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Sustainable Development and Income Inequality

An Investigation of the Relationship Between Adjusted Net Savings and Income Inequality

by

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Abstract: Income disparities and planetary boundaries present worldwide threats to social stability and security. An extensive body of literature studies the determinants of income inequality. Generally, economic growth and environmental sustainability are found to have moderating effects on income inequality. Adjusted net savings (ANS) is a composite indicator measuring sustainable development assessing the wealth of nations in a more comprehensive manner than the gross domestic product does. While ANS' relationship with welfare and wellbeing experiences growing research interest, its relationship with income inequality remains unexplored. This is surprising, as research suggests that addressing economic, environmental, and social aspects together is paramount to achieving sustainability. This thesis combines these aspects by investigating the relationship between ANS and income inequality. Analysing panel data for a host of over 50 countries with observations between 1978 and 2018, the long-term association between ANS and income inequality is scrutinized. Gross national income and net national savings serve as instruments for real ANS per capita. The findings indicate that ANS is positively related to income inequality. The relationship does not differ by state of economic development and is robust to alternative specifications. The results highlight the key role policy makers play in combining increases in sustainable development with decreasing income inequalities.

Keywords: Sustainable Development, Income Inequality, Adjusted Net Savings, Weak Sustainability

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1 Introduction

Planetary boundaries and rising income inequalities are two decisive challenges humankind currently faces. Both are inherently linked to the functioning of economies. Over the course of the past seven decades, an extensive corpus of literature has arisen on these topics. Generally, economic growth tends to reduce income inequalities (Brückner, Dabla-Norris & Gradstein, 2014; Deininger & Squire, 1998; Dollar, Kleineberg & Kraay, 2016; Dollar & Kraay, 2002; Sala-i-Martin & Pinkovskiy, 2010). At the same time, treating finite planetary resources as if infinite threatens natural and economic sustainability. The widely used gross domestic product (GDP) measures the total value of goods and services provided in a country within a year but does not account for natural depletion. Therefore, Stiglitz, Sen, and Fitoussi (2009) point out the need for the application of measures of sustainable development that account for natural depletion as well. Sustainable development describes “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland, 1987, p.43).

1.1 Research Problem

Aiming at measuring the sustainability of development, several approaches have emerged. One of the most influential ones is the composite indicator ‘adjusted net savings’ (ANS hereafter), developed by Pearce and Atkinson (1993). The composite indicator measures human, natural, and built capital that is needed for societies to function (Costanza et al., 2009). It uses national income accounts as underpinning, from which it subtracts amounts for environmental degradation and adds intangible wealth (Costanza et al., 2009). Intangible wealth takes form in social and human capital, such as skills and know-how of the labour force, the efficiency of juridical systems, enforcement of property rights, and effective governance. The underlying Hartwick rule estimates the amount of wealth needed to offset the declining stock of non-renewable resources (Ferreira, Hamilton & Jeffrey, 2008).

The effect of economic growth on income inequality has first been explored by Kuznets (1955). Based on several western countries, he lays out a theory, known as the inverted U-curve or Kuznets curve. It is posited that in developing countries income inequality rises with increasing GDP per capita, whereas in developed countries income inequality tends to reduce with an increase in aggregate output. Whether or not this pattern holds empirically is a matter of discussion. While Ahluwalia (1976a, 1976b), Anand and Kanbur (1993), Milanović (2000), and Paukert (1973) find support for the Kuznets curve, Deininger, and Squire (1998), Easterly (1999) and Fields (2001) do not. Overall, Brückner, Dabla-Norris, and Gradstein (2014) find that economic growth decreases income inequality.

Further, a rather small number of studies investigate the effect environmental sustainability has on income inequality. Islam (2015) argues that environmental sustainability is negatively associated with income inequality. This is confirmed by a case study on rural Indonesia in which Setyadharma et al. (2021) find that environmental sustainability appears to decrease income inequality.

Extensive research has been undertaken to study the relationship between ANS and welfare as well as wellbeing. Generally, these studies show that - in the long-term - higher levels of ANS are associated with an increase in subjective wellbeing and objective welfare (Qasim & Grimes, 2018). Apart from the relationship between ANS and welfare and wellbeing, no attempt has yet been made to study the relationship between ANS and income inequality. In fact, Lange et al. (2018) and Hamilton (2006) emphasize the importance of bringing these aspects together when assessing comprehensive wealth.

1.2 Aim and Scope

This thesis aims to better understand the relationship between ANS and income inequality. In order to achieve this aim, the goal of this paper is twofold. The first objective is to study the interconnectedness of economic, social, and environmental components in their relationship to sustainable development. This is in line with Leach, Raworth, and Rockström (2013) who posit that sustainability as a concept requires the amalgamation of economic, social, and environmental aspects. The second goal lies in exploring whether ANS and income inequality stand in a Kuznets curve relationship depending on the state of economic development.

Therefore, this research project seeks to answer the following research question:

What is the relationship between adjusted net savings and income inequality?

A better understanding of the relationship between ANS and income inequality is relevant for policy makers assessing the impact of policies on both income inequality and sustainable development. Lange et al. (2018) argue that both phenomena could simultaneously be addressed in policies, showing the complementarity of the topics. In fact, ANS and inequalities stand at the core of the debate on sustainable development which is reflected by the fact that this paper's topic is directly related to goal 8, decent work and economic growth, and goal 10, reduced inequalities, of the UN Sustainable Development Goals (UN, 2021). Indirectly, it relates to the majority of the Sustainable Development Goals such as goals 12 and 14, responsible consumption and production along with life on land, respectively. In addition, by applying ANS, this research contributes to the expansion of the use of measures of sustainable development in the literature.

In this study, cross-country panel data for a host of over 50 countries is examined for a time span between 1978 and 2018. The analysis is based on macroeconomic data which is publicly available on the World Bank's Microdata Library. Taking advantage of the panel data, ANS' relationship with within-country income inequality is studied. Methodology-wise, given the presence of endogeneity, gross national income (GNI) and net national savings (NNS) serve as instruments for ANS in instrumental variable estimations of country and time fixed effects. The thesis contributes to the literature by providing a new angle to both the inequality and sustainable development debates.

1.3 Outline of the Thesis

The remainder of this paper is divided in the following manner. Chapter 2 defines ANS, presents the theoretical framework as well as the literature review. Then, chapter 3 describes the empirical approach. Subsequently, chapter 4 lays out the discussion, before chapter 5 concludes.

2 Previous Research

This section is divided into three parts. The first part is dedicated to ANS, its definition, and its components. The second part lays out the theoretical framework, whereas the last part is a literature review identifying the research gap.

2.1 Adjusted Net Savings

With the aim of quantifying sustainable development, several measures have been created. The World Bank first introduced ANS as a measure for sustainable development in 1996 (Hamilton, 2006). Standard ways of national accounting solely consider the formation of fixed capital as investment in the future which constitutes an increase in the value of assets in a society. Hamilton (2006), however, argues that in order to evaluate the wealth of an economy one needs to include human and natural capital as well. Indeed, both impact the productivity and therefore the well-being of societies. ANS is defined as "the true level of saving in a country after depreciation of produced capital; investments in human capital (as measured by education expenditures); depletion of minerals, energy, and forests; and damages from local and global air pollutants are taken into account" (Hamilton, 2006, p.9). It builds on the Hartwick rule which posits that "welfare can be sustained indefinitely if gross saving just equals the sum of depreciation of produced assets, depletion of natural resources, and pollution damages" (Hamilton, 2006, p.38). There is a fierce debate on whether this is true, and this thesis makes no attempt to settle this issue.

ANS is computed as:

$$ANS = NNS + E - R - P$$

where:

ANS	adjusted net savings
NNS	net national savings
E	current public education expenditure
R	rents from (renewable and non-renewable) resources (depletion of energy, minerals, and forest)
P	damage caused by the emission of carbon dioxide (CO_2)

NNS= GNS – CFC

Where: GNS= gross national savings; CFC= consumption of fixed capital.

In the calculation of ANS, the World Bank (2018) includes current public expenditure on education such as wages and salaries but excludes capital investments in buildings and equipment. It is rather treated as saving than consumption since it increases economies' human capital. Public expenditure in education is used as a proxy for human capital accumulation. Admittedly, this approach has limitations as public expenditure on education does not perfectly equate with human capital. However, this choice appears reasonable since data is scarce for alternative measurements of human capital stocks.

Resource rents englobe the net depletion of forests, fossil energy resources, metal, and minerals. The former is calculated as the unit of resource rents times the excess of roundwood harvest over natural growth (World Bank, 2018). The World Bank calculates a country's stock of non-renewable resources as the current value of the extraction and the expected rents that may be generated from that resource until its exhaustion. Further, natural resource rents are calculated as the value of the extracted resources at international commodity market prices minus the production costs. The yearly depletion of a given resource is computed as the current value of the average annual rents which would be generated over the lifetime of the resource, assuming that the extraction rate, prices, and proven reserves remain constant (World Bank, 2018). Critics of this method, such as Neumayer (2000), argue that this way of calculation overestimates natural capital depletion. It can be posited that with the applied measures of depletion, it is rather the management style of natural resources that is reflected. Considered fossil energy sources are coal, crude oil, and natural gas. Similarly, metal and mineral depletion is determined by the ratio of the value of the stock of mineral resources to the remaining reserve lifetime.

Included minerals are tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate rock.

As to pollution, emissions of carbon dioxide are regarded. The latter being a greenhouse gas with a lifetime of up to two centuries in the atmosphere accounts for two-thirds of the global warming potential (Stern, 2007, table 8.1). Kunnas et al. (2014) point out that the crucial point with CO_2 emissions is its characteristics of a stock pollutant. In fact, annual emissions add up to the already existing concentration of CO_2 in the atmosphere. Thereby, every unit of emitted CO_2 increases the marginal damage cost of the pollutant in the future. The concept of social costs of carbon represents the net present social value of incremental damage of emitting an additional ton of carbon dioxide taking an optimal emissions scenario as the basis (Krogstrup & Oman, 2019). The damage is expressed in monetary units and reflects global losses. The World Bank estimates damage from emitted CO_2 with US$ 30 per ton of CO_2 in 2014 US dollars for CO_2 emitted in 2015. Here, the social costs of carbon are calculated with an annual increase of around 3 percent. At this rate, one ton of emitted CO_2 in 1980 stood at US$ 10.33 and will be around US$ 65 in 2040, both in 2014 US dollars (World Bank, 2018). While the World Bank argues that these social costs of carbon are in the mid-range of the literature, Pezzey and Burke (2014) contend that this price is too low. Other shortcomings of ANS are dealt with below.

The interpretation of ANS is straightforward. If the value of ANS is positive, the economy in question is assumed to be on a sustainable path. On the other hand, it is on an unsustainable path if ANS takes a negative value. In other words, when ANS takes a negative value it is suggested that the stock of national wealth is declining (Hamilton & Clemens, 1999). Hence, the future utility will be inferior to the present one. Table 1 shows the means of ANS and its components as a share of the GNI. In the table, countries are split into two income groups: low-, and lower-middle-income countries constitute the group of lower-income countries; higher middle and high-income countries form the group of higher-income countries. This classification corresponds to the country classification by the World Bank (see section: Developing versus Developed).

In table 1, it is shown that higher-income countries, on average, display higher ANS. Following the interpretation of ANS, this suggests that more developed countries have more sustainable economies. When thinking of economic sustainability this is certainly true. However, this appears to be surprising provided that developed countries tend to present a bigger threat to sustainable development in terms of greenhouse gas emissions and pollution per capita (Ali &

Oliveira, 2018; Azomahou, Laisney & Nguyen Van, 2006). As ANS estimations are rooted in GDP they tend to affirm developed countries' consumption patterns as their ANS are higher, because of higher GDP which is reflected through higher NNS per capita (Pillarisetti, 2005). Further, table 1 shows that net saving rates are about one percent higher in higher-income countries. Rents from natural resources are relatively similar throughout both groups. The average damage caused by CO_2 emissions as a share of the GNI are comparable in both lower- and higher-income countries. This, however, is not so for averages in public educational expenditures nor for ANS as share of GNI. The average of the latter is about 5 percent higher in higher income countries. Public expenditure in education also tends to be higher in higher-income countries.

Table 1. Means of ANS and its Components by Income Group; 1970–2018

Variable	Income Group	Mean	Std. Dev.
NNS (% of GNI)	Lower	9.21	13.21
	Higher	10.36	11.9
	All	9.93	12.43
Rent (% of GDP*)	Lower	7.43	9.2
	Higher	7.59	12.21
	All	7.54	11.34
Damage from CO_2 (% of GNI)	Lower	1.25	1.8
	Higher	1.2	1.47
	All	1.22	1.58
Education (% of GNI)	Lower	3.54	1.73
	Higher	4.25	2.88
	All	4.05	2.63
ANS (% of GNI)	Lower	4.24	16.2
	Higher	9.61	11.52
	All	7.47	13.83

World Bank country classification. All world countries with available data are used in the calculations. Data source: World Bank Development Indicators WDI 2021.
The averages tend to give more weight to countries with more available data (bias towards higher-income countries, within and across income groups).
*Rents from natural resources are portrayed as a share of GDP instead of GNI in order to only capture natural resources that geographically locate within the respective country.

2.2 Theoretical Framework

In the absence of an existing theory explaining the relationship ANS has with income inequality, this paper establishes a theoretical framework for a better understanding of the impact ANS has on inequality. This is achieved by bringing together relevant theories that relate the individual components of ANS (net national savings, education expenditure, damages from emission of carbon dioxide, rents from natural resources) to income inequality. In the remainder of this section, the theoretical effects of each component of ANS on income inequality are presented before bringing them together.

Net National Savings on Income Inequality

The first section sheds light on the impact that NNS have on income inequality. Following the "national income equals national product identity", a fundamental macroeconomic identity of accounting is that savings equal investments. Henceforth, NNS equal physical investments as in open economies net savings equal net investments minus the trade balance. Additionally, research indicates that investments and financial development stand in a causal relationship to each other, whereas the direction of the causal relationship is unclear (Muyambiri & Odhiambo, 2018). Therefore, when investigating the effect of NNS on income inequality one can refer to the literature on the financial development-inequality nexus for which a substantial number of studies exist (Asongu, 2013; Galor & Zeira, 1993; Greenwood & Jovanovic, 1990; Jauch & Watzka, 2016; Jaumotte, Lall & Papageorgiou, 2008). Admittedly, income inequality along with financial development and thereby NNS stand in reverse causation to each other (Galor & Moav, 2004; Galor & Zeira, 1993; Aghion & Bolton, 2005). Here, however, solely the effects of the latter on the former are regarded.

As to the effect that financial development has on income inequality, two contrasting strands of theoretical postulations can be identified. One argues that financial development enhances income inequality whereas the other posits that it first increases and then reduces inequality depending on the state of financial development in an economy. Firstly, concerning the finance-growth-inequality nexus, Greenwood and Jovanovic (1990) postulate in favour of a relationship between financial development and income inequality depending on development cycles, reminiscent of the Kuznets curve. It is argued that in the early stages of the development process, when the financial sector is underdeveloped, financial development increases income inequality. As the financial sector progresses with financial development, income inequality peaks at an intermediate phase of development. As economies mature, the relationship of interest becomes negative. Income inequality decreases with further financial development and investments. Hence, in the transition from a slowly growing economy to a fast-growing one, economies pass through a stage of high-income inequality partly determined by the level of financial development (Greenwood & Jovanovic, 1990). Secondly, another strand in the literature rather sees a linear link between financial development and income inequality. It is headed by Banerjee and Newman (1993) as well as Galor and Zeira (1993). It is argued that financial market imperfections lead to increasing inequalities. Here, financial asymmetries, transaction, and contract enforcement costs might constitute obstacles for the poor to invest. Provided that the poor often do not possess collaterals, or credit histories and relational networks like the rich, even very promising investments might not receive sufficient credit funding. This in turn reduces the efficiency of capital allocation and impedes the social mobility of the poor (Asongu, 2013). Therefore, this theoretical approach contends that increasing financial development leads to rising income inequality. It is suggested that income inequality can be reduced by enhancing capital allocation efficiency as it would facilitate productive investments also for the poor (Banerjee & Newman, 1993; Galor & Zeira, 1993).

Education on Income Inequality

According to the human capital model, the level and distribution of access to schooling within populations determine the distribution of income (Becker & Chiswick, 1966; Mincer, 1974). It suggests that both the supply and demand of educated persons affect income inequality. The variance of schooling as a proxy for educational inequality, and income inequality stand in a positive relationship to each other. Further, conditional on the rate of return on education, the theory predicts that the impact of the mean years of schooling on income inequality can either be negative or positive (Lee & Lee, 2018). De Gregorio and Lee (2002) show that if the level of an individuals' earnings is a function of the level of schooling, the rate of return on the number of years of schooling, and other factors that are not related to schooling, then income inequality increases with educational inequality. On the other hand, in the case in which the rate of return to education decreases as educational inequality increases, the relationship becomes ambiguous. Indeed, higher shares of higher-educated persons tend to lower educational inequality and the wage premium. This suggests that educational inequality and the wage premium are positively associated. However, it can also be negative in case the covariance between the return on education and the level of schooling is negative (De Gregorio & Lee, 2002). Therefore, the relation between educational expansion and income inequality shall be unclear. Furthermore, they state that depending on the initial level and distribution, educational expansion can lead to both an improved or a worsened educational distribution (Gregorio & Lee, 2002). For instance, in a society with only a small, educated share of people, average educational attainment is low and educational inequality high. If in that very society the small share of educated people was to increase their educational attainment even more, the average educational attainment would increase and income inequality too. Oppositely, if the uneducated received formal education, this would lead to an increase in average school attainment too, but to a decrease in income inequality. Indeed, this is in line with Knight and Sabot (1983) who contends that educational expansion has ambiguous effects on income inequality due to two offsetting effects: the composition effect and the wage compression effect. The former designates that income inequality increases if an educational expansion causes a higher share of educated people. The latter compresses income inequality in case the educational expansion leads the supply of educated persons to exceed their demand. Then the wage premium for educated people decreases and therefore also the wage inequality.

Environmental Sustainability on Income Inequality

"Environmental sustainability seeks to sustain global life-support systems indefinitely" (Goodland, 1995, p.6). In the realm of this paper, emissions of carbon dioxide and rents from natural resources determine the degree of environmental sustainability. While the bulk of previous research focuses on the effect of income inequality on environmental sustainability, only little attention is paid to the inverse relationship (Setyadharma et al., 2021). Natural resources provide – to a greater extent – poor people with goods for livelihoods and supply them with production capacities to generate incomes (UN, 2018). When the environment is over-exploited, in form of destruction of the environment for rent creation, pollution, or misuse of natural resources, the very basis of revenue for the people dependent on them declines which may result in declining income (Setyadharma et al., 2021). Hence, through the channel of income generated with natural resources income inequality may increase. Another channel is health. The UN (2018), Angelsen et al. (2014), and Islam (2015) suggest that the poor are affected by pollution to a greater extent than the rich due to the lack of equipment to protect themselves. Consequently, health issues might appear, negatively affecting productivity, and decreasing the number of hours worked which enhances income inequality (Angelsen et al., 2014). Islam (2015) adds that in places where natural resources are nearly depleted, influential minorities might be capable of securing monopoly positions allowing them to control the remaining resources, which would further increase income inequality.

Adjusted Net Savings on Income Inequality

Bringing together the components and their respective effects on income inequality, the theoretical relation between ANS and income inequality is unclear. Indeed, on the one hand, theoretically higher levels of educational expansion and environmental sustainability have decreasing effects on income inequality. On the other hand, following Banerjee and Newman (1993) as well as Galor and Zeira (1993) higher levels of NNS are likely to increase income inequality unless capital allocation efficiency is enhanced. However, as Greenwood and Jovanovic (1990) state, NNS and income inequality may stand in an inverted U-curve relation depending on the stage of financial development of a country. Against the backdrop of low social costs of carbon with which ANS is calculated and the fact that ANS is a GDP-based indicator (giving more weight to NNS), the effect of damages from pollution in the relationship to income inequality might not be strong. Since NNS is likely to be the most influential component when it comes to the relationship between ANS and income inequality, a Kuznets like relation between ANS and income inequality is expected. This hypothesis ensues from Greenwood and Jovanovic's theory. Hence, while in less developed countries higher levels of ANS are likely to increase income inequality, in higher-income countries it might reduce income inequality.

2.3 Literature Review

GDP and Income Inequality

Economists have long been concerned with income inequalities. Over the past seven decades, an extensive corpus of literature has arisen studying the effect of economic growth on income inequality. Based on observations of several western countries, Kuznets (1955) lays out a theory, known as the inverted U-curve or Kuznets curve. He posits that in agrarian economies concentration of savings, structural change, and intersectoral labour movements from the agricultural towards the manufacturing sector are the main drivers for rising income inequalities. The thereupon following lower inter-sectoral productivity differences, lower returns to capital, expansion of education, and distributional policies drive inequalities down. The Kuznets curve came to be the working horse of the growth-inequality debate. Later approaches argue that the driving force for inequality changes are structural changes from poor sectors, employing old technologies, to rich sectors, where more advanced techniques are applied (Helpman, 1997). The shift of labour from one sector to another requires a phase of adaptation in which familiarization and re-education happen (Aghion & Howitt, 1998). More recently, Milanović (2016) brought up the idea of Kuznets waves driving inequality whereby the first Kuznets curve is followed by a second one, driven by technological progress and intersectoral relocation of labour, this time from a more homogenous manufacturing sector towards a rather heterogeneous service sector. Further drivers of inequality are globalization and policies. Timewise, he locates the onset of the second Kuznets wave in the 1980s.

Piketty (2014) is another prominent scholar who addresses the drivers of income inequality. He argues that, throughout history, inequalities have been on the rise because rates of return for capital are higher than income growth. Rentiers enjoy larger increases to wealth than those solely relying on wage as income. According to Piketty (2014), income inequality can be reduced by minimizing the concentration of wealth in an economy, arguing for distributional policies.

Early studies on the growth-inequality nexus were mainly based on cross-country regressions (Ahluwalia, 1976a, 1976b; Anand & Kanbur, 1993; Milanović, 2000; Paukert, 1973). These studies find support for an inverted U-curve relationship between economic growth and income inequality. It appeared that middle-income countries tend to have the highest levels of income inequality. Yet, when data availability allowed for country fixed effects with panel cross-country data, studies aiming at testing the Kuznets curve became inconclusive to each other. While Barro (2000) states that the Kuznets curve is a clear empirical regularity, Forbes (2000) comes to the conclusion that income inequality has a positive effect on economic growth. Others, such as Deininger and Squire (1998), Easterly (1999), and Fields (2001) do not find support for a Kuznets curve. Instead, Dollar and Kraay (2002), Kraay (2006), and Dollar, Kleinberg, and Kraay (2016) posit that economic growth does not only reduce poverty by increasing the income share of the first income quintile by at least as much as the mean national income increases but that it also affects the income distribution in favour of lower inequality. In Africa, Sala-i-Martin and Pinkovskiy (2010) argue that economic growth has reduced income inequality. Many of these studies employ country fixed effects without instrumenting national income, which leaves endogeneity unsolved. Addressing endogeneity by employing external instruments for national income, Brückner, Dabla-Norris, and Gradstein (2014) examine the effect of aggregate output on income inequality. Taking truly exogenous instruments such as oil price shocks and trade-weighted world income for changes in national income, they find that economic growth has a moderating effect on income inequality.

Several papers also focus on the reverse causation to which economic growth and income inequality are subject. Indeed, it is worthwhile to briefly notice that research has found income inequality to partly determine economic growth. In fact, an extensive body of literature exists mainly indicating that income inequality theoretically (Galor, Moav & Vollrath, 2009) and empirically (Brückner & Lederman, 2015; Deininger & Squire, 1998; Easterly, 2007; Lundberg & Squire, 2003) impedes economic growth. A valuable finding for this paper is provided by Halter, Oechslin, and Zweimüller (2014) who introduce a time dimension to the effect of inequality on growth. In the short term, they explain, income inequality has growth-enhancing effects, whereas in the long run, the effects are growth reducing.

Environmental Sustainability and Income Inequality

A growing number of papers identify the link between income inequality and environmental sustainability. Akin to the growth-inequality nexus, environmental sustainability and income inequality are subject to reverse causation (Islam, 2015). However, as indicated above, most studies concentrate on the effect income inequality has on environmental sustainability. As to the effect environmental sustainability has on income inequality, a recent study by Setyadharma et al. (2021) finds that in rural Indonesia efforts to reduce environmental degradation lead to decreasing income inequalities.

Inversely, there is compelling evidence that income inequality can be detrimental to environmental sustainability (Islam, 2015). Islam (2015) proposes a multi-channel framework, suggesting that income inequality is related to environmental sustainability through several channels (household-, community-, national-, and international channel). Moreover, the poor and marginalized tend to be disproportionally strongly affected by environmental degradation (IPCC, 2014), which might cause negative feedback loops between environmental degradation and income inequality (Islam & Winkel, 2017). Indeed, some scholars find a causal relationship between income inequalities and loss of biodiversity (Holland, Peterson & Gonzalez, 2009;

Mikkelson, Gonzalez & Peterson, 2007). Higher levels of income inequality are also associated with higher levels of water consumption, higher waste generation, higher fish and meat consumption, and higher greenhouse gas emissions in OECD countries (Islam, 2015). Research indicates that this tends to be driven by higher consumption of resources by the rich (Dorling, 2010a, 2010b, 2014; Dorling, Barford & Wheeler, 2007). Thus, Masud et al. (2018) conclude that lower income inequality is beneficial for environmental sustainability.

Torras and Boyce (1998) study the link between income inequality and air and water pollution. They indicate that higher levels of income inequality can be associated with pollution-generating activities. Oppositely, research has shown that air pollution in terms of particulate matter emissions divergently affects different groups of populations (Nguyen & Marshall, 2018; Tessum et al., 2019). Findings by Tessum et al. (2019) for the US suggest that exposure to particulate matter emissions is disproportionately affecting black and Hispanic minorities and are mainly caused by the consumption of goods and services by the non-Hispanic white part of the population. Further, their results indicate that income – to the degree that it is associated with consumption – explains a large part of how much particulate matter emissions a person is responsible for. To a lesser extent, it also is a determinant of exposure to particulate matter emissions (Tessum et al., 2019). Channelled through ethnic inequalities in exposure to particulate matter emissions, income can be affected. Indeed, higher exposure to particulate matter emissions tends to impact health (Kim, Kabir & Kabir, 2015) in a way that decreases productivity and may lead to the inability of working or even premature death (World Bank, 2018).

Furthermore, there is a growing number of studies examining the relationship between natural resource rents and income inequality. Many studies present either inconclusive results or are inconclusive to each other (Alvarado et al., 2021; Buehn & Schneider, 2012; Howie & Atakhanova, 2014; Oded, 2011; Tian & Liu, 2020). Humphreys, Sachs, and Stiglitz (2007) state that more resource-rich countries tend to be neither more equal nor unequal than other countries. Further, research suggests that the dependence on natural resources favours economic instability due to high volatility in raw material prices (Alvarado et al., 2021). However, there is evidence that if rents from natural resources are appropriately used to implement social policies to reduce inequalities, the resource curse and corruption are no empirical regularity (Alvarado et al., 2021).

ANS and Welfare

Whilst, to the best of the author's knowledge, no study has yet investigated the relationship between ANS and income inequality, extensive research has been conducted studying the relationship between ANS, its components (natural, produced, and human capital), and subjective wellbeing but also objective welfare (Qasim & Grimes, 2018). Leigh and Wolfers (2006) look at in how far individual happiness is associated with the Human Development Index (HDI) and find a positive relationship for the 32 countries included. The HDI is a composite indicator that is calculated as the geometric mean of education (mean years of schooling & expected years of schooling), life expectancy, and GNI per capita. It is commonly used as a proxy for human and produced capital. Oppositely to Leigh and Wolfers (2006), Blanchflower and Oswald (2005) show that there are countries (e.g. Australia) in which higher HDI scores are not related to higher levels of happiness. Further, also using HDI as a proxy for human and produced capital and adding an index for ecosystem services per square kilometre as a proxy for natural capital, Vemuri and Costanza (2006) analyse their effect on human life satisfaction at a country-level. Their study finds that these proxies can explain 72 percent of the variation in life satisfaction. Likewise, Engelbrecht (2009) detects a significantly positive association between natural capital and subjective well-being.

The relationship between ANS and welfare has extensively been studied (Qasim & Grimes, 2018). A number of studies investigate its impact on objective well-being, using different measures such as the discounted value of real consumption per capita, infant mortality, or the HDI (Blum, McLaughlin & Hanley, 2013; Ferreira, Hamilton & Jeffrey, 2008; Gnègnè, 2009; Greasley et al., 2016; Hanley et al., 2016; Qasim, Oxley & McLaughlin, 2018). Overall, Blum, McLaughlin, and Hanley (2013) find positive associations between ANS and future consumption, while ANS' effects on infant mortality and average heights remain unclear. Hanley et al. (2016) detect evidence supporting the presence of a long-run equilibrium between ANS and future well-being. Employing cross-country panel data, Gnègnè (2009) finds a weak but positive and significant relationship between ANS and aggregate welfare, which gains in amplitude in the long run. Using ANS as a predictor of subjective well-being at the individual and aggregated group level, Qasim, Oxley, and McLaughlin (2018) find a negative effect in rather short-term analysis (up to 15 years). This effect neutralizes or inverses in the long-term (20 years), suggesting that present savings might not show an effect on the well-being of the current generation. Similarly, Greasley et al. (2016) indicate that ANS is a suited indicator for forward looking investigations of future well-being for periods of up to a century.

The review of the literature shows that the respective relationships between GDP, economic growth, pollution, environmental sustainability, and income inequality have already been explored. Besides, research has identified the effect economic sustainability has on welfare and well-being. However, the relationship between sustainable economic development and income inequality has not yet been investigated. Leach, Raworth, and Rockström (2013) contend that there is a dire need to address social and planetary boundaries together. In their view, sustainability as a concept calls for the fusion of environmental, social, and economic elements. This paper aims at contributing to the literature by employing ANS as a measure for sustainable development to study its relationship with income inequality. In the following chapter, the empirical approach is presented.

3 Empirical Approach

This chapter describes the approach that is taken to empirically investigate the association between ANS and income inequality. A quantitative research design appears suited since it allows to measure the relationship of interest. In the following, the data sources are briefly described before the methodology is presented. Subsequently, the results are laid out. Lastly, it is shown that the findings hold to alternative specifications.

3.1 Data

Unless otherwise stated, the various datasets used emanate from the World Bank’s Microdata Library. Thereby, despite considerable inconsistencies over the years, a certain level of comparability between datasets in terms of countries is assured. Further, to a certain extent, it indicates similar levels of data quality throughout the many merged datasets. As to the initial dataset on ANS, estimates are reported on an annual basis. Including irregularities in the data, ANS estimates are available between 1970 and 2018. Depending on the country, from the 1970s onwards, by and by, estimates become available. These are reported in current US dollars.

Concerning Gini estimates, two sources provide data for the analysis. The primary data source is the Standardized World Income Inequality Database Version 9 (SWIID), supplemented with data from the World Bank’s POVCALNET database. From the SWIID, Gini indices that compare inequality in income (as opposed to inequality in consumption) are taken into consideration. Similarly, the Gini estimates provided by the World Bank compute inequality in income. Hence, comparability between the two data sources is ensured. The merging of Gini estimates provides the advantage of maximising overlapping observations between the different variables employed. Additionally, if estimates are expressed in monetary terms (ANS and control variables), they are converted to US dollars of 2010.

3.2 Empirical Strategy

The benchmark model is:

$$\Delta\, Inequality_{it} = \alpha_i + \beta_t + \beta_1 ln\,(ANS\; p.c.)_{it} + u_{it} \qquad (1)$$

where Δ Income Inequality$_{it}$ is the change in income inequality. α_i are country fixed effects that control for cross-country differences in resource endowment, history, ethnicity, and other time-invariant determinants of income inequality. Additionally, β_t controls for year-fixed effects. Thereby, common time shocks affecting both ANS per capita and the distribution of income within countries are controlled for. Here, one could highlight common shocks to economic growth due to variation in the international commodity price markets or political factors that affect ANS through one or several of its components. The main explanatory variable is the natural logarithm of ANS per capita in constant 2010 US$. As opposed to growth rates of ANS, in the regressions, ANS per capita is opted for, which is tantamount to asking: what happens to the intra-country income distribution as the log of ANS per capita changes? Per capita instead of growth rate specifications are not only employed in the literature on the effect of aggregate output on income inequality (for instance see Brückner & Lederman, 2015; Dollar & Kraay, 2002), but also in studies on the impact ANS has on welfare and well-being (Blum, McLaughlin & Hanley, 2013; Gnègnè, 2009). De facto, the natural logarithm of ANS per capita cannot simply be calculated as it takes negative values. Therefore, a constant is added to all ANS per capita estimations to lift all observations to positive numbers. Then, the logarithm is calculated. Hence, changes in inequality due to the logarithm of ANS per capita will describe trends rather than real effect sizes of the association. Standard errors are clustered at the country level.

Multiple regressions

The econometric analysis specified above, regressing inequality as a function of ANS, does not include other factors that partly explain income inequality. To draw a more realistic picture and in an attempt to estimate the relationship between ANS and income inequality more closely, a number of seven potential variables mediating the relationship between ANS and inequality are included in the regression as control variables (Table 2). The choice of the variables is inspired by Gnègnè (2009) and Wu and Pu (2020). For explanations regarding the choice of the specific control variables, it is referred to Appendix A.

Table 2. Set of Control Variables

Variable	Form
Government consumption	Share of total final government consumption to GDP
Dependency ratio	Share of population aged <15 and >65 to population aged 15-65
Foreign direct investment (FDI)	Share of FDI to GDP
Trade openness	Share of trade to GDP
Financial development	Share of net lending by financial institutions to GDP
Urbanization rate	Share of urban population to the total population
Population growth	Change in population in percent

Data for all variables is from National Accounts Data from World Bank & OECD

Time Dimension

When studying the association between ANS and income inequality, an important factor to bear in mind is the time perspective. Specifically, the time it takes for ANS to show an impact on inequality. Theory suggests that the time for ANS to show effect can tend to infinity (Hamilton, 2005). Given practicability and data limitation, in this thesis, a 20-year sub-period is included. The 20-year sub-period has been chosen for the reason of the average lifespan of capital stock. Indeed, according to Hamilton (2005), the mean lifespan of produced capital stocks is 20 years. In a paper on the effect of ANS on welfare, Gnègnè (2009) also argues in favour of applying this sub-period length. In practice, for the different time horizons, the 20-year averages of the considered variables are computed. Next to the benefits of a longer-term perspective of the relationship between ANS and inequality, this practice allows for minimizing constraints that data availability poses. In an attempt to cope with data gaps and scarcity in general, this is a common practice when dealing with data on income inequality but also ANS (Brückner & Lederman, 2015; Gnègnè, 2009).

An important choice to make in this regard is whether to consider the effects of ANS on income inequality at some future point in time or the impact of ANS on income inequality of a certain timespan within the same period. In this thesis, the latter option is chosen with the following rationale. The effects of investments (ANS) occur over time. Additionally, what really matters is the sustainability of an investment process. Indeed, in terms of impact on income inequality, there is not much to expect from short-term investments that depreciate quickly. To illustrate, if a given country – against the otherwise observed trend – appears to show a declining ANS value for a single year, this is likely not to have a significant impact on income inequality in the following years. This is even more likely if ANS returns to a positive trend in the immediately following year, as this could correct the shocks that ANS had on inequality in the previous year. Therefore, it is of interest to study trends of ANS to see changes in income inequality over time. Taking a 20-year interval sub-period into account allows for this longer term investigation.

Endogeneity

The model presented above might suffer from endogeneity, potentially because of an omitted variable bias, or a simultaneity bias, or both. Endogeneity will result in biased estimate coefficients. This issue is addressed by applying endogeneity tests to all regressors included in the paper. More specifically, the control function approach is followed (Wooldridge, 2007). Therefore, following Gnègnè (2009), GNI and NNS serve as instruments for ANS (see full justification below). The residual of the first stage regression is added to the structural equation of ANS testing. If in the structural equation, the residual appears to be statistically significantly different from zero, the null hypothesis of exogeneity can be rejected and the variable can be treated as endogenous (Wooldridge, 2007). In the long-term, for all regressors – ANS and its variants – the null hypothesis of exogeneity can be rejected when regressed on the Gini. Therefore, instrumental variable (IV) estimations of country and year fixed effects are applied to these models.

IV estimations can help to estimate unbiased estimators if the four local average treatment effect (LATE) assumptions hold which are the existence of a strong first stage, the assumption of independence, the exclusion restriction, and the assumption of monotonicity. Following Gnègnè (2009), GNI (log; per capita) and NNS (log; per capita) are identified as instruments. In his paper, GNI and NNS are employed as instruments for ANS, with the goal to measure the effect on changes in welfare. Regarding the four LATE assumptions, the first one is fulfilled, as it can be observed in Table 3, demonstrating a strong first stage. The relationship between ANS and its instruments appears statistically significant at a 1 percent level of confidence. Concerning the second assumption, the instruments are assumed to be uncorrelated with all unobserved determinants of income inequality. The assumption of independence is supported by the use of time and country fixed effect estimations that account for unobserved heterogeneity throughout time and location, and by the inclusion of a set of control variables that maximise the chances of the assumption of independence to hold. The third assumption being the exclusion restriction – in other words, the first stage is the only source of the relationship between NNS, GNI, and income inequality – holds for the following reasons. A large corpus of literature exists investigating the effect of national income on inequality. While at first sight, this might spark doubt as to the validity of the instruments, the causal relationship is indirect and runs through channels (Barro, 2000; Galor & Zeira, 1993; Kuznets, 1955; Lewis, 1954). Through the individual components of ANS, these channels are part of the index. Hence, it can be argued that GNI and NNS affect income inequality only through the components of ANS. More closely, in a famous article by Galor and Zeira (1993) it is argued that in the presence of credit-market imperfections, investments in human capital are the main channel between economic growth and income inequality. Investigating the effect of national income on inequality, more recently, Brückner, Dabla-Norris, and Gradstein (2014) confirm human capital as the main channel mediating national income to income inequality. With public expenditure on education, a proxy for human capital is part of the composite indicator and is thus captured by ANS. Additionally, Galor and Zeira point out that the role of initial income is key when determining who is enabled to invest in human capital. While this relates back to human capital as crucial factor, the structure of the data is taken advantage of circumventing problems related to the role of initial income. By employing country fixed effects, this issue does not bias the results of this analysis since each country's data is compared to the same country's observations at a different point in time. Additional effects that appear due to a certain level of income are captured by dividing the sample into two income groups, as laid out below. An additional channel through which GNI affects inequality is saving rates, which also appears to be the second instrument. According to Barro (2000), this view is rooted in Keynes' General Theory. Here, it is argued that saving rates increase with rising income. Galor and Zeira (1993) point out that credit constraints could hamper the flow of capital to the poor with promising investment strategies due to information asymmetries, transaction- and contract-enforcement costs. Thus, to a certain extent, one can assume that when GNI increases, NNS also do so as a larger share of the population increases its individual saving rates. The inclusion of the second instrument is supported by the increase in the R^2 and the F-statistics in column (2) compared to column (1) of table 3. Figure 1 supports this point indicating a negative cross-country correlation between NNS and Gini. As the base, NNS is also part of ANS. Therefore, the saving rates channel is captured suggesting that the effect that GNI has on inequality runs through ANS. The fourth assumption, monotonicity, requires all countries to be affected in the same way when it comes to the effect the instruments have on the outcome variable through ANS. Here, once again country and time fixed effects help to control for unobserved heterogeneity and guarantee that the channels relating GNI and NNS to income inequality are the same. As laid out below, the effect of the instruments on income inequality running through ANS does not differ by state of economic development. Additionally, the F-statistics are high, suggesting that the instruments are good. Furthermore, the validity of the instrument is confirmed by conducting overidentification tests. The p-values of the Sargan tests are reported in the respective tables.

Table 3. First Stage

	(1) 1978-2018	(2) 1978-2018
GNI (log; per capita)	2.37e-05***	7.22e-06***
	(7.12e-06)	(2.12e-06)
NNS (log; per capita)		0.637***
		(0.0481)
Controls	Yes	Yes
Time FE	Yes	Yes
Country FE	Yes	Yes
F-test	8.884	99.32
Observations	184	184
R-squared	0.509	0.947
Countries	130	130

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

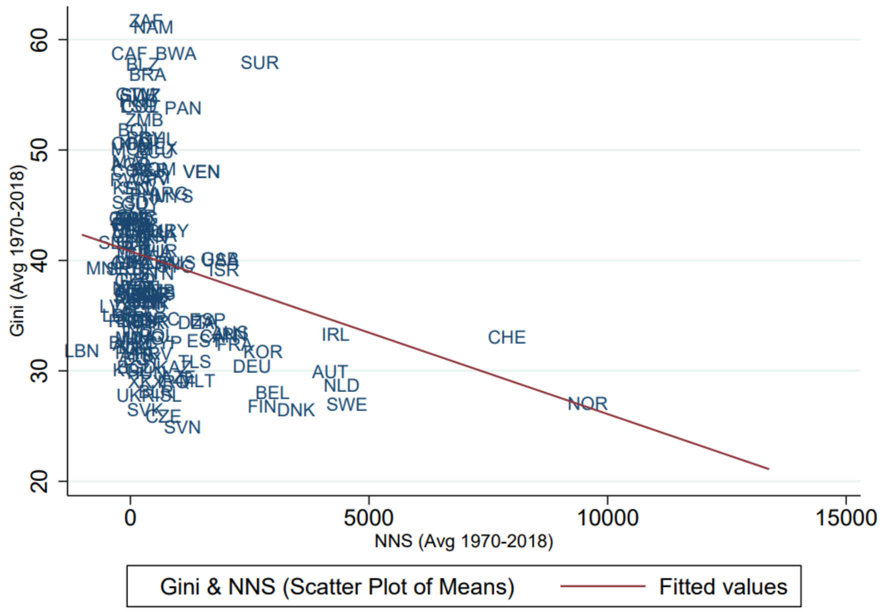

Figure 1. Gini and NNS (Averages 1970-2018)

3.3 Results

Figure 2 presents a simple correlation between ANS per capita and the Gini. A clear negative relation can be noted while bearing in mind that figure 2 simply pertains to cross-country correlations. Taking a step towards more rigorous analysis, the relation between ANS and inequality is estimated employing instrumental variable estimations of country and year fixed effects. A positive and highly significant relationship between ANS and income inequality is found in column (1) of table 4. However, in the first column, only unobserved heterogeneity is controlled for. Therefore, it should be seen as simple correlations rather than ceteris paribus approximations. Including control variables in column (2) causes the relationship to slightly decrease in effect size. The coefficient estimate is now statistically significant at a 5 percent level of confidence. For purely illustrative purposes, the result suggests that – on average – a one percent increase in ANS is associated with 0.0137 points higher Gini in the long run.

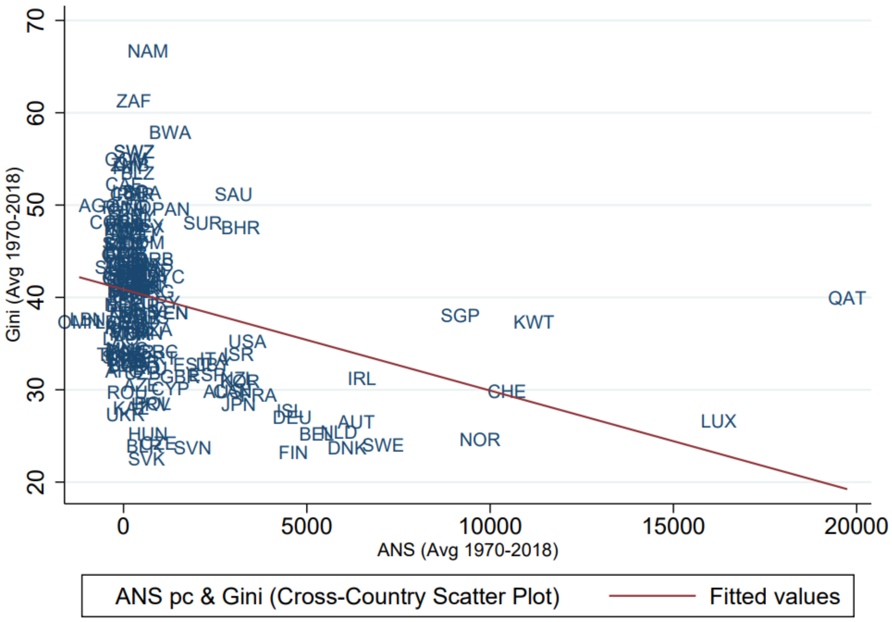

Figure 2. ANS pc and Gini (Cross-Country Scatter Plots, Averages)

Table 4. ANS and Gini

	(1) 20-year 1978-2018 (IV)	(2) 20-year 1978-2018 (IV)
	Dependent variable is Gini; For IV: Second Stage	
ANS (log; pc)	3.198***	1.374**
	(1.010)	(0.659)
Controls	No	Yes
Country FE	Yes	Yes
Year FE	Yes	Yes
Observations	170	108
F-stat	9.85	18.79
Countries	84	53
	First Stage; Dependent variable is the ANS	
GNI (log; pc)	4.96e-06**	7.22e-06***
	(1.99e-06)	(2.12e-06)
NNS (log; pc)	0.700***	0.637***
	(0.0456)	(0.0481)
Controls	No	Yes
Country FE	Yes	Yes
Year FE	Yes	Yes
F-stat	244.3	99.32
Sargan p-value	0.0424	0.38

See Appendix B for countries included in column (2)
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Reverse Causality

The analysis might be subject to reverse causality as it exists between income inequality and GDP (Brückner & Lederman, 2015). Since ANS is a GDP-based indicator of economic sustainability, reverse causality between its components and income inequality cannot be ruled out. Following Brückner and Lederman (2017) and in the attempt to figure out how reverse causality affects the analysis, the effect of income inequality on ANS is investigated, controlling for reverse causation. Therefore, an inequality variable is constructed that is adjusted for the effect ANS has on inequality. The latter is used as an instrument for inequality and is by construction uncorrelated with ANS (see Appendix C for detail). In practice, an IV regression with GNI (log; per capita) and NNS (log; per capita) as instruments for ANS is run to observe its relationship with inequality (as explained in Appendix C). Then, the residual variation of that regression is taken as an instrument for inequality in a regression investigating the effect of inequality on ANS. Herewith, reverse causation between ANS and inequality is cancelled out. The instrument is strong and statistically significant (Appendix D). The results show that an increase in income inequality is associated with a positive and insignificant increase in ANS (Appendix D, Table 8). In turn, this suggests that when performing an analysis of the relationship between ANS and income inequality, without controlling for reverse causation (as in table 4), the coefficient estimate of ANS is likely to be downward biased by the positively counteracting effect income inequality has on ANS. Therefore, the effect of ANS on inequality is likely to be underestimated.

Variants of income inequality

In the next step, aside from the widely used Gini coefficient, income shares held by each quintile in the income distribution are employed as a measure to capture income inequality. The latter provides additional information on potential patterns of differences between income levels that may be hidden by the Gini. Atkinson, Piketty, and Saez (2011) show that this distinction is crucial for an understanding of within-country inequality. Concerning the data, following Brückner, Dabla-Norris, and Gradstein (2014), the primary source is the UN-WIDER World Income Inequality Database (WIID, 2017), in which low-quality observations were filtered out. The data is supplemented with observations from the World Bank's POVCALNET database. Comparability between the two databases is assured given that overlapping observations are nearly identical. By merging these two sources, the available observations are doubled.

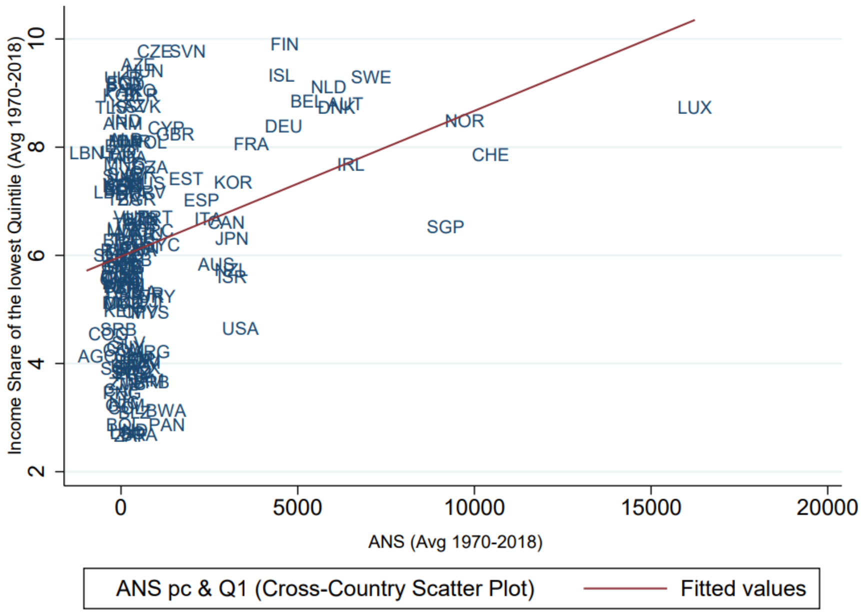

Figure 3. ANS pc and 1st Income Quintile (Cross-Country Scatter Plots, Averages)

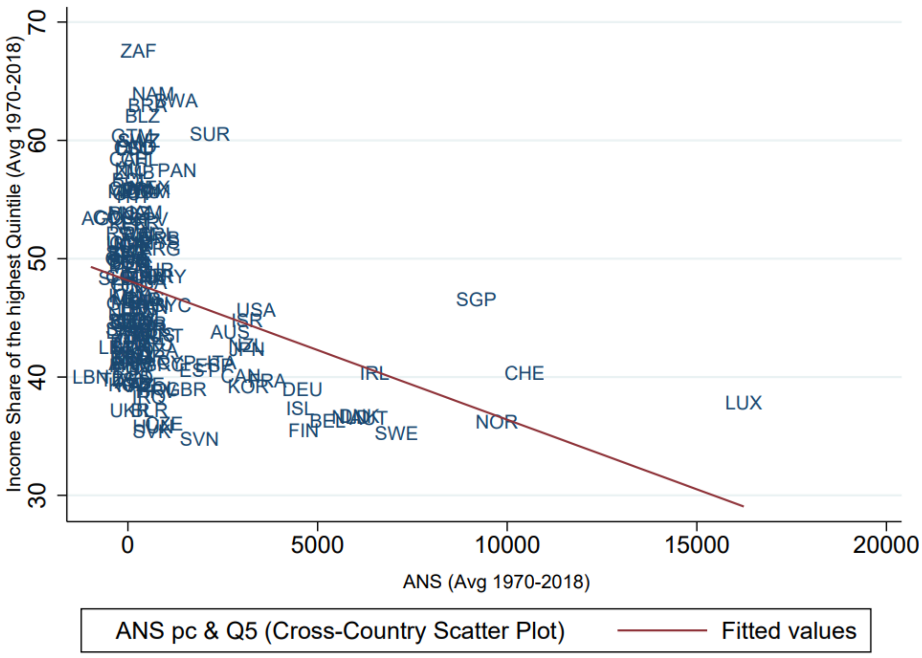

Figure 4. ANS pc and 5th Income Quintile (Cross-Country Scatter Plots, Averages)

Figures 3 and 4 show cross-country correlations between ANS per capita and the income shares of the first and fifth quintile. These simple correlations indicate that in a between-country analysis ANS and the income shares of the first quintile are positively correlated, whereas it is negatively so concerning the income shares of the fifth quintile. This picture is not confirmed in a within-country analysis found in table 9 (Appendix E). The coefficient estimates of the bottom 80 percent of the income distribution are negative, whereas the one of the top 20 percent are positive, suggesting that solely the income shares of the fifth quintile are positively related to higher ANS scores. However, while the Gini appears to stand in a statistically significant association with ANS, for the income shares of the different quintiles no significant relation is found in the long term. Two reasons are likely to be at the root of that. First, changes that occur within the income distribution of the income shares of the quintiles might not be captured. Second, given data availability constraints, different countries are included in column (1) than in columns (2) to (6). As a matter of fact, the Gini observations primarily emanate from the SWIID (and POVCALNET) database, whereas data on the income shares is from the WIID and POVCALNET databases. Hence, even though similar relationships between ANS and income inequality are observed throughout different countries, the results might partly be affected by a lack of data in the included countries which is likely to be the cause for the statistical insignificance.

Developing versus Developed

Research on the effect of GDP on income inequality suggests that the effect varies by state of economic development (Barro, 2000; Brückner & Lederman, 2015; Kuznets, 1955). Given that ANS is a GDP-based composite indicator, similar tendencies may exist. In order to investigate whether heterogenous relations between ANS and inequality exist by the state of economic development, two steps are undertaken. First, aiming at identifying a Kuznets curve like pattern between ANS and income inequality, employing country and year fixed effects, a regression will be run including the logarithm of ANS per capita and the logarithm of ANS per capita squared as independent variables. A squared term would capture the potential inverted U-shaped Kuznets curve like relationship. A second strategy that has been chosen is to split the sample into two income groups. Following the World Banks' country classification of 2010, countries are grouped into a lower income group (<US $3,975 per capita) and higher income group (> US $ 3,976 per capita). With the annual GNI per capita, countries are categorized in one of the two income groups for a given year. As GNI per capita changes over time, countries can appear in different income groups throughout time.

In table 10 in Appendix F, the Kuznets curve is tested. Therefore, the H_0 hypothesis 'ANS (log; pc) and ANS² (log; pc) are equal' is examined. The p-value of that test is significantly above 0.1 for all dependent variables. Besides, their respective coefficient estimates do not indicate opposing directions. Consequently, considering the Gini, the data does not support a Kuznets curve like relationship between ANS and income inequality. Additionally, when splitting the sample into two parts, divided by income level, table 5 shows that ANS tends to be linked to an increase in income inequality in both developing and developed countries. However, in lower-income countries the effect size of the relationship is larger while for both groups of countries the coefficient estimate is statistically insignificant, which is most likely to be explained by a significant drop in observations when splitting the sample into two groups.

Table 5. ANS and Gini Low and High-Income Countries (Long-Term)

	(1) Lower-income	(2) Higher-income
Second Stage; Dependent variable is Gini		
ANS (log; pc)	4.344	1.386
	(4.928)	(0.846)
Controls	Yes	Yes
Country FE	Yes	Yes
Year FE	Yes	Yes
Observations	30	62
F-stat	6.373	12.34
Countries	15	31
First Stage; Dependent variable is ANS		
GNI (log; pc)	1.38e-05	7.94e-06**
	(8.54e-06)	(3.40e-06)
NNS (log; pc)	0.764***	0.621***
	(0.0149)	(0.0570)
Controls	Yes	Yes
Country FE	Yes	Yes
Year FE	Yes	Yes
F-stat	29689	72.89
Sargan p-value	0.1709	0.5149

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Drivers

While analysing ANS' relationship with income inequality, it is also of interest to figure out whether different variants of ANS drive changes in inequality development differently. To a certain extent, this allows testing the theories linking the individual components of ANS to inequality. In that line, the relationship between the following variants of ANS and income inequality are portrayed (reminder: ANS = NNS + E – R – P):

NNS	Net National Savings
ANS_E	NNS - R – P (ANS without education expenditure E)
ANS_P	NNS + E – R (ANS without subtracting CO_2 damages P)
ANS_R	NNS + E – P (ANS without deducting rent from natural resources R)

Following Gnègnè (2009) and leaving out one of the components at the time allows studying the relationship the other components have with inequality, suggesting that the difference between the conventional ANS and one of its variants can be attributed to the component left out. NNS is the only component that is also individually regarded as it is the base of ANS, from which the other components are added or deducted.

Figure 5 presents a coefficient plot of the relation ANS and its variants have with the Gini. The results show that all variants of ANS are positively associated with income inequality. The coefficients are all statistically significant except for ANS_R (see Appendix G for table). From figure 5 important lessons can be drawn regarding the drivers behind the relationship between ANS and income inequality. When solely regarding the link between NNS (basis of ANS) and inequality for which solely GNI is taken as an instrument, a relatively larger positive effect size of the relation between NNS and income inequality - compared to ANS - is to be discerned. This suggests that the marginal effect of an increase in NNS is associated with a larger (than ANS) and statistically significant increase in income inequality. Further, excluding public expenditure on education from ANS causes the coefficient estimate to take a marginally greater effect size than ANS. Hence, one can assume that higher education expenditure is conducive to lower income inequality since adding educational expenditure to ANS reduces its association to income inequality. Besides, when not subtracting damages of CO_2 emissions from ANS, its impact on ANS is slightly smaller. This suggests that - given the applied social costs of carbon - the more damage is done by emitting CO_2, the lower income inequality. Besides, when rents from natural resources are not subtracted from ANS (ANS_R), the association with inequality becomes large and statistically insignificant. Although this points towards a positive association between rents from natural resources and inequality, this tendency is statistically insignificant and should therefore not be overestimated. Indeed, as shown in Appendix H, no evidence is found for a relationship indicating that countries with higher rents from natural resources are neither more nor less equal than other countries. Finally, it emerges that NNS is the main driver behind the relationship ANS has with income inequality, while the rents from natural resources distort this impact since they are not found to significantly influence income inequality.

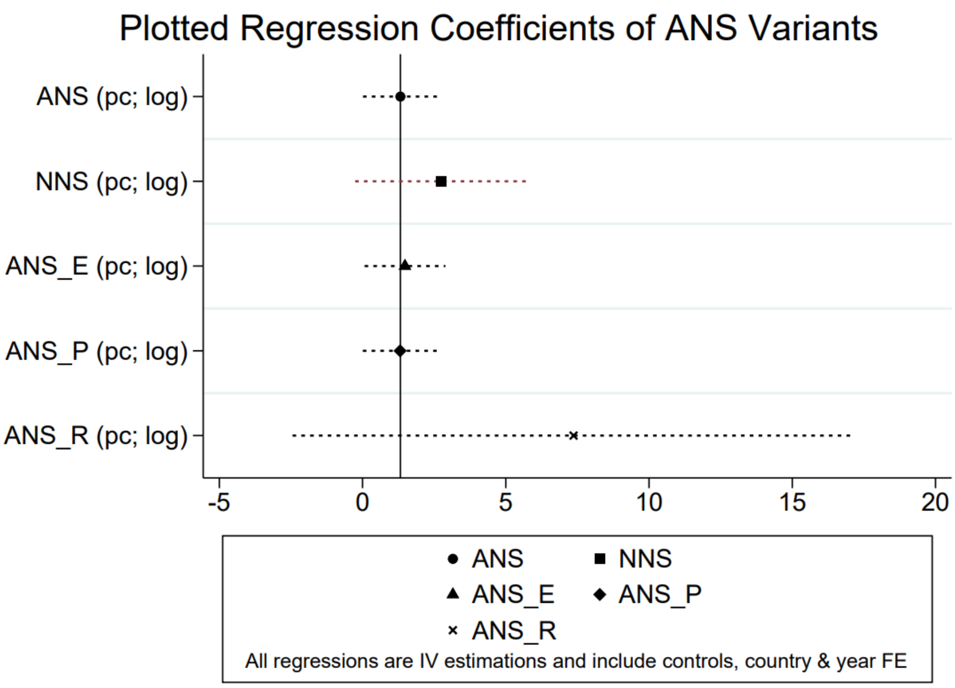

Figure 5. ANS Variants on Gini (Long-Term Relationship, Coefplot)

Robustness Checks

In the next step, the relation between ANS and income inequality will be tested to alternative specifications. Therefore, three robustness checks are run. The first two are the exclusion of outliers (identified using the interquartile range method) and the exclusion of natural resource-dependent countries (here defined as countries where rents from natural resources account for 10 or more percent of GDP). The results confirm the relationship found above (see Appendix I for results). Indeed, in both cases, the relationship between ANS and income inequality remains positive in the long term. Nonetheless, the coefficient estimates lose their statistical significance which presumably is explained by the considerable drop in observations.

A third robustness check is performed by adding particulate matter ($PM_{2.5}$) emissions to the composite indicator ANS. Indeed, as the theoretical framework shows, air pollution may have a negative association with income inequality. Though, as shown above, the basic ANS indicator does not include damages caused by air pollution in its formula. A newer version of

ANS includes particulate emissions in its equation and is included in the analysis to investigate whether its insertion affects the association between ANS and income inequality. Essentially, this version of ANS subtracts damages of particulate matter emissions from the nations' wealth. Here, damages due to air pollution are estimated as forgone labour output due to human sickness and premature death from exposure to air pollutants (World Bank, 2018). As for the ANS described above, observations for all countries are included, however, these only begin in 1990 and thereby cover a shorter period.

Table 6 presents the association between ANS and income inequality when including particulate matter emissions. In order to capture the longest term possible within the 1990 to 2018 time span for which estimates are available, 14-year intervals are chosen. For comparison purposes, the same time intervals are applied for the conventional ANS indicator in column (2). The results indicate nearly equal relationships between ANS with and without particulate matter emissions and income inequality. This confirms the robustness of the results found in this analysis.

Table 6. ANS including Particulate Emissions and Gini (14-year intervals)

	(1) Including PM 1990-2018	(2) Excluding PM 1990-2018
Second Stage; Dependent variable is Gini		
ANS (log; pc)	2.875***	2.883***
	(0.797)	(0.796)
Controls	Yes	Yes
Country FE	Yes	Yes
Year FE	Yes	Yes
Observations	146	146
F-stat	11.40	11.40
Countries	73	73
First Stage; Dependent variable is ANS		
GNI (log; pc)	0.104	0.111*
	(0.0665)	(0.0661)
NNS (log; pc)	0.729***	0.730***
	(0.0752)	(0.0749)
Controls	Yes	Yes
Country FE	Yes	Yes
Year FE	Yes	Yes
F-stat	78.73	78.79
Hansen p-value	0.0460	0.0476

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4 Discussion

The discussion positions the findings in the existing body of literature. This paper was set out to address the relationship between sustainable development and income inequality. Employing the composite indicator ANS as a measure for sustainable development, its relationship with income inequality is investigated using cross-country panel data for a host of over 50 countries covering the time between 1978 and 2018. Clearly, the main finding of this thesis is that the relationship between ANS and within-country income inequality is positive in the long run. Indeed, the results suggest that a one percent increase in ANS is associated with a statistically significant rise in income inequality by 0.0137 Gini points in a 20-year period. The relative income shares gained by each quintile - though not statistically significant - tend to support that picture by showing that solely the income share of the top 20 percent of the income distribution seems to be positively associated with higher ANS. Moreover, the data indicates that the association between ANS and income inequality does not differ by state of economic development. Indeed, a positive association between ANS and income inequality is found for both, developing and developed economies.

This paper is a first attempt to assess the relationship between sustainable economic development and income inequality. In doing so, this study demonstrates the interconnectedness of economic, environmental, and social aspects. Out of the absence of previous studies investigating the relation of interest, arises the necessity to position the results relative to findings that study the effect of the individual components of ANS on income inequality and in relation to studies examining the effect of ANS on welfare or wellbeing.

With regards to the overall positive association between ANS and inequality, it is to be noticed that, on the one hand, the results do not resonate with studies on the effect of national income, environmental sustainability, and education on income inequality (Angelsen et al., 2014; Becker & Chiswick, 1966; Brückner & Lederman, 2015). On the other hand, however, this finding is consistent with Halter, Oechslin, and Zweimüller's (2014) who are concerned with the inequality-growth debate, indicating economic growth reducing effects of income inequality in the long run. Indeed, the long-term relation between ANS and income inequality might be driven by rather slow political processes, changes of institutions, and socio-economic movements. Thus, the positive relation only occurs with a considerable time lag.

Given that no difference in the direction of the association between ANS and income inequality is found for economies at different stages of economic development, the results do not support the hypothesis of an inverted U-curve, such as Kuznets (1955) finds it for the growth-inequality relation and Greenwood and Jovanovic (1990) who contend that such a relationship exists between financial development and income inequality. Instead, the findings are in line with Banerjee and Newman (1993) and Galor and Zeira (1993) arguing that higher financial development is related to a general increase in income inequalities.

Furthermore, with regards to the time it takes for ANS to show effect, the results corroborate with studies on the effect of ANS on welfare and wellbeing (Gnègnè, 2009; Greasley et al., 2016; Hanley et al., 2016; Qasim, Oxley & McLaughlin, 2018). However, these studies' results suggest that the long-term effects positively relate to welfare and wellbeing. Nonetheless, given that these studies refer to welfare and wellbeing and do not include measures of income inequality, the present findings do not challenge their results.

Against the backdrop of a positive long-term association between ANS and income inequality, the results imply that, unlike Lange et al. (2018) argue, sustainable economic development and income inequalities cannot unambiguously be addressed together. More precisely, the results suggest that long-run reductions in income inequality are not likely to be achieved by solely putting emphasis on increasing the economic sustainability which is reflected in ANS. Instead, the positive relationship between ANS and income inequality seems to lend support to Piketty (2014), who contends that growth in national income is unlikely to reduce income inequality and therefore argues in favour of redistributional policies as the only means of reducing income inequalities. However, it is beyond the scope of this paper to further test Piketty's argumentation with regard to the influence of wealth and income inequality.

Taking a closer look at the drivers of the relationship between ANS and income inequality further nuances the picture and resonates with prior findings. As shown above, the main driver of the relationship is NNS. In the here-found results, it appears that the positive relation between NNS and income inequality is statistically significant in the long run. NNS being a transmission channel between growth and inequality (Barro, 2000), this finding lends support, as laid out above, to Halter, Oechslin, and Zweimüller's (2014) findings. Further, it is in line with

Banerjee and Newman (1993) and Galor and Zeira (1993) in regard to a positive association between financial development (standing in a causal relation to NNS) and income inequality. Concerning public expenditure on education, the findings are in line with the human capital theory (Becker & Chiswick, 1966; Mincer, 1974). Indeed, it suggests that higher educational expenditure is associated with a reduction in income inequality, most likely through an implied decline in educational inequality, and thereby tends to support De Gregorio and Lee (2002). Besides, research indicates that changes in educational policies solely show negative effects on income inequality after a considerable time lag, favouring once more, the long-term investigation of this study (Knight & Sabot, 1983). Concerning environmental sustainability, damages caused by CO_2 emissions and rents from natural resources are included. At first glance, contrary to theories and former studies finding a negative relation between pollution and income inequality (Angelsen et al., 2014; Islam, 2015; Tessum et al., 2019; Torras & Boyce, 1998), this study finds that damages from carbon emissions are negatively related to income inequality. The most likely explanation of this finding is the nature of the annually increasing social costs of carbon. Indeed, when analysing the effect on income inequality, the picture is blurred when the same social costs of carbon are applied for countries in different states of economic development. This explains why emissions of CO_2 can be positively associated with income inequality, while for damages caused by CO_2 emissions the effect can be negative. Referring to rents from natural resources, the here-employed data suggests that these rents do not affect income inequality in a statistically significant manner (figure 5 & Appendix H). That points towards prior findings by Humphreys, Sachs, and Stiglitz (2007) and Alvarado et al. (2021) stating that resource-rich countries tend to be neither more nor less unequal than less resource-rich countries and that the relationship is at best heterogeneous.

Furthermore, testing the relationship of interest to alternative specifications, the robustness of the relationship is underpinned. Indeed, adding particulate emissions to ANS' equation does not affect its relation to income inequality. When excluding outliers and natural resource-dependent countries from the regressions the direction and effect size of the relationship hold.

The study has several limitations. These are divided into three categories. The first category relates to caveats that concern ANS as an indicator of sustainable development. In fact, ANS is an indicator of weak sustainability. In contrast to strong sustainability, weak sustainability aims to sustain economic growth, not natural capital, as is the case with strong sustainability. Based on the Hartwick rule, it assumes a certain degree of substitutability of natural capital with other types of capital and a possible monetarization of natural capital (Hartwick, 1977). Given the current ecological overshoot, this approach might be untenable. Additionally, while it is in the interest of the index to provide a simple overview of how sustainable a country's investment policies are (World Bank, 2018), Everett and Wilks (1999) criticize it for synthesising economic and environmental aspects. Indeed, this might hide pressing problems and lead to erroneous policy implications. The interested reader is referred to Pillarisetti (2005). Besides, the component 'public expenditure on education' can be criticized for not being a good proxy of human capital. The depreciation (death and skill obsolescence) and appreciation (on-the-job training or gathered experience) of human capital are ignored (Blum, Ducoing & McLaughlin, 2017; Gnègnè, 2009). Furthermore, the effects of international migration on national accounts of human capital are not captured here. As to the components relating to environmental sustainability, the non-inclusion of pollutants other than CO_2 (other greenhouse gases, pollutants such as SO2 and NOx, water pollution, etc.) but also the exclusion of rather difficult to evaluate biophysical components (such as water quality and quantity, air quality, sediments, and soil nutrients, wildlife, habitat and vegetation, biota, species at risk, acoustics environment, etc.) can be criticized (Gnègnè, 2009). Despite these limitations, ANS is the most widely used measure of sustainable development with comparatively good data availability, which is why it is employed in this paper.

A second point is of methodological nature and pertains to the interpretation of the coefficient estimates. Since a constant has been added to ANS per capita in order to lift all observations to positive values with the aim to take its natural logarithm, the coefficient estimates cannot be seen as precise effect size. Instead, tendencies are displayed. This point sees itself reinforced due to reverse causality. Indeed, as laid out above, the analysis is subject to reverse causation. Having controlled for reverse causality in a regression that estimates the effect of income inequality on ANS, a positive long-term effect is detected. In turn, this suggests that the effect of income inequality on ANS counteracts the effect ANS has on income inequality. Therefore, the effect of ANS on inequality is likely to be underestimated which - once more - causes the coefficient estimates to be inexact.

A third point concerns data availability and its quality. There is a general tendency for data to be rather scarce as observations go back in time. Besides, for many indicators employed in this paper, data tends to be scarce in lower-income countries. Therefore, the results tend to be biased towards higher-income countries as fewer low-income countries are included in the analysis.

Despite having controlled for income levels, country fixed effects, and clustering standard errors at the country level, limiting the scope of this drawback, fewer observations reduce the statistical meaningfulness of these regressions. Furthermore, when studying long-term associations between ANS and income inequality with 20-year intervals, the time span (1970-2018) for which data on both ANS and income inequality is available causes that one is provided with a maximum of two observations per country. Thus, although a statistically significant relationship is found between ANS and income inequality, the analysis could have benefited from more plentiful estimations.

Thanks to the within-country analysis of more than 50 countries, the following generalizations are possible from this study. In the long term (20-year intervals), on average, higher ANS is conducive to higher income inequality. Asides, there appears to be no statistically significant difference for this relationship depending on the state of economic development.

Consequently, the subsequent recommendations for future research are given. First, given the focus on the relationship between ANS and income inequality of this paper and having proven that reverse causation is at play, leading to an underestimation of the here-found coefficient estimate indicating the effect ANS has on inequality, reverse causality is a potential matter of further inquiry. Second, the channels of transmission between ANS, its components, and income inequality and their importance are worth an investigation. Admittedly, in the context of reverse causation, this would improve the comprehension of the relationship and might point towards alleys in which sustainable economic development and a reduction in income inequalities can simultaneously be accommodated. Third, out of the fact that ANS is an indicator of weak sustainability arises the recommendation to investigate the relationship between an indicator of strong sustainability and income or other social inequalities.

5 Conclusion

The purpose of this thesis is to investigate the so far unexplored relationship between ANS and income inequality. Whilst previous research has explored the determinants of income inequality, higher levels of aggregate output, economic growth, and environmental sustainability are generally found to lower income inequality. Additionally, studies investigating ANS' relationship with objective welfare and subjective wellbeing indicate positive long-term associations. This study contributes to the literature by further exploring the interrelation between economic, environmental, and social aspects. In fact, this approach is supported by research indicating the need for a consolidation of these three facets so to truly achieve sustainability. Indeed, income inequalities and planetary boundaries present threats to social stability and global security.

Overall, this study demonstrates that ANS stands in a positive long-term relationship with income inequality. In other words, an increase in ANS is associated with a statistically significant increase in income inequality over a 20-year period. Further, the paper finds no heterogeneous associations depending on the state of economic development of economies. Given the presence of reverse causality, it is further shown that the effect of income inequality on ANS is positive but statistically insignificant which suggests that that the here-found positive effect size is likely to be underestimated. The results are proven to hold to alternative specifications such as the exclusion of outliers and natural resource-dependent countries, as well as the inclusion of particulate matter emissions to the equation of ANS.

The results incentivize a rethinking of policy approaches and underline the key role governance plays when it comes to reconciling increases in economic sustainability with decreases in income inequality. Indeed, this paper shows that policies solely focussing on enhancing sustainable development are likely to be associated with an increase in income inequality and hence threaten social stability and security. While that highlights the need for a better understanding of the exact channels of transmission, it also calls for policy makers to address sustainable development and income inequality at the same time. Hence, if the goal is to achieve higher economic sustainability as measured by ANS, policy makers are recommended to aim at decreasing the reliance on the extraction of natural resources and anthropogenic greenhouse gas emissions related to production processes. Indeed, decoupling economic development from greenhouse gas emissions and unsustainable extraction of natural resources might allow increasing economic growth without being detrimental to environmental sustainability. Increased human capital will facilitate that transition. Hence, policies should also target higher and efficient spending on education.

Lastly, as to policy making targeted to reduce income inequalities, following Rodrik and Stantcheva (2021) an important policy recommendation from this study is to opt for an integrative approach increasing the income share of the bottom quintiles, holding or increasing it for the middle class, while holding within reasonable dimensions the income share of the top incomes. This can be achieved by simultaneously intervening before, during, and after production. Measures may include improved primary education, enhanced public higher education, inheritance-, gift-, and estate taxes for the pre-production stage, the introduction of minimum wages, industrial policies, competition, and antitrust policies for the production stage as well as redistributional policies such as social transfers, unemployment insurance, pensions, wealth-, and corporate-taxes.

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Appendix A

Control variables

The control variables are the following: first, the government consumption is proxied by the ratio of total final consumption of each country's government to GDP. Indeed, government consumption can be associated to a higher scale of government transfer payments, leading to an overall reduction of income inequalities (Sylwester, 2002). Second, the dependency ratio, that is the share of those typically not in the labour force (below 15 and above 65-year-olds) to those that are (15- to 65-year-olds), is taken as control variable. To a certain degree it provides information on the age distribution of a country. Bergh and Nilsson (2010) show that a higher dependency ratio is conducive to higher income inequality. The third control variable is foreign direct investment as share of GDP. As foreign investments are made, people's incomes tend to increase which can be associated with a reduction in income inequality, even though it might create regional inequalities (Choi, 2006). Fourth, trade openness is proxied by the share of trade to GDP. Indeed, research by Meschi and Vivarelli (2009) suggests that trade openness is conducive to a lowering in income inequality through an increase of the domestic populations' income. A fifth control variable that is taken into account is financial development, measured as share of net lending by financial institutions to GDP. Similarly, higher levels of financial development promote higher incomes, by which income inequality can be lowered (Kim & Lin, 2011). An akin logic applies to the sixth control variable, urbanization rate. Lu and Chen (2006) show that compared to rural areas, incomes in urban areas are higher, so that a larger proportion of a population living in urban areas is concomitant with lower levels of income inequality. A last mediating variable that is controlled for in the analysis is population growth. Firebaugh (1999) indicates that population growth optimizes population structures, promotes growth and reduces income inequality. Further, Arrow, Dasgupta and Mäler (2003) argue in favour of including population growth as control variable - next to per capita estimations - when running models with ANS in order to aim for optimal controls.

Appendix B

Table 7. List of Countries included in the Main Regression

List of countries (53) included in column (2) of Table 4				
Argentina	Cyprus	Italy	Nicaragua	Spain
Australia	Denmark	Jordan	Norway	Sri Lanka
Belarus	Dominican Republic	Kazakhstan	Peru	Sweden
Belize	Egypt, Arab Rep.	Korea, Rep.	Philippines	Thailand
Bolivia	Finland	Latvia	Poland	Tunisia
Botswana	France	Malaysia	Portugal	Turkey
Bulgaria	Germany	Mexico	Romania	United Kingdom
Cameroon	Guatemala	Moldova	Russian Federation	United States
Canada	India	Morocco	Singapore	Uruguay
Chile	Iran, Islamic Rep.	Namibia	Slovak Republic	
Costa Rica	Israel	Netherlands	South Africa	

Appendix C

In the following is laid out how the part of inequality that is not explained by ANS can be taken as instrument for inequality in a regression that examines the effect of inequality on ANS. The econometric theory is based on the method used by Brückner (2013). The effect that real ANS per capita has on income inequality can be formulated as follows using two-stage least squares:

$$(1)\ \log(\mathrm{inequality}_{i,t}) = a_i + b_t + c \log(\mathrm{ANS}_{i,t}) + e_{i,t}$$

Where log (inequality) is the logarithm of income inequality and log (ANS) is the logarithm of real per capita ANS, a and b are country and year fixed effects respectively. If per capita ANS has a significant effect on income inequality (i.e. in equation (1) $c \neq 0$), then the estimate of the effect of income inequality on ANS is biased using ordinary least squares (OLS). Specifically, suppose that the effect of inequality on ANS can be written as

$$(2)\ \log(\mathrm{ANS}_{i,t}) = h_i + i_t + k \log(\mathrm{inequality}_{i,t}) + mZ_{i,t} + u_{i,t}$$

then cov(log(inequality), u) $\neq 0$, and the OLS estimate of k will be biased upwards if $c > 0$, and biased downwards if $c < 0$. However, this endogeneity bias due to $c \neq 0$ in equation (1) can be circumvented by (i) constructing an adjusted inequality series where the response of inequality to per capita ANS growth is partialised out, i.e..

$$(3)\ \log(\mathrm{inequality}_{i,t})' = \log(\mathrm{inequality}_{i,t}) - c \log(\mathrm{ANS}_{i,t})$$

and (ii) using this endogeneity-adjusted inequality series as an instrument for the original inequality series in equation (2). By construction, the IV estimator that uses the endogeneity-adjusted log (inequality)' auxiliary series as an instrument for log (inequality) does not suffer from simultaneity bias. Beyond removing the simultaneity bias associated with the least squares estimation of equation (2), the IV estimator provides a consistent estimate of the parameter k under the assumption (exclusion restriction) that the error in equation (1) is uncorrelated with the error in equation (2). If there are omitted variables that are part of both equation (1) and equation (2), the zero covariance assumption is violated and the IV estimator does not solve the omitted variable problem. However, the IV estimator still solves the simultaneity problem.

Note that the estimation strategy requires that the parameter c in equation (1) is estimated consistently. Due to the simultaneity of the two equations, OLS cannot provide a consistent estimate of the parameter c in equation (1) if $k \neq 0$ in equation (2). Moreover, since measurement error is a real problem in national accounts statistics of developing countries (Heston, 1994), the OLS estimate of the parameter c in equation (1) is likely to be attenuated towards zero: therefore, an IV estimate of equation (1) is required. For more details, see Brückner (2013).

Appendix D

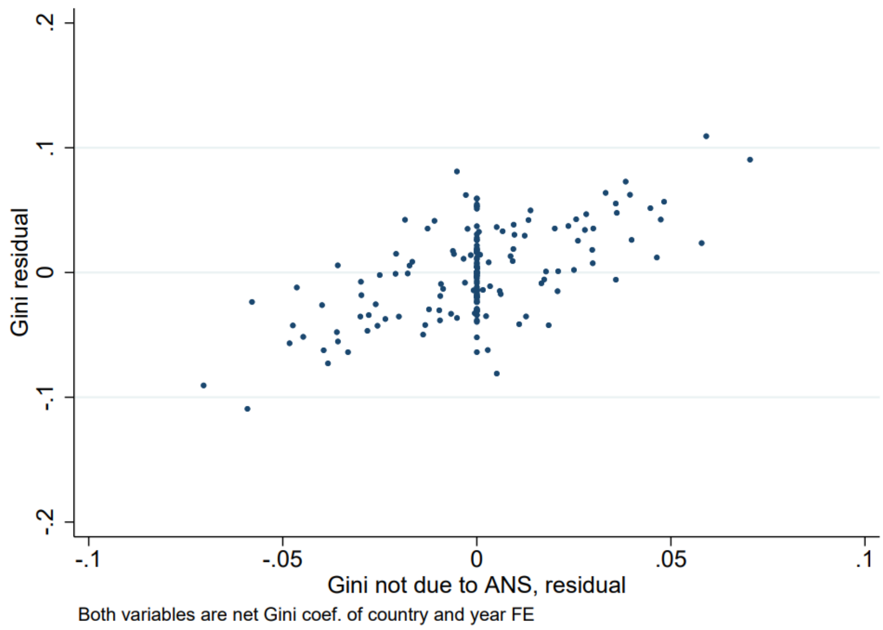

Figure 6. Relationship between Gini Coefficient and Gini Coefficient net of ANS per capita

Table 8. Effect of Inequality on ANS (Long-Term)

Second Stage. Dependent variable is ANS (log; per capita)	
Gini (log)	0.205
	(0.475)
Controls	Yes
Country FE	Yes
Time FE	Yes
F-stat	63.98
Observations	106
Countries	53
First Stage. Dependent variable is Gini (log)	
Instrument	1.008***
	(0.02)
Controls	Yes
Country FE	Yes
Time FE	Yes
F-stat	2376.22

Instrument is the part of inequality that is not explained by ANS
Sargan test p-value cannot be reported if there is only one instrument (as is the case here)
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix E

Table 9. ANS and Income Shares (Long-Term Relationship)

	(1)	(2)	(3)	(4)	(5)	(6)
	Gini	Q1	Q2	Q3	Q4	Q5
	IV	FE	FE	FE	FE	FE
Second Stage; Dependent variable are Gini & Income Share by Quintile						
ANS (log; pc)	1.322**	-0.0293	-0.144	-0.327	-0.311	0.806
	(0.667)	(0.445)	(0.408)	(0.336)	(0.432)	(1.410)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	106	172	172	172	172	172
F-stat	19.03					
R-squared		0.205	0.259	0.268	0.268	0.247
Countries	53	123	123	123	123	123
First Stage (for IV); Dependent Variable is ANS						
GNI (log; pc)	7.22e-06***					
	(2.12e-06)					
NNS (log; pc)	0.637***					
	(0.0481)					
Controls	Yes					
Country FE	Yes					
Year FE	Yes					
F-stat	99.32					
Sargan p-value	0.3823					

Performing endogeneity tests for columns (2)-(6), the null hypothesis of exogeneity cannot be rejected, therefore, ANS is treated as exogenous. Hence, country and time fixed effects are applied.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix F

Table 10. ANS, ANS² and Income Inequality (Long-Term) Fixed Effects

	(1) Gini	(2) Q1	(3) Q2	(4) Q3	(5) Q4	(6) Q5
ANS (pc; log) [A]	2.052***	0.0445	0.187	0.215	0.225	-0.535
	(0.573)	(0.464)	(0.323)	(0.384)	(0.399)	(1.423)
ANS² (pc; log) [B]	0.155	-0.132	-0.200*	-0.142	-0.0824	0.545
	(0.241)	(0.119)	(0.119)	(0.130)	(0.128)	(0.442)
Test [A]=[B], p-value	0.0121	0.7502	0.3527	0.4562	0.5260	0.5445
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	198	182	182	182	182	182
R-squared	0.517	0.208	0.262	0.209	0.246	0.245
Countries	131	126	126	126	126	126

Country and year fixed effects are applied to be able to have two versions of ANS, namely ANS and ANS², as independent variables.
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix G

Table 11. ANS and its Variants on Gini (Long-Term Relationship)

	(1)	(2)	(3)	(4)	(5)
	Second stage (for IV). Dependent variable is Gini				
ANS (log; pc)	1.322**				
	(0.667)				
NNS (log; pc)		2.731*			
		(1.526)			
ANS_E (log; pc)			1.481**		
			(0.720)		
ANS_P (log; pc)				1.311**	
				(0.665)	
ANS_R (log; pc)					7.367
					(5.006)
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
F-test	19.03	8.788	20.31	18.94	16.71
Observations	106	108	106	106	106
Countries	53	54	53	53	53
	First stage. Dependent variables are ANS and its variants (log; per capita)				
GNI (log; pc)	7.22e-06***	3.28e-06	1.13e-05***	6.60e-06***	8.10e-06***
	(2.12e-06)	(1.73e-05)	(2.86e-06)	(2.31e-06)	(1.54e-06)
NNS (log; pc)	0.637***		0.567***	0.645***	0.0469***
	(0.0481)		(0.0389)	(0.0498)	(0.0133)
GNI² (log; pc)		1.97e-10			
		(1.69e-10)			
Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
F-test	230.62	3.52	167.90	226.21	27.35
Sargan p-value	0.3823		0.4731	0.3743	0.4644

ANS_E=NNS-R-P; ANS_P=NNS+E-R ; ANS_R=NNS+E-P
In column (2) in which NNS is the independent variable, the only instrument employed is GNI (log; per capita). Therefore, no Sargan test could be conducted.
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix H

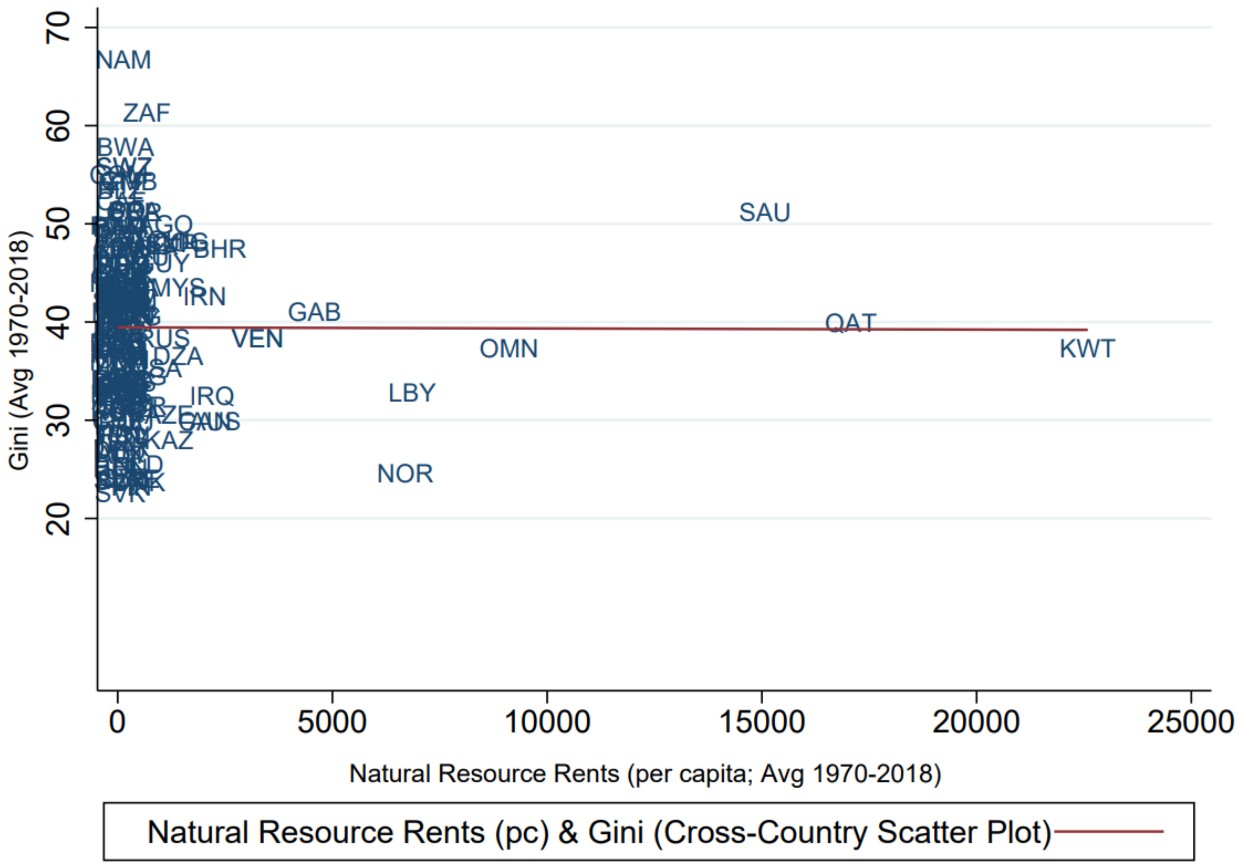

Figure 7. Natural Resource Rents (per capita) and Gini

Table 12. Natural Resource Rents and Gini (Long-Term)

	(1) Gini
Natural Resource Rents (per capita)	0.000146
	(0.000203)
Controls	Yes
Country FE	Yes
Year FE	Yes
Observations	197
R-squared	0.466
Countries	131

Country and year fixed effects are applied
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix I

Table 13. Robustness Checks (Long-Term)

	(1) Outliers excluded 1978-2018	(2) Res. dep. excl. 1978-2018
Second Stage; Dependent variable is Gini		
ANS (log; pc)	1.529	1.126
	(1.693)	(-2.94)
Controls	Yes	Yes
Country FE	Yes	Yes
Year FE	Yes	Yes
F-stat	3.72	2.78
Observations	58	36
Countries	29	18
First Stage; Dependent variable is ANS (log; pc)		
GNI (log; pc)	1.65e-05***	1.21e-05***
	(3.06e-06)	(1.78e-06)
NNS (log; pc)	0.561***	0.576***
	(0.0452)	(0.0443)
Controls	Yes	Yes
Country FE	Yes	Yes
Year FE	Yes	Yes
F-test	72.69	279.51
Sargan p-value	0.6640	0.7959

Column (2) excludes countries in which the share of rents from natural resources is above 10 percent as share of GDP. Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1