The Socio-Economic Marine Research Unit (SEMRU)
National University of Ireland, Galway

Working Paper Series

Working Paper 20-WP-SEMRU-01

Linking Sustainable Development Assessment in Ireland and the European Union with Economic Theory

Luke McGrath[†], Stephen Hynes[a] and John McHale[b]

If referencing this working paper please use:

McGrath, L., Hynes, S., & McHale J. (2020). Linking Sustainable Development Assessment in Ireland and the European Union with Economic Theory. *Economic and Social Review*, 52 (2), 327-355.

https://www.esr.ie/article/view/1446

[†] Corresponding author, (l.mcgrath6@nuigalway.ie), Socio-Economic Marine Research Unit, National University of Ireland, Galway, Ireland
[a] Director, Socio-Economic Marine Research Unit, National University of Ireland, Galway, Ireland
[b] Whitaker Institute, National University of Ireland, Galway, Ireland

SEMRU *Working Paper Series*

For More Information on the SEMRU Working Paper Series

Email: stephen.hynes@nuigalway.ie, Web: www.nuigalway.ie/semru/

Augmenting the World Bank's estimates: Ireland's Genuine Savings through boom and bust

Luke McGrath, Stephen Hynes and John McHale

Abstract

Economists offer what is arguably the most internally consistent framework for sustainable development assessment, the so-called "capital approach". To operationalise the capital approach measures of the changes in comprehensive national wealth (Genuine Savings) are required. In this paper, we present estimates of Ireland's Genuine Savings using the updated public spending code for direction and compare our results with existing estimates in the literature. For practical sustainability assessment, no single indicator is capable of providing an all-encompassing answer, but as we demonstrate, the current monitoring of sustainable development in Ireland and across the EU lacks coherence. We suggest potential paths forward for sustainability policy and assessment that preserve the link with economic theory. We show that regardless of the viewpoint taken on sustainability the capital approach can provide guidance for a coherent assessment framework.

Acknowledgements: This work was supported by the National University of Ireland Galway's Hardiman Scholarship and the Irish Research Council's Government of Ireland Scholarship [GOIPG/2018/1917

Keywords: Green accounting; Genuine Savings; Natural capital; Wealth Accounting; Environmental accounting; Sustainable development.

1. Introduction

Sustainable development as a policy goal has been widely supported by national governments following the Brundtland Commission's seminal definition, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs″ (WECD, 1987). Given the perceived negative environmental impact of economic and population growth sparked the initial fears of "unsustainable" development (Meadows et al., 1972) one might be wary of the warm embracement by policymakers of the implicit policy constraints "sustainable" development might bring. One might solve this puzzle by considering that policymakers have broadened modern sustainability concerns to such a degree that virtually any policy proposal could be touted as addressing some facet of sustainable development (Pearce and Barbier, 2000).

For sustainability to be meaningful, it must be achievable and measurable by some reasonably clear metric or metrics (Solow, 1993). Economists have long recognised that the System of National Accounting (SNA) aggregates fail to measure true economic welfare (Nordhaus & Tobin, 1973; Stiglitz et al. 2009) and are deficient for effective environmental policy (Ahmad et al., 1989; Repetto et al. 1989; Hartwick 1990; Dasgupta, 2001). Complements to the various SNA aggregates and perhaps alternatives are required for sustainability assessment (Stiglitz et al., 2009). The development of sustainability indicators has generally lacked theoretical rigour leading to an incoherent framework for assessment (Neumayer, 1999). Environmental economists have however developed what is arguably the most consistent approach to the issue.

A tight connection among the fundamental economic concepts of "wealth", "income", "sustainability", and "accounting" provides the foundation of the economic or capital theoretic approach to sustainability (Weitzman, 2017). The capital approach conceptualises a sustainable development path as one that is capable of providing the opportunity for non-declining welfare through time. Productive capacity depends on the broadly defined stock of capital resources, also referred to as "comprehensive" wealth. Wealth is comprehensive in the sense that it is inclusive of all welfare relevant assets such as our natural environment and resources, human capital and technological progression. The link between long-run human welfare and the productive capacity of an economy provides a promising avenue for sustainability assessment. Genuine Savings (GS), or more intuitively comprehensive investment, correspond to annual changes in the productive capacity of the economy.[1] Arrow et al. (2012) show that if GS at time *t* are positive and evaluated using the correct shadow prices then intergenerational well-being is rising. Negative GS provides a signal of unsustainable development implying future welfare opportunities must fall even if GDP per capita is rising in the short-term (Dasgupta and Mäler, 2000). The World Bank has operationalised the economic theory to provide regularly updated GS estimates for most

[1] GS are also referred to as 'adjusted net savings' (World Bank, 2018), 'net investment' (Dasgupta and Mäler, 2000), 'comprehensive investment' (Arrow et al. 2012), "comprehensive savings" (Mota & Cunha-e-Sá, 2019).

countries, termed Adjusted Net Savings (ANS) (World Bank 2006; 2012; 2018). Empirical applications have shown real-world GS estimates to be a reasonably good forward-looking indicator of well-being (Greasley et al., 2014; Hanley et al., 2015; Qasim et al 2018; Mota and Cunha-e-Sá 2019).

The capital approach posits that sustainable development requires the preservation and ideally the enhancement of some form of broadly defined capital assets. The debate over so-called "weak" or "strong" forms of sustainability continues and surrounds the conditions required to achieve sustainable development. Weak sustainability requires the maintenance of *total* capital and is conditional on one or more of the following; all capital forms are sufficiently substitutable with each other, technological advancement is such that substitution is a moot point or there exists super-abundant natural resources. Strong sustainability requires a stronger constraint of non-declining *natural* wealth as proponents view natural resources as a distinct and non-substitutable form of capital (Costanza et al., 1991; Cabeza-Gutés, 1996). The literature generally views GS as an indicator of weak sustainability. We discuss some of the issues surrounding these different forms of sustainability in terms of sustainability indicators and policy evaluation throughout the paper.

Economic theory suggests an appropriate indicator of sustainable economic development requires a focus on the components of national wealth thus providing a strong rationale for the inclusion of the GS measure and/or related wealth metrics within any economic component of a sustainability indicator set. Currently, both the European Union (EU) and Irish Central Statistics Office (CSO) indicator sets exclude GS. The omission of GS may be explained by the well-documented limitations of the World Bank's indicator (Ferreira & Vincent 2005; Pillarisetti 2005; Dietz & Neumayer 2006; Goossens et al., 2007; Stiglitz et al., 2009; Neumayer 2013; McGrath et al., 2019). The literature has repeatedly acknowledged the omission of local air pollutants as a key concern, particularly in the context of the EU Member States (Goossens et al., 2007; Stiglitz et al., 2009). McGrath et al., (2019) and Ferreira and Moro (2013) presented GS estimates for Ireland that refined the World Bank's estimates. A key finding of both studies was a high level of pollution damages from various local air pollutants omitted by the World Bank. The results from both studies were highly sensitive to the estimated marginal damage costs employed, particularly for sulphur dioxide. Another contentious issue when constructing GS estimates involves the choice of social discount rate for the valuation of natural assets. For Ireland, the recently updated Public Spending Code (PSC) provides guidance on the social discount rate and marginal social costs of pollution for the first time (IGEES, 2019).

In this paper, we construct Irish GS estimates following the guidance from the PSC and compare our results with the existing measures of Irish GS in the literature. We explain how the current monitoring of sustainable development at both the Irish and European Union level is incoherent and suggest potential ways forward that preserve the theoretical underpinnings of the capital approach. The remainder of the paper is as follows. In section II, we present the theoretical grounding for the economic approach to sustainable development. Section III discusses the lack of coherence with EU and Irish sustainability assessment frameworks. Section IV presents estimates of Ireland's GS following the recommendations in the public spending and includes a comparison with exiting estimates of Irish GS. Section V details potential ways forward for Irish sustainable development assessment while maintaining a consistent framework. Section VI contains our concluding remarks.

2. The Economic Approach to Sustainability

The 1987 Bruntland Commission brought the term "sustainable development" into common parlance (WECD, 1987). The economic literature on the subject pre-dates the Bruntland Commission by at least a decade without explicitly using the term. Meadows et al., (1972) postulated that unbounded economic growth might breach ecological limits. Economists were sceptical of the "Limits to Growth" and responded by analysing optimal growth models in the presence of essential non-renewable natural resources (Solow 1974; Dasgupta and Heal, 1974; Stiglitz 1974a; 1974b). As well-being (utility) is at the heart of economics and ultimately satisfied by consumption, the economists naturally examined the feasibility of non-declining consumption (or utility) through time. This is now, generally, how economists conceptualise a sustainable development path. From this economic perspective, sustainable development is feasible if the economy at least maintains "comprehensive" wealth, the productive capacity of the economy, through time. The concept echoes back to Hicks (1939) who provided the seminal definitions of income that, in essence, have sustainability built-in. Hicksian income is that which can be consumed while keeping real wealth intact. At the national level, maintaining comprehensive wealth entails the maintenance of the resource base. The resource base consists of a broad array of valuable assets, inclusive of not just produced capital but technology, human capital, social/institutional capital and natural capital.

Hartwick (1977) built upon Solow (1974) to set out the seminal rule to achieve sustainable development. Hartwick's rule requires that enough of the 'rent' earned from non-renewables be re-invested into reproducible capital to keep the total aggregate capital stock at least constant. Weitzman (1976) showed that under certain conditions accurately measured Net National Product (NNP) is the stationary equivalent of future consumption. Weitzman (1976) in parallel with the Hicksian income concept and Harwick's Rule provided a natural framework for the sustainability literature to emerge. A tight connection between current wealth and future welfare is shown within what Weitzman (2003) termed (and Weitzman (2017) solidified) as the "pure theory of perfectly complete national income accounting".

The complete accounting model considers an economy with a constant population where utility at time t, $U(C(t))$ depends on a consumption bundle inclusive of all determinants of instantaneous utility, $C(t)$.[2] Production depends on a vector of capital stocks inclusive of all determinants of net productive capacity, $K^*(t)$. Changes in the capital stocks are represented by net investments (GS), $I^+ = \dot{K}^+$ where + indicates that the broadly defined capital assets are "augmented" to permit the inclusion of exogenous

[2] Including population growth is not straightforward as it raises human capital but also strains wealth (Ferreira et al., 2008).

technical progress.[3] The production possibilities are a convex set S that depends on K^+ so that (C, I^+) is feasible given K^+ if and only if $(C, I^+) \in S(K^+)$. A resource allocation mechanism (RAM) exists within the set and characterises all the constraints faced by a given economy (whether technical, institutional or environmental) that co-evolve over time with the economy and form the superstructure for decisions regarding resource allocation (Dasgupta, 2009).[4] The RAM determines for any K^+ the related consumption and net investment flow values (Asheim, 2007). The RAM thus defines a path for $C(t), I^+(t), K^+(t)$ that may or may not be optimal. In this context, Asheim (2007) and Weitzman (2017) show that the present value of future consumption changes equals the value of net investments (GS). Using a constant real interest rate, R, then,

$$PV\Delta C = \int_t^\infty (P_C(s)\dot{C}(s))e^{-R(s-t)}ds = P_I(t)I^+(t)$$

Where P_C and P_I represent the shadow prices of consumption and investment, respectively. The properties of the Divisia consumer price index required is discussed in Asheim and Weitzman (2001) and Asheim (2007). The powerful conclusion of the general model is that the level of GS (correctly valued) corresponds to variations in intergenerational well-being. Irrespective of the sustainability definition adopted, the underlying model relates GS to future welfare changes and this relationship supports the use of GS as an indicator of sustainability.[5] Negative GS provides a clear signal of unsustainable development. However, having positive GS does not guarantee that consumption will not decrease at some period in the future and in this sense, GS is an unsustainability indicator (Asheim, 1994; Pezzey, 2004).

3. The European Union & Ireland's Sustainable Development Indicators: Measuring Sustainability?

The notion of Sustainable Development has been at the heart of the EU for decades. The EU has a Sustainable Development Strategy (SDS) that is monitored by Eurostat through a broad dashboard comprising of 100 indicators (COM (2016) 739). There were originally 155 indicators split across environmental, social and economic. In recent years, Eurostat now reports on a reduced number of indicators that are now set out in terms of the 17 UN Sustainable Development Goals (SDGs) (Table 1).[6]

---

[3] Following Pemberton and Ulph (2001) and Pezzey (2004) time is a form of capital such that $K^+ = (K, t)$ and $I^+ = (I, 1)$.

[4] The RAM need not be efficient, include a benevolent social planner or exclude real life distortions.

[5] There are two slightly different main definitions of sustainability in the literature. One postulates that development at a particular moment is sustainable if current consumption can be maintained forever (Pezzey, 2004), while the other assumes that development is sustainable if welfare is not decreasing (e.g. Arrow et al., 2012). In both cases, negative GS signals that development is not sustainable. However, having positive GS does not guarantee that consumption will not decrease at some period in the future (Asheim, 1994; Pezzey, 2004).

[6] In 2015, the EU fully committed to delivering on the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) as outlined in 'Towards a Sustainable Europe by 2030'

Table 1: United Nations Sustainable Development Goals

1. No Poverty	**2. Zero Hunger**	**3. Good Health & Well Being**	**4. Quality Education**	**5. Gender Equality**	**6. Clean Water**	**7. Affordable & Clean Energy**	**8. Decent Work & Economic Growth**	**9. Industry, Innovation & Industry**
10. Reduced Inequalities	**11. Sustainable Cities**	**12. Responsible Consumption & Production**	**13. Climate Action**	**14. Life Below Water**	**15. Life on Land**	**16. Peace & Justice Strong Institutions**	**17. Partnerships for the Goals**	

In Ireland, the monitoring and reporting of sustainability indicators comes under the remit of the Department for Communications, Climate Action and Environment (DCCAE). The Irish CSO produce a "Sustainable Development Indicators" publication, biannually reporting an indicator set comprising 48 indicators across the economy, social and environment that were developed by DCCAE (Table 2). DCCAE published a voluntary national review in 2018 that reports the SDG based indicators adopted at the EU level.[7] It is likely that the 2019 CSO "Sustainable Development Indicators" publication will report these updated SDG indicators.

These indicators are important but lack a clear interpretation for sustainability assessment. The core issue with the sustainability indicators is that none of these sets were chosen with respect to a coherent model of sustainable development. The UN SDGs provide a framework but — the UN nor the EU ever define what "sustainable" means. The lack of a proper definition and the fact that many goals are so vague mean that a comprehensive and quantifiable target is impossible. These issues lead development economist William Easterly to conclude that they might as well be called the "Senseless, Dreamy, Garbled" or "Some-such Development" Goals (Easterley, 2015). In stark contrast, a key strength of the earlier Millennium Development Goals was the precise time-bound and quantifiable nature of the goals. In the context of EU policy, it seems odd that separate indicator systems cover the Lisbon strategy (economic development strategy) and the SDS.

There have been numerous attempts to improve the interpretation of the SDGs. Sachs et al., (2018) utilised a traffic light system for each nation awarding green, orange, yellow or red light for each goal based on an assessment of the accompanying indicators. Other studies have attempted to create an overall index from the goals (Costantza et al., 2016; Clark and Kavanagh, 2019). The traffic light system and alternative indices still suffer from the same lack of theoretical rigour. For example, if GS are negative it implies unsustainable development (long run welfare must fall), there is no equivalent sustainability interpretation from these alternatives, they merely tell us if some indicators or index went up, down or remained unchanged through time.

[7] 6https://sustainabledevelopment.un.org/content/documents/19382Ireland_Voluntary_National_Review_2018.pdf

Table 2: Irish CSO Sustainable Development Indicators

Economy - 13	Social – 16	Environment -19
1. Dwellings Completions compared to EU 2007-15 2. Dwellings Completions 1970-2015 3. EU Harmonised Index of Consumer Prices 4. Gross Capital Formation 5. Gross R&D expenditures 6. Foreign Exchange Rates 7. Govt. expenditure on pay and social welfare 8. Income tax Distribution 9. Tax Revenues 10. Tax Revenues compared to EU 11. Per capita Net Receipts from EU 12. Per capita, Net Receipts from EU compared across EU **13.** General Government Debt and Balance 1995-2015 % of GDP	14. Tobacco Consumption compared across the EU 15. Alcohol Consumption compared across the EU 16. Obesity Levels in 2014 17. Usual Means for travelling to work 1981-2016 18. Usual Means for travelling to school 1981-2016 19. 2nd and 3rd Level completion rates 1995-2016 20. Average Class size compared across the EU in 2014 21. Pupil-Teacher ratio 1995-2015 22. Life Expectancy 1901-2011 23. Persons aged 80 or above as a percentage of persons aged 65 and above 1926-2016 24. Old-age dependency ratio 1996-2016 25. At risk of poverty across the EU 2007-2015 26. Net migration 1951-2016 27. Migration and emigration 1987-2016 28. Unemployment rate 1985-2016 29. Employment Rate by age class 2000-16	30. Common Bird index 1998-2014 31. Protected Areas under 20154 EU habitats directive 32. Domestic Waste Water Treatment 2002-16 33. Packaging Waste 2001-13 34. Municipal Waste 2001-12 35. New Private Cars Licensed by Emissions Class 2005-2016 36. Private cars per 1000 of population 1985-2016 37. Imported energy dependency 1990-2015 38. Contribution of renewable energy 1990-2015 39. Total primary energy requirement 1990-2015 40. Domestic Building Energy Ratings 2009-2016 41. Nitates in groundwater 1995-2014 42. River water quality 1987-2015 43. EU: Forest Cover 2015 44. GHGs by sector 1990-2015 45. GHGs per capita 46. Emissions of selected pollutants 2015 47. Particulate Matter emissions 1990-2015

The vagueness of this modern approach to sustainable development likely stems from the desire to include both current and future well-being within the viewpoint of sustainability. UN et al., (2008), a joint report on measuring sustainable development consisting of the UNECE, OECD and Eurostat, defines two different viewpoints, the "integrated" and "future oriented" approaches. The integrated view underpins the modern policy-based approach, where the goal of sustainable development is to ensure both the well-being of current citizens and the potential well-being of future generations. The future-oriented view underpins the capital approach and views sustainable development in the context of ensuring the potential well-being of future generations. The green accounting literature has long acknowledged the tension between current well-being and future well-being in the context of sustainability (Hanley et al., 2015; Neumayer, 2013). In the capital (future-oriented) approach, current well-being is pushed aside purely to permit a coherent sustainability framework as current and future well-being can conflict and complicate sustainability interpretation. In terms of potential conflicts, one might think about the opportunity costs of using resources today to tackle various current social issues rather than addressing issues such as biodiversity loss that will have future impacts. Within the capital approach, current well-being is viewed as a concern for "general" rather than "sustainable" development and can be addressed by policymakers and still satisfy the sustainability criterion as long as it does not conflict with the capital maintenance rule.

Alternative environmentally adjusted macro aggregates such as the Index of Sustainable Economic Welfare (ISEW) and the closely related Genuine Progress Indicator (GPI) attempt to operationalise the integrated view but suffer from a lack of theoretical rigour. The ISEW and GPI mesh both current and future well-being into one index and thus the indicators seemingly fail to address either (Neumayer, 1999). One could interpret the ISEW/GPI loosely as a kind of extended or expanded green Net National income (gNNI). gNNI is derived from the same theoretical model as GS and is defined as comprehensive consumption (inclusive of all utility relevant items) plus GS (Hamilton and Clemens, 1999). The interpretation of gNNI is less straightforward than GS in terms of sustainability assessment and is a key reason that GS is preferred (Dasgupta, 2009).[8] Lawn (2003) argues for a different theoretical interpretation of ISEW/GPI based not on the Hicksian income concept but on Irving Fisher's concepts of capital and income but this appears to miss the point given Weitzman (2017) shows that the Hicks, Fisher and Lindhal conceptions of income are all equivalent within the "pure theory of complete national income accounting".

The meshing of current and future wellbeing is attractive to policymakers who through the political business cycle are incentivised towards action in the short term rather than developing long-term policies (Nordhaus, 1975). The integrated view allows policymakers to cast a wide net that is inclusive of everything of social value. If everything is sustainable development then one can tout any policy as addressing some facet of the issue and this naturally leads to a lack of focus and a distortion of the opportunity costs that current policies may place on future generations. In this regard, the initial focus of sustainability that revolved around environmental concerns appears to have been lost.[9] We can demonstrate this lack of focus with reference to Eurostat's most recent report on the SDGs. Progress towards goals related to climate change, biodiversity and resource consumption/production (Goals 13, 12 and 15) have either worsened or have been amongst the lowest improving (Eurostat, 2019, pp11). The authors could not quantify progress in the marine sector (Goals 6 and 14). We found a similar trend for Ireland in Sachs et al., (2018) whose traffic light system shows only No Poverty (Goal 1) achieved a green light signifying progress towards achieving the goal. Goals 13, 12 and 14 achieved a red light (no progress) and Goals 15 and 6 recorded an orange light (little progress).

4. Estimating Ireland's Genuine Savings Using the Public Spending Code

4.1 From the theory to practical application

Moving from theory to practical application first requires the specification of the items that comprise net productive capacity (K). In theory, a complete accounting of all components of net productive capacity evaluated at the correct shadow prices is required. In practice, the literature generally posits K is dependent on physical (K_f), human (K_h) and natural capital (K_n) and relies on market prices and estimated average

[8] See Hanley et al., 2015 for a discussion. Under some certain assumptions preventing gNNI from falling is equivalent to preventing GS from becoming negative.

[9] There is some measurement of the interaction between economic growth and the environment under the indicators of "sustainable economic growth" measured by real GDP per capita, investment as a share of GDP and resource productivity but as discussed GDP cannot be a theoretically correct indicator of sustainable development.

costs for sub-soil assets and on willingness to pay estimates for the marginal social costs of pollution thus $K = (K_f, K_h, K_n)$. Pearce and Atkinson (1993) were the first to present the notion of a capital theoretic approach to sustainability measurement and provided the first empirical estimates of GS. Hamilton and Clemens (1999) developed a more formal theory and provided the foundation for the current World Bank ANS indicator calculated as:

$$ANS = NNS - D_S - D_E + A_H$$

The starting point is Net National Savings (NNS) as reported in the System of National Accounts (SNA) and represents net investments in physical capital. The World Bank then make a deduction for the depletion of the natural capital stock. Natural Capital in this framework consists of sub-soil assets (D_S) and pollution damages (D_E). D_S is valued using a simple net present value approach and covers a suite of mineral and energy resources. For D_E, the World Bank includes damages from CO_2 and Particulate Matter less than two microns in diameter ($PM_{2.5}$) both are valued at marginal damage costs reflecting the present value of future damages. Finally, an estimate of the net investments in human capital (A_H) is added through a rough proxy of net public education expenditure. Within the wealth accounting approach, there are a number of methods to estimate human capital accumulation such as expenditures on education, as a rate of return on time spent in education, or as a measure of discounted lifetime earnings by skill level (Greasley et al, 2014). The World Bank employ the public expenditure on education approach. The expenditure approach requires a strong assumption that every euro spent on public education yields exactly one euro in additional human capital formation. Consequently, the expenditure method has attracted much criticism (Jorgenson and Fraumeni, 1992; Schultz, 1988). In defence of the expenditure method, the World Bank argues that public spending education can be interpreted as a lower bound estimate for human capital accumulation that corrects for the misallocation of investment expenditures as consumption within the SNA (Hamilton and Clemens, 1999). An alternative view offered is that education spending may be an overestimate due to a lack of depreciation (Dasgupta, 2001) or the ineffectiveness of public schooling (Caplan, 2018). See World Bank (2018) for a detailed methodology.

The World Bank's ANS indicator contains a number of other well-documented limitations that may explain its absence from the EU and Irish sustainability indicator sets. The key issues relate to the substitutability assumption and the coverage and valuation of the capital assets (Ferreira & Vincent 2005; Pillarisetti 2005; Dietz & Neumayer 2006; Atkinson & Hamilton 2007; Goosens et al., 2007; Stiglitz et al., 2009; Neumayer 2013; Hanley et al. 2015). Much of the debate that surrounds the validity of the substitution assumption is confused and partly stems from differing domains marginal and total substitution. Given a domain of total substitution, strong sustainability is self-evidently true, as the total substitution of natural capital would lead to the cessation of all life. In economics, substitution is at the margin and is not costless nor constant harkening back to the classical diamond-water paradox (Smith, 1776). Given the domain of marginal substitution, the issue becomes a practical rather than a theoretical problem. In theory, the marginal utility to consumers and marginal rates of substitution in production tend to infinity when approaching biophysical limits. In practice, it may never be feasible to get sufficient coverage of assets at the appropriate prices. The identification of critical limits may require the monitoring of critical assets in physical terms. A more fundamental issue is that both strong and weak sustainability are non-provable as they both depend on the unknown future (Neumayer, 2013) and thus assertions of non-substitutability do not constitute evidence of non-substitutability (Pearce & Atkinson, 1998). A related dissatisfaction is with the aggregation of the capital stocks into a common unit (monetary) in the weak sustainability model.[10] In terms of an operational sustainability framework, strong sustainability also requires aggregation into a common unit, as without aggregation we could not deplete a single item of natural capital without replacing it with exactly the same form of natural capital. Beckerman (1994) refers to this situation as "absurdly strong sustainability".

4.2 Some Methodological Issues

The valuation and coverage of the net investments is the key methodological issue when constructing GS estimates. Contentious issues include the choice of appropriate social discount rate and of techniques used for natural capital valuation. The adoption of the United Nations System of Environmental-Economic Accounting (SEEA) central framework as a statistical standard in 2012 provides guidance on the valuation of many forms of natural capital. The World Bank has made considerable progress with a move to a country-specific net present value approach for sub-soil assets in recent years (Neumayer, 2013). Many studies have addressed the valuation of environmental damages in particular CO_2 damages, and given the uncertainty involved, it appears prudent to provide a range of estimated damages. Given the assumptions required to construct GS estimates it is understandable that governments have been reluctant to adopt such estimates within their own sustainability frameworks. However, GS and/or related wealth type measures are vital for a coherent sustainability framework. For Ireland, many of the contentious assumptions required to compute the GS indicator are now contained in the updated public spending code (IGEES, 2019). These include a decision on test discount rates and the marginal social costs of both GHG and non-GHG pollutants. `

The World Bank ANS data shows that modern developed economies consistently hold high ANS rates with Ireland's ANS rate consistently amongst the highest. Previous editions of the ANS database contained estimates for Ireland back to 1970 but following a much-improved methodology, estimates now cover 2005-16.[11] One can construct ANS back to 1990 (including the non-stock pollutant particulate matter (PM) and 1970 (excluding PM) by employing national Gross National Savings data as the World Bank reports all other ANS components. The World Bank's goal is to provide a comparable and consistent dataset and this leads to an inevitable trade-off between the capture of country-specific characteristics and

[10] The original arguments for and against the aggregation and maintenance of a total national capital stock go back to the Hayek-Pigou-Hicks debates and discussions during the 1940s (Pigou, 1941; Hayek 1941; Hicks 1942).

[11] https://datacatalog.worldbank.org/dataset/adjusted-net-savings

the application of a common methodology. One key concern is that developed economies might be much less sustainable owing to important omissions such as local air pollution and that country-specific estimates may offer a more accurate reflection of the true underlying GS. Studies have shown that the omission of local air pollutants may have a considerable impact on Ireland (McGrath et al., 2019; Ferreira and Moro, 2013).

Ferreira and Moro, (2013) and McGrath et al., (2019) showed that it is possible to construct expanded GS estimates from official national data sources. Ferreira and Moro (2013) studied 1995-2005 and focused on expanding the coverage of pollution damages. McGrath et al., (2019) analysed a longer time series from 1990-2016 and further extended the pollution coverage as well as the array of assets to include changes in agricultural land value, technological progress and the impacts of potentially catastrophic climate change damages. These studies showed how the results were highly sensitive to the marginal pollution damage costs employed and, to a lesser degree, the choice of social discount rate.

The recently updated version of the PSC provides guidance on the social discount rate (4%) and marginal social costs for Greenhouse Gases (GHGs) and local air pollutants. For GHGs the PSC recommends that they be expressed in terms of CO_2-equivalent and sets a trajectory of carbon prices up to the year 2050 starting at €20/tCO_2 if not within the emission trading scheme (ETS) sector and €23.6/tCO_2 if within the ETS sector. Non-GHGs to be included in economic appraisals are nitrogen oxides (NO_x), sulphur oxides (SO_x), PM, non-metallic volatile organic compounds (NMVOC) and noise pollution where these emissions are considered "relevant, significant and practicable for inclusion" (IGEES, 2019). We estimate Irish GS using the guidance from the public spending code (GSPSC) and compare with the existing estimates of Irish GS from the literature. The inclusion of pollutants within the GS model requires caution. Changes in productive capacity are the focal point of the model thus there is a strong argument for the inclusion of stock pollutants (e.g. GHGs) that cause damage by accumulating as a stock. Non-stock pollutants that damage other productive stocks (e.g. PM causing increased morbidity) should also be included (Hamilton & Atkinson 1996; Pearce & Atkinson 1998; Atkinson and Hamilton 2007). Noise pollution although covered by the PSC is not relevant for GS as the literature treats noise as a pure flow pollutant.[12] The marginal damages employed are largely attributable to negative health impacts (discussed below) and thus largely (negatively) affect the human capital stock.[13]

To estimate Irish GS we employ emissions data from official Irish sources back to 1990 and use the marginal damage estimates contained in the PSC. The source of the marginal damage cost estimates

[12] "Pure flow" pollutants do not accumulate in the atmosphere nor impact productive capacity and instead merely reduce the current utility of those directly affected. Damage (generally) ceases with exposure.

[13] One should be careful to mitigate the potential problem of double counting the pollution damages to changes in the stock of human capital. Lindmark and Acar (2013) provide an excellent discussion on the double counting problem. In short, one might argue that, if the present value of expected future income is used to estimate the human capital stock then the negative pollution impacts should be captured with declining wages (reflecting the damages to human capital). There is a further complication when one considers that productivity determines wages and productivity is in term impacted by technological change and ultimately depends on the available stock of human capital. Lindmark and Acar argue double counting is abated under the expenditure method where human capital formation is endogenous and determined by formal investments in education.

contained in the PSC is the Update of the Handbook on External Costs of Transport prepared by the consulting firm Ricardo-AEA (Ricardo-AEA, 2014). Given the uncertainty and diverse range of marginal damage estimates in the literature McGrath et al., (2019) presented a range of estimates and constructed three baseline measures of GS; GS1, GS2, and GS3 ranging from the largest damage cost estimates in GS1 to the smallest in GS3. In addition to the GHGs, SO_x, PM, NMVOC and NO_x, McGrath et al., (2019) further added Carbon Monoxide (CO), and ammonia (NH_3). The authors utilised a slightly more recent study by the European Environment Agency (EEA, 2014) that followed a similar methodology to Ricardo-AEA (2014) to obtain damage costs for Ireland. The EEA (EEA, 2014) assessed total damages caused by air pollution by industrial facilities in the EU, Norway, and Switzerland in contrast to Ricardo-AEA who examined transport and power generation emissions. The EEA (2014) approach provides a lower bound estimate of marginal damage costs obtained using the value of a life year (VOLY) method, and an upper-bound estimate using the value of statistical life (VSL) method for each country. Table 3 shows the marginal damage costs used in each study. [14]

Another key issue with historical estimates of pollution damages is the fact that studies report the marginal damages in base-year prices and thus require deflation to obtain values for all other years.[15] Unless otherwise stated we report the results where we assume a non-constant marginal damage function where we deflated the marginal damage costs with a real wage index constructed from CSO data on historical earnings. Results assuming constant marginal damage costs through time are included in Figure A1 in the appendix. We discount CO_2 damages at 3% per year following World Bank (2018). For the other GS components, we follow the data and methods from McGrath et al., (2019). We then compare our results to the GS1 and GS2 measures from McGrath et al (2019) excluding NH_3, CO and NH_3 (as there is no guidance on these pollutants within the PSC) as well as the World Bank ANS indicator. To be clear, the only differences between our estimates using the GSPSCs and GS1 and GS2 from McGrath et al., 2019 relate to the marginal damage costs employed and the pollutants covered (see McGrath et al., 2019 for full methodology).[16]

[14] The damages quantify the health effects of primary PM as well as SO_x, NO_X, NH_3 and NMVOC as a result of their formation of secondary PM and ozone through chemical reactions in the atmosphere. Damages to crops and building material damages are also included. It is not easy to asses if soil damage impacts future output nor is it easy to exclude the crop damages from thus estimates thus we include them in our analysis.

[15] See Lindmark and Acar (2013) for a discussion of the issues involved.

[16] There are slight differences with McGrath et al (2019) due to updates to the national accounts.

Table 3: Marginal Social Costs of Pollution Employed

Pollutant	Public Spending Code	McGrath et al., 2019	
		Constant Damage Function (CDF)	Non-CDF
Marginal Damage Cost in €/t for the year 2016			
Carbon Dioxide	20-24	N/A	7-50
Methane	20-24/tCO2-e	200-1100/tCH_4	N/A
Carbon Monoxide	n/a	2-700	N/A
Sulphur Oxides	7000	5300-33500	6000-36000
Ammonia	n/a	1000-5200	1000-5600
Nirtogen Oxides	5700	1100-10100	1200-11000
Non-Metallic Volatile Organic Compounds	1400	1000-2700	1100-3000
Particulate Matter (<2.5 microns)	19000*	8300-42000	9000-45000

Source: IGEES (2019) and McGrath et al., (2019).
*Note:**National estimate is based on the appendix from Ricardo-AEA (2014).

4.3 Results

Figure 1 provides a comparison of the GSPSC based indicator with the World Bank ANS indicator as well as the re-constructed GS1 and GS2 measures from McGrath et al., (2019). All three alternative GS measures are consistently and considerably lower than the World Bank's ANS estimates, particularly during the early 1990s and driven largely by the expanded coverage of pollution damages (see Table 4). Over the entire period, the GSPSC indicator averaged 11% of GNI, 4 percentage points below the mean of the ANS indicator. Our results suggest the construction of country-specific GS estimates that focus on individual national characteristics and data can lead to a considerable divergence from the ANS estimates.

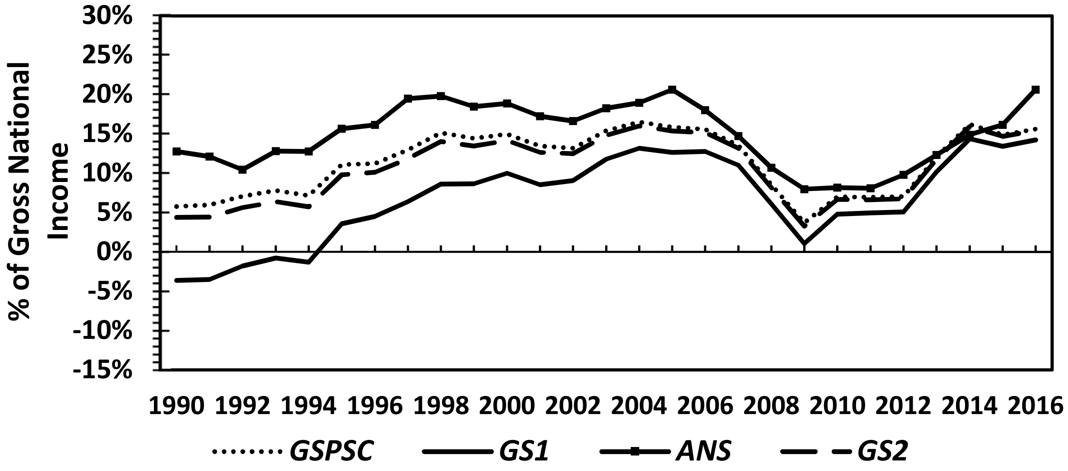
TABLE 4: Comparison of the Components of the GS rate: Averages as % of GNI 1990-2016

Indicator	NNS	Human Capital	Pollution Damages		Oth. Natural Capital
			Non-Cons MDF	Cons MDF	
GS1	10.1	4.8	-7	-8	-1.1
GSPSC	10.1	4.8	-2.3	-3	-1.1
ANS	10.3	5.3	-0.6		-0.1

Source: Authors' Calculations
Notes: Other natural capital in the ANS model includes natural gas, coal, zinc, lead and silver; GS1 and GSPSC further include peat, forestry growth and changes in agricultural land value.

McGrath et al., (2019) found negative savings during the early 1990s in Ireland but that this result was highly sensitive to the marginal damage costs employed. Only when the upper limits of the marginal damage costs from EEA (2014) were employed (GS1) were negative savings revealed. This result was robust to a comprehensive sensitivity analysis that included various assumptions including a non-constant marginal damage function. Our GSPSC based results are very similar to the GS2 measure from McGrath et al., (2019). The GS2 measure employed the lower bound estimate from EEA (2014). In both the GS2 and GSPSC models savings rates rose almost linearly from 1990-2004 before a collapse during the economic recession and a strong rebound during the recovery. Ferreira and Moro (2013) covered 1995-2005 and found GS rates in line with the GS2 measure.

Figure 1: GS estimates Non-Constant Pollution Marginal Damage Function 1990-2016



GS1, GS2, GSPSC and ANS all converge through time because of a remarkable decline in total environmental damages. Fig. 2 illustrates the sharp reduction in total environmental damages as a % of GNI. There has also been a considerable reduction in real terms (Figure 3).

Figure 2: Environmental Damages as a % of GNI 1990-2016

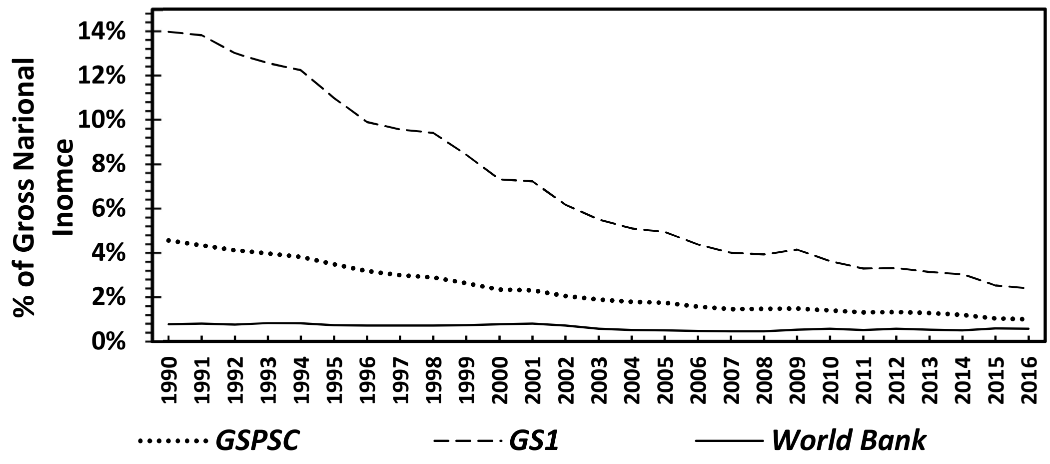
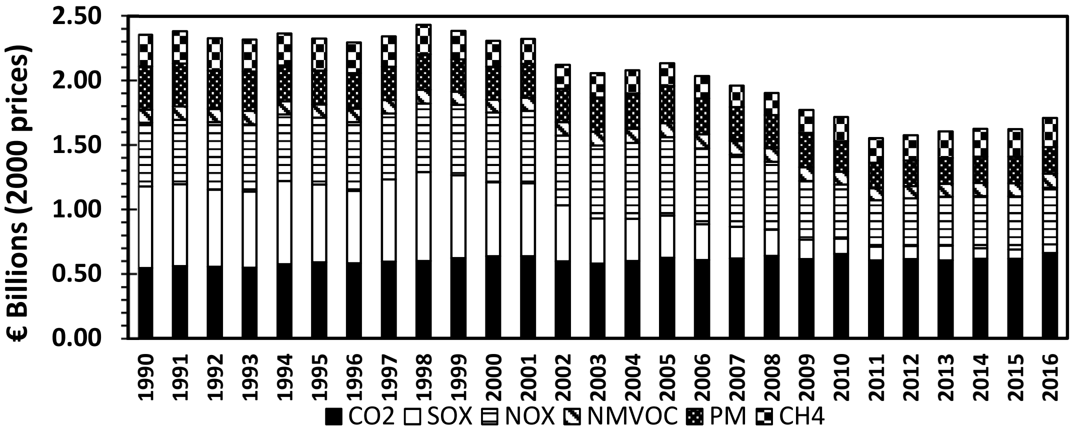


Figure 3 provides the breakdown of the total pollution damages by pollutant in the GSPSC scenario. Our results demonstrate the potentially large benefits attainable from pollution reductions and show that there are many damaging air pollutants. SO_x was the largest component of total damages for the first decade averaging 30% of total damages in the GSPSC model followed by CO_2 (25%) and NO_X (22%). Remarkably, SO_x became the smallest component of total damages from 2014. The damages from the GHGs make up a large proportion of the total damages in the GSPSC model but it is worth noting that we apply different accounting methods for the GHGs and non-GHGs as is common in the literature. The accounting method applied to the GHGs is the "polluter pays" principle and as such, we notionally charge Ireland for its contribution to global damages (rather than damages to Ireland). The theoretical rationale for applying the polluter pays principle in the context of GHGs stems from Hamilton and Clemens (1999) where the pollution externality is internalised in the GS model by the optimal Pigouvian tax. Arrow et al., (2012) argue an alternative method that accounts for direct damages to country X from global emissions (including emissions from country X). See McGrath et al., (2019) for a comprehensive discussion and empirical application of alternative methods to account for CO_2 and CH_4 damages in the Irish context. The authors suggest the polluter pays principle may be more appropriate for Ireland. We account for non-GHGs as damages directly accruing to Ireland from emissions in Ireland. The results provide a reminder that a system of regulations prioritising one particular problem such as carbon dioxide at the expense of others such as damaging local air pollutants may result in misguided public policy. Our results also illustrate a key issue with physical emissions without reference to monetary damages. In this regard, CO_2 damages (in 2000 prices) were higher in 2016 than in 2005 despite emissions being lower in 2016 compared with 2005. Similarly, NMVOC emissions were lower in 2016 than in 2007 but the damages were higher in 2016 (in 2000 prices).

Figure 3: Breakdown of Pollution Damages from GSPSC 1990-2016



The decline in total damages largely reflects a sharp decline in the emissions of most pollutants since 1990 (Table 5). Only CO_2 emissions are higher in 2016 than in 1990. A strong decoupling between all non-GHGs included in the analysis and economic growth occurred over the period. SO_x emissions, the largest component of damages for much of the period have fallen considerably due to a mixture of market-based incentives, structural changes, technological development and environmental policies (EPA, 2018).

Table 5: Emissions from 1990-2016

Pollutants*	Emissions 1990	Emissions 2016	% Change in Emissions
CO_2	32878 kt	39928 kt	+21%
PM2.5	35 kt	15 kt	-58%%
SO_x	184 kt	14 kt	-93%
NOx	175 kt	107 kt	-39%
NMVOC	146 kt	108 kt	-26%
CH_4	595 kt	548 kt	-8%

*CO_2 =carbon dioxide; PM2.5 = particulate matter, SO_x = sulphur oxides, NOx = nitrogen oxides, NMVOC =non-metallic volatile organic compounds & CH_4 = methane. It should be noted that CH_4 emissions have been rising from 2012 reflecting an increase in dairy production.

4.4 Limitations and Further Development

In terms of policy use, the practical limitations of real-world GS calculations relate to the coverage and appropriate valuation of the net investments. In particular, our valuation techniques fail to capture the non-marketed value of natural capital. For some natural assets such as peatlands, this may be a considerable omission. Peatlands represent a natural carbon store and provide a multitude of other non-marketed ecosystem services. Importantly, our estimates, unlike the World Bank, implicitly capture the damages from the burning of peat within the environmental damage estimates. Other salient issues include the treatment of future technological progress and population growth. McGrath et al., (2019) contains a discussion and incorporates both of these issues within GS models.

Many environmentalists reject the notion of weak sustainability in general, largely due to the substitutability assumption (Pillarisetti 2005). The debate around the substitutability assumption is often confused and in part stems from differing substitution domains. Given a domain of total substitution, strong sustainability is self-evidently true, as a complete substitution of natural capital for physical capital would cease all life. Economists theorise at the margin where substitution is not costless nor constant. Within a domain of marginal substitution, the issue is of a practical rather than a theoretical nature. In theory, given perfect foresight and the correct accounting prices all assets and threshold effects could be captured. In practice, it seems sensible to supplement weak sustainability indicators by identifying and monitoring critical natural assets in physical terms. Given these limitations, it is important to stress what GS theory actually tells us; if savings are negative, the economy is on an unsustainable path, the opposite is not necessarily true. Positive savings imply a welfare improvement and this has been demonstrated empirically with historical estimates of real-world GS estimates (Greasley et al, 2014; Hanley et al., 2015; Greasley et al., 2017; Qaism et al., 2018; Mota and Cunha-e-Sá, 2019), but positive savings are not sufficient to ensure a sustainable path (Pezzey, 2004). For policymakers, a finding of low or negative savings provides a strong warning but we should not take positive rates as a clean bill of health but that further analysis is required. GS provides a valuable aggregate indicator that can be highly informative for an initial sustainability assessment and provide a useful guide to where further analysis is required.

5. Linking Theory with Assessment & Policy

It is obvious that no single indicator can provide an all-encompassing answer to questions surrounding sustainable development, but it is also clear that the current monitoring of sustainable development in Ireland and across the EU lacks coherence. The capital approach derives from economic theory and provides a consistent and theoretically grounded framework for sustainability assessment. The capital approach encompasses two interpretations of the conditions required to achieve sustainability, both strong and weak sustainability. Advocates of strong sustainability will be inclined towards ecological indicators that assume non-substitution between natural and other capital forms. Advocates of weak sustainability stress substitution possibilities and technological optimism such that aggregative indicators such as GS are more appealing. In theory, a perfect measure of GS could incorporate any degree of substitution through the relevant accounting prices but as this may never be feasible in practice alternative measures, in physical terms, may be required for stocks of so-called "critical" natural capital.[17] One can view weak sustainability as a sub-set of a stronger form. If one advocates strong sustainability, *additional* rather than alternative indicators are required.

Even if one takes a broader view of sustainable development than the capital approach (e.g. the integrated view) a strong link can be maintained through further *additional* indicators that focus on current well-being and/or other social issues. A salient example that seeks to preserve the theoretical framework of the capital approach can be found in the "proposed set of practical indicators" from the UN and others (UNECE et al., 2008). The proposed set of practical indicators sought to establish commonalities between the integrated and future-oriented views. A tight set of indicators were proposed and split between "foundational well-being" and "economic well-being". The foundational well-being metrics relate to some strong sustainability indicators and some current welfare indicators. The economic well-being component is effectively total comprehensive wealth and changes in wealth (GS) in disaggregated form. It is easy to imagine how an amended set for Ireland might be agreed upon, perhaps emphasising the role of peat as well as the agricultural and marine sectors within the economic well-being component and adjusting foundational well-being to account for the various social and environmental concerns already expressed within the DCCAE indicator set (Table 2). UNECE (2014) offers a closely related approach that more explicitly acknowledges environmental impacts where the framework includes the three sustainability dimensions of "human well-being", "capital" and "transboundary impacts". The three dimensions are linked across twenty themes that contain various sub-indicators. Gnegne (2019) offers an alternative portfolio approach where separate indicators measure the distinct issues of current well-being, sustainable well-being and environmental sustainability. Gnegne (2019) suggested a potential portfolio with current

---

[17] Critical natural capital is defined as an asset within the stock of natural capital stock that must be maintained to preserve welfare and is therefore non-substitutable. Pearce et al., (1989) view the assimilative capacity of the environment as well as a certain stock of living natural resources that function as basic life-support systems as "critical".

well-being monitored by the Human Development Index, the sustainability of well-being by GS and environmental sustainability by the Ecological Footprint indicator.

Table 6: UN et al. (2008) Proposed Indicator Set

Indicator Domain	Stock Measure	Flow Measure
Foundational well-being	Health-Adjusted Life Expectancy	Index of changes in age-specific mortality and morbidity
	% of the population with post-secondary education	Enrolment in post-secondary education
	Temperature Deviations	Greenhouse gas emissions
	Ground Level Ozone and Fine Particulate Concentrations	Smog-forming pollutant emissions
	Quality-Adjusted Water Availability	Nutrient loadings to water bodies
	Fragmentation of natural habitats	Conversion of natural habitats to other uses
Economic well-being	Real Per Capita net foreign financial asset holdings	Real per capita investment in foreign financial assets
	Real per capita produced capital	Real per capita net investment in produced capital
	Real per capita human capital	Real per capita net investment in human capital
	Real per capita natural capital	Real per capita net depletion of natural capital
	Reserves of energy resources	Depletion of energy resources
	Reserves of mineral resources	Depletion of mineral resources
	Timber resource stocks	Depletion of timber resources

A proposed broader view of sustainable development is the "systems thinking" approach where the emphasis is on the interdependence of humans, the natural environment and the economy. The systems approach would involve a move from the measurement of individual stocks and flows to a focus on the "resilience" of the total integrated system (De Smedt et al., 2018). Ecosystem resilience is the ability to maintain 'self-organisation' and therefore absorb stresses and shocks (Dietz and Neumayer, 2006). De Smedt et al., (2018) argue that the systems approach provides a powerful complement to the capital approach. On close inspection, it appears the systems approach is a form of strong sustainability and thus falls under the umbrella of the capital approach. The confusion might seem semantic but stems from the authors view that the treatment of capital forms within the capital approach *"implicitly assumes their independence and, therefore, substitutability*" (De Smedt et al., 2018). While substitutability is a key assumption of the weak sustainability paradigm, this is not true of strong sustainability and both of which comprise the capital approach, as discussed above. This is a subtle but important point. To explain let us take the OECD definition of the Capital approach: "sustainable development is development that ensures non-declining per capita national wealth by replacing or conserving the sources of that wealth; that is, stocks of produced, human, social and natural capital". In the weak-sustainability model, the sources of wealth are substitutes but non-substitutable in the strong sustainability model hence disagreement occurs over the *conditions* required to provide non-declining wealth not the *concept* of sustainability as non-declining wealth. In terms of sustainability indicators, to have any idea about ecosystem resilience we obviously require information on the stocks and flows within the system, a point acknowledged by De Smedt et al., (2018).

The strength of sustainability indicators is dependent on the quality of data available to construct them. An appropriate measure of GS (or total national wealth) would offer a clear link between EU development strategies and provide a comprehensive measure of the capital approach to sustainability. At present, we can only make rough GS and wealth estimates, relying on the weak sustainability model. The literature shows rough estimates of GS to be reasonably good predictors of future well-being but an expansion of natural capital accounting is required for a more detailed assessment. Accounting for natural capital offers a way to embed our natural assets within the realm of political decision-making, would feed naturally into much improved GS and wealth estimates and provide indicators in both physical and monetary terms for further "strong" indicators. The SEEA provides a framework for organizing and presenting statistics on the environment and its relationship with the economy using an internationally agreed set of standard concepts and definitions. The SEEA 1993 emerged from ongoing discussions surrounding the assessment and measurement of the concept of sustainable development (UN SEEA, 2012). The SEEA framework consists of two key components. Firstly, the Central Framework (SEEA CF) designed to be consistent with the SNA covers the accounts where a wide consensus has emerged. The United Nations Statistical Commission adopted the SEEA CF as an international standard in 2012 and it forms the basis for the EU's programme of natural capital accounting. The revised 2014 SEEA CF outlines three basic approaches to natural capital accounting:

1. Physical flow Accounts to quantify, in physical terms, flows from the economy to the environment (e.g. emissions of pollutants) and from the environment to the economy (e.g. the felling of trees) for different economic sectors.

2. Environmental Asset Accounts to assess the stocks of natural capital in physical (e.g. cubic metres of natural gas) or monetary terms (using the net present value of future flows). The SEEA lists seven categories of environmental assets: mineral and energy resources, land, soil, timber, water, aquatic resources, and other biological resources.

3. Environmental Expenditure Accounts to tabulate and separate environmentally-related monetary transactions already recorded in the SNA such as government spending on environmental protection and resource management, the collection of environmental taxes, and expenditures on subsidies.

in 2013 the UN also endorsed the development and testing of what is referred to as Experimental Ecosystem Accounting aimed at incorporating physical and monetary expressions of ecosystem service flow benefits within the SNA accounting framework (UN et al. 2014). The lesson to take from the SEEA is that it is possible to craft a coherent and rigorous measurement framework for complex, non-traditional forms of capital starting from the basic elements of the SNA. The EU requires all Member States to construct natural capital accounts under Regulation (EU) No 691/2011 (as amended by Regulation (EU) No 538/2014). All Member States must regularly report on the three areas/modules included in the Annexes to Eurostat, the European Statistical Office. At present, the regulations cover six separate modules and relate to various physical flow and defensive expenditure accounts; (i) air emissions, (ii) environmental taxes, (iii) economy-wide material flows, (iv) environmental protection expenditure, (v) physical energy flows, and (vi) environmental goods and services. The accounts are consistent with the UN SEEA CF but as of yet do not include environmental asset accounts.

In Ireland, the Central Statistics Office (CSO) is required to submit data for the six modules on an annual basis. The CSO compile other accounts, at least partially, on a voluntary basis. Ireland has closely followed the EU regulations and as such have focused on physical flow and expenditure accounts. Asset accounts are more relevant for sustainability assessment, as it is only through asset maintenance that flows can continue. Another ongoing project in Ireland is the Irish Natural Capital Accounting for Sustainable Environment (INCASE) project. INCASE is an Environmental Protection Agency funded, transdisciplinary project, with the aim of developing natural capital accounting systems in Ireland. The project involves a review approaches and data sources to develop ecosystem and environmental flow accounts for Irish catchments.

It should be clear that the development of sustainability indicators does not hinge on one's view of sustainability policy but evaluation criteria will differ based on whatever stance is taken whether explicit or not. Irish government policy in relation to natural capital accounting is most relevant within the National Biodiversity Action Plan (NBAP) 2017-2021 (DAHG, 2017) although the details are vague.[18] Policy formation and evaluation regarding weak sustainability is consistent with cost-benefit analysis. Traditional cost-benefit analysis is at odds with strong sustainability, as under strong sustainability one must observe the constraint of non-declining natural capital regardless of opportunity costs. Strong sustainability also has implications for the choice of policy instruments. Quantity based tradable quota systems will be preferred to Pigouvian taxes, as will command and control regulations under the strong sustainability criteria (Pearce, 2000).

6. Conclusions

It is clear that much work remains to be done in order for an adequate sustainability assessment of Ireland's economic development. It is obvious that no single indicator is capable of providing an all-encompassing answer, but it is also clear that the current monitoring of sustainable development is incoherent. A key

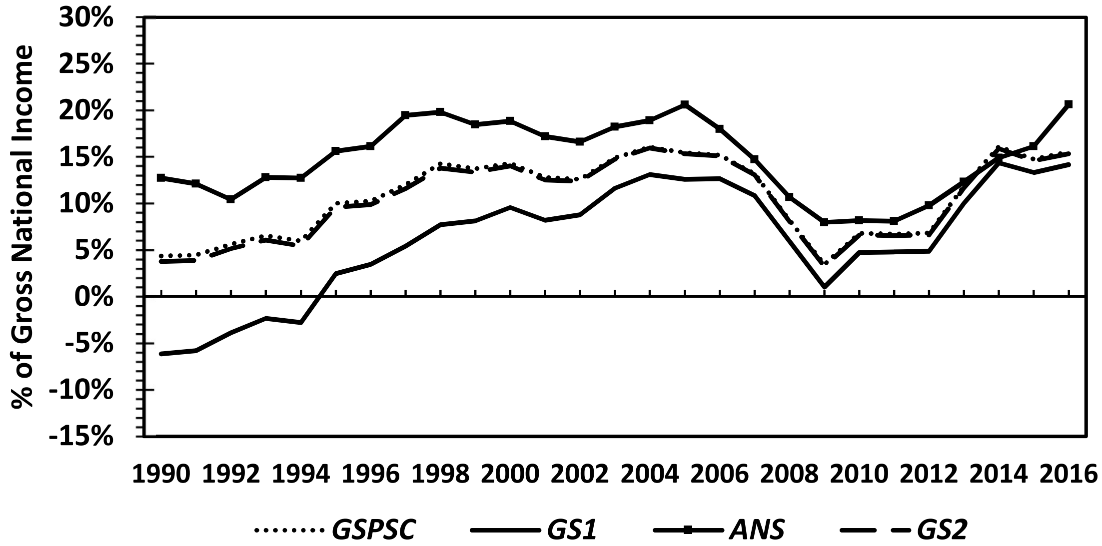
[18] "That biodiversity and ecosystems in Ireland are conserved and restored, delivering benefits essential for all sectors of society and that Ireland contributes to efforts to halt the loss of biodiversity and the degradation of ecosystems in the EU and globally". Objective 1 of the NBAP is to mainstream biodiversity into decision-making across all sectors. Action 1.1.0 is to develop a Natural Capital Asset Register and national natural capital accounts by 2020 and to integrate these accounts into economic policy and decision-making.

policy implication of this paper is that governments should be cognisant of the theoretical literature that suggests components of wealth should be the focus of sustainability assessments. We set out the capital approach derived from economic theory and arguably the most consistent sustainability framework. To operationalise the capital approach we need measures of the changes in broadly defined national wealth. The GS indicator derives naturally from this approach to serve as a sustainability indicator. We argue that estimates of GS warrant a place within the economic component of any sustainable development indicator set. Governments constructing sustainable development indicator sets and/or implementing natural capital accounting systems should be aware of the limitations the World Bank's GS indicator. We show how to construct Irish GS estimates from national data sources and by using guidance from the updated public spending code further strengthening the argument for the development of national GS estimates. The UN SEEA provides further guidance on the valuation of natural capital. Given Ireland is required under Regulation (EU) No 691/2011 (as amended by Regulation (EU) No 538/2014) to construct national accounts and given the guidance available from the PSC, the UN SEEA and the World Bank it seems feasible that a measure of Irish GS could be regularly constructed. In addition, if the DCCAE request it, these estimates could be included within the national sustainable development indicator set. Alternatively, the World Bank ANS data could be reported within such an indicator set.

The strength of sustainability assessment depends on a coherent framework and sufficient data. Developing robust natural capital accounts will be an important future development in this regard. There have been many positive developments regarding natural capital accounting in Ireland but we still lag behind pioneers such as Norway, the Netherlands and the UK (e.g. ONS, 2019). The CSO's implementation of the SEEA CF through EU regulations is one major positive development. The development of detailed environmental asset accounts in both physical and monetary terms, comprehensive wealth accounts and historical analysis of Irish GS would represent highly valuable research projects.

Appendix

Figure A1: GS estimates Constant Pollution Marginal Damage Function 1990-2016



References

Ahmad, Y.J., El Serafy S., & Lutz, E., 1989. Environmental accounting for sustainable development. A UNEP-World Bank Symposium. The World Bank, Washington, D.C. Alternative progress indicators to Gross Domestic Product (GDP) as a means towards sustainable development. EU Parliament, Policy Department, Economic and Scientific Policy.

Arrow, K. J., Dasgupta, P., Goulder, L. H., Mumford, K. J., & Oleson, K., 2012. Sustainability and the measurement of wealth. Environment and Development Economics 17, 317–353.

Asheim G.B, 2007. Can NNP be used for welfare comparisons? Environment and Development Economics 12, 11–32.

Asheim, G. B. 1994, Net National Product as an Indicator of Sustainability. Scandinavian Journal of Economics 96(2), 257. 11, 12.

Atkinson, G., & Hamilton, K., 2007. Progress along the path: evolving issues in the measurement of genuine saving. Environmental and Resource Economics 37, 43-61.

Beckerman W. 1994. Sustainable development: is it useful? Environmental Values 3: 191–209.

Cabeza-Gutés, M., 1996. The concept of weak sustainability. Ecological Economics 17, 147- 156.

Central Statistics Office, 2018. Environmental Accounts Air Emissions 2016. Central Statistics Office, Dublin.

Central Statistics Office, 2018. Material Flow Accounts 2016. Central Statistics Office, Dublin.

Costanza, R., Daly, H. E. & Bartholomew, J., A., 1991. Goals, agenda and policy recommendations for ecological economics, in Costanza, R. (Ed.), Ecological Economics: The Science and Management of Sustainability, Columbia University Press, New York, pp. 1-20.

Costanza, R., Daly, L., Fioramonti, L., Giovannini, E., Kubiszewski, I., Mortensen, L.F., Pickett, K.E., Ragnarsdottir, K.V., De Vogli, R., Wilkinson, R., 2016. Modelling and measuring sustainable wellbeing in connection with the UN Sustainable Development Goals. Ecol. Econ. 130, 350–355.

Dasgupta, P., & Heal, G., 1974. The Optimal Depletion of Exhaustible Resources. Review of Economic Studies 41, 3-28.

Dasgupta, P., & Mäler, K. G., 2000. Net national product, wealth, and social well-being. Environment and Development Economics 5, 69-93.

Dasgupta, P., 2001. Human Well-being and the Natural Environment. Oxford University Press, Oxford and New York.

Dasgupta, P., 2009. The welfare economic theory of green national accounts, Environmental and Resource Economics 42, 3–38.

De Smedt, M., Giovannini, E., & Radermacher, W. J. (2018). Measuring Sustainability. In J. E. Stiglitz, J.-P. Fitoussi, & M. Durand (Eds.), For Good Measure: Advancing Research on Well-being Metrics Beyond GDP (pp. 243–284).

Department of Arts Heritage and Gaeltacht. (2017). National Biodiversity Action Plan: 2017-2021. Ireland.

Dietz, S., & Neumayer, E., 2006. A critical appraisal of genuine savings as an indicator of sustainability. In: P. Lawn (Ed.). Sustainable Development Indicators in Ecological Economics. Edward Elgar. Cheltenham, Northampton, 117-135.

Easterly, W. 2015. The SDGs Should Stand for Senseless, Dreamy, Garbled. Foreign Policy.

Environmental Protection Agency (Ireland), 2018 Ireland's Air Pollutant Emissions 2016 [online] available at: http://www.epa.ie/pubs/reports/air/airemissions/irelandsairpollutantemissions2016.html[Accessed 1 March 2018]

European Commission. 2016. COM(2016) 739 final - Next Steps for a Sustainable European Future. European Action for Sustainability: European action for sustainability

European Environment Agency (EEA), 2014. Costs of air pollution from European industrial facilities 2008–2012 — an updated assessment, Technical Report No. 20/2014

Eurostat, 2019. Sustainable development in the European Union — Monitoring report on progress towards the SDGs in an EU context — 2019 edition.

Fenichel E.P, & Abbott JK. 2014. Natural Capital: From Metaphor to Measurement. Journal of the Association Environmental Resource Economics 1, 1–27.

Ferreira S., & Moro, M., 2013. Response to the Comments on Ferreira and Moro (2011) 'Constructing genuine savings indicators for Ireland, 1995–2005 Journal of Environmental Management 127, 337-338.

Ferreira, S., & Vincent, J. R., 2005. Genuine savings: leading indicator of sustainable development? Economic Development and Cultural Change 53, 737-754.

Ferreira, S., Hamilton, K. and Vincent, J. R. 2008. Comprehensive Wealth and Future Consumption: Accounting for Population Growth. The World Bank Economic Review 22(2), 233–248.

Gnègnè Y., 2019. Assessing Sustainable Development: Toward a Portfolio of Indices? Journal of Sustainable Development 12 4 225-238.

Goossens, Y., A. Mäkipää, P. Schepelmann, I. van de Sand, M. Kuhndtand, M., & Herrndorf, M, 2007.

Greasley D., McLaughlin E., Hanley N., & Oxley L., 2017. Australia: A land of missed opportunities? Environment and Development Economics 22, 674–698.

Greasley D., McLaughlin E., Hanley N., Oxley L., & Warde P., 2014. Testing Genuine Savings as a Forward-looking Indicator of Future Well-being over the (Very) Long Run. Journal of Environmental Economics and Management, 67, 171–88.

Growth Paths. The Review of Economic Studies 41, 123–137.

Hamilton K., & Clemens M., 1999. Genuine Savings Rates in Developing Countries. The World Bank Economic Review 13 (2), 333–356.

Hamilton, K., & Atkinson, G., 1996. Air pollution and green accounts. Energy Policy 24, 675-684.
Hanley, N., Dupuy L., and McLaughlin E., 2015. Genuine savings and sustainability. Journal of Economic Surveys 29(4), 779–806.

Hartwick J., M., 1990. Natural resources, national accounting and economic depreciation. J Public Econ 43: 291–304.

Hartwick, J.M., 1977. Intergenerational equity and the investing of rents from exhaustible resources. American Economic Review 67, 972-974.

Hayek F.A., 1941. Maintaining Capital Intact: A Reply, Economica 8, 276–80.

Hicks J.R., 1942. Maintaining Capital Intact: A Further Suggestion, Economica, 9 174–9

Hicks, J., R., 1939. Value and Capital (2nd ed. 1946), Clarendon Press, Oxford.

Irish Government Economic and Evaluation Service, 2019. Valuing Greenhouse Gas Emissions in the Public Spending Code [online]: https://igees.gov.ie/wp-content/uploads/2019/07/Valuing-Greenhouse-Gas-Emissions-in-the-Public-Spending-Code.pdf

Joint UNECE/OECD/Eurostat Working Group on Statistics for Sustainable Development. 2008. Report on Measuring Sustainable Development: Statistics for Sustainable Development, Commonalities between Current Practice and Theory. ECE/CES/2008/29. New York, United Nations, Economic and Social Council.

Lawn, P.A. 2003. A theoretical foundation to support the index of sustainable economic welfare (ISEW), genuine progress indicator (GPI) and other related indexes Ecological Economics, 44 105-118.

McGrath, L., Hynes, S., & McHale, J., 2019. Augmenting the World Bank's estimates: Ireland's Genuine Savings through boom and bust. Ecological Economics, 165.

Meadows, D. H., Meadows D. L., Randers J., and Behrens W. W. 1972. The limits to growth. Universe Books, New York, New York, USA.

Mota R.P., & Cunha-e-Sá, M.A., 2019. The Role of Technological Progress in Testing Adjusted Net Savings: Evidence from OECD Countries. Ecological Economics, 164.
Neumayer E., 1999. The ISEW: not an index of sustainable economic welfare. Social Indicators Research 48, 77–101

Neumayer, E., 2013. Weak versus Strong Sustainability. Edward Elgar, Cheltenham, UK.

Nordhaus, W., 1975. The political business cycle. Review of Economic Studies, 42, 169–190.

Nordhaus, W., & Tobin J., 1973. Is Growth Obsolete? In the Measurement of Economic and Social Performance, National Bureau of Economic Research.
Office for National Statistics, 2018. UK natural capital: Ecosystem service accounts, 1997 to 2015. [online]: https://www.ons.gov.uk/releases/uknaturalcapitalmonetaryestimates2017 [Accessed 23 August 2019].

Pearce, D. & Barbier, E. B. 2001. Blueprint for a Sustainable Economy (Earthscan, London).

Pearce, D., & Atkinson, G., 1993. Capital theory and the measurement of sustainable development: an indicator of 'weak' sustainability. Ecological Economics 8, 103-108.

Pearce, D., & Atkinson, G., 1998. The concept of sustainable development: an evaluation of its usefulness ten years after Brundtland. Swiss Journal of Economics and Statistics 134, 251 – 269.

Pearce, D.W., 2000. Public Policy and Natural Resources Management: A Framework for Integrating Concepts and Methodologies for Policy Evaluation. Economics Department, University College, London.

Pemberton, M., Ulph, D., 2001. Measuring Income and Measuring Sustainability, Scandinavian Journal of Economics 103, 25–40.

Pezzey, J.C.V., 2004. One-sided sustainability tests with amenities, and changes in technology, trade and population, Journal of Environmental Economics and Management 48(1), 613– 631.

Pigou A.C., 1941. Maintaining Capital Intact, Economica 8 271–5.
Pillarisetti, J. R., 2005, The World Bank's 'genuine savings' measure and sustainability', Ecological Economics 55(4), 599–609.

Qasim, M., Oxley, L., & McLaughlin E., 2018. Genuine savings as a test of New Zealand weak sustainability. Environment, Development & Sustainability 95, 1-39.

Repetto, R., Magrath, W., Wells, M., Beer, C., & Rossini, F., 1989. Wasting Assets, Natural Resources in the National Income Accounts. Washington, World Resources Institute.

Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G. & Fuller, G. 2018. SDG Index and Dashboards Report 2018. New York.

Smith, A. The Wealth of Nations. 1776. Edited by Edwin Cannan, 1904. Reprint. New York: Modern

Solow R.M. 1993. Sustainability: An Economist's Perspective. In Economics of the Environment, eds. R. Dorfman and N. S. Dorfman. New York: Norton.

Solow R.M., 1974. Intergenerational Equity and Exhaustible Resources. The Review of Economic Studies 41, 29-45.

Stiglitz, J. E., 1974a. Growth with Exhaustible Natural Resources: Efficient and Optimal

Stiglitz, J. E., 1974b. Growth with Exhaustible Natural Resources: The Competitive Economy'.

Stiglitz, J.E., Sen, A., & Fitoussi, J.P., 2009. Report by the Commission on the Measurement of Economic Performance and Social Progress. The Review of Economic Studies 41, 139–152.

United Nations, European Commission, Food and Agricultural Organization of the United Nations, Organisation for Economic Co-operation and Development, The World Bank (2014b) System of Environmental–Economic Accounting 2012—experimental ecosystem accounting. United Nations, New York.

United Nations. 2012. System of Environmental-Economic Accounting. Central Framework, New York.

WCED, 1987. Our Common Future (The Brundtland Report), World Commission on Environment and Development, Oxford University Press, Oxford.

Weitzman M.L. 2017. A Tight Connection Among Wealth, Income, Sustainability, and Accounting in an Ultra-Simplified Setting. In: Hamilton K, Hepburn C (eds) National Wealth: What is missing, Why it matters. Oxford University Press, New York.

Weitzman M.L., 1976. On the Welfare Significance of National Product in a Dynamic Economy. The Quarterly Journal of Economics 90(1):156-162.

Weitzman M.L., 2003. Income, Wealth, and the Maximum Principle. Harvard University Press, Cambridge.

World Bank, 2006. Where is the Wealth of Nations? Measuring Capital in the 21st Century. Washington, DC: World Bank.

World Bank, 2011. The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium, Washington: DC. World Bank.

World Bank, 2018. The Changing Wealth of Nations 2018: Building a Sustainable Future. Washington, DC: World Bank.

semru

Socio-Economic Marine Research Unit