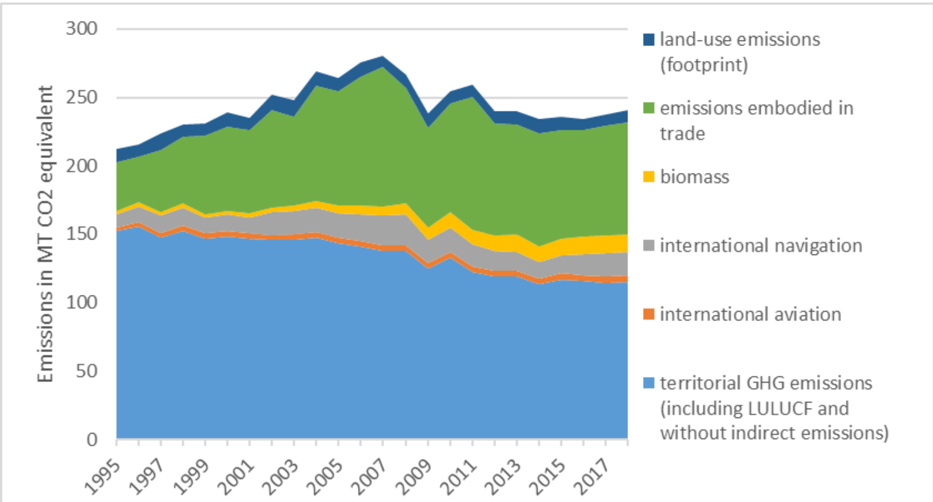
The appropriate approach to account for climate breakdown depends on the welfare interpretation and measure used. BCPA includes future and distant costs and thus can make use of a SCC to capture climate change related damages caused by current emissions. However, BCE measures experiences and should only focus on the local and current costs arising from climate change, i.e. the damages suffered. That is why, the item *costs of climate breakdown* is only included in the broader ecological costs. Yet, the new item *costs of extreme weather events,* which approximates the damages suffered 'here and now', is to be included in the narrow ecological costs (see Table 1). The latter item is excluded

[10] We prefer to use the term climate breakdown instead of a mere change in climate as recent evidence on climate tipping points indicates the threat of rapid and irreversible changes in the climate system that would severely disrupt ecosystems, societies and economies.

from BCPA to avoid double counting with the cost of climate breakdown. Both measures do not account for the costs or investments to adapt to climate change because of a lack of available data. Yet, in theory climate adaptation costs should be deducted from consumption expenses because adaptation costs are a key example of defensive expenditures.

Other methodological novelties regarding the calculation of the cost of climate breakdown are a broader set of emissions beyond territorial GHG-emissions. The quantity of emissions is based on the data countries send to UNFCCC and includes: territorial GHG-emissions (with Land Use, Land-Use Change and Forestry (LULUCF), without indirect CO_2), the emissions from international bunkers (aviation and navigation), and CO_2 emissions from biomass. Furthermore, two types of footprint emissions are added to register the emissions beyond domestic borders that can be related to national consumption. The first type involves the carbon dioxide emissions embodied in goods and services.[11] The second type of footprint emissions relates the land-use change emissions from the Global Carbon Project to Belgium's share in the global land-use consumption footprint using the SCP-HAT provided by UN Environment (2020). A detailed explanation on the quantity of emissions can be found in Appendix A. Fig. 6 provides an overview of the emissions from these different sources and illustrates that total emissions do not follow the steadily decreasing trend of territorial emissions.

Figure 6: Greenhouse gas emissions by category (in MT CO_2 equivalent).



These broader set of emissions are linked to a SCC estimate to calculate the damage caused by climate disruption. The SCC estimates available in literature differ significantly. Ackerman and Stanton's (2012) SCC-estimates for production losses (i.e. losses in global GDP) caused by climate change vary in 2010 between \$28 and \$892 in 2007\$ per tonne. The range of these estimates depends on the specific

[11] These transfer emissions are updated from Peters et al. (2011) in the Global Carbon Project by Friedlingstein et al. (2019).

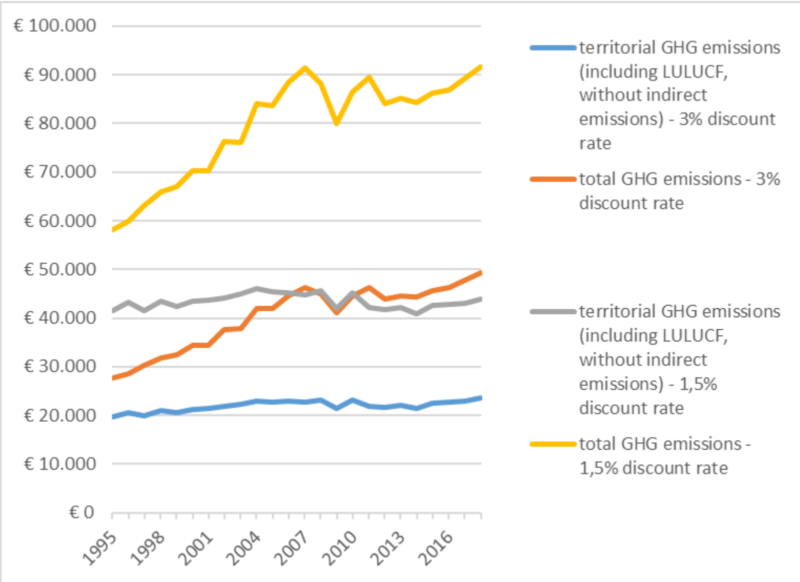
parameter choices such as damage functions, discount rate and climate sensitivity. Climate sensitivity is a parameter that captures the expected long-term temperature increase based a doubling of the concentration of carbon dioxide in the atmosphere. Ackerman and Stanton provide different scenarios with average versus 95th percentile climate sensitivity, Nordhaus versus Hanemann damage estimates at low temperatures, Nordhaus versus Weitzman damage estimates at high temperatures and 3.0 versus 1.5-percent discount rate. There are two ways to obtain discount rates: a descriptive and a prescriptive approach. The former uses an appropriate market interest rate, while the latter sees the discount rate as the sum of a pure time preference and the growth rate of per capita consumption (Ackerman and Stanton, 2012). The link between discount rates, time preferences and consumption growth rates are given by the "Ramsey rule" – see Ackerman et al. (2009) for a comprehensive derivation of this rule. In the absence of uncertainty, the Ramsey rule and discount rate can be obtained from this formula:

$$1 + r = (1 + g)^{\varepsilon}(1 + \rho) \Rightarrow r \approx \rho + \varepsilon g \tag{6}$$

In Eq. 6 r is the discount rate, ρ is the "rate of pure time preference" that is used to discount utility, g is the growth rate of consumption, while ε is the "coefficient of relative risk aversion". The approximation for r holds for small ρ and g. It should be noted that ε is the same parameter ε as was used for the elasticity of marginal utility to income in Section 3.4.1. So ideally, the assumption on ε used for the inequality correction should be the same as the one used for the SCC.

In the Spanish ISEW-study, O'Mahony et al. (2018) based their estimate on the study by Ackerman and Stanton. O'Mahony et al. used an estimate of \$232 in 2010\$ or €175.37 in 2010€ per tonne of CO_2 (equivalent), which is based on a 3% discount rate, 95th percentile climate sensitivity and Hanemann-Weitzman damage functions. Stern (2006), however, argues in favor of a lower discount rate based on intergenerational equity. In order to suitably measure the future costs and thus discount future costs less, we suggest to use a lower discount rate than O'Mahony et al. We decide to stick to Hanemann-Weitzman damage functions, because the Nordhaus damage functions are severely underestimating the cost of climate change (Keen, 2020). Using the same damage functions, a 1.5% discount rate would lead to SCC-estimates of \$445 and \$892 in 2007\$ (or €340.23 and €681.98 in 2010€), for respectively average and 95th percentile climate sensitivity (Ackerman and Stanton, 2012). As the lowest of these SCC's is almost the double of O'Mahony et al.'s estimate, we use the 2010-estimate based on average climate sensitivity and apply an annual growth rate of 1.45% to obtain time-varying estimates for the years before and after 2010.[12] The discount rate of 1.5%, is similar the 1.4% discount rate proposed by Stern (2006).[13] Fig. 7 illustrates the cost of climate breakdown given various parameter choices.

Figure 7: Comparison of the effect of alternative approaches to the cost of climate breakdown (million, 2010 prices).



3.6 Depletion of non-renewable energy resources

The item *depletion of non-renewable energy resources* aims to capture the depletion of non-renewable energy stocks. While the item *costs of climate breakdown* measures the damages caused from greenhouse gas emission related to the combustion of fossil fuels, this item measures the depletion of the natural capital resource stock. The former looks at *sinks*, while the latter focuses on *sources*. In the past, scholars have adopted either a production or a consumption perspective in order to calculate the depletion of non-renewable resources. The former traces the depletion related to the extraction of a country's domestic energy stocks, while the latter measures how a country's domestic resource consumption contributes to the depletion of global energy stocks. The production view looks within borders, whereas the consumption counterpart looks beyond borders. Yet, the key difficulty lies in connecting this item to the experiential welfare interpretation. Talberth and Weisdorf (2017), for instance, wonder if future studies should still include this item if it is not better linked to current

[12] The annual growth rate of 1.4452407% is obtained by interpolating Ackerman and Stanton's (2012) 2010 values to 2050.

[13] Stern (2006) obtained a 1.4% discount rate as the sum of a 0.1% pure time discount rate and the growth rate of per capita consumption. According to Stern a 0.1% discount rate indicates a 91% probability for humanity to survive 100 years. Given that more consumption is not desirable from a well-being perspective, one could use Stern's case to argue for using a discount rate of 0.1%. As Ackerman and Stanton (2012) only provide 1.5% and 3% discount rates, this is left for future refinements.

experiential welfare. Hence we omit this item in the BCE. Nonetheless, including resource depletion is needed in the BCPA as it is a cost originating from present activities that is passed on to the future.

The common methodology to value this item employs the replacement cost method that captures the investments needed to replace non-renewable energy resources with a renewable substitute – see, for instance, Bleys (2008, 2013) and Held et al. (2018). Yet, Neumayer (2000) was critical of this method because it assumes that all resource depletion needs to be replaced annually. In a response to address this criticism, O'Mahony et al. (2018) put forward the transition cost method, in which the depletion issue is seen as a gradual transition away from non-renewable energy resources in order to meet the climate targets agreed upon in the Paris Agreement.[14] We build on this transition cost method, yet, O'Mahony et al.'s cost estimate is updated as their estimate is based on a not so ambitious scenario to halve global CO_2-emissons by 2050. A recent report by the IPCC (2018) illustrates that more drastic emission cuts are needed in the near present to limit global warming to 1.5°C: global net emissions need to decline by 45% in 2030 (compared to 2010) and the net zero target should be reached in 2050.[15]

The valuation of this item is based on the total energy investments expenditures needed in the European Union under the requirement of meeting certain climate goals agreed upon by the European Council. These targets include an overall GHG emission reduction of at least 40% compared to 1990 and a share of renewable energy in final energy consumption of at least 27%. Moreover, the European Council agreed on the following minimum ambition level for the energy efficiency target: a 27% reduction of primary energy consumption compared to 2007. The investments needed are calculated, given the various policy options for 2030 energy efficiency targets (European Commission, 2016). A mid-value of 33% efficiency target was chosen, which leads to an investment cost of €797.45 (in 2010 prices) per ton of oil equivalent of primary energy consumption. Fig. 8 compares this updated method with the transition cost method by O'Mahony et al. (2018).

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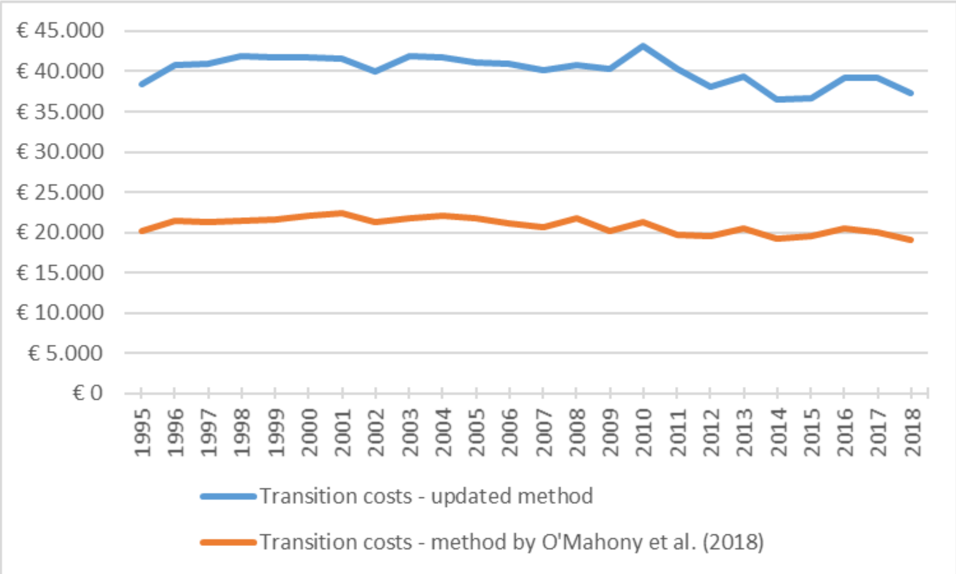
[14] Recent evidence has shown that the remaining carbon budget related to climate change goals of limiting global heating to 1.5 or 2 °C – see, for instance, McGlade and Ekins (2015) and IPCC (2018) – imposes a more imminent limit on using non-renewable resources compared to their depletion. Achieving climate goals requires drastic and rapid reductions in human carbon emissions and phasing out fossil fuels (Rockström et al., 2017; Jackson, 2019), which can be met by an expansion of renewable energy resources (Rockström et al., 2017) together with a lower energy demand (Grubler et al., 2018), or a degrowth scenario (D'Alessandro et al., 2020; Victor, 2012).

[15] As early-industrialized countries have a higher historical responsibility, their net zero targets should be sooner. Jackson (2019), for instance, argues that the United Kingdom should set its target for net zero emissions by 2030 or earlier.

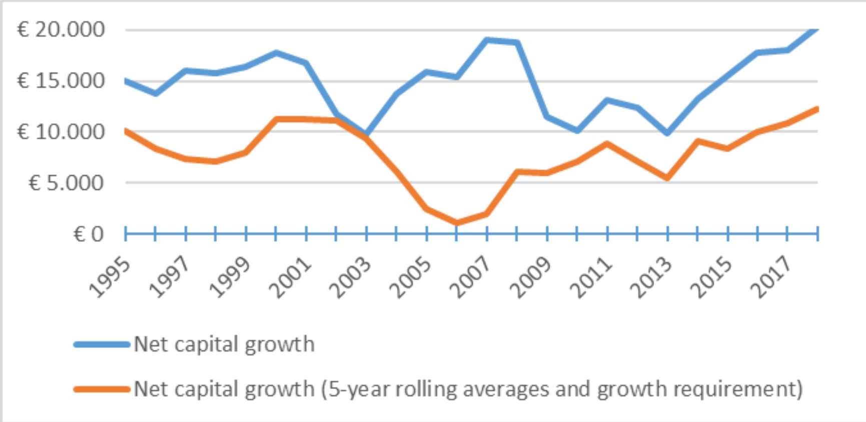
Figure 8: Comparison of the updated and previous transition cost method for the depletion of non-renewable resources (million, 2010 prices).



3.7 Net capital growth

As explained in Section 2, BCPA should include changes in physical capital stocks like *net capital growth* as this is a benefit (or cost if negative) originating from present activities. In contrast to previous studies, this study's net capital growth only traces mere capital adjustments: it breaks with taking 5-year rolling averages and by omitting the growth requirement in this item. Following Hicks' income concept, capital changes should be counted as income. However, by taking 5-year rolling averages to smooth out fluctuations, one is actually treating this item as the services flowing from a stock that would last five years. Furthermore, the net capital growth required to keep the capital stock per worker intact is removed as this procedure is inconsistent with Hicksian income in which raw capital changes are counted. Daly and Cobb (1994) included the capital requirement as they assumed that economic sustainability requires that the amount of capital available for each worker remains constant or even increases. We believe the growth requirement can be omitted based on the grounds that we are not trying to capture sustainability but merely the benefits and costs of present activities and that Hicksian income only includes 'raw' capital changes. Fig. 9 gives on overview of the impact these methodological changes on net capital growth.

Figure 9: Comparison of the effect of an alternative valuation method to net capital growth (million, 2010 prices).



4. Results

This section presents Belgium's economic performance from 1995 until 2018 using BCE and BCPA and analyses the relative importance and changes over time of the various welfare categories. The per capita results of Belgium's BCE, BCPA and GDP are shown in absolute and indexed values in Fig. 10. Hereafter, we will only focus and report per capita values without explicitly referring to it. Hereafter, we use lower case to refer to per capita values, while we use capital letters for aggregate numbers. Throughout the entire period, bcpa is lower than gdp. Bce, in contrast is higher than gdp from 1995 to 2004 and from 2009 until 2013. The absolute difference between bcpa and bce indicates that there are substantial broader ecological costs that are shifted in time and space – without adding the positive capital adjustment to bcpa, the difference would even have been higher. Over the entire period all indicators increased: gdp improved by 30.1%, bcpa by 17.9% and bce by 14.9%, while on average per year gdp grew by 1.31% versus 0.78% for bcpa and 0.65% for bce.

At different time periods, however, there are marked differences between gdp and the welfare indicators as indicated in Table 2. From 1995 to 2007, gdp grows on average by 1.9% per year, versus only 0.86% for bce and 0.24% for bcpa. During and after the financial crisis from 2007 to 2010, bce and bcpa outperformed gdp: gdp declined by 0.46% per year, while bce and bcpa grew by respectively 1.37% and 1.9%. This welfare trend was driven by the fact that individual consumption per capita grew. For bcpa, the higher average annual growth rate comes from the lower starting point to evaluate this consumption growth since the combined effect of the broader ecological costs and capital adjustment per capita was slightly negative (i.e. the declining broader ecological costs per capita were overcompensated by a reduction in the capital adjustment per capita). If we scrutinize the years 2009 and 2010, we observe a lagged effect on bcpa while gdp fell already in 2009. This lag was caused by the fact that the broader ecological costs fell dramatically in 2009, resulting in an upward bcpa-trend, while the economic gdp-recovery in 2010 and the corresponding rising ecological cost made bcpa go down. In constrast to gdp and bcpa, there was not a negative crisis effect on bce, which stagnated at its 2009-level for five years.

During the subsequent eurocrisis from 2010 to 2014, gdp and bce only increased by respectively 0.41% and 0.04% per annum whereas bcpa increased by 1.98% per year because broader ecological costs (per capita) fell dramatically. After the eurocrisis from 2014 to 2018 gdp grew by 1.47% per year, yet, this growth was is lower than the annual growth rate of 1.89% from 1995 to 2007. Contrarily to gdp, bce and bcpa barely improved: bce decreased by 0.02% per year, while bcpa increased by 0.11% per year. Since the financial crisis of 2009, gdp and bcpa increased by respectively 9.8% and 3.7% while bce decreased by 0.3%. These trends in bce and bcpa are mainly caused by welfare growth in 2018. Bce remained almost constant between 2009 and 2014 and fell in 2015, while bcpa diminished between 2014 and 2017.

Figure 10: Welfare and GDP per capita for Belgium in prices of 2010 (left panel) and as index values with 2007 = 100 (right panel).

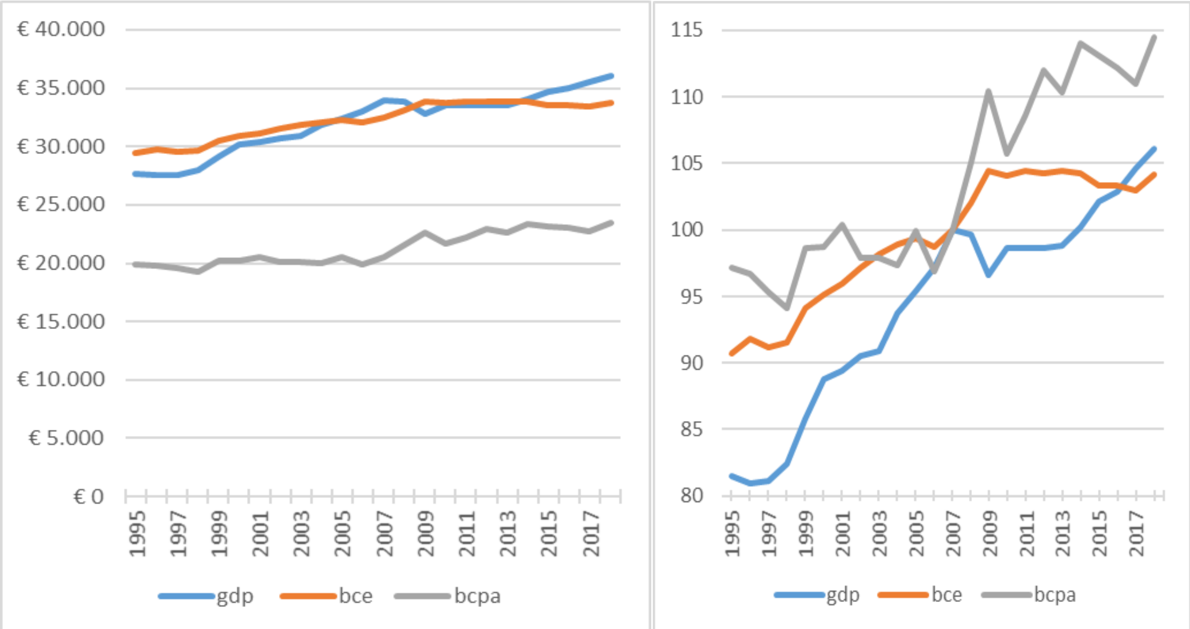


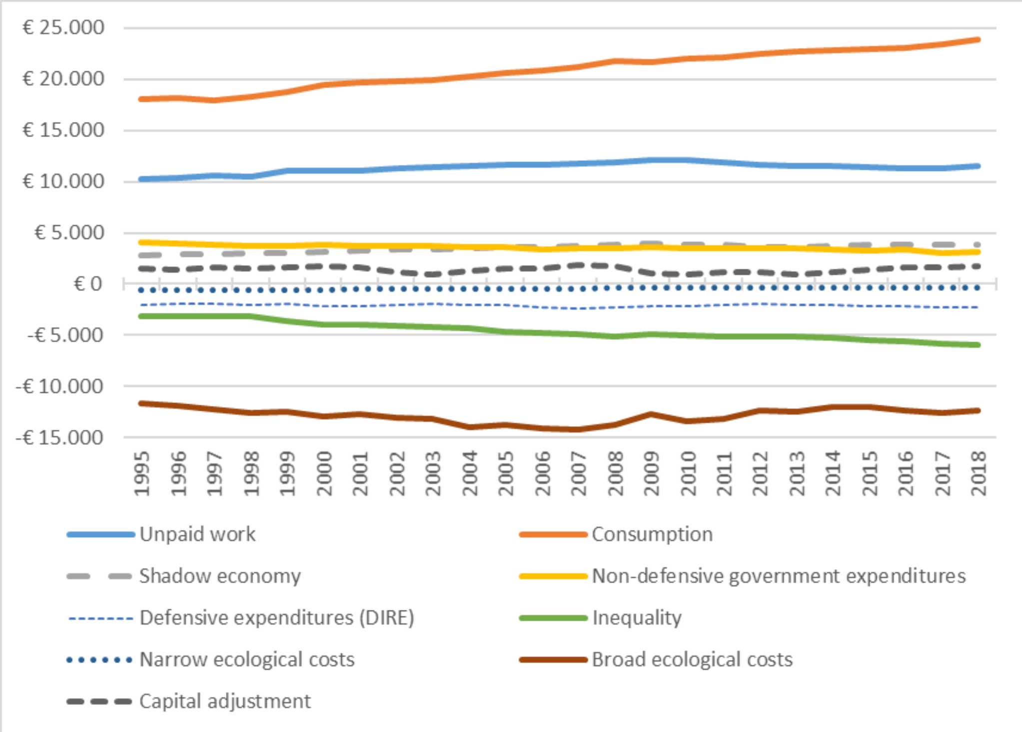
Table 2: Average annual and total growth rates of welfare and GDP per capita.

Time period	gdp	bce	bcpa
1995-2007	1,89	0,86	0,24
2007-2010	-0,46	1,37	1,90
2010-2014	0,41	0,04	1,98
2014-2018	1,47	-0,02	0,11
	1,31	0,65	0,78
1995-2018	*(30,1)*	*(14,9)*	*(17,9)*

Note: The brackets indicate the total trend over the entire period, in contrast to the average annual trends in the subperiods.

One must be cautious of the fact that these aggregate welfare trends hide crucial information about evolutions in the different welfare categories (introduced in Eqs. 1 and 2) – especially of those categories that are of minor quantitative importance. Fig. 11 illustrates that unpaid work and net consumption are the most important positive contributors to welfare, while the welfare losses from inequality and broader ecological costs (the latter only for bcpa) are the most important welfare deductions. The value of unpaid work per capita increased over the studied time period by 11.6% (as shown in Table 3) since increasing wages more than compensated a reduction in the time devoted to unpaid work. Individual per capita consumption outpaced unpaid work as it surged by 32.3% over time. Per capita shadow economy even grew by 37.1%, while per capita defensive, intermediate and rehabilitative expenditures only increased by 11.7%. Because of the sharp rise in the welfare losses from income inequality by 89.9%, an increasing part of individual consumption expenditures and the benefits from the shadow economy was not translated into welfare because of the adjustment for the diminishing marginal utility of income. The government's per capita welfare contribution became less important (-23.4%), while for bcpa per capita the capital adjustment increased by 20%. Broad ecological costs per capita increased by 6.8%. This evolution was caused by increases in the time-varying cost estimate (+40%) and greenhouse gas emissions (+13%), which both made the cost of climate breakdown rise by +58%, which outweighed reductions in all other ecological costs. The overall increase in the aggregate broad ecological costs is higher than per capita increases since population grew too (by 12.5%): aggregate broad ecological costs increased by 20.2%. The increase in broad ecological costs contrasts heavily against the per capita narrow ecological costs in bce that fell by 52.4%, which further reduced the – already negligible – quantitative importance of this item.

Figure 11: Positive and negative contributions of per capita welfare categories (2010 prices).



Note: In this figure welfare deductions have been reclassified as negative numbers, even though these categories are deducted as positive numbers in Eqs. 1 and 2 to calculate the aggregate welfare level.

Table 3: Annual growth rates of per capita welfare categories during several time periods.

Time period	uw	c_i	s	g_c	$dire_p$	inq	nec	bec	Δk
1995-2007	1,19	1,47	2,49	-1,16	1,37	4,65	-2,57	1,84	1,78
2007-2010	1,03	1,30	1,05	-0,44	-2,56	1,04	-3,48	-1,75	-15,98
2010-2014	-1,23	0,90	-0,37	-0,38	-1,73	1,28	-4,48	-2,76	6,73
2014-2018	-0,08	1,13	0,96	-2,11	2,92	3,11	-1,59	0,93	12,42
1995-2018	0,50 *(11,6)*	1,40 *(32,3)*	1,61 *(37,1)*	-1,02 *(-23,4)*	0,51 *(11,7)*	3,91 *(89,9)*	-2,28 *(-52,4)*	0,29 *(6,8)*	0,87 *(20,0)*

Note: The brackets indicate the total trend over the entire period, in contrast to the average annual trends in the subperiods.

The EWM compiled in this study (i.e. BCE and BCPA) employ different time and boundary perspectives. Our results suggest, on the one hand, that the negligible narrow ecological costs have decreased. On the other hand, substantial broader ecological costs increased, which indicates that Belgium is increasingly shifting ecological costs in time and space. If one "would only look at current experiences, then this could mistakenly lead to the conclusion that one can happily enjoy experiences in the present while depleting physical capital and plundering the planet" (Van der Slycken and Bleys, 2020). We would suggest to use the broad perspective on ecological costs as this is more consistent with seeing the economy as embedded in the ecosystem. This view helps to focus on the environmental impacts caused by present economic activities. Instead of overlooking broader ecological costs, "fully accounting" for these costs would better inform policy-makers about the adverse effects of economic activities. This position is shared by Clarke (2007), who argued that EWM should account for the environmental costs that are outsourced to other regions. Moreover, this way, attention is paid to the "margins", that is to those who are marginalized in the growth economy, as recommended by Hanaček et al. (2020). Yet, this study does not account for the social costs shifted to the margins of the growth economy.

5. Conclusion: toward a 2.0 methodology

This paper contributes to the standardization of the methodology of economic welfare measures (EWM), such as the ISEW and GPI by addressing the cross-time and cross-boundary issues involved and the discussion on Fisherian versus Hicksian income as theoretical underpinnings. Two EWM with distinct time and boundary views to deal with ecosystem costs and physical capital changes are compiled for Belgium from 1995 to 2018: the *benefits and costs experienced* (BCE) only look at the present and within domestic borders while the *benefits and costs of present economic activities* (BCPA) also look at the impacts of present activities that are shifted in time and space. Other methodological novelties besides our dual welfare approach are that this study is the first to adopt a consumption footprint view for the emissions embodied in trade, to register the climate impacts of aviation and shipping, to include an approximation for the shadow economy and to introduce a sufficiency threshold for consumption expenditures when accounting for the diminishing marginal utility of income.

The results indicate that there are substantial and increasing ecological costs that are shifted in time and space in the BCPA, while the present ecological costs within domestic borders in the BCE are negligible and decreasing. This study found that BCPA and BCE improved over time, just as GDP did. Yet, there is a clear divergence between welfare and GDP: GDP per capita grew by 30%, while BCE per capita rose by 15% and BCPA per capita increased by 18%. We found a lagged effect of the financial crisis in 2009 on BCPA, as BCPA increased in 2009 and decreased in 2010 because ecological costs respectively fell and rose. Furthermore, the positive aggregate welfare evolutions hide that BCE per capita stagnated and then decreased between 2009 and 2017, while BCPA per capita fell between 2014 to 2017. Moreover, caution is needed against the aggregate welfare trend because the broader ecological costs have increased over time. Since important information might get lost during the aggregation procedure, we advise to also look at EWM's disaggregated welfare categories to evaluate economic performance in greater detail.

Future studies should carefully consider welfare's time and boundary views because without a careful reflection, EWM may give the impression that it is possible to fare well while consuming physical capital and fueling ecological breakdown. We argued to use BCPA as it accounts for the ecological costs shifted in time and space, which is more compatible with an ecological economic position of seeing the economy as embedded in the ecosystem. A second reason to use BCPA is that it also accounts for the consumption of physical capital. Such a beyond border viewpoint would better inform policy-making about the impacts abroad and the importance not only to reduce domestic emissions but also to devise policies like a carbon border adjustment tax to reduce the emissions embodied in trade (Van der Slycken and Bleys, 2020). The BCE are less useful for 'full' accountability or policy-making as BCE only includes present ecological costs that happen within borders and regard physical capital consumption as beneficial to welfare. We believe that any 2.0 methodology for EWM should take these time and boundary issues into account when evaluating a country's economic performance.

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