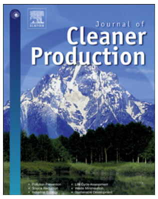
Journal of Cleaner Production xxx (2015) 1–19

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro



The proximity of nations to a socially sustainable steady-state economy

Daniel W. O'Neill [a], [b], [*]

[a] Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds LS2 9JT, UK
[b] Center for the Advancement of the Steady State Economy, 5101 S. 11th Street, Arlington, VA 22204, USA

ARTICLE INFO

Article history:
Received 29 January 2015
Received in revised form
14 July 2015
Accepted 22 July 2015
Available online xxx

Keywords:
Indicators
Steady-state economy
Degrowth
Resource use
Well-being

ABSTRACT

There has been increasing interest in new economic models that aim to improve quality of life without increasing consumption. This article provides the first empirical analysis of how close modern-day economies are to the concept of a “steady-state economy”, and explores whether there is any relationship between a country's proximity to such an economy and its social performance. The analysis is carried out using the *Degrowth Accounts*, a set of 16 biophysical and social indicators that are derived from Herman Daly's definition of a steady-state economy and the social goals of the degrowth movement. These indicators are applied to ~180 countries over a 10-year period. The analysis reveals that the majority of countries in the world are biophysical growth economies. There are only a small number of countries where resource use is relatively constant from year to year (e.g. Denmark, France, Japan, Poland, Romania, and the US), and only four countries experiencing biophysical degrowth (Germany, Guyana, Moldova, and Zimbabwe). There are no countries that achieve a true steady-state economy, defined as an economy with a stable level of resource use maintained within ecological limits. However, a few countries come relatively close, including Colombia, Cuba, Kyrgyzstan, Romania, and South Africa. In general, countries with stable resource use perform better on many social indicators than countries with either increasing or decreasing resource use. This finding runs contrary to conventional economic thought. However, social performance is also higher in countries with greater per capita resource use. Overall, these findings suggest that a steady-state economy can be socially sustainable, but countries need to become much more efficient at transforming natural resources into human well-being if all seven billion people on Earth are to lead a good life within ecological limits.

1. Introduction

The scale of the human enterprise has increased at an unprecedented rate since the beginning of the industrial revolution. Over the last century, the size of the global economy (as measured by real GDP) increased by a factor of twenty-four (Maddison, 2010). At the same time, global energy use increased by a factor of eleven and material use increased by a factor of eight (Krausmann et al., 2009). Environmentally-minded critics of growth argue that the increasing scale of economic activity cannot continue indefinitely due to finite environmental limits (Rees, 2003), many of which are already being surpassed (Hoekstra and Wiedmann, 2015; Steffen et al., 2015). Socially-minded critics argue that even if economic growth could continue, it is no longer a desirable goal for wealthy nations to pursue because it is failing to improve people's lives: although per capita GDP has more than tripled in nations like the US and UK since 1950, measures of subjective well-being (e.g. happiness) have flat-lined (Layard, 2005; Easterlin et al., 2010). Finally, practically-minded critics argue that high rates of growth may simply not be possible in industrialised countries anymore due to structural changes such as an ageing population and high levels of debt (Gordon, 2012).

These criticisms have led a number of authors to call for a different economic model whose aim is to improve quality of life without relying on increasing consumption (Victor, 2008; Jackson, 2009; Chancel et al., 2013). Two ideas that are particularly important in this discourse are “degrowth” (Latouche, 2009; D'Alisa et al., 2014) and a “steady-state economy” (Daly, 2008; Czech, 2013; Dietz and O'Neill, 2013). The concept of a steady-state economy was

---

[*] Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds LS2 9JT, UK. Tel.: +44 113 343 1631; fax: +44 113 343 5259.
E-mail address: d.oneill@leeds.ac.uk.

http://dx.doi.org/10.1016/j.jclepro.2015.07.116
0959-6526/© 2015 Elsevier Ltd. All rights reserved.

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

largely developed by ecological economist Herman Daly in the 1970s (Daly, 1973, 1977), although it traces its roots as far back as the classical economists. It may be defined as an economy where the main biophysical stocks and flows are stabilised, and where material and energy flows are kept within ecological limits. It is worth stressing that the definition of a steady-state economy is entirely biophysical. It does not refer to rates of GDP growth (or other socio-economic indicators for that matter).

The idea of degrowth, on the other hand, largely emerged in France as *la décroissance*, but has proliferated in recent years. Since 2007 there have been close to 130 academic articles published on the topic, and seven special issues in peer-reviewed journals (including two in this journal). Although definitions of degrowth remain contentious, it has been defined as an equitable down-scaling of economic production and consumption that increases human well-being and brings material and energy use within ecological limits (Schneider et al., 2010; Kallis, 2011). While steady-state economists tend to believe market mechanisms can be used to stabilise resource use, advocates of degrowth question increased commodification, and are more sceptical of capitalist institutions in general. Moreover, advocates of degrowth tend to place more emphasis on social outcomes than their steady-state counterparts. Nevertheless, the two concepts are seen by many as complementary (Martínez-Alier, 2009; Kerschner, 2010; Kallis et al., 2012). If resource use and waste emissions exceed ecosystem limits, then a process of degrowth may be needed before a steady-state economy can be established.

Both of these concepts, and the debates surrounding them, have remained largely theoretical to date. This study attempts to answer two important empirical questions: (i) How close are modern-day national economies to a steady-state economy? (ii) Are countries that are closer to a steady-state economy better or worse places to live than those that are further away?

These questions are answered using the *Degrowth Accounts*, a set of 16 biophysical and social indicators designed to measure progress in the degrowth transition to a steady-state economy. The indicators reflect Daly's biophysical definition of a steady-state economy and the social goals of the degrowth movement. The conceptual development of the Degrowth Accounts is discussed in detail in two earlier publications (O'Neill, 2012a, 2015). The purpose of this article is to operationalise these accounts.

The remainder of this article is organised as follows. Section 2 briefly summarises the structure and indicators contained in the Degrowth Accounts. Section 3 presents an empirical analysis of these indicators for ~180 countries over a 10-year period. The analysis shows how close countries are to the biophysical definition of a steady-state economy (Section 3.1), how close countries are to the social goals of degrowth (Section 3.2), and the relationship between social performance and both biophysical stability and biophysical scale (Section 3.3). Section 4 then discusses the implications of the empirical analysis, in particular the findings on growth, degrowth, and stability (Section 4.1), unemployment (Section 4.2), and democracy (Section 4.3). This discussion is followed by a summary of the main contributions (Section 4.4) and limitations (Section 4.5) of the study. Section 5 concludes.

2. The Degrowth Accounts

This section describes the Degrowth Accounts, including the conceptual framework used to organise the indicators (Section 2.1), their division into Biophysical Accounts (Section 2.2) and Social Accounts (Section 2.3), and the specific indicators that are included (Section 2.4).

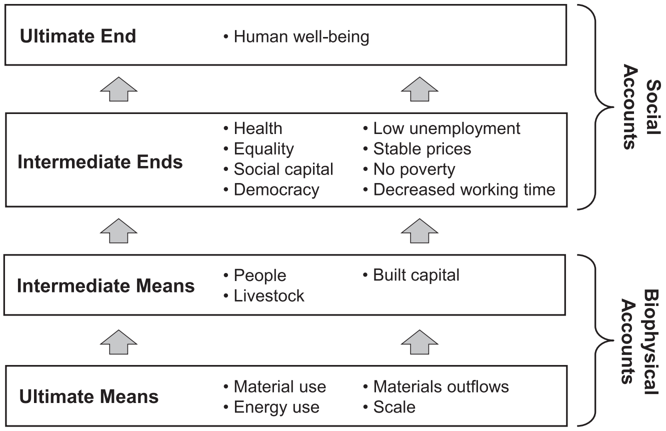


Fig. 1. The indicators in the Degrowth Accounts. The indicators are divided into two separate accounts (biophysical and social) and are organised along a spectrum from means to ends.

2.1. Conceptual framework

The 16 indicators in the Degrowth Accounts are organised using Herman Daly (1977) "Ends–Means Spectrum", which acts as a unifying conceptual framework (Fig. 1). This framework was originally suggested by Meadows (1998) as the basis of an information system for sustainable development. Such a framework is needed to help ensure that the set of indicators is comprehensive, and to interpret the relationships among indicators.

The Ends–Means Spectrum organises items in a hierarchy from *ultimate means* (the natural resources that sustain life and all economic transactions) to *intermediate means* (the factories, machines, and skilled labour that transform natural resources into products and services) to *intermediate ends* (the goals that the economy is expected to deliver) to *ultimate ends* (those goals that are desired only for themselves, and are not the means to achieve any other end). The spectrum effectively divides the indicators into two separate accounts: biophysical and social. The Biophysical Accounts measure the use of means, while the Social Accounts measure progress towards ends.

2.2. Biophysical Accounts

The Biophysical Accounts are constructed around Herman Daly's definition of a steady-state economy (SSE).[1] It is worth noting that Daly's definition has evolved somewhat over time. While all of Daly's definitions contain the same basic components, earlier definitions (e.g. Daly, 1973, 1977) tend to focus more on the idea of constant stocks, while more recent definitions (e.g. Daly, 1996, 2008) tend to focus on constant flows. Daly acknowledges this evolution in one of his more recent definitions:

> Following Mill we might define a SSE as an economy with constant population and constant stock of capital, maintained by a low rate of throughput that is within the regenerative and assimilative capacities of the ecosystem… Alternatively, and more operationally, we might define the SSE in terms of a constant flow of throughput at a sustainable (low) level, with population and capital stock free to adjust to whatever size can be maintained by the constant throughput beginning with depletion and ending with pollution (Daly, 2008, p. 3).

---

[1] Given this fact, they might also be referred to as the *Steady-State Economy Accounts*—a biophysical subset of the full Degrowth Accounts.

In general, Daly's definitions contain three components: *stocks* (the absolute size of the economy in physical terms), *flows* (the material and energy throughput required to support the economy), and *scale* (the size of the economy in relation to ecological limits). The Biophysical Accounts include three stocks (people, livestock, and built capital), three flows (material use, energy use, and material outflows), and a single measure of scale (discussed in Section 2.4.5). The result is a set of seven biophysical indicators.

In order to determine how close a country is to a steady-state economy, two quantities are calculated: (1) the annual rate of change of the above biophysical stocks and flows, and (2) the scale of the flows in relation to ecosystem sources and sinks. If an economy manages to achieve relatively constant stocks and flows over the analysis period, then it is referred to as a *biophysically stable economy*. In this context, "stable" does not imply sustainable; it simply indicates that resource demands are not changing over time. If the economy also manages to maintain material flows within ecological limits, then it is referred to as a *steady-state economy*. If, in addition to these biophysical criteria, the country manages to achieve a high quality of life for its citizens, then it is referred to as a *socially sustainable steady-state economy*. These classifications are consistent with Daly's definitions, and earlier conceptual work (O'Neill, 2015).

2.3. Social Accounts

Unlike the idea of a steady-state economy, which is defined in biophysical terms, degrowth is a multidimensional concept. Demaria et al. (2013) identify six key sources from which degrowth draws inspiration: ecology, bioeconomics, critiques of development, democracy, justice, and the meaning of life and well-being. In particular, degrowth draws on the culturalist critique of development (e.g. Illich, 1973; Castoriadis, 1985; Latouche, 2009), which questions the consumer society and its focus on progress, science, and technology. To many, degrowth is a *mot-obus* (missile word) that challenges the hegemony of growth and the idea of "development" itself (Demaria et al., 2013).

Kallis et al. (2014) stress that degrowth is not just about *less*, but about *different*. The authors state that degrowth "signifies a society with a smaller metabolism, but more importantly, a society with a metabolism which has a different structure and serves new functions" (p. 4). These new functions include sharing, simplicity, conviviality, care, and autonomy, while structures to achieve these functions include cooperatives, work sharing, public money, and the commons (D'Alisa et al., 2014).

The Social Accounts are constructed around the stated goals of the degrowth movement, as articulated in the declaration from the first international conference on degrowth, held in Paris in 2008 (Research & Degrowth, 2010). The declaration was the result of a workshop entitled "Toward a Declaration on Degrowth", whose goal was to produce a statement that would not only reflect the points of view of conference participants, but also articulate their shared vision of the degrowth movement. Although the goals of degrowth continue to be refined, the Paris Declaration provides a good starting point for analysis.

There are 24 individual social goals within the text of the declaration, which have been grouped and reduced here to seven general goals. These goals are human well-being, health, equality, increased social capital, participatory democracy, the elimination of poverty, and decreased working time. Two other goals have been added to the seven goals from the Paris Declaration. The first is low unemployment, and the second is stable prices. The result is a set of nine social indicators that measures the functioning of the socio-economic system, and how effectively it delivers human well-being.

As discussed in O'Neill (2012a), there are two main reasons to include unemployment in the Social Accounts. The first is the well-being benefit of employment, and the second is the critique (e.g. by Jackson, 2009) that degrowth will result in job losses. Although full employment (as currently defined) might no longer be a goal in a degrowth future, it is still important to track the number of people who are looking for a job but unable to find one. Price stability is also important to include as it is hard to imagine calling an economy "socially sustainable" if it does not have relatively stable prices. An extensive survey by Shiller (1996) found that people have very negative perceptions of inflation. These include concerns that inflation lowers people's standard of living, allows opportunists to take advantage of others, creates a social atmosphere that is harmful to morale, and causes political instability.

2.4. Specific indicators

For each of the 16 relatively abstract indicators discussed above (and shown in Fig. 1), one or more measurable proxies were chosen based on the best data available for a large number of countries (Table 1). The rationale for the selection of individual indicators is described in detail in O'Neill (2012b). In general, only indicators that were available for a large number of countries were considered. Two exceptions are the poverty and working time indicators, where internationally comparable data were simply not available for very many countries. In these cases it was necessary to use proxies with data for fewer countries than the other indicators.

Ideally, consumption-based indicators that include the hidden flows embodied in trade would be used to measure material and energy flows within the Biophysical Accounts (O'Neill, 2015). However, although indicators of the resource use associated with final consumption are becoming increasingly available (e.g. Peters et al., 2011; Lenzen et al., 2012; Wiedmann et al., 2015), the uncertainty associated with these is still higher than territorial measures. In order to maximise the number of countries covered, and minimise the amount of error in the estimate of time trends, relatively conventional measures were used for the first instance of the Degrowth Accounts. Material use and material outflows were both measured using territorial indicators that do not account for trade, while energy use and biophysical scale were measured using indicators of "apparent consumption". The latter indicators account for trade by adding imports and subtracting exports, but do not include the foreign resources required to produce traded goods. Following O'Neill (2015), the Biophysical Accounts use aggregated indicators that measure the *quantity* of resource use (e.g. tonnes of materials and Joules of energy), as opposed to its quality.

Some of the indicators in the accounts, such as the measures of population growth and price stability, are simple indicators where data were readily available. Others, such as the measures of human well-being and scale, are fuzzier concepts, and were more difficult to quantify. Although it is beyond the scope of this article to discuss each of the 16 indicators in depth (see O'Neill, 2012b for this discussion), some comments are warranted on five of the specific indicators: human well-being, equality, democracy, built capital, and scale. These are the indicators where the choice of a proxy was most difficult, or where additional information is needed to understand the analysis that follows. For the full set of 16 indicators (and their proxies), the reader is directed to Table 1.

2.4.1. Human well-being

The goal of increasing human well-being is central to degrowth, and is often included in its definition. For example, Schneider et al. (2010, p. 512) define degrowth as "an equitable downscaling of production and consumption that increases human well-being and enhances ecological conditions", while Kallis (2011, p. 879)

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

Table 1
Indicators and the proxies used to measure them in the Degrowth Accounts.

Indicator	Proxy	Source	Description
Human well-being	Life satisfaction	World Database of Happiness (Veenhoven, 2014)	Response to the question "All things considered, how satisfied are you with your life as a whole these days?"
Health	Healthy life expectancy at birth	World Health Organization (United Nations, 2010)	Number of years a newborn could expect to live in full health, taking into account time lived in less than full health due to disease and/or injury
Equality	Gini coefficient	Standardized World Income Inequality Database (Solt, 2009)	Measure of inequality in household disposable income (i.e. income after tax transfers)
Social capital	Index of interpersonal safety and trust	Institute of Social Studies (ISS, 2011)	Composite indicator that includes measures of social trust and reported levels of crime victimisation
Democracy	Index of voice and accountability	Worldwide Governance Indicators (World Bank, 2011)	Composite indicator that measures the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media
Low unemployment	Unemployment rate	World Development Indicators (World Bank, 2014)	Share of total labour force that is without work but available for and seeking employment
Stable prices	Inflation rate	World Development Indicators (World Bank, 2014)	Annual percentage change in the consumer price index
No poverty	Human Poverty Index (HPI-1)	United Nations Development Programme (UNDP, 2009)	Composite indicator that measures deprivations in three areas: health, education, and living standards
Decreased working time	Annual working hours	International Labour Organization (ILO, 2011)	Total number of hours actually worked during a year per employed person
People	Δ Human population	United Nations Population Division (United Nations, 2009)	Total population (both sexes combined)
Livestock	Δ Livestock population	Food and Agriculture Organization (FAOSTAT, 2011)	Number of livestock units (a standardised unit obtained by multiplying the number of animals by a conversion factor that takes into account the feed requirements of each type of animal)
Built capital	Δ Night-time lights	National Geophysical Data Center (Elvidge et al., 2011)	Intercalibrated sum-of-lights, capturing both changes in the intensity and area of nocturnal lighting
Material use	Δ Domestic material extraction	Global Material Flows Database (SERI, 2010)	Mass of domestically extracted biomass, minerals, and fossil fuels
Energy use	Δ Total primary energy supply	Energy Information Administration (EIA, 2011)	Apparent consumption of technical energy
Material outflows	Δ CO_2 emissions	Carbon Dioxide Information Analysis Center (Boden et al., 2010)	Total CO_2 emissions from fossil-fuel burning, cement production, and gas flaring
Scale	Ratio of per capita ecological footprint to fair earthshare	Global Footprint Network (GFN, 2010)	Compares a country's ecological footprint to the area of biologically productive land that would be available to each person if global biocapacity were divided equally among all people

Note: The Δ symbol signifies that a biophysical indicator is an annual rate of change.

envisions "a society with a stable and leaner metabolism, where well-being stems from equality, relation and simplicity".

There are a number of different approaches to defining and measuring human well-being, both subjective and objective. Subjective approaches include the *hedonic approach*, which relates well-being to the balance between positive and negative feelings (Kahneman et al., 2004); the *evaluative approach*, which relates well-being to an individual's appraisal of how his or her life is going (Layard, 2010); and the *eudaimonic approach*, which relates well-being to positive psychological functioning and the realisation of potential (Ryan et al., 2008). Objective approaches, on the other hand, include the *preference satisfaction approach*, which relates well-being to the satisfaction of wants and desires (Harsanyi, 1997); and the *capabilities approach*, which relates well-being to an individual's freedom to choose between different ways of living (Sen, 1993).

With such a wide array of different approaches, it is difficult to know which to use in the Social Accounts. Some authors, such as Layard (2009), advocate using a single over-arching indicator to measure well-being. Layard claims that a single indicator is necessary in order to be able to evaluate policy options against one another. Other authors, such as Michaelson et al. (2009), advocate using a collection of indicators from multiple approaches in a system of national accounts.

A single subjective measure of well-being was chosen as the ultimate end in the Social Accounts, while objective measures like health were included as intermediate ends. This choice was made in part because of the causal relationship between indicators. Although causality could go both ways, the evidence suggests that health has more of an impact on subjective well-being than subjective well-being does on health (Dolan et al., 2006; Deaton, 2008; Graham, 2008).

Ideally, human well-being would be measured using an index that combines a small number of indicators from the hedonic, evaluative, and eudaimonic approaches. Such an index would capture whether people were both "feeling good" and "doing well". However, the data needed to construct such an index were not available for enough countries. In the interests of pragmatism, human well-being has therefore been measured using a single evaluative (i.e. life satisfaction) indicator.

The data used are from the World Database of Happiness (Veenhoven, 2014). For most countries, these data are based on responses to the question "All things considered, how satisfied are you with your life as a whole these days?" Respondents were asked

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

to give their answer on a numerical scale from 0 to 10, where 0 is dissatisfied and 10 is satisfied.[2]

2.4.2. Equality

Greater social equity is an important objective of the degrowth movement, and is often viewed as an end in itself, as evidenced by the expression "degrowth *for* social equity" (Schneider et al., 2010; my emphasis). According to Demaria et al. (2013, p. 209), "degrowth implies an equitable redistribution of wealth within and across the Global North and South, as well as between present and future generations". For some advocates, such as Paul Ariès (2005), the most important type of degrowth is degrowth in inequality.

There are two types of equity that are important to discuss. The first, which is emphasised in the Paris Declaration, is equity *between* nations, largely in terms of levels of resource use. The declaration refers to "right-sizing" national economies, and suggests that for wealthy nations this implies reducing per capita ecological footprint to the sustainable global level, while for poorer nations this implies increasing consumption to a "level adequate for a decent life" (Research & Degrowth, p. 524).

The second type of equity, which is emphasised more by Daly (1977, 2008) and advocates of a steady-state economy, is equity *within* nations. Daly argues that without growth, the only way to alleviate poverty is through redistribution, and that it is therefore necessary to limit the range of income inequality within society. Wilkinson and Pickett (2009) make even stronger arguments for reducing income inequality. In their book *The Spirit Level*, they show that societies with higher income inequality tend to have more health and social problems, including higher crime rates, increased mental illness, and decreased trust.

The focus in the Social Accounts is largely on the second type of equity (i.e. equity within nations). The reason is that the type of international "resource access equity" described in the Paris Declaration is already accounted for in the Biophysical Accounts, using the indicator of sustainable scale (see Section 2.4.5). Equity between nations is also captured, to some degree, by the inclusion of a measure of absolute poverty within the Social Accounts (see Table 1).

Although equity within nations could theoretically be measured using a variety of different variables (e.g. gender, education, or happiness), income inequality has been used in the Social Accounts because low income inequality is an established goal for a steady-state economy, and data for this indicator are widely available. The specific indicator used is the Gini coefficient of net income, which measures inequality in household disposable income (i.e. income after taxes and transfers). The data used are from Solt's (2009) Standardized World Income Inequality Database (SWIID), which provides the largest set of intercomparable data available.

2.4.3. Democracy

A deepening of democracy is another important goal of the degrowth movement. A number of degrowth scholars claim that the transition to a more ecologically sustainable society and the transition to a more participatory and democratic society are mutually supportive goals that must be achieved together (e.g. Schneider et al., 2010). Cattaneo and Gavaldà (2010) argue that degrowth must be the outcome of a general transition towards a more democratic and autonomous society—the result of a collective decision for a better life. They stress that degrowth must not be an externally-imposed imperative, otherwise it could lead to some form of eco-dictatorship. Cattaneo et al. (2012) suggest that there is a continuum of positions on the form of democracy needed for degrowth: while some argue that degrowth would be possible in a reformed parliamentary democracy, others call for a radical overhaul of the political system and the establishment of direct democracy.

References to the role of democracy in achieving a steady-state economy are much harder to find. It is a topic that Daly does not really discuss, and where it is mentioned by other authors the focus is often on whether a democratic system could lead to a steady-state economy. As Victor (2008, p. 193) writes, "The dilemma for policy makers is that the scope of change required for managing without growth is so great that no democratically elected government could implement the requisite policies without the broad-based consent of the electorate. Even talking about them could make a politician unelectable". Nevertheless, Lawn (2005) argues against critics who suggest that a steady-state economy could only be accomplished under an authoritarian regime. He claims that a government wishing to make the transition to a steady-state economy would be democratically electable provided that people could be convinced of the severity of the ecological crisis, the desirability of a steady-state economy, and that their current freedoms would be preserved.

Most existing indicators of the strength of democratic institutions are based solely on expert opinion, and do not differentiate between countries at the top of the scale (i.e. those deemed most democratic). One exception is the "voice & accountability" indicator from the World Bank's (2011) World Governance Indicators. This indicator combines survey data with expert opinions to measure "perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media" (Kaufmann et al., 2010, p. 4). While it is questionable whether this indicator adequately captures the deepening of democracy envisaged by many proponents of degrowth, it is the best indicator available for a large number of countries, and it has therefore been included in the Social Accounts.

2.4.4. Built capital

In his definition of a steady-state economy, Daly (1977) refers to a constant stock of artefacts (i.e. built capital), which he defines as including both producer goods and the total inventory of consumer goods. Producer goods include the machines and other infrastructure like buildings, roads, and factories that contribute to the production process, but do not become embodied in its output. Consumer goods could theoretically include both durable goods (e.g. automobiles, furniture, and household appliances) and non-durable goods (e.g. food, beverages, clothing, and shoes). However, many non-durable goods move through the economy so quickly that it is probably more appropriate to think of them as a flow than as a stock.

Theoretically, it is possible to calculate whether the stock of built capital is growing in quantity terms using data from Material Flow Accounting studies (Eurostat, 2001, 2007). If direct material inputs to the economy are larger than direct material outputs, then the stock of built capital will increase. If the two quantities are equal, the stock will not change. However, with the exception of a small number of specific studies (e.g. Matthews et al., 2000; Pauliuk and Müller, 2014; Wiedenhofer et al., 2015), national material flow accounts are currently not comprehensive enough, particularly on the outflows side, to allow for the calculation of net additions to stock. Therefore it is necessary to consider other methods for calculating the change in the stock of built capital over time.

One approach would be to use traditional economic data such as the World Bank's (2014) data on gross fixed capital formation.

---

[2] Most questions are of type O-SLW/c/sq/n/10/a (used in the World Values Survey) and O-SLW/c/sq/n/11/a (used in the Gallup World Poll). In some cases the scale used was 1–10, but all results are standardised to a 0 to 10 scale.

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

However, there are two problems with using these data to measure change in the stock of built capital: (1) they measure the economic value of the stock, not its physical quantity, and (2) they do not account for depreciation. It is likely for these reasons that there is no significant correlation between the World Bank data and the limited biophysical data that are available to measure net additions to stock (O'Neill, 2012b).

The approach used in this analysis therefore relies on night-time lights data. Nocturnal lighting is one of the hallmarks of humanity's presence on earth, and the density of lighting has been shown to match the density of infrastructure (Elvidge et al., 2007). In order to calculate national trends, annual "sum-of-lights" data published by Elvidge et al. (2011) were used. These data capture both changes in the intensity and area of nocturnal lighting, based on satellite imagery from the National Geophysical Data Center. They therefore capture both densification and expansion of infrastructure. Change in night-time lighting is a very rough approximation of change in built capital, but one that is more consistent with the biophysical definition of a steady-state economy than monetary measures such as gross fixed capital formation (O'Neill, 2012b).

2.4.5. *Scale*

Daly suggests that the maximum sustainable scale for the economy should be determined based on either the capacity of ecosystem sources to regenerate materials, or the capacity of ecosystem sinks to assimilate wastes—whichever limit is reached first (Daly, 2010). On the source side, only the flow of renewable materials (i.e. biomass and water) is relevant for assessing the scale of economic activity, as these are the only materials that ecosystems regenerate. The flow of non-renewable materials (i.e. minerals and fossil fuels) is largely irrelevant on the source side, since ecosystems do not regenerate these materials (except over geological time periods), and hence there is no ecosystem threshold to compare them to.

Human appropriation of net primary production (HANPP; Vitousek et al., 1986; Haberl et al., 2007; O'Neill et al., 2007) is an indicator that could be used to assess the scale of biomass use relative to ecosystem sources. HANPP measures the amount of biomass that human beings either (1) harvest, or (2) make unavailable through land cover change. It may be compared to the potential net primary production that would be available in the absence of human disturbance, to arrive at a measure of the magnitude of human activity with respect to available biomass flows. The most detailed HANPP study to date (Krausmann et al., 2013) indicates that human beings currently appropriate about 25% of global potential net primary production.

Daly (1991, p. 245) suggests that HANPP is "[p]robably the best index of the scale of the human economy as a part of the biosphere". However, the problem with using HANPP as an indicator of scale is that HANPP does not provide a clear sustainability threshold. Although 100% appropriation would clearly be destructive because it would leave no resources for other species, levels much lower than this may not be sustainable either (Haberl et al., 2004). Based on the precautionary principle, Weterings and Opschoor (1992) argue that the level of HANPP should be "small" compared to natural processes, and propose 20% appropriation as a sustainability threshold. However, this number is not based on scientific criteria, and it is debatable how to set a meaningful lower threshold (Haberl et al., 2004).

With respect to water, the blue water footprint (Hoekstra and Hung, 2002; Hoekstra et al., 2011), which measures the consumption of surface and ground water, is an indicator that could theoretically be used to assess the scale of water use. Gerten et al. (2013) suggest that global blue water use should not exceed 1100–4500 billion m^3 per year. However, there is currently no complementary measure of national water availability/regeneration to compare the blue water footprint to.

While on the source side only the flow of renewable resources is relevant for assessing sustainability, the same is not true on the sink side. On the sink side, all outflows must be considered. Given the sheer number and wildly different characteristics of these materials, it might seem to be an almost impossible task to estimate whether material outflows are within the assimilative capacity of ecosystem sinks.

However, the dominant material outflow from industrial economies is CO_2—a pollutant with a clear link to a global environmental problem, namely climate change. In a study of five industrial economies, Matthews et al. (2000) found that CO_2 emissions accounted for more than 80% of total material outflows by weight, making the atmosphere the "largest dumping ground for industrial wastes" (p. xii). As the authors explain, "Modern industrial economies, no matter how high-tech, are carbon-based economies, and their pre-dominant activity is burning material" (p. 23).

There is a growing consensus that global warming must be limited to no more than 2 °C above pre-industrial levels if dangerous climate change is to be avoided. Based on a comprehensive probabilistic analysis, Meinshausen et al. (2009) conclude that if cumulative global CO_2 emissions were limited to 1000 Gt over the period 2000–2050, the probability of exceeding 2 degrees of warming would be 25% (i.e. relatively low). These, or other similar data, could be used to construct national carbon budgets, acknowledging that there are many different ways that "carbon space" could be allocated among nations (Opschoor, 2010). National carbon budgets could be compared to national CO_2 emissions data to arrive at an indicator of the scale of waste outflows in comparison to ecosystem sinks. While such an approach would not account for all waste emissions from industrial economies, it would relate the largest of these to an established limit on the sink side.

While the separate indicators discussed above have a certain appeal, there are problems with implementing them in practice, particularly with regard to establishing sustainability thresholds for the source indicators. For the first instance of the Degrowth Accounts, a hybrid indicator that combines information on both sources and sinks is therefore used in order to measure maximum sustainable scale. This indicator is the ecological footprint (Wackernagel and Rees, 1996). Although the method used to calculate the footprint has been criticised by a number of authors (van den Bergh and Verbruggen, 1999; Fiala, 2008; Wiedmann and Barrett, 2010), it remains the only indicator of resource use and waste emissions that has a clear sustainability threshold for individual nations.

The ecological footprint measures the area of biologically productive land that a country needs to produce the biomass it consumes, and assimilate the CO_2 emissions it generates. The footprint does not include the flow of non-renewable materials such as minerals, but it does include fossil fuels in terms of the CO_2 emissions that are produced during their combustion. These emissions are translated into the area of forested land necessary to sequester the CO_2 emitted (Ewing et al., 2010).

The ecological footprint may be compared to biocapacity (the supply of biologically productive land) to arrive at a ratio of the scale of economic activity in relation to what the environment can sustain. At the national level, a country's footprint may either be compared to its national biocapacity (the area of biologically productive land within the country's borders), or to the concept of a "fair earthshare" (the area of biologically productive land that would be available to each person if global biocapacity were divided equally among all people). "Fairness" in this sense is

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

entirely anthropocentric; it does not make any allowance for other species.

From a technical perspective there is no right or wrong answer to which of these two approaches should be taken. Either approach, if adopted by all nations, would lead to ecological sustainability (assuming we accept the ecological footprint as a meaningful measure of sustainability). However, given the strong focus on equity in the degrowth movement, it is probably more appropriate to compare the ecological footprint to a fair earthshare. The Paris Declaration explicitly mentions the goal of "right-sizing" national economies, suggesting that "in countries where the per capita footprint is greater than the sustainable global level, right-sizing implies a reduction to this level within a reasonable timeframe" (Research & Degrowth, 2010, p. 524). The ratio of per capita ecological footprint to a fair earthshare has therefore been used as the indicator of scale in the Biophysical Accounts.[3] The data are from the National Footprint Accounts, as published by the Global Footprint Network (GFN, 2010).

3. Analysis

This section presents and analyses the data in the Degrowth Accounts. Section 3.1 analyses the data in the Biophysical Accounts, starting with the indicators used to measure biophysical stability, followed by the indicator used to measure biophysical scale. Two methods are employed to assess how close countries are to biophysical stability: (1) a multi-indicator categorisation approach, and (2) an index of biophysical stability. Following this, Section 3.2 presents the data in the Social Accounts. To help assess the relative social performance of different countries, the data are normalised and aggregated to create an overall index of social performance. Finally, Section 3.3 brings the Biophysical and Social Accounts together to investigate the relationship between resource use and social performance. Tests are performed to see whether there is any relationship between biophysical stability and performance on each of the social indicators, and then biophysical scale and each of the social indicators. Multiple regression analysis is used to assess whether the stability findings are robust to the inclusion of scale.

3.1. *How close are countries to a steady-state economy?*

To determine how close countries are to a steady-state economy, the seven indicators in the Biophysical Accounts are analysed over a 10-year time period (1997–2007), for 181 countries. This time period was chosen to be long enough to observe trends, but not so long as to introduce a significant constraint on the number of countries that could be analysed. Importantly, the analysis period ends before the beginning of the global financial crisis. This period was chosen in part to avoid introducing an additional complicating factor into the analysis of the relationship between biophysical trends and social performance.

There are two types of indicators in the Biophysical Accounts: (1) indicators that measure the rate of change of stocks and flows, and (2) indicators that measure the scale of the economy in relation to the capacity of ecosystems. Although the ecological footprint is primarily used as an indicator of scale in the Biophysical Accounts, it is also included as a rate-of-change indicator for completeness.

3.1.1. *Calculating rates of change*

The rate of change for each of the seven biophysical indicators was estimated over the 10-year analysis period (1997–2007) using log-linear regression, following a method suggested by Gujarati (1995, pp. 169–171). The method uses all data points in the period to calculate the compound annual rate of change, and is therefore superior to simpler approaches that use only the end-points. Following Equation (1), the compound annual rate of change r was calculated as:

$$r = [\exp(m) - 1] \times 100 \quad (1)$$

where m is the slope of the best-fit line generated using ordinary least squares regression, after log-transforming the data.

There is clearly value in having some measure of the level of uncertainty in the trend. The standard measure of goodness-of-fit for a regression (R^2) is of little use here, however, because R^2 is zero whenever the rate of change is zero (the desired state in a steady-state economy). Therefore the standard error of the slope was used to measure the uncertainty in the trend.

A high standard error in the slope could either indicate some form of discontinuity in the data, or simply the absence of a consistent trend. Either way, it could be argued that rates of change with a high standard error should be excluded from the analysis of how close countries are to biophysical stability. As a cut-off, all data points with a standard error greater than 2% were excluded.[4] For the "cleanest" of the indicators (population) no data points were excluded using this threshold, whereas for the "noisiest" of the indicators (the ecological footprint), 13 data points were removed.

Two different approaches were used to assess how close countries are to biophysical stability: (1) a multi-indicator categorisation approach, and (2) an index of biophysical stability.

3.1.2. *Categorisation approach*

In the first method, a country's performance on each of the seven indicators was classified as either "degrowth", "stable", or "growth" depending on the value of the indicator. In general, a rate of change was classified as degrowth if it was less than −1% per year, stable if it was between −1% and +1%, and growth if was greater than +1% per year. The one exception is the rate of change of population where thresholds of −0.5% and +0.5% were used, due to the lower range and lower standard error for this indicator.

Each country was then placed into one of five categories based on which of these three classifications dominated (Table 2). In general, if four or more of the classifications were of one type (e.g. "stable") then the economy was categorised as that type (i.e. "stable"). Two shoulder categories ("partial degrowth" and "partial growth") were used to capture economies that fell between types. A total of 174 countries were classified into these five groups, while the remaining seven countries were classified as "mixed". In general, the "mixed" countries were missing data for one or more of the indicators, which made it difficult to categorise them.

Fig. 2 presents the rate-of-change data and categorisations for a selection of the 181 countries in the Biophysical Accounts (see Supplementary Data for all results). The results show that the vast majority of countries in the world are biophysical growth economies. These countries account for roughly 80% of global population. Moreover, there are 32 countries (accounting for 12% of global population) where all seven biophysical indicators are increasing. The world as a whole is also a growth economy, with high rates of growth in five of the seven indicators.

There are 22 countries that have relatively stable stocks and flows, and another 24 close to this situation (i.e. countries categorised as either "partial degrowth" or "partial growth"). The

---

[3] A "fair earthshare" is equal to 1.8 global hectares per person in the year 2007. This value is obtained by dividing global biocapacity by global population.

[4] The 2% cut-off is somewhat arbitrary, but matches the size of the groups that were used to categorise economies, and serves to remove any extreme outliers.

Table 2
Categorisation of countries based on the rate of change of the seven stock and flow indicators in the Biophysical Accounts.

Category	Criteria	Number of countries	% of people
Degrowth	≥4 degrowth classifications	4	1.5
Partial Degrowth	≥5 stable or degrowth classifications	5	1.9
Stable	≥4 stable classifications	22	11.8
Partial Growth	≥5 stable or growth classifications	19	3.9
Growth	≥4 growth classifications	124	80.2
Mixed	All others	7	0.7

majority of the countries that are classified as "stable" are located in Europe, although a handful of Latin American countries also make the list.

There is only one country in the world (Japan) that achieves relative stability in all seven of the stocks and flows, while five countries (Denmark, France, Poland, Romania, and the US) achieve stability in six out of the seven. Interestingly, the one indicator that does not meet the stability criterion in the US is population, which is growing at 1.1% per year.

There are four countries in the world (Germany, Guyana, Moldova, and Zimbabwe) which achieve biophysical degrowth in the majority of the indicators, and another five countries that straddle the boundary between degrowth and stable (Lithuania, Slovakia, Sweden, the Ukraine, and the UK). There are a total of seven countries in the world that are either degrowing or stable in all indicators (Belgium, Denmark, Germany, Japan, Moldova, Romania, and Zimbabwe). The UK performs well in general, achieving degrowth or stability in six out of the seven indicators. The one indicator that is increasing in the UK is the ecological footprint, which is growing at 1.2% per year.

3.1.3. *Biophysical Stability Index*

The second method that was used to assess how close countries are to biophysical stability was to create a composite indicator (or index) from the seven rate-of-change indicators. As discussed in O'Neill (2012a), there are dangers associated with aggregating individual indicators together to create an index. In such a process, information is inevitably lost, which may invite overly simplistic policy conclusions. However, the largest danger—that of mixing social and environmental objectives in a single measure—was avoided by creating a purely biophysical index in which the data were normalised as percentage rates of change. The index adds value by providing a single measure of stability, thus making the results easier to interpret and communicate.

There were 137 countries for which clean data (i.e. standard error <2%) were available for all seven of the indicators. The Biophysical Stability Index (BSI) was calculated by taking the arithmetic mean of the absolute values of the indicators. In developing this index, a number of different methods of aggregating the data were explored (including taking the geometric and quadratic mean). These different methods did not significantly change the results of the analysis, however, and so the simplest approach was applied (the arithmetic mean) following standard index construction methods (OECD, 2008). Each of the indicators was weighted equally.

The average of the absolute values was used, rather than the raw values, in order to create an index that does not allow negative rates of change on some indicators to cancel out positive rates of change on others. Unlike the multi-indicator approach used to categorise countries, the BSI does not distinguish between growing and degrowing economies. It simply measures how close economies are to biophysical stability. This approach is consistent with the definition of a steady-state economy, which is concerned with stability rather than growth or degrowth.

The results of the index-based analysis (Table 3 and Supplementary Data) paint a similar picture to the categorisation analysis. The top ten countries on the BSI list are all identified as biophysically stable economies using the categorisation method. Both methods identify Japan as having the most biophysically-stable economy in the world. Japan has the lowest BSI score and is the only country that achieves a stable classification on all seven indicators. Although Japan tops the list, seven of the top ten countries on the BSI list are in Europe. While Switzerland achieved stability in only five of the seven indicators using the categorisation method, it finishes second on the BSI list because these five rate-of-change indicators are all very close to zero.

The country furthest away from biophysical stability is Turkmenistan, followed by Vietnam and then Angola. The majority of countries at the bottom of the list (i.e. those with the highest rates of increase of stocks and flows), are relatively poor developing nations, although a few wealthier countries in the Middle East are also found near the bottom. China has one of the highest rates of biophysical growth in the world, finishing at number 125 on the list.

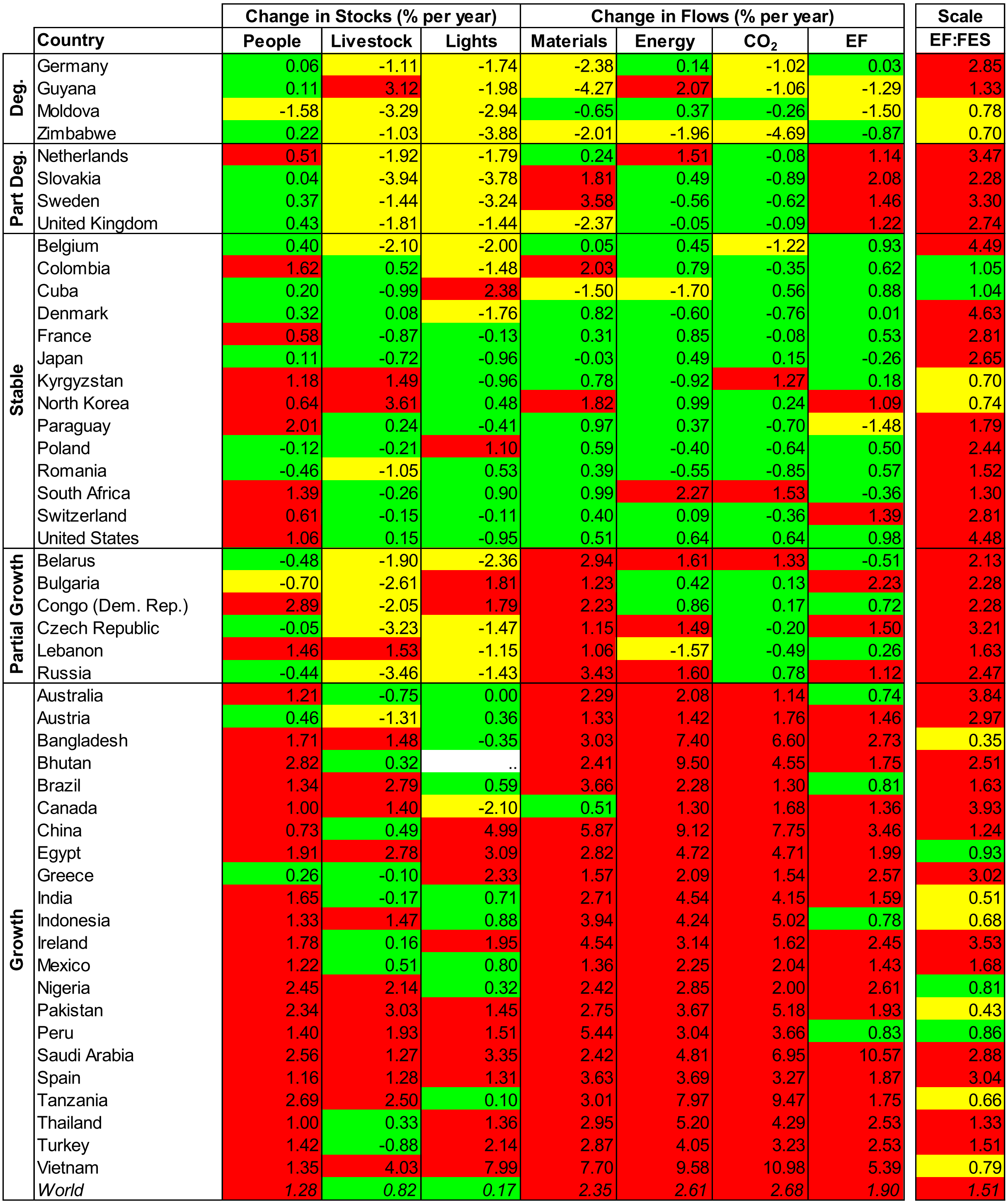
3.1.4. *Scale and proximity to a steady-state economy*

A steady-state economy is not just an economy where stocks and flows are stable over time. It is also an economy where the level of flows is within the carrying capacity of ecosystems. The indicator of scale used in the Biophysical Accounts is the ratio of per capita ecological footprint to a fair earthshare (FES), calculated for the year 2007. Countries were placed into three categories based on their performance on this indicator: small, medium, and large (Table 4).

Roughly half of the global population live in countries with an ecological footprint above a fair earthshare, while the other half live in countries where the footprint is at or below a fair earthshare. A relatively small number of people (10% of the global population) live in countries where the footprint is roughly equal to a fair earthshare. The countries with the lowest per capita ecological footprint tend to be relatively poor countries in Africa and Asia, while those with the highest footprint tend to be relatively wealthy countries in the Middle East and Europe (Fig. 2). There is a diverse mix of countries with a per capita ecological footprint close to a fair earthshare, although the majority are in Africa, Latin America, and Western Asia.

Having calculated indicators of both stability and scale, it is now possible to assess whether there are any countries that are close to a steady-state economy. The data reveal that the majority of countries that have achieved biophysical stability have done so at a level of resource use that is substantially above a fair earthshare (Fig. 2). While we might refer to these as "biophysically stable economies", they are not "steady-state economies" because their level of resource use is beyond what is globally sustainable. There are only a handful of countries that achieve something approaching both biophysical stability and medium scale. These include Colombia, Cuba, Kyrgyzstan, Romania, and South Africa.

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116



		Change in Stocks (% per year)			Change in Flows (% per year)				Scale
	Country	People	Livestock	Lights	Materials	Energy	CO_2	EF	EF:FES
Deg.	Germany	0.06	-1.11	-1.74	-2.38	0.14	-1.02	0.03	2.85
	Guyana	0.11	3.12	-1.98	-4.27	2.07	-1.06	-1.29	1.33
	Moldova	-1.58	-3.29	-2.94	-0.65	0.37	-0.26	-1.50	0.78
	Zimbabwe	0.22	-1.03	-3.88	-2.01	-1.96	-4.69	-0.87	0.70
Part Deg.	Netherlands	0.51	-1.92	-1.79	0.24	1.51	-0.08	1.14	3.47
	Slovakia	0.04	-3.94	-3.78	1.81	0.49	-0.89	2.08	2.28
	Sweden	0.37	-1.44	-3.24	3.58	-0.56	-0.62	1.46	3.30
	United Kingdom	0.43	-1.81	-1.44	-2.37	-0.05	-0.09	1.22	2.74
Stable	Belgium	0.40	-2.10	-2.00	0.05	0.45	-1.22	0.93	4.49
	Colombia	1.62	0.52	-1.48	2.03	0.79	-0.35	0.62	1.05
	Cuba	0.20	-0.99	2.38	-1.50	-1.70	0.56	0.88	1.04
	Denmark	0.32	0.08	-1.76	0.82	-0.60	-0.76	0.01	4.63
	France	0.58	-0.87	-0.13	0.31	0.85	-0.08	0.53	2.81
	Japan	0.11	-0.72	-0.96	-0.03	0.49	0.15	-0.26	2.65
	Kyrgyzstan	1.18	1.49	-0.96	0.78	-0.92	1.27	0.18	0.70
	North Korea	0.64	3.61	0.48	1.82	0.99	0.24	1.09	0.74
	Paraguay	2.01	0.24	-0.41	0.97	0.37	-0.70	-1.48	1.79
	Poland	-0.12	-0.21	1.10	0.59	-0.40	-0.64	0.50	2.44
	Romania	-0.46	-1.05	0.53	0.39	-0.55	-0.85	0.57	1.52
	South Africa	1.39	-0.26	0.90	0.99	2.27	1.53	-0.36	1.30
	Switzerland	0.61	-0.15	-0.11	0.40	0.09	-0.36	1.39	2.81
	United States	1.06	0.15	-0.95	0.51	0.64	0.64	0.98	4.48
Partial Growth	Belarus	-0.48	-1.90	-2.36	2.94	1.61	1.33	-0.51	2.13
	Bulgaria	-0.70	-2.61	1.81	1.23	0.42	0.13	2.23	2.28
	Congo (Dem. Rep.)	2.89	-2.05	1.79	2.23	0.86	0.17	0.72	2.28
	Czech Republic	-0.05	-3.23	-1.47	1.15	1.49	-0.20	1.50	3.21
	Lebanon	1.46	1.53	-1.15	1.06	-1.57	-0.49	0.26	1.63
	Russia	-0.44	-3.46	-1.43	3.43	1.60	0.78	1.12	2.47
Growth	Australia	1.21	-0.75	0.00	2.29	2.08	1.14	0.74	3.84
	Austria	0.46	-1.31	0.36	1.33	1.42	1.76	1.46	2.97
	Bangladesh	1.71	1.48	-0.35	3.03	7.40	6.60	2.73	0.35
	Bhutan	2.82	0.32	..	2.41	9.50	4.55	1.75	2.51
	Brazil	1.34	2.79	0.59	3.66	2.28	1.30	0.81	1.63
	Canada	1.00	1.40	-2.10	0.51	1.30	1.68	1.36	3.93
	China	0.73	0.49	4.99	5.87	9.12	7.75	3.46	1.24
	Egypt	1.91	2.78	3.09	2.82	4.72	4.71	1.99	0.93
	Greece	0.26	-0.10	2.33	1.57	2.09	1.54	2.57	3.02
	India	1.65	-0.17	0.71	2.71	4.54	4.15	1.59	0.51
	Indonesia	1.33	1.47	0.88	3.94	4.24	5.02	0.78	0.68
	Ireland	1.78	0.16	1.95	4.54	3.14	1.62	2.45	3.53
	Mexico	1.22	0.51	0.80	1.36	2.25	2.04	1.43	1.68
	Nigeria	2.45	2.14	0.32	2.42	2.85	2.00	2.61	0.81
	Pakistan	2.34	3.03	1.45	2.75	3.67	5.18	1.93	0.43
	Peru	1.40	1.93	1.51	5.44	3.04	3.66	0.83	0.86
	Saudi Arabia	2.56	1.27	3.35	2.42	4.81	6.95	10.57	2.88
	Spain	1.16	1.28	1.31	3.63	3.69	3.27	1.87	3.04
	Tanzania	2.69	2.50	0.10	3.01	7.97	9.47	1.75	0.66
	Thailand	1.00	0.33	1.36	2.95	5.20	4.29	2.53	1.33
	Turkey	1.42	-0.88	2.14	2.87	4.05	3.23	2.53	1.51
	Vietnam	1.35	4.03	7.99	7.70	9.58	10.98	5.39	0.79
	World	*1.28*	*0.82*	*0.17*	*2.35*	*2.61*	*2.68*	*1.90*	*1.51*

Fig. 2. The Biophysical Accounts. Data are for a selection of countries. See Supplementary Data for full results. Note: "Change in Stocks" and "Change in Flows" data measure annual percentage rates of change, calculated over the 10-year analysis period (1997–2007). "Scale" data measure the ratio of per capita ecological footprint to a fair earthshare for the year 2007. Rate-of-change values are classified as *degrowth* (yellow), *stable* (green), and *growth* (red). Scale values are classified as *small* (yellow), *medium* (green), and *large* (red). The boundaries between colours are at −1% and +1% for all rate-of-change indicators, with the exception of population, where −0.5% and +0.5% are used instead. The boundaries between colours for the scale indicator are at 0.8 and 1.2 times a fair earthshare. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

3.2. How close are countries to the social goals of degrowth?

Of the 181 countries included in the analysis, social data were available for between 48 and 181 depending on the individual indicator. In general, data were widely available for seven of the nine social indicators. The two exceptions were the poverty indicator (which was only available for 131 relatively poor countries) and the working time indicator (which was only available for 48 relatively wealthy countries).

Where possible, the social indicators were calculated using data covering the same 10-year period (1997–2007) as the biophysical data. For some indicators, data were not available for this exact

Table 3
The Biophysical Stability Index (BSI) and sub-indicators. Data are for a selection of countries. See Supplementary Data for full results.

Country		Change in stocks (%/year)			Change in flows (%/year)				BSI
		People	Livestock	Lights	Materials	Energy	CO_2	EF	
1	Japan	0.11	−0.72	−0.96	−0.03	0.49	0.15	−0.26	0.39
2	Switzerland	0.61	−0.15	−0.11	0.40	0.09	−0.36	1.39	0.44
3	France	0.58	−0.87	−0.13	0.31	0.85	−0.08	0.53	0.48
4	Poland	−0.12	−0.21	1.10	0.59	−0.40	−0.64	0.50	0.51
5	Denmark	0.32	0.08	−1.76	0.82	−0.60	−0.76	0.01	0.62
6	Romania	−0.46	−1.05	0.53	0.39	−0.55	−0.85	0.57	0.63
7	New Zealand	1.12	−0.05	−0.64	1.02	1.02	0.78	−0.19	0.69
8	United States	1.06	0.15	−0.95	0.51	0.64	0.64	0.98	0.70
9	Italy	0.42	−1.14	0.62	0.07	1.08	0.74	1.12	0.74
10	Hungary	−0.26	−0.92	−1.43	1.81	0.99	−0.70	0.03	0.88
11	Paraguay	2.01	0.24	−0.41	0.97	0.37	−0.70	−1.48	0.88
12	Germany	0.06	−1.11	−1.74	−2.38	0.14	−1.02	0.03	0.93
13	Kyrgyzstan	1.18	1.49	−0.96	0.78	−0.92	1.27	0.18	0.97
14	Belgium	0.40	−2.10	−2.00	0.05	0.45	−1.22	0.93	1.02
15	Netherlands	0.51	−1.92	−1.79	0.24	1.51	−0.08	1.14	1.03
16	Colombia	1.62	0.52	−1.48	2.03	0.79	−0.35	0.62	1.06
17	United Kingdom	0.43	−1.81	−1.44	−2.37	−0.05	−0.09	1.22	1.06
18	Uruguay	0.15	0.91	−2.51	2.64	0.06	0.96	−0.21	1.06
19	Lebanon	1.46	1.53	−1.15	1.06	−1.57	−0.49	0.26	1.07
20	Norway	0.67	−0.42	−0.05	0.71	0.49	3.05	2.19	1.08
…	…	…	…	…	…	…	…	…	…
125	China	0.73	0.49	4.99	5.87	9.12	7.75	3.46	4.63
…	…	…	…	…	…	…	…	…	…
128	Albania	0.18	−1.44	6.20	6.09	3.88	10.55	5.49	4.83
129	Sierra Leone	3.31	3.24	9.12	4.17	4.06	9.82	1.16	4.98
130	Chad	3.48	2.85	4.66	2.48	3.10	16.83	2.78	5.17
131	Benin	3.30	3.18	1.74	2.27	11.30	12.36	3.00	5.31
132	Sudan	2.18	2.21	6.58	2.41	12.22	10.54	2.00	5.45
133	Oman	1.79	2.70	5.75	2.59	7.16	9.96	8.24	5.46
134	Trinidad & Tobago	0.37	6.40	3.73	8.68	8.66	6.68	4.02	5.50
135	Angola	2.94	1.38	6.50	5.79	8.27	13.24	3.80	5.99
136	Vietnam	1.35	4.03	7.99	7.70	9.58	10.98	5.39	6.72
137	Turkmenistan	1.42	9.35	3.10	9.52	14.41	4.70	5.53	6.86

Note: Data show annual percentage rates of change for the seven stock and flow indicators, as well as the BSI, and are calculated over the 10-year analysis period (1997–2007).

period. In these cases, data for the closest corresponding period were used. If data were available for multiple years within the analysis period, then the average value over the period was calculated.

On their own, the nine indicators in the Social Accounts are difficult to interpret, particularly since some of them (e.g. the indicators of democracy and social capital) are dimensionless indices. Without some kind of summary indicator that normalises and aggregates the data, it is difficult to say how countries are performing overall on the social objectives described in the Paris Declaration.

In order to assess the relative social performance of different countries, an index based on the social indicators was created. The index includes all of the social indicators, with the exception of the poverty and working time indicators, which were available for a much smaller number of countries than the others.

The Social Performance Index (SPI) was calculated for countries where all seven of the included indicators were available. The index was calculated by normalising each indicator so that it was on a zero to ten scale (with zero representing the worst score and ten representing the best score for the indicator), and then taking the arithmetic mean of these seven values. Standard index construction methods were used (OECD, 2008), and an equal weight was given to each indicator.

There were 108 countries for which all seven social indicators were available. Table 5 presents the SPI and normalised sub-indicators for a selection of these countries (see Supplementary Data for all results). The countries that achieve the highest scores on the SPI are almost exclusively wealthy European nations, with Switzerland, Denmark, and Iceland topping the list. Nine of the top ten social performers (and sixteen of the top twenty) are European countries. Japan is the only non-European country to finish in the top ten. By contrast, the countries that achieve the lowest scores on the SPI are almost exclusively poor African nations, with Zambia and Kenya finishing at the bottom of the list. Nine of the bottom ten social performers (and fourteen of the bottom twenty) are African countries. Iraq is the only country in the bottom ten that is not located in Africa.

Table 4
Categorisation of countries based on the scale of resource use (per capita ecological footprint) relative to a fair earthshare.

Category	Criteria	Number of countries	% of people
Small	<0.8 FES	48	38.0
Medium	0.8 to 1.2 FES	34	10.4
Large	>1.2 FES	98	51.6

3.3. *Resource use and social performance*

Having calculated indicators to measure both biophysical stability and biophysical scale, as well as indicators to measure performance on the main social objectives described in the Paris Declaration, it is now possible to use these indicators to investigate the social performance of countries that are closer to a steady-state economy, in comparison to those that are further away.

3.3.1. *Visualising country performance*

An earlier article (O'Neill, 2012a) suggested plotting biophysical scale versus individual rate-of-change indicators as a way to visualise how close countries are to a steady-state economy. Such an

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

Table 5
The Social Performance Index (SPI) and sub-indicators. Data are for a selection of countries. See Supplementary Data for full results.

Country		Life Sat.	Health	Gini	Trust	Voice	Unemp.	Inflat.	SPI
1	Switzerland	9.14	9.72	8.35	10.00	9.71	7.94	8.76	9.09
2	Denmark	9.54	8.89	10.00	9.35	10.00	6.98	7.12	8.84
3	Iceland	9.38	9.44	9.07	9.68	9.75	8.73	5.46	8.79
4	Norway	8.87	9.17	9.49	8.82	9.87	7.86	7.25	8.76
5	Sweden	8.80	9.44	9.87	7.84	9.87	5.76	8.07	8.52
6	Netherlands	8.35	9.17	8.95	8.11	9.94	7.81	6.93	8.46
7	Finland	8.93	8.89	9.41	9.09	9.98	4.65	7.76	8.39
8	Luxembourg	8.52	9.17	8.71	7.14	9.63	8.19	6.97	8.33
9	Austria	8.38	8.89	8.86	7.82	9.28	7.36	7.39	8.28
10	Japan	6.48	10.00	6.99	9.30	7.98	7.15	10.00	8.27
11	Belgium	7.94	8.89	8.96	8.82	9.36	5.19	7.26	8.06
12	New Zealand	8.17	9.17	6.41	8.47	9.97	6.59	6.88	7.95
13	Ireland	8.43	9.17	7.19	9.00	9.32	6.61	5.85	7.94
14	Germany	7.57	9.17	8.49	8.02	9.40	4.70	7.88	7.89
15	Malta	7.55	8.89	8.29	8.53	8.91	5.64	6.87	7.81
16	Canada	8.42	9.17	7.25	7.38	9.70	5.49	6.99	7.77
17	Cyprus	7.34	8.33	8.46	8.16	8.28	7.20	6.51	7.76
18	Australia	8.64	9.44	7.25	7.04	9.45	6.07	6.34	7.75
19	United Kingdom	7.61	8.89	6.25	7.62	9.23	6.58	7.85	7.72
20	France	6.67	9.17	8.57	7.23	8.82	4.48	7.59	7.51
…	…	…	…	…	…	…	…	…	…
24	United States	8.13	8.33	5.43	6.72	8.96	6.87	6.64	7.30
…	…	…	…	…	…	…	…	…	…
39	China	6.14	7.22	4.73	8.14	0.33	7.82	8.50	6.13
…	…	…	…	…	…	…	…	…	…
99	Ethiopia	2.45	2.78	6.26	4.79	1.64	3.37	4.80	3.73
100	Burkina Faso	2.71	0.83	1.24	0.84	3.80	9.24	7.10	3.68
101	Malawi	5.95	1.11	3.08	4.31	3.90	5.27	1.61	3.60
102	Cote d'Ivoire	2.87	1.94	2.79	1.94	1.26	7.48	6.43	3.53
103	Botswana	3.31	2.50	0.43	4.71	6.93	2.07	3.84	3.40
104	South Africa	5.28	2.22	0.00	2.06	7.12	0.93	4.93	3.22
105	Cameroon	1.97	1.39	2.29	0.52	1.70	6.67	7.06	3.09
106	Iraq	3.26	3.89	6.48	3.70	0.00	1.51	1.16	2.86
107	Kenya	1.50	2.22	1.92	0.29	3.75	4.47	3.76	2.56
108	Zambia	3.79	0.00	1.16	3.55	3.79	3.63	1.39	2.47

Note: All results are normalised to a 0–10 scale, where 10 is the best score achieved, and 0 is the worst.

approach would place countries into one of four quadrants on a two-dimensional plot: *desirable growth*, *undesirable growth*, *desirable degrowth*, and *undesirable degrowth*. Countries at the centre of the plot (where the two axes meet) would approach a steady-state economy for the indicators considered.

In Fig. 3, countries are plotted using this method and the ecological footprint data from the Biophysical Accounts. The results suggest a rather uneven distribution of countries among the four quadrants. In general, there are more countries experiencing undesirable growth than desirable growth, and almost no countries experiencing degrowth (whether desirable or not).

In Fig. 3, life satisfaction data from the Social Accounts are also included by colour-coding the points for each country. Countries are coded as *happy* (life satisfaction greater than 7 out of 10), *relatively happy* (6–7), *relatively unhappy* (5–6), and *unhappy* (less than 5). The four-quadrant plot clearly suggests a correlation between biophysical scale and human well-being. Countries with a large per capita ecological footprint tend to score highly on life satisfaction (most of the blue points are near the top of the plot), while countries with a small per capita footprint tend to score poorly (most of the grey points are near the bottom). In this plot, however, there is no obvious relationship between the rate of change of per capita ecological footprint and life satisfaction.

It is worth noting that Fig. 3 only considers a single biophysical indicator (the ecological footprint) and a single social indicator (life satisfaction). The next two subsections investigate the relationship between resource use and social performance across multiple indicators. Statistical techniques are used to test for a relationship between biophysical stability and social performance, and then test for a relationship between biophysical scale and social performance. Finally, a test is performed to see whether biophysical stability is robust to the inclusion of scale.

3.3.2. *Biophysical stability and social performance*

To test for a relationship between biophysical stability and social performance, countries were placed into four groups based on their performance on the biophysical rate-of-change indicators. A comparison of means was then performed to test whether there was a statistically significant difference between the groups in terms of their average scores on the nine social indicators.

Countries were placed into the following groups: partial degrowth, stable, partial growth, and growth. These groups correspond to the groups used in the earlier rate-of-change categorisation (Table 2), except that the "degrowth" and "partial degrowth" groups were merged into a single "partial degrowth" group due to the small number of countries in these two groups. The four resulting groups include 174 of the 181 countries in the accounts. The seven countries categorised as "mixed" were not included in the analysis. The comparison of means was performed using all available data for each of the nine social indicators, and statistical significance was tested using analysis of variance (ANOVA).

In general, countries classified as biophysically stable perform better on the social indicators than countries in the two shoulder groups ("partial degrowth" and "partial growth"), who in turn perform better than countries in the "growth" group (Fig. 4). There is a statistically significant relationship between the biophysical stability groups and five of the social indicators (life satisfaction,

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

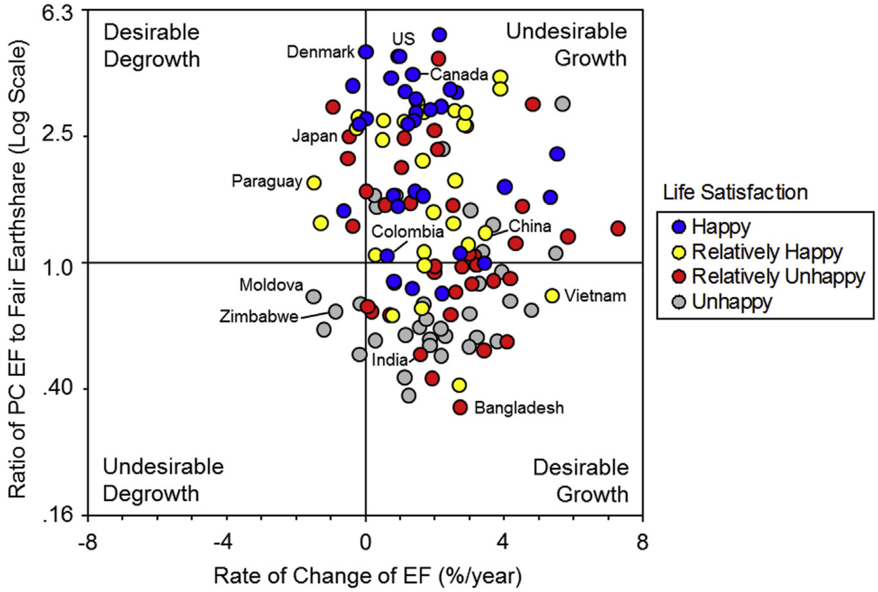


Fig. 3. The rate of change of ecological footprint vs. biophysical scale (as measured by the ratio of per capital ecological footprint to a fair earthshare). In this visualisation, a steady-state economy is reached at the centre of the plot, where the two axes intersect. Points are colour-coded according to life satisfaction. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

healthy life expectancy, Gini coefficient, voice & accountability, and poverty). The strongest relationships involve the Gini coefficient and voice & accountability indicators.

Interestingly, countries in the two shoulder groups ("partial degrowth" and "partial growth") perform similarly to each other on the social indicators. In fact, there is not a statistically significant difference between the two shoulder groups for any of the social indicators. By contrast, there is almost always a significant difference between the "stable" group and the "growth" group. The biophysically stable economies have higher life satisfaction, better

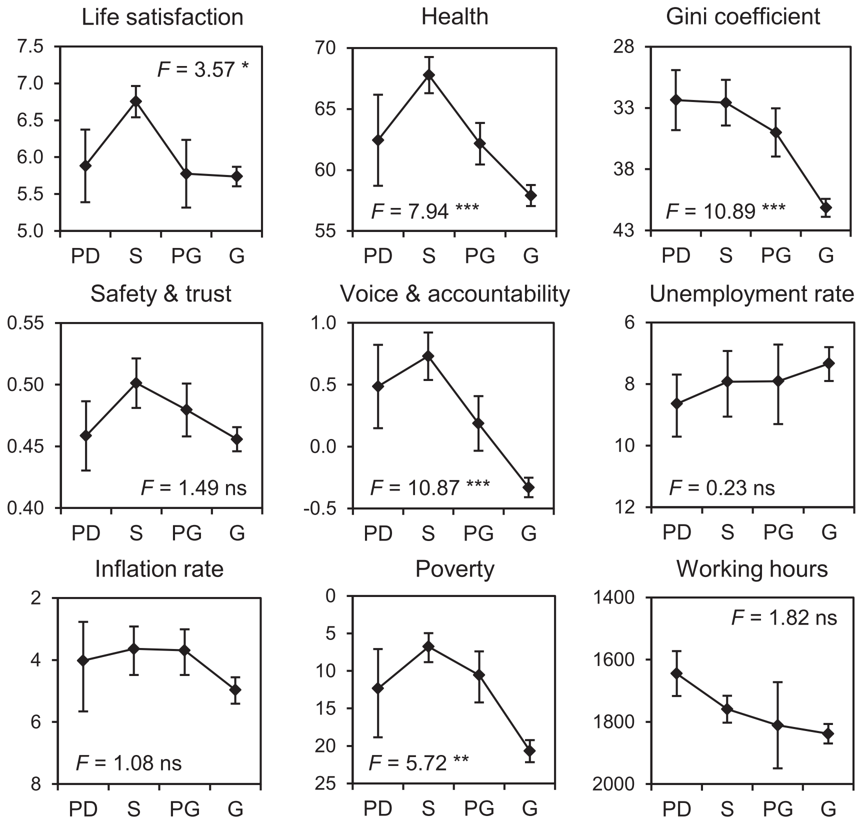


Fig. 4. Means plots (with standard errors) for the nine indicators in the Social Accounts, grouped according to biophysical stability. The vertical axis is oriented so that a value at the top is 'good'. Note: PD = Partial Degrowth, S = Stable, PG = Partial Growth, G = Growth. *F* is the ANOVA *F*-statistic for the comparison of means, ***$p < .001$, **$p < .01$, *$p < .05$, 'ns' not significant.

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

health, greater equality, stronger democracy, and less poverty than the growing economies. Average life satisfaction in biophysically stable economies is a full point higher than in growing economies (6.8 versus 5.7 on the original ten-point scale), while healthy life expectancy is almost ten years longer (68 versus 58 years).

Finally, there is no statistically significant relationship between biophysical growth and the unemployment rate. The average unemployment rate in biophysically stable economies (7.9%) is almost the same as the average unemployment rate in growing economies (7.3%). The variation in the unemployment rate within the four groups is greater than the variation among them.

3.3.3. Biophysical scale and social performance

In order to investigate whether there is a relationship between biophysical scale and social performance, a second comparison of means was performed. This time countries were classified into four groups based on their performance on the biophysical scale indicator (i.e. the ratio of per capita ecological footprint to a fair earthshare). The groups were *small* (less than 0.8 times a fair earthshare), *medium* (0.8–1.2 times a fair earthshare), *large* (1.2–2.5 times a fair earthshare), and *very large* (greater than 2.5 times a fair earthshare). These groups correspond to the groups used in the previous scale categorisation (Table 4), except that the "large" group was split into two separate groups due to the sizeable number of countries it contains. The four resulting groups include 180 of the 181 countries in the accounts.

In general, the larger a country's per capita ecological footprint, the better its social performance (Fig. 5). There is a statistically significant relationship between biophysical scale (as measured by per capita ecological footprint) and all nine of the social indicators. The strongest relationship is with healthy life expectancy, while the weakest relationship is with unemployment.

The relationship between biophysical scale and four of the indicators (life satisfaction, healthy life expectancy, voice & accountability, and poverty) appears to be monotonic, with higher biophysical scale associated with better scores on these indicators. On average, countries with a "very large" ecological footprint enjoy life satisfaction values more than two full points higher, and healthy life expectancies almost 20 years longer, than countries with a "small" footprint.

For three of the indicators (Gini coefficient, safety & trust, and unemployment), there appears to be a V-shaped relationship between scale and social performance. In all three cases the best performance is achieved at very large scale, and the worst performance is achieved at medium scale. For example, the average Gini coefficient is almost 12 points lower in countries with very large scale than in countries with medium scale, while the average unemployment rate is close to 3% lower. Interestingly, the unemployment rate in countries with small scale is also relatively low.

For the two remaining social indicators (inflation and working hours) the best performance is achieved at very large scale, with worse (and statistically indistinguishable) performance at the other scales. For example, the inflation rate is about 3% lower on average in countries with very large scale than countries with medium scale, while average working hours are almost 200 h less per year. Unfortunately there are no working hours data available for countries with small biophysical scale (and only six countries at medium scale), which limits the conclusions that can be drawn from this indicator.

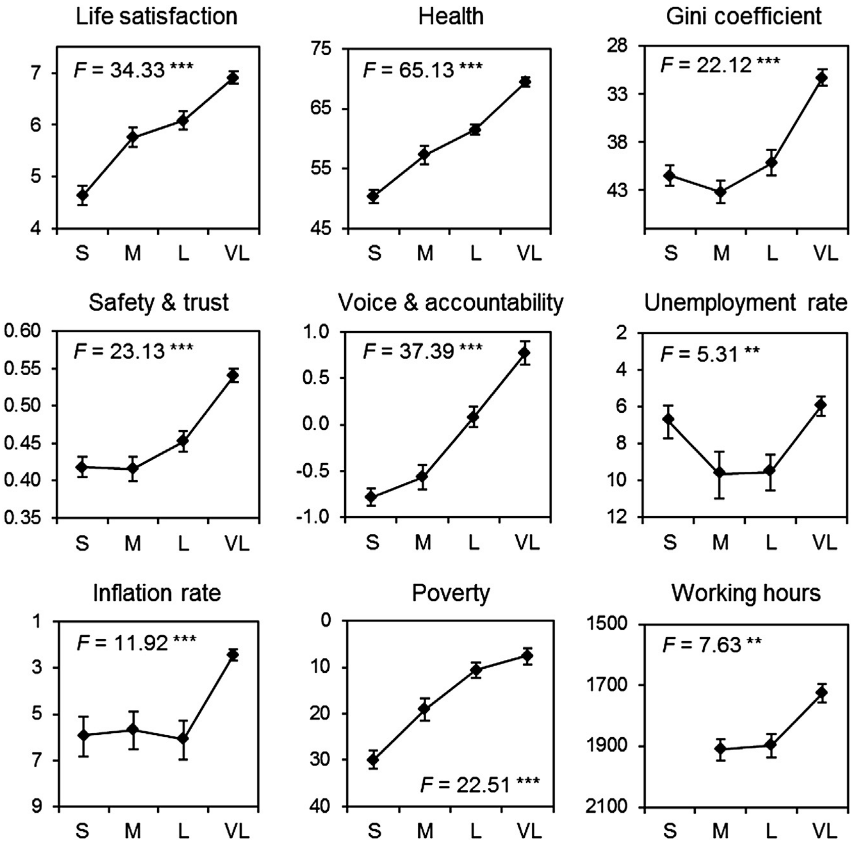


Fig. 5. Means plots (with standard errors) for the nine indicators in the Social Accounts, grouped according to biophysical scale. The vertical axis is oriented so that a value at the top is 'good'. Note: S = Small, M = Medium, L = Large, VL = Very Large. *F* is the ANOVA *F*-statistic for the comparison of means, $^{***}p < .001$, $^{**}p < .01$.

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

3.3.4. Robustness of stability to the inclusion of scale

The results thus far suggest a relationship between social performance and both biophysical stability and biophysical scale. Countries where stocks and flows are relatively constant appear to be better places to live than countries where stocks and flows are either growing or degrowing. At the same time, countries with a larger per capita ecological footprint appear to be better places to live than countries with a smaller per capita footprint. An important question that remains to be answered is whether biophysical stability is actually a significant predictor of social performance, or just a correlate of biophysical scale.

Multiple regression analysis was used to address this question. Each social indicator was regressed against both the indicator of scale (per capita ecological footprint) and the Biophysical Stability Index. Two regression models were fitted to the data for each of the social indicators: a linear model of the form $y = b_0 + b_1x_1 + b_2x_2$, and a semi-logarithmic model of the form $y = b_0 + b_1\ln(x_1) + b_2\ln(x_2)$. Of the two models, the one with the highest R^2 value and the most normally-distributed residuals was chosen as the more accurate reflection of the relationship between social performance and resource use.

The results show that the scale indicator (per capita ecological footprint) is a statistically significant predictor of all of the social indicators (Table 6). With larger scale, comes better social performance. However, for three of the social indicators (unemployment rate, inflation rate, and working hours), the regression models explain very little of the variance in the data. The unemployment rate, in particular, appears to be almost completely unrelated to biophysical quantities.

There are four social indicators (life satisfaction, healthy life expectancy, voice & accountability, and poverty) where both scale and stability are significant to the model. The *t*-value for scale is larger than the *t*-value for stability in each model, but stability is a significant predictor of performance nonetheless. In all four cases, greater biophysical stability (i.e. a lower rate of change of stocks and flows) is associated with better social performance. For both healthy life expectancy and voice & accountability, more than 50% of the variance in the data is explained by the two biophysical indicators.

Interestingly, the four indicators where stability is significant are also the four indicators where the best fit for scale is semi-logarithmic. For these indicators, it may be the case that as per capita resource use increases, the stability of stocks and flows becomes a more important determinant of social performance than additional resource use. For the two remaining social indicators (Gini coefficient and safety & trust), scale is significant to the model, but stability is not.

4. Discussion

This section discusses the main implications of the empirical results. These include the general findings regarding growth, degrowth, and stability (Section 4.1), as well as the findings on unemployment (Section 4.2) and democracy (Section 4.3). The main contributions of the study are summarised in Section 4.4, while its limitations are discussed in Section 4.5.

4.1. Growth, degrowth, and stability

In his most famous work, *The Wealth of Nations*, Adam Smith expounds the virtues of the "progressive state" (economic growth), and laments the alternative of the "stationary" or "declining" state. He writes:

> It deserves to be remarked, perhaps, that it is in the progressive state, while the society is advancing to the further acquisition, rather than when it has acquired its full complement of riches, that the condition of the labouring poor, of the great body of the people, seems to be the happiest and the most comfortable. It is hard in the stationary, and miserable in the declining state. The progressive state is in reality the cheerful and the hearty state to

Table 6
Multiple regression models for all social indicators as a function of scale (per capita ecological footprint) and stability (Biophysical Stability Index).

Dependent variable	Best-fit Model	*N*	Adj. R^2	Independent variable	β	*t*	
Life satisfaction	Log	123	0.396	Constant		20.30	***
				PC EF	0.526	6.26	***
				BSI	−0.174	−2.07	*
Healthy life expectancy	Log	133	0.597	Constant		35.71	***
				PC EF	0.655	10.45	***
				BSI	−0.209	−3.33	**
Gini coefficient	Linear	121	0.313	Constant		19.46	***
				PC EF	−0.571	−6.38	***
				BSI	−0.003	−0.03	ns
Interpersonal safety and trust	Linear	121	0.358	Constant		14.67	***
				PC EF	0.645	7.95	***
				BSI	0.145	1.79	ns
Voice and accountability	Log	133	0.517	Constant		1.24	ns
				PC EF	0.570	8.30	***
				BSI	−0.253	−3.68	***
Unemployment rate	Linear	114	0.027	Constant		11.98	***
				PC EF	−0.221	−2.12	*
				BSI	−0.174	−1.67	ns
Inflation rate	Linear	114	0.198	Constant		12.71	***
				PC EF	−0.519	−5.39	***
				BSI	−0.170	−1.77	ns
Human Poverty Index	Log	100	0.466	Constant		5.80	***
				PC EF	−0.547	−7.22	***
				BSI	0.308	4.06	***
Working hours	Linear	44	0.219	Constant		19.02	***
				PC EF	−0.481	−3.13	**
				BSI	0.047	0.31	ns

Note: ***$p < .001$, **$p < .01$, *$p < .05$, 'ns' not significant. *N* is the number of data points in each regression and R^2 is the adjusted coefficient of determination for the best-fit model. All regression coefficients β are standardised.

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

> all the different orders of the society. The stationary is dull; the declining, melancholy (Smith, 1776, p. 120).

However, in contrast to Smith's views, the results reported here suggest that it is much better to live in a society that has acquired "the full complement of riches", and has stopped increasing these riches, than to live in a society that is still "advancing to further acquisition". Countries with a larger per capita ecological footprint are, in general, better places to live than countries with a smaller per capita ecological footprint. Greater per capita resource use is associated with higher life satisfaction, better health, greater equality, more social capital, stronger democracy, less poverty, fewer working hours, and—to some extent—lower inflation.

Furthermore, although the empirical analysis shows that the level of resource use is a more significant predictor of social performance than its rate of change, the rate of change of stocks and flows predicts social performance as well, but not in the direction suggested by Smith. Countries with stable stocks and flows tend to have higher life satisfaction, longer healthy life expectancies, stronger democracies, and less poverty than those with either increasing or decreasing stocks and flows, all else being equal.

These findings should be interpreted with some caution, however. They suggest that, given two countries with a similar level of resource use, we would expect social performance to be higher in the one where resource use was more stable over time. They also suggest that, given two countries with stable resource use, we would expect social performance to be higher in the one with greater resource use. They do not necessarily suggest that it is possible to substitute for a higher level of resource use simply by stabilising stocks and flows.

The empirical analysis suggests that there are very few countries experiencing biophysical degrowth, and thus it is difficult to draw any firm conclusions about the social performance of degrowing economies. Nevertheless, the data suggest that countries experiencing partial growth and countries experiencing partial degrowth are indistinguishable from each other in terms of their social performance. Stability appears to be more important for achieving positive social outcomes than either growth or degrowth.

This tentative finding has both positive and negative implications for advocates of degrowth. On the one hand, it suggests that degrowth may be no worse than growth (from a social perspective), and thus there is less to fear from a degrowth transition to a steady-state economy than people might think. On the other hand, if lower social performance is associated with degrowth than with stability, then it may still be difficult to find support for a degrowth transition to a steady-state economy, especially if the end point of that transition is a much lower level of resource use than wealthy countries enjoy at present.

The empirical analysis identified around twenty countries that have achieved relatively stable stocks and flows over the 10-year analysis period. However, the majority of these countries have done so at a level of resource use that is well above a fair earthshare. While we might refer to these as "biophysically stable economies", they are not "steady-state economies" because the level of resource use that they enjoy is above what is globally sustainable.

Research on social metabolism (e.g. Fischer-Kowalski and Haberl, 2007; Krausmann et al., 2008; Haberl et al., 2011) describes two major transitions that have occurred (and are still occurring) in human societies. The first is the transition from a hunter-gatherer regime to an agrarian regime, and the second is the transition from an agrarian regime to an industrial regime. Although it is tempting to view the biophysically stable economies identified in the analysis as potential models of sustainability, these economies may simply be experiencing the completion (or final stages) of the transition to an industrial regime. Biophysical stability at a high level of resource may be "business as usual"—the inevitable outcome of the transition to an industrial society. If this is the case, then a third major transition is still required in these countries in order to reduce resource use to a sustainable level. This could either be the degrowth transition to a steady-state economy, or the advent of a "green economy" (UNEP, 2011) powered by more efficient technologies. If one believes that decoupling human well-being from GDP is relatively hard, but decoupling GDP from resource use is relatively easy, then the solution is the green economy. If, however, one believes that the reverse is true, then degrowth is the solution.

The fact that around twenty countries have managed to stabilise resource use, even if it is at a level that is too high, is an important finding. It suggests that continuous growth is not needed in order to maintain a high level of social performance. A biophysically stable economy can also be socially sustainable. Furthermore, as Daly (1977) points out, the first step in achieving a steady-state economy is to stabilise resource use at existing or nearby levels. The second step is to decide whether the optimum level of resource use is greater than or less than the present level. In Daly's words, "[W]e cannot go into reverse without first coming to a stop" (p. 52).

4.2. *Unemployment and growth*

Another very interesting finding is that the unemployment rate is largely unrelated to the rate of change of biophysical stocks and flows. In some ways this finding flies in the face of conventional economic theory which posits that economic growth is necessary to prevent rising unemployment. It calls into question the concern that the stabilisation of consumer demand, coupled with steadily increasing labour productivity, would inevitably lead to job losses in a steady-state economy unless some preventive action were taken. This concern has led a number of authors to suggest that special policies would be needed to maintain full employment in a steady-state economy. These include working time reduction (Lintott, 2004; Schor, 2005; Kallis et al., 2013), a job guarantee (Lawn, 2004; Alcott, 2013), or the shift towards lower productivity sectors of the economy (Jackson and Victor, 2011; Nørgård, 2013).

Some countries, such as Germany, already use the sorts of policies advocated for a steady-state economy to prevent unemployment from rising (e.g. working time reduction; Crimmann et al., 2010). Others, such as Japan, may simply have different cultural values that discourage businesses from laying off workers during an economic downturn (The Economist, 2006). Interestingly, it would seem that subjective measures such as life satisfaction are easier to predict across a wide range of countries than objective indicators like the unemployment rate. All in all, these findings may give some support to ecological economist Blake Alcott's claim that "Ultimately society, not the economy, determines how many people are out of work" (Dietz and O'Neill, 2013, p. 127).

It is important to note, however, that the findings for unemployment are based on a cross-sectional analysis. Further research needs to be done using time series data for individual countries to test, for example, whether there is a biophysical equivalent of Okun's Law (the observed relationship between change in GDP and change in unemployment).

4.3. *Democracy and degrowth*

Another interesting finding of the empirical analysis is that countries with stable stocks and flows tend to have stronger democratic institutions. These results challenge the idea that a steady-state economy could only be achieved under an authoritarian regime (a topic discussed by Lawn, 2005). Instead, the results suggest that biophysical stability and participatory democracy may be compatible aims, which is good news for achieving a socially sustainable steady-state economy.

In part, the findings also support the view held by many degrowth scholars that the transition to a more ecologically sustainable society and the transition to a more democratic society are mutually supportive goals (Cattaneo and Gavaldà, 2010; Schneider et al., 2010; Cattaneo et al., 2012). The problem for advocates of degrowth, however, is that it is not just biophysical stability and strong democracy that seem to go hand in hand, but also biophysical scale and strong democracy. Strong democracies are characterised by both stable stocks and flows, and high resource use. This creates something of a Catch-22: while strong democratic institutions might be compatible with a steady-state economy (once achieved), such institutions could also make the degrowth transition to such an economy less likely to occur in the first place.

Of course, the results presented here are derived from an analysis of the relationship between resource use and social performance in countries where the main aim is economic growth. This relationship could look very different in a society where economic growth was no longer part of the social imagination. Matthey (2010) presents some experimental evidence to support this idea. She shows that the less people aspire towards a high level of consumption, the smaller the loss in their well-being when material aspirations are not fulfilled. She suggests that degrowth would be easier to achieve if people's material aspirations were moderated, for example by limiting advertising.

4.4. *Contributions of this study*

This study makes a number of important contributions. Drawing on previous conceptual work (O'Neill, 2012a, 2015), it translates Daly (2008) biophysical definition of a steady-state economy, and the stated social goals of the degrowth movement (Research & Degrowth, 2010), into a set of 16 measureable indicators. In doing so it presents the first empirical analysis of how close countries are to a socially sustainable steady-state economy, and provides a common information system to measure important elements of both degrowth and a steady-state economy. This information system builds on Kerschner's (2010) work showing the complementary nature of these two ideas. The biophysical indicators aim to measure what would be held steady in a steady-state economy, while the socials indicators aim to measure what would *not* be held steady, but would be encouraged to improve over time.

The study offers two novel methods to assess how close different economies are to the biophysical stability objective of a steady-state economy: (1) a multi-indicator categorisation approach, and (2) a composite indicator. These methods show which economies are growing, which are degrowing, and which are stable, based on the rates of change of seven biophysical indicators. The study also provides a composite indicator to measure progress towards the social objectives of the degrowth movement, as articulated in the Paris Declaration.

Perhaps most importantly, though, the study compares the social performance of countries that are closer to, and further away from, the idea of a steady-state economy. It suggests that a biophysically stable economy can also be socially sustainable, although the level of resource use accompanying stability may be problematic. Finally, the analysis suggests important relationships between individual biophysical and social indicators. These include a positive relationship between strong democracies and biophysical stability, and no relationship between biophysical growth rates and the level of unemployment.

4.5. *Limitations*

Perhaps the most important limitation of this analysis relates to the concept of indicators themselves. Indicators are only partial reflections of reality, based on uncertain and imperfect models. They are not the “real system”, and this must be kept in mind when interpreting the results of any indictor analysis, including this one. That said, we need indicators to summarise and condense the enormous complexity of the real world into a manageable amount of information (Meadows, 1998).

Some of the results of the analysis, such as the finding that the US is a biophysically stable economy, and the UK is a partially degrowing one, may come as a bit of a surprise. These findings might make some members of the steady-state and degrowth communities question whether the indicators that were chosen are appropriate. One of the difficulties with trying to measure how close countries are to a steady-state economy is that not all of the data needed are currently available. A consumption-based approach should ideally be used to measure flows (O'Neill, 2015), and yet the approach taken here, which aims to minimise uncertainty and maximise country coverage, only partially accounts for consumption. The ecological footprint and energy use indicators measure apparent consumption, but the material use and CO_2 emissions indicators are territorial measures. The incorporation of new consumption-based indicators such as the “material footprint” (see Wiedmann et al., 2015) could cast some countries in a very different light.

Similarly, the analysis also neglects global power relations and path dependency. It says nothing about *how* some countries have managed to stabilise resource use. Is it through strong environmental policy, lower rates of GDP growth, or offshoring environmental impacts to other countries? This question should be investigated in future analyses, particularly as consumption-based indicators become more available.

The indicator chosen to measure biophysical scale (i.e. the ratio of per capita ecological footprint to a fair earthshare) also represents a compromise. The footprint was chosen because it relates national resource use to a clear sustainability threshold, and such a threshold is needed in order to identify whether the sustainable scale criterion associated with a steady-state economy is being met. However, as an aggregated indicator of resource use, the footprint provides no information on when specific ecological limits related to key ecosystem services might be reached (Wiedmann and Barrett, 2010). Future research should aim to develop new measures of sustainable scale based on indicators such as HANPP, water use, CO_2 emissions, and other planetary boundaries (e.g. Steffen et al., 2015).

As new data become available, it will be possible to update the accounts and see whether countries such as the US and UK perform as well when more comprehensive resource use indicators are applied. The results presented in this article are a “first pass”—an attempt to survey a large number of countries to see which ones might be closest to a steady-state economy. Armed with the results from this study, however, it becomes possible to identify individual countries for further analysis using more comprehensive indicators.

5. Conclusion

This study aimed to answer two questions: (i) How close are modern-day national economies to a steady-state economy? (ii) Are countries that are closer to a steady-state economy better or worse places to live than those that are further away?

These questions were investigated using a collection of 16 indicators applied to 181 countries over a 10-year period. The results

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

show that most countries in the world are biophysical growth economies, although there are around twenty countries that achieve relatively stable stocks and flows over the analysis period. There is only one country in the world (Japan) that achieves relative stability in all seven of the biophysical indicators, while five countries (Denmark, France, Poland, Romania, and the US) achieve stability in six out of the seven. There are no countries in the world that achieve a true steady-state economy (i.e. stable stocks and flows at a level of resource use that is environmentally sustainable). However, a small number of countries come relatively close, including Colombia, Cuba, Kyrgyzstan, Romania, and South Africa.

Countries with stable stocks and flows tend to be better places to live than countries with either growing or degrowing stocks and flows. Biophysically stable economies are more democratic and more equal, and their citizens are happier and healthier than those in growing or degrowing economies. This is encouraging news for achieving a steady-state economy. However, social performance is also higher in countries with greater per capita resource use, and a high level of social performance is in general only attained at a level of resource use that is too high to be environmentally sustainable (as measured by the ecological footprint at least).

Indicators such as the ecological footprint suggest that resource use in wealthy nations must be reduced if these nations are to achieve a steady-state economy. However, the fact that social performance is in general lower in countries where biophysical scale is smaller presents a challenge to the degrowth agenda. If all seven billion people on Earth are to lead a good life within ecological limits, then we need to become much more efficient at translating resource use into human well-being.

This article challenges the idea, going back at least as far as Adam Smith, that growth is synonymous with positive social outcomes. The finding that biophysical stability and high social performance are compatible increases the viability of the steady-state alternative. The article does not show, however, that a high level of social performance can be achieved at an environmentally sustainable level of resource use. Further research is needed to understand the relationship between resource use and human well-being, and the extent to which this relationship is mediated by different policies, aspirations, and institutions. Such research is important because degrowth is not about scaling back resource use within the current economic regime. It is about creating a new economic model with different structures and objectives, where very different understandings of “the good life” could emerge.

Acknowledgements

I am grateful to Tim Foxon, Julia Steinberger, Peter Victor, Helmut Haberl, and John Barrett for their helpful comments on various iterations of this research, and to three anonymous reviewers for their suggestions which have improved the manuscript. I would also like to thank Stephan Lutter, Fridolin Krausmann, Monika Dittrich, and Chris Elvidge for their helpful correspondence, and the Global Footprint Network for providing the ecological footprint data used in the analysis. This research was partially supported by an International Research Scholarship at the University of Leeds, and funding from the Center for the Advancement of the Steady State Economy.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jclepro.2015.07.116.

References

Alcott, B., 2013. Should degrowth embrace the job guarantee? J. Clean. Prod. 38, 56–60.

Ariès, P., 2005. Manifeste pour une décroissance équitable. Edition Golias.

Boden, T., Marland, G., Andres, R.J., 2010. Global, Regional, and National Fossil-Fuel CO_2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy. http://cdiac.ornl.gov/trends/emis/tre_coun.html (accessed 29.11.10.).

Castoriadis, C., 1985. Reflections on ‘Rationality’ and ‘Development’, pp. 18–36. Thesis Eleven 10/11(1).

Cattaneo, C., Gavaldà, M., 2010. The experience of rurban squats in Collserola, Barcelona: what kind of degrowth? J. Clean. Prod. 18 (6), 581–589.

Cattaneo, C., D'Alisa, G., Kallis, G., Zografos, C., 2012. Degrowth futures and democracy. Futures 44 (6), 515–523.

Chancel, L., Demailly, D., Waisman, H., Guivarch, C., 2013. A Post-Growth Society for the 21st Century: Does Prosperity Have to Wait for the Return of Economic Growth? IDDRI, Paris.

Crimmann, A., Wießner, F., Bellmann, L., 2010. The German Work-sharing Scheme: an Instrument for the Crisis. Conditions of Work and Employment Series No. 25. International Labour Organization, Geneva.

Czech, B., 2013. Supply Shock: Economic Growth at the Crossroads and the Steady State Solution. New Society Publishers, Gabriola Island, BC, Canada.

D'Alisa, G., Demaria, F., Kallis, G. (Eds.), 2014. Degrowth: a Vocabulary for a New Era. Routledge, New York.

Daly, H.E. (Ed.), 1973. Toward a Steady-state Economy. W.H. Freeman, San Francisco.

Daly, H.E., 1977. Steady-state Economics: the Economics of Biophysical Equilibrium and Moral Growth. W.H. Freeman, San Francisco.

Daly, H.E., 1991. Steady-state Economics, second ed. Island Press, Washington, D.C.

Daly, H.E., 1996. Beyond Growth: the Economics of Sustainable Development. Beacon Press, Boston, Massachusetts.

Daly, H.E., 2008. A Steady-state Economy. Opinion Piece for Redefining Prosperity. Sustainable Development Commission, UK. http://www.sd-commission.org.uk/publications.php?id=775.

Daly, H.E., 2010. From a failed-growth economy to a steady-state economy. Solutions 1 (2), 37–43.

Deaton, A., 2008. Income, health, and well-being around the world: evidence from the Gallup World Poll. J. Econ. Perspect. 22 (2), 53–72.

Demaria, F., Schneider, F., Sekulova, F., Martinez-Alier, J., 2013. What is degrowth? From an activist slogan to a social movement. Environ. Values 22 (2), 191–215.

Dietz, R., O'Neill, D.W., 2013. Enough Is Enough: Building a Sustainable Economy in a World of Finite Resources. Berrett-Koehler, San Francisco.

Dolan, P., Peasgood, T., White, M., 2006. Review of Research on the Influences on Personal Well-being and Application to Policy Making. Defra, London.

Easterlin, R.A., McVey, L.A., Switek, M., Sawangfa, O., Zweig, J.S., 2010. The happiness–income paradox revisited. Proc. Natl. Acad. Sci. U. S. A. 107 (52), 22463–22468.

EIA, 2011. International Energy Statistics. U.S. Energy Information Administration (accessed 28.11.11.). http://www.eia.gov/countries/data.cfm.

Elvidge, C.D., Tuttle, B.T., Sutton, P.S., Baugh, K.E., Howard, A.T., Milesi, C., Bhaduri, B.L., Nemani, R., 2007. Global distribution and density of constructed impervious surfaces. Sensors 7 (9), 1962–1979.

Elvidge, C.D., Sutton, P.C., Baugh, K.E., Ziskin, D., Ghosh, T., Anderson, S., 2011. National Trends in Satellite Observed Lighting: 1992–2009. ftp://ftp.ngdc.noaa.gov/DMSP/national_trends/remotesensing-7760-2.docx.

Eurostat, 2001. Economy-wide Material Flow Accounts and Derived Indicators: a Methodological Guide. Office for Official Publications of the European Communities, Luxembourg.

Eurostat, 2007. Economy-wide Material Flow Accounting: a Compilation Guide. European Statistical Office, Luxembourg.

Ewing, B., Reed, A., Galli, A., Kitzes, J., Wackernagel, M., 2010. Calculation Methodology for the National Footprint Accounts, 2010 ed. Global Footprint Network, Oakland, California.

FAOSTAT, 2011. Production: Live Animals: Stocks. Statistics Division. Food and Agriculture Organization. http://faostat.fao.org/site/573/default.aspx (accessed 11.07.11.).

Fiala, N., 2008. Measuring sustainability: why the ecological footprint is bad economics and bad environmental science. Ecol. Econ. 67 (4), 519–525.

Fischer-Kowalski, M., Haberl, H. (Eds.), 2007. Socioecological Transitions and Global Change: Trajectories of Social Metabolism and Land Use. Edward Elgar, Cheltenham, UK.

Gerten, D., Hoff, H., Rockström, J., Jägermeyr, J., Kummu, M., Pastor, A.V., 2013. Towards a revised planetary boundary for consumptive freshwater use: role of environmental flow requirements. Curr. Opin. Environ. Sustain. 5 (6), 551–558.

GFN, 2010. National Footprint Accounts, 2010 ed. Global Footprint Network http://www.footprintnetwork.org.

Gordon, R.J., 2012. Is US Economic Growth Over? Faltering Innovation Confronts the Six Headwinds. Policy Insight No. 63. Centre for Economic Policy Research, London.

Graham, C., 2008. Happiness and health: lessons—and questions—for public policy. Health Aff. 27 (1), 72–87.

Gujarati, D.N., 1995. Basic Econometrics, third ed. McGraw-Hill, New York.

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116

Haberl, H., Wackernagel, M., Krausmann, F., Erb, K.H., Monfreda, C., 2004. Ecological footprints and human appropriation of net primary production: a comparison. Land Use Policy 21, 279–288.

Haberl, H., Erb, K.H., Krausmann, F., Gaube, V., Bondeau, A., Plutzar, C., Gingrich, S., Lucht, W., Fischer-Kowalski, M., 2007. Quantifying and mapping the human appropriation of net primary production in earth's terrestrial ecosystems. Proc. Natl. Acad. Sci. U. S. A. 104 (31), 12942–12947.

Haberl, H., Fischer-Kowalski, M., Krausmann, F., Martinez-Alier, J., Winiwarter, V., 2011. A socio-metabolic transition towards sustainability? Challenges for another great transformation. Sustain. Dev. 19 (1), 1–14.

Harsanyi, J.C., 1997. Utilities, preferences, and substantive goods. Soc. Choice Welf. 14 (1), 129–145.

Hoekstra, A.Y., Hung, P.Q., 2002. Virtual Water Trade: a Quantification of Virtual Water Flows between Nations in Relation to International Crop Trade. Value of Water Research Report Series No.11. UNESCO-IHE, Delft, The Netherlands. http://www.waterfootprint.org/Reports/Report11.pdf.

Hoekstra, A.Y., Wiedmann, T.O., 2015. Humanity's unsustainable environmental footprint. Science 344 (6188), 1114–1117.

Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M., Mekonnen, M.M., 2011. The Water Footprint Assessment Manual: Setting the Global Standard. Earthscan, London.

Illich, I.D., 1973. Tools for Conviviality. Calder & Boyars, London.

ILO, 2011. Key Indicators of the Labour Market (KILM), seventh ed. International Labour Organization http://www.ilo.org/kilm. (accessed 27.10.11.).

ISS, 2011. Indices of Social Development. Institute of Social Studies. http://www.IndSocDev.org/ (accessed 24.11.11.).

Jackson, T., 2009. Prosperity without Growth: Economics for a Finite Planet. Earthscan, London.

Jackson, T., Victor, P., 2011. Productivity and work in the 'green economy': some theoretical reflections and empirical tests. Environ. Innov. Soc. Trans. 1 (1), 101–108.

Kahneman, D., Krueger, A.B., Schkade, D., Schwarz, N., Stone, A., 2004. Toward national well-being accounts. Am. Econ. Rev. 94 (2), 429–434.

Kallis, G., 2011. In defence of degrowth. Ecol. Econ. 70 (5), 873–880.

Kallis, G., Kerschner, C., Martinez-Alier, J., 2012. The economics of degrowth. Ecol. Econ. 84, 172–180.

Kallis, G., Kalush, M., O'Flynn, H., Rossiter, J., Ashford, N., 2013. "Friday off": reducing working hours in Europe. Sustainability 5, 1545–1567.

Kallis, G., Demaria, F., D'Alisa, G., 2014. Introduction: degrowth. In: D'Alisa, G., et al. (Eds.), Degrowth: a Vocabulary for a New Era. Routledge, London, pp. 1–17.

Kaufmann, D., Kraay, A., Mastruzzi, M., 2010. The Worldwide Governance Indicators: Methodology and Analytical Issues. World Bank Policy Research Working Paper No. 5430. http://ssrn.com/abstract=1682130.

Kerschner, C., 2010. Economic de-growth vs. steady-state economy. J. Clean. Prod. 18 (6), 544–551.

Krausmann, F., Fischer-Kowalski, M., Schandl, H., Eisenmenger, N., 2008. The global sociometabolic transition. J. Ind. Ecol. 12 (5–6), 637–656.

Krausmann, F., Gingrich, S., Eisenmenger, N., Erb, K.-H., Haberl, H., Fischer-Kowalski, M., 2009. Growth in global materials use, GDP and population during the 20th century. Ecol. Econ. 68 (10), 2696–2705.

Krausmann, F., Erb, K.-H., Gingrich, S., Haberl, H., Bondeau, A., Gaube, V., Lauk, C., Plutzar, C., Searchinger, T.D., 2013. Global human appropriation of net primary production doubled in the 20th century. Proc. Natl. Acad. Sci. 110 (25), 10324–10329.

Latouche, S., 2009. Farewell to Growth. Polity Press, Cambridge, UK.

Lawn, P., 2004. Reconciling the policy goals of full employment and ecological sustainability. Int. J. Environ. Workplace Employ. 1 (1), 62–81.

Lawn, P., 2005. Is a democratic-capitalist system compatible with a low-growth or steady-state economy? Socio Econ. Rev. 3, 209–232.

Layard, R., 2005. Happiness: Lessons from a New Science. Penguin Press, New York.

Layard, R., 2009. Why subjective well-being should be the measure of progress. In: The 3rd OECD World Forum on "Statistics, Knowledge and Policy": Charting Progress, Building Visions, Improving Life, Busan, Korea, October, pp. 27–30.

Layard, R., 2010. Measuring subjective well-being. Science 327 (5965), 534–535.

Lenzen, M., Kanemoto, K., Moran, D., Geschke, A., 2012. Mapping the structure of the world economy. Environ. Sci. Technol. 46 (15), 8374–8381.

Lintott, J., 2004. Work in a growing and in a steady-state economy. Int. J. Environ. Workplace Employ. 1 (1), 40–52.

Maddison, A., 2010. Statistics on World Population, GDP and Per Capita GDP, 1–2008 AD. Groningen Growth and Development Centre, University of Groningen (accessed 22.02.12.). http://www.ggdc.net/MADDISON/oriindex.htm.

Martínez-Alier, J., 2009. Socially sustainable economic de-growth. Dev. Change 40 (6), 1099–1119.

Matthews, E., Amann, C., Bringezu, S., Fischer-Kowalski, M., Hüttler, W., Kleijn, R., Moriguchi, Y., Ottke, C., Rodenburg, E., Rogich, D., Schandl, H., Schütz, H., van der Voet, E., Weisz, H., 2000. The Weight of Nations. Material Outflows from Industrial Economies. World Resources Institute, Washington, D.C.

Matthey, A., 2010. Less is more: the influence of aspirations and priming on well-being. J. Clean. Prod. 18 (6), 567–570.

Meadows, D.H., 1998. Indicators and Information Systems for Sustainable Development: a Report to the Balaton Group. The Sustainability Institute, Hartland, Vermont. http://www.iisd.org/pdf/s_ind_2.pdf.

Meinshausen, M., Meinshausen, N., Hare, W., Raper, S.C.B., Frieler, K., Knutti, R., Frame, D.J., Allen, M.R., 2009. Greenhouse-gas emission targets for limiting global warming to 2 degrees C. Nature 458 (7242), 1158–U1196.

Michaelson, J., Abdallah, S., Steuer, N., Thompson, S., Marks, N., 2009. National Accounts of Well-being: Bringing Real Wealth onto the Balance Sheet. nef, London.

Nørgård, J.S., 2013. Happy degrowth through more amateur economy. J. Clean. Prod. 38, 61–70.

O'Neill, D.W., 2012a. Measuring progress in the degrowth transition to a steady state economy. Ecol. Econ. 84, 221–231.

O'Neill, D.W., 2012b. Measuring Progress towards a Socially Sustainable Steady State Economy. University of Leeds, Leeds, UK. Ph.D. Dissertation.

O'Neill, D.W., 2015. What should be held steady in a steady-state economy? Interpreting Daly's definition at the national level. J. Ind. Ecol. http://dx.doi.org/10.1111/jiec.12224.

O'Neill, D.W., Tyedmers, P.H., Beazley, K.F., 2007. Human appropriation of net primary production (HANPP) in Nova Scotia, Canada. Reg. Environ. Change 7 (1), 1–14.

OECD, 2008. Handbook on Constructing Composite Indicators: Methodology and User Guide. Organisation for Economic Co-operation and Development, Paris.

Opschoor, H., 2010. Sustainable development and a dwindling carbon space. Environ. Resour. Econ. 45 (1), 3–23.

Pauliuk, S., Müller, D.B., 2014. The role of in-use stocks in the social metabolism and in climate change mitigation. Glob. Environ. Change 24, 132–142.

Peters, G.P., Minx, J.C., Weber, C.L., Edenhofer, O., 2011. Growth in emission transfers via international trade from 1990 to 2008. Proc. Natl. Acad. Sci. 108 (21), 8903–8908.

Rees, W.E., 2003. Economic development and environmental protection: an ecological economics perspective. Environ. Monit. Assess. 86, 29–45.

Research & Degrowth, 2010. Degrowth declaration of the Paris 2008 conference. J. Clean. Prod. 18 (6), 523–524.

Ryan, R.M., Huta, V., Deci, E.L., 2008. Living well: a self-determination theory perspective on eudaimonia. J. Happiness Stud. 9 (1), 139–170.

Schneider, F., Kallis, G., Martínez-Alier, J., 2010. Crisis or opportunity? Economic degrowth for social equity and ecological sustainability. Introduction to this special issue. J. Clean. Prod. 18 (6), 511–518.

Schor, J.B., 2005. Sustainable consumption and worktime reduction. J. Ind. Ecol. 9 (1–2), 37–50.

Sen, A., 1993. Capability and well-being. In: Nussbaum, M., Sen, A. (Eds.), The Quality of Life. Clarendon Press, Oxford, pp. 30–53.

SERI, 2010. Global Material Flows Database. Sustainable Europe Research Institute. http://www.materialflows.net (accessed 24.11.10.).

Shiller, R.J., 1996. Why Do People Dislike Inflation? Cowles Foundation Discussion Paper No. 1115. Cowles Foundation for Research in Economics, Yale University, New Haven, CT.

Smith, A., 1776. An Inquiry into the Nature and Causes of the Wealth of Nations, vol. 1. Printed for Messrs. Whitestone [and 19 others], Dublin. Retrieved from The Making of the Modern World, May 18, 2012.

Solt, F., 2009. Standardizing the world income inequality database. Soc. Sci. Q. 90 (2), 231–242.

Steffen, W., Richardson, K., Rockström, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sörlin, S., 2015. Planetary boundaries: guiding human development on a changing planet. Science 347 (6223), 1259855.

The Economist, 2006. Japan's Economy: Free at Last. The Economist. July 20. http://www.economist.com/node/7193984/print.

UNDP, 2009. Human Development Report 2009. United Nations Development Programme, New York.

UNEP, 2011. Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. United Nations Environment Programme. http://www.unep.org/greeneconomy.

United Nations, 2009. World Population Prospects: the 2008 Revision, CD-ROM Edition. Population Division. Department of Economic and Social Affairs, United Nations.

United Nations, 2010. Healthy Life Expectancy (HALE) at Birth. UNdata. http://data.un.org/Data.aspx?q=hale&d=WHO&f=MEASURE_CODE%3aWHOSIS_000002 (accessed 01.11.11.).

van den Bergh, J.C.J.M., Verbruggen, H., 1999. Spatial sustainability, trade and indicators: an evaluation of the 'ecological footprint'. Ecol. Econ. 29 (1), 61–72.

Veenhoven, R., 2014. States of Nations: Data File to Be Used for the Cross-national Analysis of Happiness. World Database of Happiness. Erasmus University Rotterdam. http://worlddatabaseofhappiness.eur.nl/statnat/statnat_fp.htm (accessed 15.07.14.).

Victor, P.A., 2008. Managing without Growth: Slower by Design, Not Disaster. Edward Elgar, Cheltenham, UK.

Vitousek, P.M., Ehrlich, P.R., Ehrlich, A.H., Matson, P.A., 1986. Human appropriation of the products of photosynthesis. BioScience 36 (6), 368–373.

Wackernagel, M., Rees, W.E., 1996. Our Ecological Footprint: Reducing Human Impact on the Earth. New Society Publishers, Gabriola Island, BC, Canada.

Weterings, R.A.P.M., Opschoor, J.B., 1992. The Ecocapacity as a Challenge to Technological Development. Advisory Council for Research on Nature and Environment, Rijswijk.

Wiedenhofer, D., Steinberger, J.K., Eisenmenger, N., Haas, W., 2015. Maintenance and expansion: modeling material stocks and flows for residential buildings and transportation networks in the EU25. J. Ind. Ecol. http://dx.doi.org/10.1111/jiec.12216.

Wiedmann, T., Barrett, J., 2010. A review of the ecological footprint indicator — Perceptions and methods. Sustainability 2 (6), 1645–1693.

Wiedmann, T.O., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J., Kanemoto, K., 2015. The material footprint of nations. Proc. Natl. Acad. Sci. 112 (20), 6271–6276.

Wilkinson, R., Pickett, K., 2009. The Spirit Level: Why More Equal Societies Almost Always Do Better. Allen Lane, London.

World Bank, 2011. The Worldwide Governance Indicators, 2011 Update: Aggregate Indicators of Governance 1996–2010. http://www.govindicators.org (accessed 03.11.11.).

World Bank, 2014. World Development Indicators (May 2014). Mimas. University of Manchester. http://dx.doi.org/10.5257/wb/wdi/2014-05-09 (accessed 09.07.14.).

Please cite this article in press as: O'Neill, D.W., The proximity of nations to a socially sustainable steady-state economy, Journal of Cleaner Production (2015), http://dx.doi.org/10.1016/j.jclepro.2015.07.116