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SAVING OR INVESTING FOR THE FUTURE? METHODOLOGY MATTERS IN INCLUSIVE WEALTH ACCOUNTING

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Saving or Investing for the Future?
Methodology Matters in Inclusive Wealth Accounting

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Abstract

This paper investigates the sensitivity of Genuine Savings (GS), a widely used economic indicator of sustainable development, to methodological choices in practical wealth accounting. Using a sample of 33 countries and two major international datasets (World Bank and AMECO), theoretically equivalent but methodologically distinct savings-based (GS) and investment-based (GI) approaches are compared. The results show that substantial discrepancies can arise between GS and GI estimates, both across and within the datasets. Disparities generally exceed the magnitude of the key environmental adjustments in standard GS calculations and can result in conflicting sustainability signals. We highlight internal savings–investment consistency issues, particularly within the World Bank dataset, and demonstrate that, despite theoretical equivalence, the GS and GI estimates can diverge considerably in practice. Our findings suggest that policymakers using wealth-based indicators should shift focus from a binary interpretation (positive = sustainable, negative = unsustainable) to identifying persistently low savings levels. More broadly, it is important to conduct internal consistency checks for robust empirical assessments of sustainable development.

Keywords: Wealth, Sustainability, Natural Capital, Sustainable Development

JEL Codes: Q01, Q56, N10,

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1 Introduction

During the past 50 years, debates about the environmental impact of economic growth and its long-term sustainability have spurred efforts to develop more holistic measures of economic progress (Nordhaus and Tobin, 1973; Solow, 1974; Dasgupta and Heal, 1974; Solow, 1993; Fleurbaey and Blanchet, 2013; Stiglitz et al., 2009). A growing consensus now advocates for moving beyond Gross Domestic Product (GDP) to focus on the management of the capital assets that underpin future well-being opportunities, specifically (changes in) national *wealth* (Polasky et al., 2015; Clark and Harley, 2020; Dasgupta, 2021, 2025). This shift in perspective has led to a revision of the System of National Accounting that now explicitly acknowledges this clear link between our current wealth and future well-being:

> *'From an economic and accounting perspective, the capacity to provide well-being in the future is most readily interpreted in terms of the capital available to underpin future well-being, with the relevant stocks of capital encompassing economic, natural, human, and social capital.'* (United Nations, 2025, Ch. 35)

As emphasized in the *Economics of Biodiversity Review*, to assess the sustainability of economic development, "nations need to adopt a system of economic accounts that records an inclusive measure of their wealth" (Dasgupta, 2021). This perspective aligns with a well-established theoretical framework for measuring wealth in the context of sustainable development (Dasgupta, 2014; Hanley et al., 2015). Two contrasting approaches, though theoretically consistent, have emerged for providing empirical estimates of inclusive or comprehensive wealth.

The first, developed by the United Nations Environment Programme (UNEP), adopts a "bottom-up" framework for estimating inclusive wealth. Drawing on the work of Partha Dasgupta, Kenneth Arrow, and colleagues (Arrow et al., 2012; Dasgupta, 2009; UNEP, 2023), this method constructs direct estimates of each individual capital stock; natural, physical, and human. The policy relevance of this approach lies in how inclusive wealth changes over time, offering insight into whether national wealth is increasing or depleting.

The second approach, led by the World Bank, originated as a "top-down" or indirect empirical method developed from the work of David Pearce, Kirk Hamilton, and others (Pearce and Atkinson, 1993; Hamilton and Clemens, 1999). Rather than directly estimating capital stocks, this method adjusts existing national accounting aggregates to approximate changes in wealth through an indicator termed Genuine Savings (GS). A finding of negative GS implies unsustainable development, since year-on-year total capital is declining. GS begins with Net National Savings (NNS) and introduces adjustments for depreciation of natural resources, pollution damage, and investment in human capital. In recent years, however, researchers at the World Bank have shifted focus to bottom-up estimation of what it calls Comprehensive Wealth, alongside its top-down or indirect measures of Adjusted Net Savings (ANS), or "real-world" GS.

Within both approaches, wealth is defined as encompassing all assets from which people derive well-being over time, either directly or indirectly (Dasgupta, 2001; Hamilton and Clemens, 1999). As shown by Arrow et al. (2012), current changes in wealth are then proportional to future changes in welfare thus positive growth in per capita wealth is a necessary condition for sustainable development (Weitzman, 2017; Fenichel and Abbott, 2014; Yun et al., 2017). Although both approaches are theoretically consistent, they are led by different international agencies, each employing distinct methodologies for calculating real-world estimates. The existing literature highlights several methodological issues, leading to considerable discrepancies in the direct wealth estimates provided by the World Bank and UNEP (McLaughlin et al., 2024; Tokimatsu and Yasuoka, 2025). Additionally, internal inconsistencies within the World Bank's approach have been noted, as its indirect estimates of GS often differ substantially from the direct estimates of the change in wealth (McLaughlin et al., 2014, 2024). This paper investigates the sensitivity of the indirect GS approach to methodological choices in practical wealth accounting.

In addition to the existing literature, the paper highlights further methodological issues that affect the World Bank GS database and offer potential resolutions. Our first contribution relates to the limited historical coverage of the GS database, largely due to missing data on Gross National Savings (GNS). To address this gap, the European Commission's Annual Macro-Economic (AMECO) database is utilised. AMECO allows an extension of the World Bank series for several countries but reveals considerable discrepancies between the two datasets for overlapping years. Secondly, as alluded to above and discussed in more detail within Section 2, there is confusion in the wealth accounting literature over the use of savings and investment terminology. Those scholars favouring the investment terminology (as in comprehensive, net or genuine investment (GI)), do so on the basis of avoiding confusion over common usage of the term savings in macroeconomics (Neumayer, 2025). However, a similar argument could likewise be used to defend the savings terminology.

The core contribution of this paper is to investigate if there are more substantive empirical or methodological reasons for preferring an estimate of GI over GS as a sustainability indicator, or vice versa. To our knowledge, this is the first paper in the GS literature to explicitly focus on the implications of a potential savings-investment methodological mismatch. Savings and investment disparities can occur within national accounting due to the calculation of conventional savings as a residual (Gross National Income - Consumption), whereas investment is calculated more directly. We utilise a sample of 33 countries and two major international datasets (World Bank and AMECO) to compare theoretically equivalent though methodologically distinct savings-based (GS) and investment-based (GI) approaches to investigate two key research questions;

RQ1. Can the choice of data source for conventional savings result in meaningful differences in the GS estimate?

RQ2. Can utilising GI lead to a meaningful difference in the sustainability signal compared to GS?

We demonstrate that changing the dataset for conventional savings or investment yields disparities between estimates of GS and GI that are generally larger than the adjustment for natural capital in the standard GS calculation. These disparities are also large enough to change the sustainability signal from positive to negative GS/GI, or vice versa, in several countries in at least one year. Furthermore, we find that, while theoretically equivalent, estimates of GS and GI can differ even within the two datasets. Finally, we highlight instances where it may be methodologically more appropriate for researchers to use a measure of GI rather than GS.

2 Wealth Accounting in Theory & Practice

The stocks of produced, natural, human and social capital in an economy at any point in time, together referred to as comprehensive or inclusive wealth, ultimately provide future flows of well-being. Thus, declining wealth signifies falling future well-being. Sustainable development is defined as non-declining well being (or well-being opportunities) over time thus a wealth-well-being equivalence exists between current period changes in the capital stock and future well-being (Pearce and Atkinson, 1993; Hamilton and Clemens, 1999; Arrow et al., 2012).

The comprehensive accounting model can be conceptualised within what has been referred to as the "pure theory of perfectly complete national income accounting" (Weitzman, 2017). The general model considers an economy where the population is constant, and well-being or utility at time t, $U(C(t))$, depends on a consumption bundle representing all determinants of instantaneous utility, $C(t)$. A vector of broadly defined capital stocks captures the determinants of net productive capacity, $K^*(t)$, i.e., comprehensive or inclusive national wealth. The literature generally posits that K is comprised of physical (K_f), human (K_h), and natural capital (K_n) assets. Thus, $K = (K_f, K_h, K_n)$. A resource allocation mechanism (RAM) characterizes all the constraints an economy faces at any given time, which could be technical, institutional, or environmental. Net investments correspond to changes in the capital stocks such that $I^+ = \Delta K^+$. The superscript $+$ indicates the "augmentation" of the assets to reflect exogenous technical progress, following Pemberton and Ulph (2001) and Pezzey (2004), where time can be modelled as a form of capital, i.e., $K^+ = (K, t)$ and $I^+ = (I, 1)$. The set of production possibilities is a convex set S that depends on K^+, such that (C, I^+) is feasible given K^+ if and only if $(C, I^+) \in S(K^+)$. The RAM defines the path for $C(t), I^+(t), K^+(t)$, which is not necessarily optimal. In this context, the present value of future consumption changes equals the value of net investments, i.e., Genuine Savings (GS). Using a constant real interest rate, R, this can be written as;

$$PV\Delta C = \int_t^{\infty} P_C(s)C(s))e^{-R(s-t)}ds = P_I(t)I^+(t) \tag{1}$$

where P_C and P_I represent the shadow prices of consumption and investment, respectively. The powerful conclusion of the general model is thus that the level of GS 'correctly' valued $(P_I(t)I^+(t))$ corresponds to variations in inter-generational well-being, and is thus a forward-looking indicator of sustainability (Dasgupta, 2009). Positive GS implies at least an initial welfare improvement (Arrow et al., 2012) but cannot guarantee that well-being will never decline at some future point, as an assessment of the entire and unobservable equilibrium path would be needed to make this stronger claim (Asheim, 1994; Pezzey, 2004). Although the theory provides a strong set of foundations that underpin the comprehensive/inclusive wealth concept, there remains a demanding assumption of "complete accounting" where all capital stocks are included and accounted for with the correct shadow prices (Weitzman, 2003). Real world empirical application will naturally be constrained by data availability and market failures and will be heavily influenced by different methodological choices used to approximate the theory.

2.1 Wealth Accounting in Practice

The core methodological starting point for wealth accounting lies in the choice between two approaches: savings or investment.

The first is the bottom up approach: directly measuring wealth by assessing the total value of each capital asset to determine total wealth (W) and then assessing net investment (changes in total wealth) through time. The World Bank has been publishing comprehensive wealth reports since 2006 (World Bank, 2006; 2011; 2018; 2021; 2024). The United Nations Environment Programme (UNEP) began releasing similar assessments from 2012 (UNEP, 2012; 2014; 2018; 2023). Both institutions adopt a comparable framework, estimating (W) as the sum of natural, human, and physical capital (note that social capital is not explicitly accounted for). However, they differ in their methodological choices in terms of valuation and the data sources used to estimate the value of each stock. Recent studies have examined the implications of these methodological differences. McLaughlin et al. (2024) demonstrate that these differences can produce contradictory sustainability signals. In some cases, countries rated as unsustainable under the UNEP framework perform favourably in the World Bank dataset. Tokimatsu and Yasuoka (2025) similarly report large disparities between the two institutions.

The second approach is top down: estimating changes in wealth indirectly (Δw) starting with adjustments to System of National Accounts (SNA) aggregates to yield a measure of GS for each year. The World Bank has published GS figures in the *World Development Indicators* since 1997 (World Bank, 1997). Conceptually, (W) refers to the aggregate stock of capital assets, whereas GS measures changes in that stock over time (Δw), without capturing wealth directly. For physical capital, the stock represents the accumulated value of past investment in produced capital, net of depreciation, an analogous concept to Net National Savings (NNS), calculated as Gross National Savings (GNS) minus depreciation. Hamilton and Clemens (1999), building on Pearce and Atkinson (1993), developed the theory that underpins the World Bank's GS indicator, termed Adjusted Net Savings (ANS), as shown in Eq. 2. For a detailed exposition of this methodology, see World Bank (2018).

$$GS = GNS - D_f - D_n + A_h \tag{2}$$

Starting from the conventional measure of savings, GNS, the net depreciation of physical capital (D_f) is subtracted using the reported consumption of fixed capital (CFC) estimate. GNS-CFC equates to NNS, another standard item in the national accounts. The depletion of natural capital (D_n) is subtracted and valued by estimating the extraction of subsoil assets (oil, natural gas, coal, bauxite, copper, gold, iron ore, lead, nickel, phosphate, silver, tin, and zinc), timber resources, and pollution damage (carbon dioxide and particulate matter). Finally, human capital accumulation (A_h) proxied by educational expenditures is added.[1] For cross-country comparisons, GS is reported as a savings rate by dividing GS by Gross National Income (GNI).

2.2 A Brief Defence of Indirect Wealth Accounting

Until recently, the World Bank's comprehensive wealth estimates were accompanied by a strong emphasis on GS. World Bank (2021) marked a considerable shift in focus towards direct wealth accounting by explicitly stating that its "preferred measure of sustainability is the change in total wealth per capita". World Bank (2024) was then the first comprehensive wealth report to omit a complementary GS analysis section.

We believe that the declining prominence of the indirect GS approach is unfortunate for several reasons. First, World Bank (2021) does not provide any empirical justification for favouring direct wealth accounting. In contrast, a substantial body of theoretical and empirical literature supports GS as a predictor of long-term well-being, consistent with economic theory (Ferreira and Vincent, 2005; Ferreira et al., 2008; Hamilton and Hartwick, 2005; Greasley et al., 2014; McGrath et al., 2024). Another key strength of GS is the capacity to produce long historical

[1]The education spending approach has attracted criticism (Jorgenson and Fraumeni, 1992) as it implies a 1 for 1 relationship between spending and human capital accumulation. This method is defended as it corrects for the misallocation of investment expenditures as consumption within the national accounts and may be interpreted as a lower-bound estimate (Hamilton and Clemens, 1999.)

data series and more timely, policy-relevant estimates, owing to its lesser data requirements and closer alignment with SNA conventions. The availability of long-term historical data is crucial for empirical studies to test the key propositions of wealth accounting theory (Greasley et al., 2014; McGrath et al., 2021). Direct wealth estimates, whether from UNEP or the World Bank, are only available from 1990 onwards. In contrast, empirical GS studies provide estimates dating back to the mid 18th century (Greasley et al., 2014). For policymakers, the most recent direct wealth estimates relate to 2018. The World Bank GS estimates are currently available for 2021 and this time series is limited by a need for comparability across a large sample. It is feasible that a researcher or national statistical agency could calculate more recent GS for individual countries by using national data. For example, the UK Office of National Statistics has published inclusive income and wealth estimates for the UK from 2005-22 (Heys and Taylor, 2025).

The World Bank states several omissions within its own GS measure as reasons for preferring direct accounting. These omissions include population growth, technological change, and resource discovery (Pezzey, 2024). However, researchers have demonstrated that GS estimates can be constructed to account for capital gains (Rubio, 2004; Pezzey et al., 2006), resource discoveries (Qasim et al., 2020), and technological progress (Greasley et al., 2014; Mota and e Sá, 2019; McGrath et al., 2024). Regarding population growth, the World Bank presents GS as a share of GNI to facilitate cross-country comparisons. However, GS can easily be presented on a per capita basis by dividing GS by the population (Ferreira and Vincent, 2005; Ferreira et al., 2008; Greasley et al., 2014). To directly compare GS with changes in total wealth, it is necessary to adjust for 'wealth dilution' (Asheim et al., 2023). Several studies have included this wealth dilution term within GS (Ferreira et al., 2008; Greasley et al., 2014).

Given the strengths and weaknesses of both direct and indirect wealth accounting, it seems prudent to use both approaches in a complementary fashion. We echo the call of McLaughlin et al. (2024) who propose the use of semi-regular direct estimates of wealth, possibly at five-year or decadal intervals. These broad, data-intensive exercises could then be supplemented by annual estimates of indirect wealth changes, with periodic assessments of the accuracy of these estimates and adjustments as needed (Pezzey, 2024). This approach mirrors how annual vital registrations supplement population census data.

2.3 Issues with the World Bank's Genuine Savings Database

Since the seminal work of Hamilton and Clemens (1999), the World Bank GS database had contained a consistent and comparable time-series for most countries in the world extending back to 1970. However, the shift in focus away from indirect to direct wealth accounting has coincided with the 2024 iteration of the GS database being severely limited. For most countries, the GS estimates start in 1990 or 1995.

The World Bank's methodology has undergone some major changes since the publication of Hamilton and Clemens (1999). However, a key limiting factor in the current database is the basic issue of missing GNS data, without which GS cannot be computed. The methodology employed by the World Bank to add local air pollution, and indeed in many cases, the inclusion of carbon damages does also limit most countries to 1990. Here, it should be noted that historical GS estimates can be made for individual countries that include long-term carbon and local air pollution damages (McGrath et al., 2021a; Lindmark and Acar, 2013, 2014) and GS estimates for much larger samples have been made that incorporate pollution damages (McLaughlin et al., 2023)). The focus of this paper relates to conventional savings and investment aggregates, and although remedies to missing historical carbon damages could be applied, for ease of exposition, we focus on a more limited estimate of GS that excludes pollution damages.[2]

A partial remedy for missing GNS data is to use an alternative data source. In our study, we employ the annual macroeconomic database of the European Commission's Directorate-General for Economic and Financial Affairs (AMECO). We use AMECO data for thirty-three countries, twenty-two of which have a longer GNS time series than the World Bank dataset (see table 1). Notably, the AMECO dataset extends back to 1970 for as many as nineteen countries, compared to just five in the World Bank series.

Table 1: Gross National Savings (GNS) Data Availability: World Bank and AMECO

Country	GNS World Bank	GNS AMECO	Country	GNS World Bank	GNS AMECO
Belgium	2002	1970	Finland	1975	1970
Denmark	1975	1970	Sweden	1970	1970
Ireland	2005	1970	United Kingdom	1970	1970
Greece	2006	1970	Slovenia	1995	1990
Spain	1975	1970	Slovakia	1995	1991
France	1975	1970	Poland	1995	1991
Italy	1970	1970	Latvia	1995	1992
Iceland	1976	1970	Lithuania	1995	1993
Netherlands	1970	1970	Czechia	1993	1993
Austria	2005	1970	Estonia	2000	1993
Japan	1996	1970	Hungary	1993	1993
Switzerland	1995	1970	Bulgaria	1980	1995
Norway	1975	1970	Croatia	1995	1995
South Korea	1976	1970	Cyprus	1976	1995
Malta	1971	1995	Serbia	1974	1970
North Macedonia	1996	1997	Portugal	1975	1970
United States	1970	1998			

Source: World Development Indicators and AMECO Database downloaded November 2024

[2]In fact, the precise incorporation of pollution damages within the GS calculation is debated within the literature (McGrath et al., 2021b; Mota et al., 2010; Mota and Domingos, 2013).

2.4 Genuine Savings or Genuine Investment?

There is considerable confusion in the economics literature on sustainable development regarding the savings versus investment terminology. Usually, the literature speaks in terms of savings, referring to "Genuine Savings" (GS) rather than "Genuine Investment" (GI), even though the two are theoretically equivalent.[3]. However, several scholars argue that investment would have been a better descriptor (Dasgupta, 2001; Arrow et al., 2004, 2007; Neumayer, 2025).

Hamilton (1994) introduced the GS term to represent the change in wealth captured by a comprehensive measure of net investment over some period. GS thus reflects the change in the welfare equivalent value of all capital assets. Later, Hamilton and Clemens (1999) presented a more formal theory and empirical method to calculate GS using real-world data. Hamilton was building on the concept of a welfare relevant measure of net national product i.e., consumption plus comprehensive net investment (Weitzman, 1976; 1997), whilst Pearce and Atkinson (1993) utilised capital theory to develop a "savings rule" for sustainable development. Hamilton and Clemens note that conventional savings (gross and net) represent the *"traditional measure of a nation's rate of accumulation of wealth"* thus "genuine" distinguished the metric as a more comprehensive measure of wealth changes. The World Bank then began constructing real-world GS estimates, based on Hamilton and Clemens, but adopted the term "adjusted net savings" to differentiate the empirical methods from the theory (Bolt et al., 2002).

Neumayer (2025) argues that using investment rather than savings would avoid confusion with the narrower concept of private savings which is a common definition for savings in macroeconomics. Neumayer explains that this is an important distinction as *"in a closed economy, private savings is equal to investment plus government expenditures minus taxes. Savings in the usage of genuine savings instead refers to the sum of private and public savings (taxes minus government expenditures), which generates the equality between total savings and investment."*

Neumayer quite rightly uses the example of a closed economy to illustrate his point clearly. However, when we consider the savings-investment equality for an open economy it becomes more complicated regarding investment in comparison to savings. This may lead to a different source of confusion and another possible reason for the persistent use of the savings terminology.

To explain, first consider that, beginning in the Bolt et al. (2002) "Manual for Calculating Adjusted Net Savings", the GS calculation starts from GNS a standard item in the national accounts (Eq .2) and then subtracting depreciation yields net savings, another standard item. However, an equivalent net investment figure, in the context of GS, is not simply gross investment (GCF) less depreciation as this is only true in a closed economy. In an open economy the savings-investment equality must account for net exports (NX) with the rest of the world (Eq. 3).

[3] For example, in their survey of the literature, Hanley and McLaughlin (2015) use the terms GS and GI interchangeably

$$NX = S - I \tag{3}$$

To better illustrate the savings-investment equality we can re-arrange into Eq. 4

$$S = I + NX. \tag{4}$$

In the terminology of the modern system of accounts, this savings-investment equality can be formulated within the well known Current Account Balance (CA) identity (IMF, 2009) as shown in Eq. 5.

$$CA = GNS - GCF. \tag{5}$$

The current account balance is the difference between domestic savings (GNS) and domestic investment (GCF) thus a surplus means that the domestic savings being generated are being invested abroad and thus creating foreign assets i.e., a nation is exporting more than it imports. In the context of GS, it makes more sense to re-arrange into Eq.6 which is equivalent to Eq. 4.

$$GNS = GCF + CA \tag{6}$$

One can then naturally think of an investment-based measure of GS, which we term Genuine Investment (GI), by subbing in GCF + CA for GNS into Eq.2 thus yielding Eq. 7 and the obvious conclusion that GS = GI amounts to an accounting identity.

$$GI = GCF + CA - D_f - D_n + A_h = GS \tag{7}$$

For simplicity, we define Gross Investment (GInv) as GCF + CA and thus the GI calculation simplifies to Eq 8:

$$GI = GInv - D_f - D_n + A_h \tag{8}$$

Net investment is commonly understood as GCF less depreciation but, as shown above, in the context of GS would equate to (GCF + CA) less depreciation. Those scholars favouring the investment terminology do so on the basis of avoiding confusion over the term savings rather than for any empirical reason. However, one might likewise defend the savings terminology to avoid confusion over the term investment.

The focus of our paper is to investigate if there are substantive empirical or methodological reasons for one to prefer an estimate of GI over GS, or vice versa. Interestingly, Hamilton and Clemens (1999), cited by Bolt et al. (2002), as the basis for the World Bank GS indicator, actually produced estimates of what we term as GI rather than GS. Hamilton and Clemens clearly state that *"the starting point in the calculation of genuine savings is just standard national accounting...**gross domestic investment**.... Net foreign borrowing, including net official transfers, is then subtracted...to give gross savings"*. [4] It appears that Bolt et al., likely for convenience, took it as given that GNS = GCF + CA held in the data and simply start the GS calculation from GNS. However, a key methodological issue here relates to the fact that GNS is calculated as a residual in the national accounts (national income less total consumption) whereas GCF and CA are calculated more directly. The residual nature of the savings calculation means that GNS can be more inconsistent and more sensitive to data revisions than GCF and CA (Beckmann et al., 2022). Consequently, the assumption that GNS = GCF + CA may not always hold in the real-world data due to measurement error or statistical discrepancies meaning that real-world estimates of GS and GI could differ.[5]

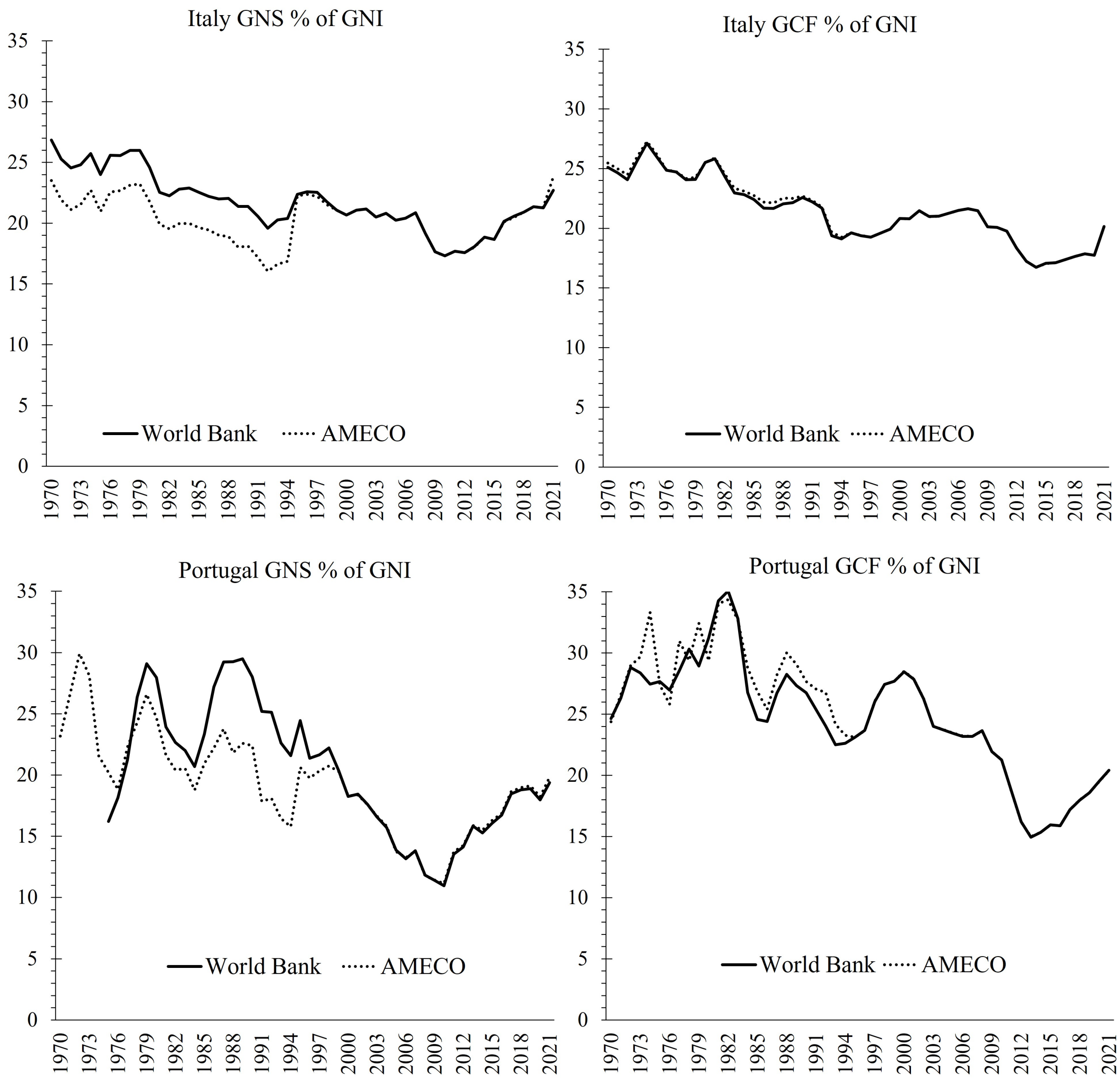
In this regard, we found an interesting puzzle when we compared the estimates of GNS in both the AMECO and the World Bank datasets as we noticed some remarkable disparities. The cases of Italy and Portugal provide clear illustrations. As shown in Figure 1, there are stark differences particularly between 1970 and 2000. This is important as any large disparity in the estimate of GNS will naturally feed into the resultant GS calculation. If these large differences across the two data sources stem from the residual calculation of GNS, one indication would be that the more directly measured investment aggregates would be more consistent. Figure 1 tentatively supports this hypothesis, revealing much more consistent estimates of GCF for both Portugal and Italy throughout the entire time series.

To investigate this potential savings-investment mismatch more generally, we utilise the World Bank and AMECO datasets to construct investment-based equivalent measures of GS, termed Genuine Investment (GI) to compare with the conventional savings-based approach across a sample of 33 countries.

[4] Please note that gross domestic investment is now termed gross capital formation to better distinguish capital accumulation from financial investment (IMF, 2009) and net foreign borrowing (including transfers) is the mirror of the current account balance i.e., a nation with a current account deficit is a net foreign borrower

[5] Savings volatility has led some authors who construct long-run historical GS estimates to prefer NCF over NNS in the computation of GS (Greasly et al., 2014).

Figure 1: Italian and Portuguese Gross Savings and Gross Capital Formation: World Bank and AMECO



3 Testing the Consistency of the Savings and Investment Data - World Bank v AMECO

3.1 Comparing Genuine Savings Estimates: World Bank v AMECO

Our first research question (RQ1) examines how using different sources for conventional savings data impacts the resulting GS estimates. To this end, we construct two series of GS estimates for each country in our sample, GSWB and GSAM. Gross Savings, depreciation, and national income data are sourced either from the World Bank's WDI dataset (GSWB) or the EU AMECO dataset (GSAM). All other components are common and taken from the World Bank WDI dataset (see data appendix). The AMECO dataset permits the construction of a longer time series for twenty two out of the thirty three countries in the sample. However, for a fair comparison of GSWB and GSAM, the estimates for each country are limited by whichever series has the shortest time series (see Table 1).

Table 2 compares the averages of the two GS measures over the full sample. No general pattern of one series being consistently higher was observed. The annual differences that are positive in some years are partially or wholly 'washed away' in the average by negative differences others. Comparing averages can thus hide some large disparities. An extreme case is Malta, where the mean of GSAM and GSWB were almost identical yet the average absolute difference was over 3 percentage popints (pp) of GNI. Consequently, our main metric of interest is the average of the absolute differences between both series.

For the full sample, the average annual difference was 0.92pp of GNI with a large standard deviation of 0.90pp of GNI. This disparity is far from inconsequential, as this average difference is more than double the average adjustment for the totality of estimated natural resource depletion (0.4% of GNI). The use of averages also masks the large disparities that occurred in individual years and the resulting contrast in policy signals - since GS is interpreted as an instantaneous signal of future sustainability. The estimates of GS differed by more than 20 pp of GNI in Cyprus and by more than 5 pp of GNI in six other countries, in at least one year (Portugal, Iceland, Luxembourg, Bulgaria, North Macedonia and Malta).

McLaughlin et al. (2024) as well as Tokimatsu and Yasuoka (2025) show that methodological differences between direct estimates by the World Bank based on changes in total wealth and indirect estimates of GS can lead to divergent sustainability signals for the same country. These discrepancies arise when, in a given year, the direct measure suggests positive savings, while the indirect GS estimate reports negative savings, or the reverse. Our findings show that even within the indirect GS approach, the methodological choice of data source for conventional savings can also generate inconsistent policy signals. In our analysis, this kind of policy signal disagreement occurred in at least one year for seven countries; Bulgaria, Cyprus, Greece, Malta, Slovakia, North Macedonia, and Iceland.

The disparity across the savings estimates was far more pronounced prior to the 2000s. This increased variation may relate to how revisions to the System of National Accounts have been handled in each dataset. For example, a major revision to the accounting framework occurred in 1995 (ESA95) stemming from the 1993 revisions to the SNA. According to the notes accompanying the AMECO dataset, modern data relies on the the European System of Accounts (ESA) 2010, based on the SNA, while relying on the ESA 95 and ESA 79 versions for earlier periods. To address discontinuities, the AMECO dataset utilises data for overlapping years and

Table 2: Full Sample Averages of Gross National Savings: World Bank vs. AMECO (% of GNI)

Country	GSWB	GSAM	Absolute Annual Difference
Malta	12.58	12.43	3.39
Iceland	7.34	7.70	2.98
Cyprus	8.74	7.11	2.85
Portugal	8.00	6.43	2.00
North Macedonia	6.17	6.66	1.87
Italy	10.48	8.77	1.76
Switzerland	16.41	14.93	1.47
UK	6.17	7.08	1.12
Bulgaria	9.97	9.00	1.09
Sweden	17.07	17.58	0.97
Netherlands	15.18	14.58	0.87
Serbia	4.42	3.58	0.84
Croatia	6.36	5.61	0.80
Estonia	15.19	14.59	0.69
Denmark	13.97	13.36	0.67
Ireland	14.52	14.03	0.62
Czechia	10.34	9.78	0.56
Greece	(-3.41)	(-3.83)	0.50
Slovenia	10.86	10.47	0.41
France	11.11	10.79	0.40
Spain	11.28	10.94	0.40
Poland	10.09	10.44	0.39
Slovak, Rep.	4.66	4.59	0.34
Latvia	(-0.32)	(-0.26)	0.28
USA	6.88	6.32	0.26
Norway	16.42	16.57	0.24
Finland	13.53	13.51	0.23
Belgium	12.85	13.04	0.20
Lithuania	7.51	7.47	0.16
Japan	7.76	7.88	0.15
Hungary	8.34	8.37	0.14
Austria	14.00	14.06	0.11
Korea, Rep.	22.81	22.84	0.08
Sample Avg.			0.92
Sample Std. Dev.			0.90

then adjusts the older series by applying historical growth rates to newer series' levels. It is not clear how the World Bank deals with these discontinuities.

Circa 1995, GSWB and GSAM tend to converge for many countries. However, several notable exceptions show a persistent disagreement, even in the modern data. For example, in the UK, there is a gap, as large as 4pp of GNI, until 1996, after which the two series converge. In contrast, Iceland exhibits a persistent gap between the two GS measures throughout the entire sample period (see Figure A.1 in the appendix).Similar long-lasting discrepancies were observed in Bulgaria, Croatia, Cyprus, Luxembourg, Malta, Switzerland, Poland, and Serbia.

To examine the historical divergence in greater detail, we restricted the analysis to countries with a sufficiently long time series of overlapping data for both GSWB and GSAM (Table 3). In this historical sub-sample, the average absolute annual difference in the GS rate reached 1.5pp of GNI, 63% higher than the disparity observed in the full sample. A larger standard deviation of 1.2 pp of GNI was also observed. In some cases, such as Portugal, Italy, Iceland, and the UK, the difference between the two measures was found to be as large as 2-4 pp of GNI on average. This represents a substantial divergence in practical terms, comparable to the adjustment for human capital in the conventional GS calculations. For example, in Italy, the average absolute difference between GSWB and GSAM from 1970-95 was 3.4% of GNI. Over the same period, the average human capital adjustment was 4% of GNI.

Table 3: GSWB and GSAM: Pre-1995 Sub-Sample

% of GNI			
Country	GSWB	GSAM	Avg. Absolute Annual Difference
Portugal	12.2	9.0	4.1
Italy	13.2	10.1	3.4
Iceland	8.3	5.9	2.6
UK	7.4	8.8	1.8
Sweden	16.2	17.2	1.7
Netherlands	15.8	14.5	1.4
Denmark	11.7	10.7	1.0
Spain	11.9	11.2	0.8
France	12.0	11.5	0.6
Finland	13.5	13.6	0.2
Norway	13.5	13.5	0.1
Korea	25.5	25.5	0.1
Sample Avg.			1.5
Sample Dev.			1.2

It is clear from the results above that, in relation to RQ1, there can be meaningful differences in the estimated measure of GS depending on the methodological choice of database used for conventional savings.

3.2 Comparing Genuine Investment Estimates - World Bank V AMECO

Section 3.1 revealed some considerable discrepancies between GSAM and GSWB, which may stem from the residual-based nature of the savings aggregates within the national accounting framework. As outlined in Section 2, a theoretically equivalent investment-based version of GS, which we term GI, can be derived using Eq. 8. We examine both (i) the extent of the difference between GI estimates based on World Bank (GI(WB)) and AMECO data (GI(AM)) and (ii) whether these differences are larger or smaller than those observed using the GS approach. GI(WB) and GI(AM) differ only in their sources of income, capital formation and the current account balance, all other components are common (see data appendix).

As noted in Section 3.1, discrepancies between the two GS measures were considerably larger during the period from 1970-95. Table 5 presents a comparison of the GI estimates over the same pre-1995 sub-sample of countries, directly comparable with Table 4. Our initial findings suggest greater consistency under GI, as evidenced by a lower average absolute difference of 1.1 pp of GNI, compared to 1.5 pp under the GS approach. The standard deviation was also lower under GI, at 0.7 pp of GNI, compared to 1.2 pp for GS. Furthermore, GI demonstrated greater consistency over time. The average disparity between GSAM and GSWB was notably greater during the pre-1995 period (1.5 pp of GNI) than over the full sample (0.9 pp). In contrast, the difference between GI(WB) and GI(AM) remained stable, at 1.1 pp of GNI pre-1995 and 1.0 pp in the full sample.

Although the GI approach offered less variation and more consistency, on average, the lower levels of disparity were not universal. Six of the twelve countries (Portugal, Italy, Iceland, Netherlands, Spain, and Denmark) exhibited smaller discrepancies using GI than GS. Two countries (the UK and Sweden) showed virtually no difference between the two methods, while four (Finland, France, the Republic of Korea, and Norway) actually recorded greater divergence using GI.

Table 4: GI(WB) and GI(AM): Pre-1995 Sub-Sample

% of GNI			
Country	GI(WB)	GI(AM)	Absolute Annual Difference PP of GNI
Portugal	13.0	11.6	2.8
UK	10.4	8.9	1.9
Sweden	18.5	15.9	1.7
Iceland	7.6	7.8	1.5
Finland	12.4	14.6	1.4
France	12.1	11.3	0.9
Korea, Rep.	25.4	25.8	0.9
Netherlands	16.2	16.9	0.8
Italy	13.8	13.0	0.8
Spain	13.2	12.6	0.5
Norway	13.4	13.2	0.4
Denmark	10.3	10.4	0.3
Sample Avg.			1.1
Sample Std. Dev.			0.7

Table 5 presents the results for the full sample, the average absolute difference between the two GI measures was similar to the differences observed using the GS approach though slightly higher (0.99 v 0.92% of GNI).[6]. However, there was less variation observed, under GI, as evidenced by a lower standard deviation when compared with the GS approach (0.67 v 0.90% of GNI). As with the pre-1995 sample, no universal improvement was observed using the GI approach. In fact, just over half of the sampled countries (17 of the 32) recorded less disparity under GS.

In relation to RQ2, GI offered less disparity and less variation in historical estimates before

[6]While the results are not impacted there is a slight difference in the time periods included in the GI sample compard to GS sample. For GI, Romania goes back to 1989 rather than 1990; and Croatia goes back to 1999 rather than 1995

1995, on average, and less variation across the entire of the sampled countries than the savings-based GS approach. However, this improvement was not universal. This suggests that the residual-based calculation of the savings aggregates cannot solely explain the disparity observed between GS and GI. A related driver is the internal consistency of the datasets, i.e., the extent to which Eq. 6 holds in the real world data which we explore in Sections 3.3 and 3.4.

Table 5: Full Sample Averages of Gross National Savings: World Bank vs. AMECO (% of GNI)

Country	Avg. GI(WB)	Avg. GI(AM)	Avg. Absolute Annual Difference
Malta	14.59	12.32	3.11
Cyprus	8.85	7.10	2.95
Hungary	8.63	8.37	1.82
Ireland	15.45	14.25	1.61
Bulgaria	8.23	9.65	1.61
Portugal	8.39	7.67	1.47
Iceland	8.46	9.18	1.45
Slovak, Rep.	5.39	4.56	1.29
Sweden	18.08	17.59	1.18
Belgium	11.87	13.03	1.17
Estonia	15.05	14.70	1.16
North Macedonia	6.44	6.08	1.04
Switzerland	15.85	14.94	1.02
UK	7.91	7.10	1.02
Serbia	2.83	3.57	0.88
Greece	(-3.13)	(-3.84)	0.86
Lithuania	8.23	7.45	0.85
France	10.78	10.79	0.83
Netherlands	15.71	15.82	0.81
Finland	12.89	13.41	0.80
Czechia	10.19	9.81	0.73
Slovenia	11.19	10.48	0.72
Latvia	0.20	(-0.31)	0.66
Croatia	6.29	6.32	0.61
Italy	10.92	10.38	0.57
Korea, Rep.	22.74	22.83	0.56
Norway	16.40	16.53	0.44
Denmark	13.09	13.36	0.39
Spain	12.11	11.74	0.38
Poland	10.27	10.44	0.33
Austria	14.02	14.09	0.25
USA	6.54	6.48	0.08
Japan	7.83	7.88	0.06
Sample Avg.			0.99
Sample Std. Dev.			0.67

3.3 Comparing Internal Consistency: Does Saving Equal Investment in AMECO and/or World Bank datasets?

The internal consistency of both the World Bank and AMECO datasets is tested by examining whether the theoretical savings-investment equality for an open economy, Gross National Savings (GNS) = Gross Investment (GInv), holds in each dataset.[7] Deviations can occur in national accounting data due to measurement error and statistical discrepancy. Internal consistency is thus measured as the average absolute deviation between GNS and GInv during the observed period. A deviation of zero would indicate perfect internal consistency. Tables 6 and 7 report the results for the twelve countries where data are available from the 1970s onwards. All variables are expressed as shares of GNI.

For the World Bank sub-sample (Table 6), the average absolute deviation between GNS and GInv was nearly 1 pp of GNI over the full period. In line with the earlier findings, this inconsistency was higher in the period before 1995, averaging 1.2 pp, and improved modestly to 0.7 pp after 1995. No country in the World Bank sub-sample achieved full internal consistency across the entire sample period or within either the pre-1995 or post-1995 sub-periods. The smallest deviation was observed in Norway, at 0.4 percentage points of GNI, while the largest was recorded in the United Kingdom, where the deviation reached 3 pp of GNI in the pre-1995 period. These findings are of practical importance for sustainability measurement as the observed inconsistency is also equivalent to the deviation that would be observed between a GS and GI measure. In fact, for Iceland there was one year, 2012, where the sustainability signal differed as GI was 2.3% of GNI compared with negative GS of (-1.7)% of GNI.

Table 6: World Bank Does S = I? - Pre 1995 Sub Sample

World Bank Data: % of GNI				
Country	1970-2021	Pre-1995	Post-1995	GS v GI Signal Change?
Denmark	0.9	1.0	0.8	No
Finland	0.9	1.4	0.4	No
France	0.7	0.6	0.8	No
Iceland	1.6	0.6	2.5	Yes
Italy	0.4	0.5	0.4	No
Korea	0.6	0.9	0.4	No
Netherlands	0.8	0.5	1.0	No
Norway	0.4	0.4	0.3	No
Portugal	0.9	1.4	0.5	No
Spain	0.8	1.5	0.3	No
Sweden	1.5	2.4	0.7	No
United Kingdom	1.7	3.0	0.4	No
Sample Avg.	0.9	1.2	0.7	Yes = 1

[7]Where GInv is defined as Gross Capital Formation (GCF) plus the Current Account Balance (CA) (see Section 2.4).

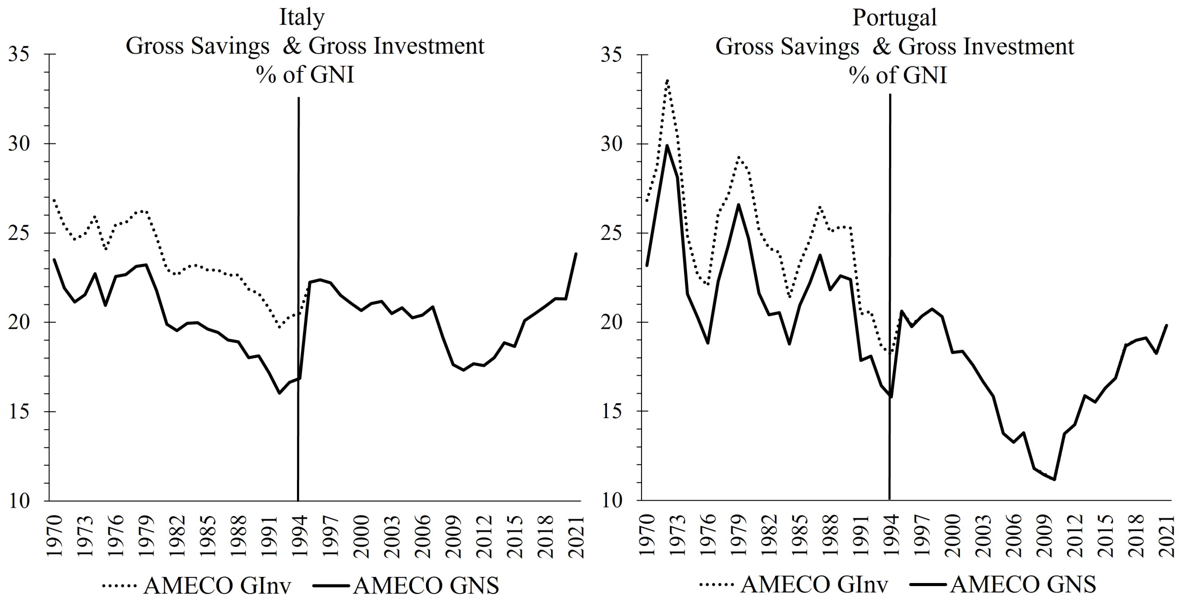
Table 7: AMECO Does S = I? - Pre 1995 Sub Sample

AMECO Data: % of GNI				
Country	1970-2021	Pre-1995	Post-1995	GS v GI Signal Change?
Denmark	0.0	0.0	0.0	No
Finland	0.4	0.5	0.3	No
France	0.0	0.0	0.0	No
Iceland	1.4	2.2	0.6	No
Italy	1.6	3.0	0.0	No
Korea	0.1	0.1	0.0	No
Netherlands	1.2	2.3	0.0	No
Norway	0.1	0.1	0.1	No
Portugal	1.2	2.5	0.0	No
Spain	0.8	1.6	0.0	No
Sweden	0.5	1.0	0.0	No
United Kingdom	0.1	0.3	0.0	No
Sample Avg.	0.6	1.2	0.1	Yes = 0

In contrast, the AMECO sub-sample (Table 7) demonstrated much stronger internal consistency. The average deviation, post 1995 was just 0.1 pp of GNI. Furthermore, after 1995, nine of the twelve countries exhibited perfect alignment between GNS and GInv and only a minor deviation of 0.1pp of GNI was observed in Norway. Similar to the findings above, there seems to be a break in the data prior to 1995 for some countries. Four countries maintained near-perfect consistency but the average deviation across the sample rose to 1.2 pp of GNI, matching that of the pre-1995 World Bank data. The increased deviation was driven by outliers in Italy, Portugal, and the Netherlands, that largely reflected volatility in AMECO's conventional savings data. Figure 2 illustrates this volatility in both Portugal and Italy. For both countries there is a distinct level shift between 1994 and 1995, whereas the investment series transition far more smoothly. Several factors may explain this discrepancy. One possibility is that the splicing method used to align pre-1995 data with the modern accounting framework was applied to the investment data in AMECO, but not to the savings series. Relatedly, inconsistencies may be a consequence of GNS being calculated indirectly as a residual of the more directly spliced aggregates comprising the GNI and consumption series (recall, GNS = GNI minus consumption).

Across the AMECO dataset, countries generally fall into three groups. First, some countries such as Denmark, France, Korea, Norway, and the United Kingdom show perfect or near-perfect internal consistency throughout the time series. Second, countries like Italy, Netherlands, Spain, Sweden and Portugal are consistent after 1995, but exhibit pre-1995 volatility primarily driven by savings inconsistencies. Finally, Iceland and Finland show persistent inconsistency that narrows in the post-1995 period but does not completely dissipate and does not appear obviously driven by savings volatility. The World Bank dataset presents a more general pattern of persistent inconsistency with a modest improvement after 1995.

Figure 2: Italian and Portuguese Gross Savings and Gross Investment: AMECO



The internal inconsistencies can help to explain the disparities observed in Sections 3.1 and 3.2 between the measures of GSAM/GSWB and GI(WB)/GI(AM). For example, the savings volatility in AMECO for Portugal and Italy explains the large disparity between GSAM and GSWB where Portugal and Italy both held the largest average deviations in the pre-1995 sub-sample (Table 3). GI(WB) and GI(AM) were much closer as the investment aggregates were less volatile (Table 4). Another example is Denmark where similarly there was a large disparity between GSAM and GSWB and a closer relationship between GI(AM) and GI(WB). However, in the Danish case, there was perfect internal consistency within the AMECO dataset. The large disparity between GSAM and GSWB was instead driven by volatility in the World Bank savings data. We investigate this measurement error more generally and more formally in section 3.4.

Table 8 presents the results for the modern data period (post-2000), extending the analysis to all thirty-three countries. The findings confirm AMECO's superior internal consistency. Within the AMECO dataset, the average annual deviation was just 0.1pp of GNI. Furthermore, seventeen countries showed perfect internal consistency, while six had deviations of only 0.1 pp, and three more showed deviations of 0.2 pp. In contrast, the World Bank data displayed an average deviation of nearly 1 pp of GNI. In every country examined, AMECO outperformed the World Bank in terms of internal consistency. Additionally, the World Bank data showed several conflicting sustainability signals. In at least one year, Bulgaria, Malta, Latvia, Slovakia, North Macedonia, and Iceland all recorded a positive GIWB but a negative GSWB.

Table 8: Does S = I? Post 2000 Full Sample

% of GNI				
Country	World Bank	Signal Change?	AMECO	Signal Change?
Austria	0.2	No	0.1	No
Belgium	1.0	No	0.0	No
Bulgaria	0.9	Yes	0.6	No
Croatia	0.8	No	0.2	No
Cyprus	0.7	No	0.2	No
Czechia	0.9	No	0.0	No
Denmark	0.6	No	0.0	No
Estonia	0.6	No	0.3	No
Finland	0.4	No	0.2	No
France	0.8	No	0.0	No
Greece	0.6	No	0.0	No
Hungary	0.4	No	0.0	No
Iceland	2.8	Yes	0.6	No
Ireland	1.6	No	0.5	No
Italy	0.4	No	0.0	No
Japan	0.1	No	0.0	No
Korea	0.4	No	0.0	No
Latvia	0.6	Yes	0.1	No
Lithuania	0.9	No	0.1	No
Malta	4.2	Yes	0.4	No
Netherlands	1.1	No	0.0	No
North Macedonia	0.9	Yes	0.6	Yes
Norway	0.4	No	0.1	No
Poland	0.4	No	0.0	No
Portugal	0.4	No	0.0	No
Serbia	1.6	No	0.1	No
Slovakia	1.0	Yes	0.0	No
Slovenia	0.4	No	0.1	No
Spain	0.3	No	0.0	No
Sweden	0.5	No	0.0	No
Switzerland	0.8	No	0.0	No
United Kingdom	0.3	No	0.0	No
United States	0.6	No	0.6	No
Sample Avg.	0.8	Yes = 6	0.1	Yes = 1

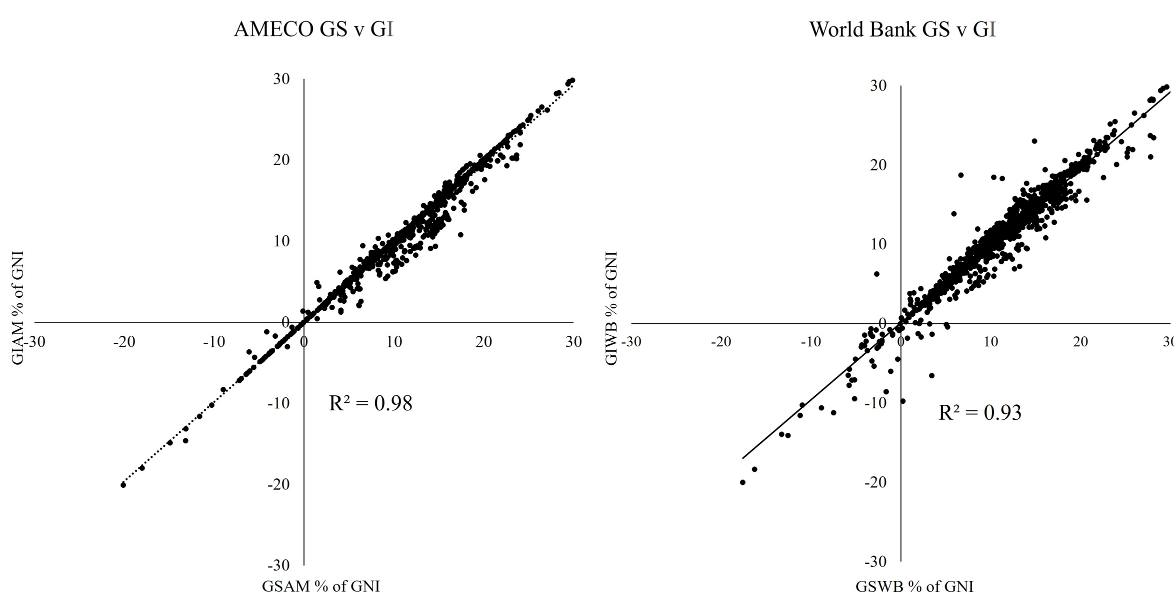
In relation to RQ2, our results show that there can be meaningful differences between GS and GI even when utilising a consistent source for the conventional savings and investment data. The empirical GS literature primarily tests the hypotheses of the theory using real-world data (Ferreira and Vincent, 2005; Ferreira et al., 2008; Gnégé, 2009; Hanley et al., 2015; McGrath et al., 2024) or explores broader questions surrounding sustainable economic development (Dietz et al., 2007; Neve and Hamaide, 2017; Din et al., 2022). These studies rely on GS, rather than GI, and often employ the World Bank dataset. Our results suggest that AMECO is preferable when available owing to its superior internal consistency and its ability to support and extended time-series for both GS and GI estimates (see Table 1). Moreover, if one aims to construct historical estimates using AMECO, the investment-based GI approach appears more reliable, as internal inconsistencies are primarily concentrated in the savings rather than investment data.

More generally, when working with the World Bank dataset in particular, researchers should conduct internal consistency checks to test if GNS = GInv, if not then further analysis should be undertaken to determine which metric is more appropriate. It is important to note that the AMECO dataset primarily includes high-income countries, which are less likely to exhibit low, negative, or marginal GS rates. In contrast, in lower-income countries, where persistently low or negative GS rates are more common (World Bank, 2018) differences in policy signals arising from the use of GS versus GI measures, or from different data sources, may be more pronounced.

3.4 Examining Measurement Error and Structural Breaks in the Savings and Investment "Identity".

Figure 3 plots the full sample of GI and GS data. Given GS = GI is an accounting identity (Eq. 7), we should observe a perfect linear relationship between the series. However, there are outliers in both cases, with greater inconsistency observed in the World Bank data. The upper left and lower right quadrants of Figure 3 contain the extreme cases of sustainability signal disagreements. The disparities between GS and GI reflect inconsistency between Gross Savings and Gross Investment. In turn, this inconsistency reflects measurement error that stems from the challenges statisticians face in constructing national accounts. Measurement error can also cause issues within econometric analysis (Wooldridge, 2010), a concern for the use of historical GS in the theoretical testing literature.

Figure 3: Genuine Savings and Genuine Investment Scatter Plots



A similar inconsistency issue has been shown in the macroeconomics literature. Beckmann et al. (2022) analysed the consistency of *Current Account Balance = Gross Savings - Gross Capital Formation* in the real-world data and found measurement error within both the World Bank and International Monetary Fund (IMF) datasets. Beckmann et al. applied the method of inverse least squares regression and found that the Savings-Investment side was the source of larger measurement error. The authors noted that they expected Gross Savings to likely suffer the most from measurement error followed by Gross Capital Formation and the Current Account Balance. Importantly, Beckmann et al. found that the World Bank data had a higher degree of measurement error than the IMF data and that high-income countries were much less likely to suffer from measurement error.[8] Given our study is limited to the generally high-income countries contained within the AMECO dataset it is reasonable to expect even larger measurement error and greater levels of inconsistency between GS and GI across the full World Bank GS database.

To examine measurement error in the GS = GI "identity" a similar inverse-regression approach to Beckmann et al was utilised. Two bivariate regressions were estimated that include country-specific fixed effects for both the World Bank and the AMECO datasets and then the Mean Squared Error (MSE) for each pair of regressions was compared. The first regression, in each case, (in levels) is as follows:

$$GS = \beta_0 + \beta_1 GI + \varepsilon \tag{9}$$

The second regression in each case is the inverse relationship:

$$GI = \beta_0 + \beta_1 GS + \varepsilon \tag{10}$$

GS = *GI* is an accounting identity; therefore, we know that that β_1 should equal one when using a consistent data source for both savings and investment. By extension, the same holds for the inverse regression, *GI* = *GS*. Any deviation from the true value of one can be attributed to measurement error. We compare the mean squared error (MSE) from each regression to assess which side of the identity is more affected by such error. For example, a higher MSE in the regression of *GI* = *GS*, relative to its inverse, implies greater measurement error on the savings side of the equation.

Tables 9 and 10 present the results of equations (9) and (10) using both the World Bank and AMECO datasets for the full sample of overlapping observations. The World Bank data were again shown to be less consistent than AMECO. The estimated β_1 coefficients, in the World Bank regressions, deviated further from one, and both the standard errors and MSE values were

[8] which they attribute to higher levels of human capital aiding the compilation of the national accounts.

higher. In contrast, for the AMECO data, the hypothesis that $\beta 1$ was equal to one in the *GI* = *GS* regression could not be rejected at the 5% significance level. There was some modest evidence of greater measurement error on the savings side of the equation in both datasets, although the MSE values in each pair of regressions were quite close.

Table 9: Inverse Regressions: World Bank Data Full Sample

Dep. Variable	Ind. Variable	Estimate	Std. Error	t-value	MSE
GSWB	GIWB	0.93***	0.02	41.68	2.24
GIWB	GSWB	0.94***	0.02	52.38	2.27

Notes: *** p<0.01, Observations = 1,081.

Table 10: Inverse Regressions: AMECO Data Full Sample

Dep. Variable	Ind. Variable	Estimate	Std. Error	t-value	MSE
GSAM	GIAM	0.95***	0.01	132.6	0.62
GIAM	GSAM	1.01***	0.01	162.6	0.67

Notes: *** p<0.01, Observations = 1,081.

Section 3.3 showed that the AMECO data appeared to be highly internally consistent in the modern period, with some outliers observed in the historical sample. To further investigate this issue, the inverse regression analysis was restricted to data from the pre-1995 period (Table 11). There is evidence that the relationship was less consistent in this earlier period, as the β_1 coefficients deviated further from one (0.91 and 1.03, compared with 0.95 and 1.01 in the full sample) and the standard error doubled. There was also a slight increase in the difference between the MSE values of the two regressions, again indicating relatively more measurement error on the savings side of the identity.

Table 11: Inverse Regressions: AMECO Data pre 1995 sample

Dep. Variable	Ind. Variable	Estimate	Std. Error	t-value	MSE
GSAM	GIAM	0.91***	0.02	41.17	0.60
GIAM	GSAM	1.03***	0.02	53.72	0.68

Notes: *** p<0.01, Obervations = 283.

Tests for structural breaks were also conducted using the `xtbreak` command in Stata (Table 13).[9] Two clear structural breaks were found in the relationship between GS and GI within the AMECO dataset. These breaks align closely with major revisions to the European System of

[9] `xtbreak` estimates and tests for multiple structural breaks in panel data, based on Bai and Perron (1998); Ditzen et al. (2021); Karavias et al. (2023)

National Accounts in 1979 and 1995 (ESA79 and ESA95). The estimated break dates fall within narrow confidence intervals; 1976–1980 and 1993–1995. In contrast, the World Bank data did not exhibit consistent structural breaks. The *GS* = *GI* specification showed no significant breaks at conventional confidence levels. The inverse regression did identify breaks in 1992, 1999, and 2014, but the associated confidence intervals were wide (1991–1993; 1996–2002; and 2009–2014).

Table 12: Structural Break Tests

xtbreak test	**Breaks at 1% level***	**Breaks at 5% level***	**95% Confidence Interval**
GSAM = GIAM	2 (1979; 1994)	2 (1979; 1994)	1978–80; 1993–95
GIAM = GSAM	2 (1977; 1994)	2 (1977; 1994)	1976–78; 1993–95
GSWB = GIWB	0	0	0
GIWB = GSWB	3 (1992; 1999; 2014)	3 (1992; 1999; 2014)	1991–93; 1996–2002; 2009–14

Notes: *Bai & Perron Critical Values.

These results are consistent with our earlier findings. The World Bank data exhibits a greater degree of persistent inconsistency over time, whereas the AMECO data appear stable post-1995 but less reliable prior to that. We also found some evidence of larger measurement error on the savings side of the equation, reinforcing the potential preference for the use of GI over GS, particularly when working with historical AMECO data.

4 Discussion and Concluding Remarks

This study examined the sensitivity of Genuine Savings (GS), a widely used economic indicator of sustainable development, to methodological choices in practical wealth accounting. Using a sample 33 countries and two major international datasets (World Bank and AMECO), theoretically equivalent but methodologically distinct savings-based (GS) and investment-based (GI) approaches were compared.

Addressing our first research question (RQ1), our findings show that estimated GS can differ considerably based on data source selection and this methodological choice can have practical implications for sustainability assessments. The choice between using the World Bank or AMECO as sources for conventional savings data led to substantial differences in GS estimates, with an average annual discrepancy close to 1pp of GNI across the entire sample with much larger deviations in some countries and in particular years. The deviations were more than double the average adjustment for total natural resource depletion within the GS calculation and were enough to change the policy signal (positive to negative GS, or vice versa) in at least one year in seven countries. The deviations were particularly pronounced in earlier periods, especially prior to 1995. We suspected that the deviations across the two datasets may be related to the residual nature of the calculation of the savings aggregate in national income accounting and this prompted our second research question (RQ2) where we assessed whether the investment-based, theoretically equivalent though methodologically different, GI approach offered could differ from GS.

Our results show clearly that there can be substantial and meaningful differences between GS and GI even when utilising a consistent source for the conventional savings and investment data. The key driver of these differences was found to be savings = investment inconsistency within the datasets, attributable to measurement error in the national accounts. Measurement error resulted in cases where estimates of GS and GI differed considerably including several extreme cases where where the policy signal conflicted. These extremes were mostly concentrated in the World Bank data where negative GS but positive GI was recorded in the same year for six countries. The World Bank dataset was found to be persistently inconsistent across the observed period. The AMECO dataset was generally consistent after 1995 with pre-1995 inconsistency due to volatility in the savings rather than the investment data. Structural breaks in the relationship between GS and GI, in the AMECO data, aligned with revisions to the European System of National Accounts in 1979 and 1995. The timing of the breaks in conjunction with an inverse regression analysis suggests measurement error, particularly in relation to the savings data, may be exacerbated by attempts to reconcile historical and modern vintages of national accounting data. Given the greater volatility in the savings data the investment-based GI approach is likely to be more reliable when constructing historical estimates.

Our findings have broader implications for empirical work on GS and sustainable development. The empirical GS literature is centered on testing key theoretical hypotheses related to green accounting theory or exploring broader empirical questions of sustainable economic development. These studies utilise estimates of GS, rather than GI, and rely on large samples of countries with extended time series necessitating the use of major international databases such as AMECO and the World Bank. Our results reinforce the well-documented advice in the literature that the construction of country specific GS offers greater reliability (Greasley et al., 2014; McGrath et al., 2019). If a large database is required then the AMECO dataset appears preferable, when available, due to its superior internal consistency and given it permits the extension of the time-series for GS and GI for many countries. In more general terms, researchers using aggregated international datasets should routinely perform internal consistency checks and consider constructing both GS and GI to assess the robustness of their conclusions.

Finally, policymakers using GS should shift focus from a binary interpretation (positive vs negative) to identifying persistently low savings levels. It is worth noting, in this regard, that our sample consists of generally high income countries and thus are far less likely to have GS rates that are low or negative. Future work could explore these issues in more detail.

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5 Appendix

World Bank Data: World Development Indicators

Indicator	Code
Adjusted savings: consumption of fixed capital (% of GNI)	NY.ADJ.DKAP.GN.ZS
Adjusted savings: education expenditure (% of GNI)	NY.ADJ.AEDU.GN.ZS
Adjusted savings: energy depletion (% of GNI)	NY.ADJ.DNGY.GN.ZS
Adjusted savings: gross savings (% of GNI)	NY.ADJ.ICTR.GN.ZS
Adjusted savings: mineral depletion (% of GNI)	NY.ADJ.DMIN.GN.ZS
Adjusted savings: natural resources depletion (% of GNI)	NY.ADJ.DRES.GN.ZS
Adjusted savings: net forest depletion (% of GNI)	NY.ADJ.DFOR.GN.ZS
Gross capital formation (current US$)	NE.GDI.TOTL.CD
GNI (current US$)	NY.GNP.MKTP.CD
Current account balance (BoP, current US$)	BN.CAB.XOKA.CD

AMECO Data

Indicator	Code
Balance on current transactions with the rest of the world	UBCA
Gross capital formation	UIIT
Consumption of fixed capital	UKCT
Gross saving, National	USGN
Gross National Income	UVGN

Figure A.1: United Kingdom and Iceland estimated Genuine Savings: World Bank and AMECO