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Louis Dupuy

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## International Trade and Sustainability: A survey

Louis Dupuy

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## Abstract

This paper aims at reviewing the literature on international trade and sustainability. In the neoclassical sense sustainability is interpreted as the imperative to maintain constant consumption over time. The literature provides several indicators to assess sustainability empirically. Theoretical and empirical studies alike usually consider the world either as an integrated economy where international is no different from intra-national trade and can be neglected or a juxtaposition of closed national economies. Some useful insights can be drawn from the literature on trade and the environment to finally understand the impact of international trade on all the dimensions of sustainability.

**Keywords:** Sustainability, International Trade, Environmental Accounting

**JEL Classification:**F11,F18,Q01,Q56

# 1 Introduction

The literature on sustainable development and sustainability saw a dramatic increase in the past two decades. The empirics of sustainability have been notably improved as exemplified by numerous World Bank reports. The Bruntland report ([World Commission on Environment and Development 1987](#)) defines sustainable development as “satisfying our current needs without compromising the ability of future generations to satisfy theirs”. Sustainable development encompasses dimensions beyond the scope of economic analysis. For that reason, economists have tried to narrow it down to fit the economic analysis. The literature on sustainability in economics could be dated back to the 19<sup>th</sup> century with [Malthus \(1817\)](#) analysing population growth and [Marshall \(1961\)](#) studying land use. Following [Hicks \(1939\)](#), neoclassical authors define income as the return on wealth, wealth being the assessment of the economic value of a country.

Modern definitions of sustainability were proposed by the Meadows report ([Meadows et al. 1972](#)) and emerged from the debates between members of the neoclassical school of Cambridge, MA ([Solow 1974](#), [Stiglitz 1974](#), [Dasgupta and Heal 1979](#), [Solow 1986](#)). They conclude an economy is sustainable if consumption is non-declining over time. This implies a flow of income high enough to guarantee a given level of constant consumption. [Hartwick \(1977\)](#) uses this neoclassical framework (the DHSS model, for Dasgupta-Heal-Solow-Stiglitz) to propose the first sustainability rule: invest all rents from natural resources extraction in capital to maintain constant consumption over time. Those theoretical principles required empirical testing, a daunting task as an indicator of sustainability should meet several conditions:

- To be related to well being.
- To be related to wealth and income.
- To be an indicator of current and future sustainability.

A first method for sustainability assessment was proposed by [Weitzman \(1976\)](#) using the Net National product (NNP). NNP was related to well-being and resource exhaustion through the DHSS model. Using capital theory ([Victor 1991](#)) to overcome the problems of incommensurable sources of wealth, [Pearce and Atkinson \(1993\)](#) proposes an alternative indicator of sustainability termed Genuine Savings (GS). It is now more commonly referred to as Adjusted Net Savings (ANS). The World Bank adopted this indicator and now publishes estimates on a regular basis with the World Development Indicators<sup>1</sup> and some dedicated studies ([World Bank 1997, 2006, 2011](#)). Both ANS as an indicator and the underlying theory of sustainability have to deal with some challenges to their comprehensiveness:

- The role played by technical progress on sustainability, either through factor-augmenting innovations or improvement in total factor productivity.
- The role played by institutions: they usually are assumed to have an impact on overall productivity, but their role is obviously wider.
- The role played by international trade, by allowing exports and imports of capital services embodied in goods and services.

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<sup>1</sup>see [The World Bank website](#)

This survey will focus on this third issue, international trade. The theoretical literature on sustainability claims the largest impact of international trade is through capital gains [Asheim \(1986\)](#), [Vincent et al. \(1997\)](#): international trade affects the optimal path of use/depletion of a given resource.

Empirical estimates of sustainability usually handles international trade in two ways. The first method is to estimate the level of *global* sustainability, to evaluate if the world as a whole is on sustainable course. This method can be related to the “Angel parable” of [Samuelson \(1949\)](#), where free trade allows the world to behave like a closed economy. The second method sees the assessment of sustainability on a country by country basis, as if the world was a juxtaposition of mostly closed economies. The existence of the rest of the world doesn’t have an impact on domestic options regarding resource use and depletion. The dynamic effects of international trade are simply ignored. [Proops et al. \(1999\)](#) and [Atkinson and Hamilton \(2002\)](#) try to use Input/Output analysis to re-affect the consumption of resources to the final consumer when different from the producing country. Involved in this strategy is the idea that foreign customers can be responsible for the depletion of resources in the home country. The same strategy was followed by the recent Inclusive Wealth Report<sup>2</sup> about water consumption. One could also cite the literature on the resource curse ([Atkinson and Hamilton 2003](#)), where the proceeds of resource extraction are usually exported and the rent captured by a minority. Overall, there is evidence that international trade is not neutral for sustainability, even if a unified theory of international trade and sustainability is still missing.

To address this problem, the appropriated theory is the Heckscher-Ohlin (H-O) theory of international trade. The similarities between the H-O model and sustainability are obvious, capital stocks being factor endowments in essence. The capital stocks composing wealth are immobile in line with the standard Ricardian and H-O view. The H-O approach allows to address the issues regarding factor services exchanges using the multi-cone version and discussing the factor price equalisation hypothesis. A first step in that direction was made in the literature on trade and the environment ([Copeland and Taylor 2003](#), [Umanskaya and Barbier 2008](#), [Bogmans and Withagen 2010](#)) but further investigation and adaptation to the specifics of sustainability analysis is needed.

This article surveys the literature on sustainability and international trade. I start by presenting the leading indicators of sustainability in part 2 and show why ANS, although imperfect are best designed to fit the sustainability theory. Part 3 lists the numerous attempts to assess the impact of international trade on sustainability and sustainability indicators. in part 4.1 I review the literature on trade and the environment highlighting how it could contribute to our debate. I end this paper showing with international trade could provide answers regarding other debates in the sustainability literature about inequalities, trade policy and deglobalization (part 4.2).

## 2 Adjusted Net Savings as the leading indicator of sustainability

Adjusted Net Savings have the strongest theoretical basis of all sustainability indicators. Estimates show ANS are a good predictor of future sustainability for developing countries, but fails for developed countries ([Ferreira and Vincent 2005](#)).

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<sup>2</sup>see [Inclusive Wealth Report website](#)



## 2.1 Adjusted Net Savings versus The Ecological Footprint

As presented among others by [Van Den Bergh and Verbruggen \(1999\)](#) and [Musson \(forthcoming\)](#) a good indicator must be relevant (for the final user), robust, transparent, measurable and comparable (vis-à-vis other indicators). [Repetto et al. \(1989\)](#) were the first to try to build integrated accounts for sustainability assessment. Several indicators have been built to measure sustainability and/or comprehensive wealth and proved useful for policy guidance and sustainability assessment. [Daly and Cobb \(1989\)](#) present the index of sustainable economic welfare (ISEW) trying to discriminate between utility-increasing expenditures and defensive expenditures (expenses to compensate the degradation of the environment). [Asheim \(1994\)](#) thinks of the NNP as the genuine indicator of sustainability. [Martinet and Doyen \(2007\)](#) stress the need for an indicator reflecting the physical dimension of sustainability. Going further, [Martinet \(2011\)](#) insists on defining Safe Minimum Standards (SMS) as the only way to preserve the productive base critical for future generations and propose a new maximin criterion. [Krautkraemer \(1985\)](#), [D'Autume and Schubert \(2008\)](#) stress the need to take into account the amenity value of natural capital for accurate sustainability assessment. [Nourry \(2008\)](#) presents the main indicators and calculates them for France. A critical review of those same indicators can be found in [Kulig et al. \(2010\)](#), who also suggest to consider the physical as well as monetary dimension of capital.

Two indicators seem to have taken the lead. The first one is the ecological footprint presented by [Wackernagel & Rees \(Wackernagel and Rees 1996, Wackernagel et al. 2002\)](#). Comparing the amount of space required to produce what is necessary to satisfy the needs of a given population and the actual amount of space it can use, the ecological footprint gives a straightforward measure of sustainability. But this indicator focuses on the physical dimension, ignoring the economics behind it from technical progress to trade. As presented by [Rees \(2006\)](#) a view of international trade based on the ecological footprint rests on the carrying capacity of the environment. International trade is just a way to import the carrying capacity of other nations. The ecological footprint gives a diagnostic, but the policy implications are not really clear and the recommendations amounts to “downsizing the economy” with little prioritization. A comprehensive critique of the indicator can be found in [Van Den Bergh and Verbruggen \(1999\)](#). [Moran et al. \(2008\)](#) following [Dasgupta \(2001\)](#) couple the ecological footprint with the human development index to try to encompass another dimension of sustainability.

The second leading indicator is the adjusted net savings (ANS) or Genuine Savings (GS). ANS is primarily an empirical measure but its roots are in the neoclassical theory. ANS manage however to incorporate some contributions and criticism from both neoclassical and heterodox thinkers. ANS are based on the stock-and-flow view of the economy found in [Fisher \(1911\)](#), [Hicks \(1939\)](#) and [Samuelson \(1961\)](#). ANS are computed using an expanded system of accounts maintained by the World Bank and formalised in the SEEA<sup>3</sup>. For more details see [Dietz and Neumayer \(2007\)](#). ANS do not bear the constraints of the NNP as it is not theoretically related to GDP. ANS are also less demanding in assumptions. [Dasgupta \(Dasgupta and Maler 2000, Dasgupta 2001, 2009\)](#) consider ANS to be a better indicator of sustainability than NNP. Using capital theory ([Victor 1991](#)) and developed by the authors of the “school of London” ANS are based on the Hartwick’s rule and empirical works by [Pearce, Atkinson \(Pearce and Atkinson 1992, 1993\)](#) and [Hamilton \(Hamilton 1994, 1996, Hamilton et al. 1997, 1998\)](#). The leading role of David Pearce is stressed in [Simpson \(2007\)](#). Interpretation of the ANS is clear-cut: if the indicator takes a negative value, the considered country is not sustainable.

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<sup>3</sup>System of environmental economic accounts. See the [UN website](#)

ANS started as an empirical indicator, and found a theoretical foundation in [Hamilton and Clemens \(1999\)](#). The authors link ANS to the theoretical NNP as in [Asheim \(1994\)](#). The concepts of comprehensive wealth and comprehensive investment make ANS the “real” savings of an economy, once taken into account contributions by factors of production neglected before. Successive amendments include population growth, health, renewable and non-renewable exhaustible resources and stress the links between the productive base and agents’ preferences. From a theoretical point of view, ANS are not related to GDP anymore. ANS are an indicator of the monetary equivalent of the resources put aside at one period to sustain the wealth of the economy and a level of income and consumption for an infinity of future periods. The first simple empirical model of ANS was presented by [Pearce and Atkinson \(1993\)](#). If  $S$  is savings,  $Y$  GDP,  $\delta_m$  the depreciation of produced capital and  $\delta_n$  the depreciation of natural capital, an economy is sustainable if:

$$S > \delta_m + \delta_n \quad (1)$$

And ANS being our indicator of sustainability:

$$ANS = \left(\frac{dS}{dY}\right) - \left(\frac{d\delta_m}{dY}\right) - \left(\frac{d\delta_n}{dY}\right) \quad (2)$$

ANS (in percentage) measure the spread between savings and the destruction of capital over national income. There is a difference between comprehensive wealth and the rate of change of this comprehensive wealth, this rate of change being the ANS. This first empirical model used GDP as a reference for national income. If the value for ANS was negative, the considered country was on an unsustainable path. ANS have since then been expanded to better reflect the different kinds of capitals essential to the development of an economy ([Hamilton et al. 1997](#), [World Bank 1997](#), [Hamilton and Clemens 1999](#), [World Bank 2006](#), [Oleson and Goulder 2007](#), [Atkinson and Hamilton 2007](#)). [Hamilton \(1996\)](#) studies the impact of several pollutants on the ANS. This original (amended since) way of calculating the ANS is still used by the World Bank for its annual estimates ([World Bank 1997, 2006, 2011](#)). They use the following formula:

ANS= Net national savings + education expenditures - use of energetic resources - use of mineral resources - net use of forests - damages attributable to carbon emissions ( $CO_2$ ) - damages attributable to particle emissions ( $PM_{10}$ ).

Details for those calculation can be found in the [World Bank \(2011, p. 151\)](#) or figure 2.1 in the [World Bank \(2006, p.22\)](#). This method is used because of the lack of accurate yearly data. Every 5 years the [World Bank \(2011\)](#) presents a more theoretically rigorous method. Using the definition of Hicksian income ([Hicks 1939](#)) where income is the return on wealth, the authors show that current estimates of wealth imply a very high rate of return (about 36% for Canada ). So it seems estimates of wealth are incomplete and some other forms of capital get into comprehensive wealth. Formally ([Hamilton and Hartwick 2005, World Bank 2011](#)):

$$W = K + H + S = \int_t^{\infty} C(s) \exp\left(-\int_t^s r(z) dz\right) ds \quad (3)$$

Where  $W$  is comprehensive wealth,  $K$  is produced capital,  $H$  human capital and  $S$  natural capital. The integral on the RHS represents the present value of future consumption flows, over an infinite horizon. The authors then make some assumptions on consumption growth and the discount rate using the Ramsey formula ([World Bank 2011](#)). An implicit rate of return on wealth is created by combining this implicit rate of return (from the Ramsey formula) with a consumption profile over a generation (25 years). 80% of countries showing a return on comprehensive

wealth between 4% and 6% the authors believe their estimates are reasonable. They then decompose this total wealth into three components. Produced and natural capital are estimated using national accounts and contingent valuation techniques (Hanley et al. 2001) while human capital is estimated as a residual. Human capital is more of an intangible capital aggregating the role of institutions, human capital *per se*, total factor productivity, etc. An attempt to decompose that intangible capital is presented in World Bank (2006, see p.88). In this global approach ANS are the rate of change on comprehensive wealth from one period to the next, i.e comprehensive investment.

Another technique is used by Arrow et al. (2007) on the US/China relationship and Arrow et al. (2010)<sup>4</sup> on 5 countries. The authors start with a definition of sustainability based on intergenerational well-being (V being the value function of well-being):

$$V(t) = \int_t^{\infty} [(U(C(s)) \exp(-\delta(s-t)))] ds, \delta \geq 0 \quad (4)$$

Where development is sustainable if  $\frac{dV}{dt} \geq 0$ . Shadow prices are defined by:

$$p_i(t) \equiv \frac{dV(t)}{dK_i(t)} \quad (5)$$

So comprehensive wealth is equal to:

$$W(t) = r(t)t + \sum p_i(t)K_i(t) \quad (6)$$

In other words, comprehensive wealth W in time t is equal to the sum of monetary equivalents of capital stocks at shadow prices plus the monetary equivalent of time (this variable encompassing any change not included in the sum, mostly total factor productivity growth). This approach is based on welfare economics and links sustainability to agents' preferences. ANS are defined as the comprehensive investment  $I_t$ , which is the monetary equivalent of the raise in value in the capital stocks composing comprehensive wealth.

$$\Delta V(t) = r(t)\Delta t + \sum p_i(t)I - i(t)\Delta t \quad (7)$$

With:

$$I_i(t) = \frac{\Delta K_i(t)}{\Delta t} \quad (8)$$

The World Bank approach could qualify as "top-down" (starting with an estimation of comprehensive wealth providing a cap and decomposing that value to get back to the individual contribution of the capital stocks), whereas the approach by Arrow et al. (2010) is essentially "bottom-up" (providing an individual estimation for the contribution of each capital stock and adding up to get close to the total value of comprehensive wealth). The second approach is less demanding in terms of assumptions, more in terms of data.

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<sup>4</sup>See Arrow et al. (2010) p.14 for a comparison of methods

## 2.2 How do Adjusted Net Savings perform as an indicator? The role of substitutability, institutions and international trade

As an indicator trying to picture the entire wealth of a country, ANS is usually challenged on its comprehensiveness. Although legitimate, the critique could be applied to any synthetic indicator. The common finding of ANS studies is that mostly exhaustible resources-rich (but usually poor) countries are not sustainable. In a recent study, [Heal \(2011\)](#) shows that the gap between a developing country following the simple Hartwick rule and another not following it can be very rapidly significant. It is also the conclusion of the counter-factual study undertaken by the World Bank ([World Bank 2006](#), see chapter 4). Do ANS perform well as an indicator of sustainability? Two issues have been identified:

- ANS do better than other measures such as GDP as a predictor of future consumption levels. ([Ferreira et al. 2008](#), [Pezzey et al. 2006](#)) but are not completely accurate.
- ANS do a fair job for developing countries but fail for developed countries ([Ferreira and Vincent 2005](#)).

According to [Ferreira et al. \(2008\)](#) the second puzzle is probably due to the difference in nature of growth in developing and developed countries. Developing countries rely more on produced and natural capital, stocks that ANS estimate fairly well, whereas developed countries rely at more than 75% on human capital, an element only estimated as a residual in most ANS studies. Other authors have tried to reconcile sustainability analysis and consumption paths ([Arrow et al. 2004](#), [Cheviakov and Hartwick 2009](#)). Authors have also tried to link ANS with the ecological footprint. [Pillarsetti \(2005\)](#) criticise ANS as an irrelevant weak sustainability indicator which underestimates the role of developed countries in the current ecological crisis. [Hanley<sup>5</sup>](#) presents some leads to narrow the gap between the average message of ANS (a world generally sustainable) and the average message of the ecological footprint (a world already unsustainable and getting more and more so). The main one is to price carbon at a higher level, suggesting that current estimates of carbon damage are too low. The role of health capital is still debated: is health part of well-being or an instrument to measure well-being? If both, how to avoid double counting? The same questions could be asked for other variables used to estimate human capital (education, mortality rates, etc.).

Those shortcomings could be at least partially addressed using more comprehensive and accurate datasets. But there are some more fundamental issues with ANS linked with substitutability, institutions and international trade. The issue of substitutability is presented in [Dietz and Neumayer \(2007\)](#), [Nourry \(2008\)](#), [Neumayer \(2010\)](#). Amongst assumptions commonly made in wealth estimates are assumptions regarding the functional form used in the estimates. To estimate non-market prices authors ([World Bank 2006](#)) use a production function to describe the economy and the interaction between the capital stocks. [Solow \(1974\)](#) advise a Cobb-Douglas function as it was the only functional form that made exhaustible resources essential to production. But the Cobb-Douglas production function supposes a perfect substitutability between the different capital stocks, so it should only be used once some certainty has been obtained about the outcome of the weak versus strong sustainability debate. What is the actual degree of substitutability between capital stocks? [Hamilton \(1994\)](#) and [Hamilton and Clemens \(1999\)](#) use CES and nested CES functions to estimate ANS, which allows for the elasticity of substitution between factors to be different from one. This would be a good way to see if some Safe Minimum Standards (SMS) have to be imposed on capital depletion, to maintain capital stocks (especially stocks of renewable resources) in the perfect-substitutability zone.

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<sup>5</sup>In a presentation for the Stirling Environment Camp, March 2011.

The [World Bank \(2006, chapter 8.\)](#) tests that elasticity and concludes it is fairly high (80%). [Okumura and Cai \(2007\)](#) show that when factors of production are complementary and countries semi-open to trade, countries start importing foreign assets to compensate for the depletion of domestic ones. Could it be that substitutability was high up to the recent period, and may decrease in the future?<sup>6</sup> Therefore, the issue of substitutability can't be treated independently from the international trade issue. The role of institutions have been highlighted most recently by [Acemoglu and Robinson \(2012\)](#) and [Arrow et al. \(2010\)](#) acknowledge this is one of the main limits of ANS right now. The role of institutions is captured by the total factor productivity component in most estimates, but more work is needed. This brings us to the core of this article. We saw international trade had an impact on the way countries deal with potential complementary between capital stocks. How has international trade been addressed in the empirical and theoretical literature?

### 3 International trade in the sustainability literature

Starting from the theoretical points presented in subsection 3.1, authors have tried to develop several empirical applications (subsections 3.2 and 3.3) that could be divided into two categories. A first set attempts to assess the extend to which international trade allows for a dissociation of production and consumption of services provided by capital stocks. The idea was to see if some countries consume a lot of good and services provided by other's capitals, and therefore "export their exhaustion" of resources. The second set use relations derived from the international trade literature, authors tried to see how they affect sustainability. For example, trade is usually assume to allow for international technological spillovers. Therefore, the World bank assumed that trade openness would boost total factor productivity.

#### 3.1 Openness and sustainability: the role of capital gains

The first article on openness and sustainability is [Asheim \(1986\)](#), building on the founding papers of [Hartwick \(1977\)](#) and [Dixit et al. \(1980\)](#). The standard Hartwick's rule state that to maintain a level of comprehensive wealth and the related level of consumption, a country must reinvest all Hotelling rents ([Hotelling 1931](#)) from exhaustible resources into reproducible (or man-made) capital. Any depreciation of produced capital must also be compensated by extra investment. The open economy version of the Harwick rule takes into account the possibilities induced by international trade. According to the Hotelling rule the rent extracted from exhaustible resources must grow at the rate of interest prevailing in the economy for extraction to happen. An open economy will face higher world prices for its natural resources in the future due to the increased scarcity of supply, and could invest less today relying on higher prices tomorrow. Those are the "capital gains" from international trade and as [Asheim \(1986\)](#) explains, their effect is similar to a violation of the constant technology assumption in the Hartwick rule. A small open economy is subject to terms-of-trade shocks that change the economic conditions future generations will face.

[Daly \(1996\)](#) adds an ethical dimension to capital gains. Does the current generation have rights to consume tomorrow's resources (according to the sustainable path) relying on assumptions regarding future prices? This

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<sup>6</sup>For a critical presentation of functional forms and calculations on capital stocks in ANS studies see [Oleson and Goulder \(2007\)](#).

question reaches beyond our scope, but is particularly topical when dealing with capital gains. Optimality cannot be assessed without considering equity. [Hartwick \(1995\)](#) and [Asheim \(1996\)](#) study the link between capital gains and constant consumption over time. They show a given country cannot diverge in the long run from its long term sustainable path, defined by its comprehensive wealth.

Although valid from a theoretical point of view, this version of the open economy Hartwick rule did not fit in the 1980's picture. As natural resources prices were falling<sup>7</sup>, especially after the second oil shock, natural resources-rich countries found themselves in the need for more savings, not less. This argument was developed by [Vincent et al. \(1997\)](#) who show that once taken into account the dynamics of the terms of trade effect resource-rich countries should indeed save more for the future and consume less. [Vincent et al. \(1997\)](#) insist that most resource-rich countries are price takers because of the size of international markets. As a consequence, they face anticipated and unanticipated variations of resource price and must adapt their investing behaviour constantly. Technological shocks and exogenous price changes have the same effect. As later showed by [Rubio \(2004\)](#) in the case of Venezuela and Mexico, resource rich countries failed to save more in the short run and found themselves unsustainable for several years. Were those countries waiting for an inevitable rebound in natural resource prices or following an unsustainable policy?

[Van der Ploeg \(2010\)](#) sums up the main reasons (assuming a standard maxi-min optimal behaviour) countries may have to invest less than the Hotelling rents they get from extraction:

1. Anticipations about world prices: this is the [Asheim \(1986\)](#) argument. Van der Ploeg argues that sustainability estimates should be carried out using marginal rents and not world market prices.
2. Anticipations about returns on financial assets: if interest rates on financial assets (bought using income from rents) are anticipated to be higher, then countries (and/or sovereign funds) have an incentive to save less.
3. Internal factors: extraction costs, property rights, monopoly power of the extractive industry and rent seeking from political groups will all play a role.

The author's argument boils down to recognising that international trade brings an element of uncertainty into optimal planning, introducing exogenously determined variables or impacting randomly endogenously determined variables. What seemed to be a behaviour of under-investment, documented by [Vincent et al. \(1997\)](#) and [World Bank \(2006, see p.49\)](#) might be attempts to deal with uncertainty. Not only does trade introduce those perturbations, but it also has an impact through:

1. Technological spillovers brought by foreign firms, imports of goods and imports of capital goods.
2. Price-induced evolutions of the specialisation of the country along the line of its comparative advantages.

International trade calls for a different treatment depending on the goal of the analyst. Are we trying to set a rule for sustainability assessment and see the impact of international trade on that normative rule or are we trying to explain the actual behaviour of countries? Countries can draw expectations and see their strategy validated by economic evolutions, as the recent raise in commodities prices demonstrated. But is that strategy sustainable or too risky because of terms of trade fluctuations? The safe answer is that the trend (determined by the Hotelling rule)

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<sup>7</sup>See the famous Simon and Erlich bet: Paul Erlich bet that absolute scarcity will result in the price of commodities sky-rocketing by the end of the 80's. Simon, taking into account price-induced substitution effects, thought those commodities will be less demanded and prices will fall. Simon won and received Erlich's check by post.

reflects the fundamentals and short run volatility speculation. This should lead to more conservative estimates of the optimal level of savings from extracted rents.

[Asheim \(1996\)](#) suggests a country should not consume more than its share of the world comprehensive wealth at any time, without integrating expectations. Should countries opt for that conservative strategy, or risk themselves to “dance” with the terms-of-trade? It would probably be wiser to take into account the long run impacts of trade on comprehensive wealth (i.e specialisation and domestic capital accumulation) and adopt a more conservative strategy regarding less permanent effects (the portfolio of international assets).

Those are the amendments made to adapt sustainability rules in open economy. The following section presents the attempts to quantify the impact of international trade on sustainability.

### **3.2 Input/output analysis and general equilibrium models: empirical tests of international trade and sustainability**

[Martinez-Alier \(1995\)](#) observes that developing countries are usually considered less sustainable, or even unsustainable in original estimates of ANS. He believes this is because of international trade. Could rich countries import goods and services that could make their development unsustainable if produced at home? [Sefton and Weale \(1996\)](#) provide a first theoretical answer showing that some of the income adjustment for resource depletion should be heard by the importer. To test this hypothesis, [Proops et al. \(1999\)](#) and [Atkinson and Hamilton \(2002\)](#) develop an Input/Output (I/O) analysis à la Leontieff ([Leontief 1936](#)). Using a sample of developed countries [Proops et al. \(1999\)](#) try to re-affect the physical stock of capital depleted by producing countries for exports to consuming countries. They argue that sustainability measures should be corrected this way following a “footprint” ([Wackernagel and Rees 1996](#)) logic. They conclude that sustainable and unsustainable countries are less so, but the global picture of a sustainable world economy is not affected. Similar quantitative estimates are produced by [Atkinson and Hamilton \(2002\)](#) but their conclusions are slightly different, especially in terms of responsibility. Are international producers or consumers of natural resources responsible for the depletion of resource stocks? Although their analysis shows that there is clear interdependency between trade partners, they suggest that the burden of adjustment should fall mostly on the unsustainable exporting countries. They suggest this situation is the result of domestic mismanagement not international trade. Trade policy should only deal with economic efficiency, and natural resources management should be only tackled using environmental policy. Hence, the responsibility of resource management falls on the producing countries. This point of view makes sense in a balanced trade relationship where both partners have the same institutional framework and ability to enforce environmental and resource policies. But, as shown by the World Bank ([World Bank 1997, 2006](#)) the least sustainable countries are also the poorest in terms of GDP and GDP per capita. Relying on those poorer and institutionally weaker states to enforce a rigorous environmental policy casts doubts on chances of success. In that context, sharing the burden between trade and environmental policy and involving all trade partners into the management of exhaustible resources seems a better and more equitable response.

Another class of models following the same “footprint” logic are the computable general equilibrium models (CGEM). They were first used to our knowledge in the sustainability context by [Bailey and Clarke \(2000\)](#). Making

projections for local and global sustainability between 1985 and 2050 they find the world to be globally sustainable over the period on the average scenario. They use the OECD model GREEN, which notably include bilateral trade flows between the regions considered (the US, the EU, the former Soviet Union, etc.). CGEM models have also been used by [Turner et al. \(2011\)](#) to assess the impact of steel exports on the carbon footprint of the Welsh economy. They show the Welsh economy is sustainable once adjusted for those steel exports. A general table of the studies on sustainability can be found in [page 1](#).

### 3.3 Adjustments for international trade in the Adjusted Net Savings literature

Coming back to the main sustainability indicator, what are the adjustments of ANS to assess the impact of international trade? The first adjustment was proposed by [Hamilton and Clemens \(1999\)](#). The authors started with an economy where produced capital, human capital and one natural resource are used in the production process. Consumers value consumption and a flow of environmental services degraded by pollution. The dynamics of this economy are estimated using a Hamiltonian. This gives an expression for the Hicksian income which equals the NNP:

$$NNP = C + \dot{K} - (1 - be_F)F_R(R - g) - b(e - d) + \frac{q}{q'} \quad (9)$$

Where  $C$  is consumption,  $\dot{K}$  investment,  $b$  the marginal cost of pollution abatement,  $e$  pollution emissions,  $F$  the production function,  $R$  resource use,  $g$  growth of the resource stock,  $d$  natural dissipation and  $q$  the function of human capital accumulation. Then, they add a co-state variable for the current account:

$$\dot{A} = iA + E - M \quad (10)$$

Where  $\dot{A}$  is the variation of the stock of foreign assets,  $iA$  is the interest received from foreign assets held by residents,  $E$  exports and  $M$  imports. Adding depreciation of produced capital the final expression for NNP in the model becomes:

$$NNP = C + \dot{K} - \delta K + E - M + iA - (1 - be_F)F_R(R - g) - b(e - d) + \frac{q}{q'} \quad (11)$$

ANS are the rate of change of this expression between two periods. This intuitive adjustment takes the standard patrimonial perspective of ANS, seeing openness as a source of additional assets. ANS are here corrected by the ex-post impact of asset accumulation on wealth, the addition to the stock. But none of the impacts on productivity (via the production function) and domestic asset accumulation is taken into account. This adjustment is merely descriptive and fails to grasp the full impact of international trade. Subsequent publications by the World Bank ([World Bank 2006, 2011](#)) use the same method. International trade is a way to source capital abroad and earn income from that wealth more efficiently invested ( $iA$ ) and a source of capital embodied in goods not available inside the national borders ( $M$ ) “paid” with national stocks of capital embodied in goods ( $X$ ). International trade draw resources from outside national borders, but the impact of this possibility on the local production (and the production abroad) is not explained. This vision is related to the works of [Proops et al. \(1999\)](#) and [Atkinson and Hamilton \(2002\)](#) we presented earlier. This is an empirical adjustment that fits the data, but the economic rationale is missing.



The second approach was presented by the World Bank in its milestone study (World Bank 2006, p.103, see also estimates p. 111 and p. 113). Trying to assess the real substitutability between different capital stocks the authors estimate a CES function:

$$W = A \left[ \frac{(K, H, L)}{E} \right] \quad (12)$$

Where W is comprehensive wealth, K produced capital, H human capital, L labour and E exhaustible resources. A is an efficiency parameter as in a standard AK model (Aghion and Howitt 1998). The authors then test if the coefficient of openness would have a positive impact on the overall efficiency of the economy. In order to test this, they combine trade openness (the percentage of exports+imports over GDP) with other indicators of efficiency (the rule of law, etc.) and run the regression using OLS to obtain a value for the coefficient A:

$$A = \lambda_1 TOPEN + \lambda_2 PCREDIT + \lambda_3 VA + \lambda_4 PIV + \lambda_5 GE + \lambda_6 RB + \lambda_8 CC \quad (13)$$

With:

**TOPEN** : Trade openness

**PCREDIT** : Private sector investment

**VA** : Voice and accountability

**PIV** : Political instability and violence

**GE** : Government effectiveness

**RB** : Regulatory burden

**RL** : Rule of law

**CC** : Control of corruption

They find trade openness to be statistically significant as a part of the coefficient A: trade openness increase the overall efficiency of the economy. They also find the substitutability between the different kinds of capital to be fairly high (over 80%). This study was empirical, so *assuming* that trade openness has a positive impact and testing that assumption is perfectly valid. But this still does not provide a full explanation of the impact of trade. Efficiency is linked to productivity which sends up to Ricardian motives for trade (see below) either direct (exporting goods you have a comparative advantage into) or indirect ("importing" technology and innovations to increase productivity and interest on comprehensive wealth). Are the authors referring to total factor productivity improvement ? The theoretical mechanism to explain those findings is clearly missing. The question of capital gains is mentioned but only to put it aside. The authors only consider one generation in the future (25 years). Taking side neither for Asheim (1986) nor Vincent et al. (1997) they choose to neglect capital gains. This seems understandable because of the limited nature of the exercise of casting previsions for the next 25 years. But as Rubio (2004) and Van der Ploeg (2010) demonstrate, countries take into account those capital gains, even if not properly. Therefore they should be taken into account one way or the other in empirical estimates. Arrow et al. (2010) use a different strategy. They set a starting point where they estimate rents, and then provide a set of shadow prices for every period using the Hotelling rule to estimate the raise. Those gains are mirrored by equivalent losses for consumer countries in line with their future purchases of oil.

We are left with transboundary ownership of firms and transboundary externalities. Transboundary externalities

(such as greenhouse gases and climate change) are estimated by [Arrow et al. \(2010\)](#) using a method different from the World Bank ([World Bank 2006](#)): they assume global air quality to be a global public good and relax the assumption of optimal international cooperation. Transboundary ownership of firms is a two-sided question related to the nature and the destination of production for the considered firms. If foreign-owned firms have settled in a country to serve the local market, then the right way to look at that firm is the one adopted by the World Bank: financial returns belong to the country of origin, production and capital should be affected to the local country. But how to consider a firm that settle in a country to use the local conditions and re-export its production? Or move again as soon as more favourable conditions can be met elsewhere? Is that firm part of the local country's comprehensive wealth, or part of the origin country's wealth temporarily outsourced to "consume" capital overseas?

The capital gains are related to the terms-of-trade literature. Can a country passively wait for technological transfers and cheaper imports to prop it up closer to the front of the international stage? Or could terms-of-trade be permanently set in a way that condemn the development of some countries? This sends us back to the debate of Weak vs. Strong sustainability. As we saw earlier we live in a Cobb-Douglas world, the different kinds of capital are highly, if not perfectly substitutable. But what if that relation breaks down at some point in the future, for example if critically low level of natural capital are hit? Then international trade could be used by countries to deplete critical capital elsewhere and preserve strategic reserves at home. What would be the impact on ANS if that possibility was taken into account? It is important both to know the impact of international trade on sustainability, and on our indicator of sustainability. The current treatment of international trade in the ANS makes it likely for the indicator to over-estimate the sustainability of countries taken one by one by underestimating the vital impact of technological transfers and raw material imports and exports. All those unanswered theoretical questions logically created empirical loopholes. Combined with the limited amount of data available, especially for the oldest studies, the sometimes diverging results are not surprising. To fully assess the impact of international trade on the ANS a general equilibrium approach is required. Only a general equilibrium model will be able to show the impact of the terms trade on the different sources of comprehensive wealth and the composition effects induced by those evolutions. This kind of general equilibrium modelling has already been presented in the related literature on trade and the environment.

Table 1: Synthetic table of main ANS studies

Study	Pearce and Atkinson (1993)	Hamilton et Clemens (1999)	Proops et al. (1999)	Atkinson & Hamilton (2002)	World Bank (2006)	World Bank (2010)	Arrow et al. (2010)
Objectives	propose an indicator of sustainability, empirical approach	propose improved ANS including pollutants and estimates for developing countries	determine the global environmental footprint of countries using closed economy as a benchmark	determine the value of resources used by developed countries in surplus of national production	present comprehensive wealth and ANS estimates for every country	present comprehensive wealth and ANS estimates for every country	extend the scope of comprehensive wealth estimates
Data Years	1981 for the US, 1991 for Germany, 1989 for Japan and Mexico	from 1970 to 1993	from 1980 to 1990	1980, 1985, 1990	2000	1995, 2000, 2005 for comprehensive wealth estimates, 2008 for ANS	1995, 2000
Countries	18	103	world economy divided in 12 regions	The European Union, Japan, The US	the whole world	the whole world	Brazil, China, India, Venezuela and the US
Method used	adjust standard savings ratios using national accounts and environmental studies	correct the assessment of well-being using comprehensive wealth by taking into account the impact of pollutants	input/output analysis, based on a division of wealth into 3 capital stocks: natural resources, labour and capital	slight modifications from Proops et al.	estimating comprehensive wealth and estimates of ANS from net savings figures	estimating comprehensive wealth and estimates of ANS from net savings figures	estimates of comprehensive wealth as a sum of capital stocks and of ANS as the rate of change of comprehensive wealth
Definition of sustainability	ratio gross savings/GDP and Genuine Savings	Genuine Savings, % of GNP	contribution of the region to global sustainability, GS compared to global GDP	difference between the use of domestic exhaustible resources and overall consumption of exhaustible resources	Gross Savings and ANS, % of GNI	Gross Savings and ANS, % of GNI	GDP per capita and comprehensive wealth per capita growth rate
Savings rate before adjustment	US 18 Germany 26 Japan 33 Mexico 24	US 15 Germany 22,6 Japan 34,3 Mexico 21,7	N/A N/A N/A N/A	N/A N/A N/A N/A	US 17,4 Germany 20,3 Japan 28,4 Mexico 21	US 12,6 Germany 25 Japan 25,9 Mexico 25,3	US 2,93 China 7,6 Brazil 0,5 Venezuela 1,2
Savings rate after adjustment	US 2 Germany 8 Japan 17 Mexico 0	US 8,8 Germany 11,1 (15) Japan 28,7 Mexico 2	US 0,76 Germany -0,44 Japan 2,19 Latin America (Region) -0,22	US -7500 European Union -17 500 Japan -12500 Latin America (Region) 6000	US 8,2 Germany 9,3 Japan 15,1 Mexico 8,4	US 0,9 Germany 14 Japan 15,3 Mexico 9	US 1,7 China 5,63 Brazil 0,14 Venezuela -2,94

Source: Author

The Table 1. presents the main characteristics of ANS studies in the past 20 years. As datasets become more comprehensive and detailed, the overall picture of a world experiencing less actual increase in wealth emerges.

The previous sections presented the numerous empirical and theoretical approaches used to take into account international trade in the sustainability literature. The loopholes are also numerous. There is no analysis of trade policy on sustainability, whether using quotas, a Pigovian tax at the borders (such as the carbon tax) or tariffs. More generally, the impact of trade frictions is not taken into account and there is not theoretical model using a general equilibrium framework to capture the impact of trade on factor use. General equilibrium modelling seems appropriate, as trade will have an impact on technical progress, composition of the economies and will produce some capital gains (or losses). International trade will have an impact on the productive base, income and consumption possibilities, and in fine sustainability. We saw in this section the role of exogenous price and technological shocks, and the potential importance of foreign assets. Growing financial and trade flows between developed and developing countries make those economic ties important for sustainability. International trade should be one of the core components of sustainability approaches, and as stated by [van den Bergh \(2010\)](#) international trade is the biggest gap in the literature as of today.

## 4 What can we learn about trade and sustainability from the rest of the literature ?

Some theoretical links between trade and sustainability have already been demonstrated by the trade and the environment literature, but the links between trade, the environment and inequalities are still debated.

### 4.1 The literature on trade and the environment

The international trade theory in general and the Heckscher-Ohlin analysis in particular can make a significant contribution to the understanding of the links between international trade and sustainability. Since [Ricardo \(1817\)](#) gains from international trade originates in comparative advantages. First exposed by [Smith \(1776\)](#) then completed by Ricardo, the theory of comparative advantages stresses that a country should specialize in the production of the goods where it has a comparative advantage. There are four main sources of comparative advantage :

- Productivity differences related to technology differences
- Differences in factor endowments resulting in different specialisation
- Differences in the size of the internal market
- Differences in the property right regime

In a dynamic perspective, those advantages are self-reinforcing. The better one country becomes at producing a set of goods, the more likely it is to produce it in the future. [Baumol and Oates \(1988\)](#) in their seminal work on environmental policy, highlighted the critical role of property rights in ensuring that environmental externalities

where taken into account. A few years later, the NAFTA raised the issue of the impact of trade liberalisation on the environment, due to differences in property regimes and environmental standards between the US and Mexico. An analysis is presented by Grossman & Krueger in their reference paper (Grossman and Krueger 1991) and an extension (Grossman and Krueger 1995). They propose to assess the impact of trade on the environment using three effects:

**Scale effect** : When an economy is growing, the level of pollution emissions rises through a simple quantitative effect.

**Technical effect** : When the income of an economy increase, productivity gains and the larger share of resources available for pollution abatement reduce the overall level of pollution emissions.

**Composition effect** : When an economy is open to international trade sectorial specialisation will change in line with the comparative advantage. If the economy has a comparative advantage in the relatively clean sector, the production of clean goods will increase and the production of dirty goods decline. The opposite will happen in the country with a comparative advantage in the dirty sector.

Chichilnisky (1994) concludes that differences of property rights could provide a motive for trade between otherwise identical regions. The case was made that the environment being a good subject to several externalities, some provisions should be made in trade agreement to protect it. Grossman and Krueger (1991) also propose the environmental Kuznets curve (EKC). A country where income is rising will first start by polluting more. Then, after a given threshold, agents' preferences for a healthy environment and the related investment in pollution reduction and abatement will decrease pollution as income rise. This gives us an inverted U-shaped relationship between income and pollution. A review of this literature can be found in Dinda (2004) and Kijima et al. (2010). In later works Copeland and Taylor (1994, 1995, hereinafter C&T) then Antweiler et al. (2001) and Copeland and Taylor (2003) unify this literature on pollution emissions, abatement costs, property rights and trade using the general equilibrium framework of the Heckscher-Ohlin model and the canonical theorems (Stolper-Samuelson and Rybczynski) to back their reasoning. They test the relative importance of the Pollution Haven hypothesis (PHH) against the traditional Factor Endowments Hypothesis (FEH). The PHH states that differences in regulatory regimes will create incentives to concentrate the production of dirty goods in low-regulation countries (mostly in developing countries). But as those dirty industries are usually capital intensive, their natural location would be in developed countries. In empirical tests of the C&T model environmental impacts are estimated using an air pollutant ( $SO_2$  for local and  $CO_2$  for global impacts). The indicator of impact on the productive sector is the income generated. The consumer welfare is assessed using a utility function with three arguments: prices, income and pollution level. The authors start by assessing the links between pollution and growth, and then pollution and trade (considering that the links between trade and growth are well established and already contained in the model). Using this model they conclude that there is a real pollution haven effect (Copeland and Taylor 2003) but this effect is at the margin. A full pollution haven motive for sourcing production in low regulation country does not show in the data. According to the authors, this is due to the low level of abatement costs in overall production cost (an average of 10%, never higher than 20%). The impact of trade on the environment is mainly driven by traditional factor endowments motives, regulation does not play a very significant role. Those results have been confirmed since then by several studies (Cole and Elliott 2003b, Frankel and Rose 2005, Ederington et al. 2005) and one on unemployment and the environment (Cole and Elliott 2003b). Another study by Kellenberg (2008) investigates a wider array of pollutants. This literature is reviewed in Kirkpatrick and Scricciu (2008).

C&T believe the lack of empirical support for the EKC is a consequence of a misspecification of the relation. The interactions between income and pollution are more complex, and depends a lot on the variable you use as a proxy for pollution. Data are mostly available for air pollutants, but recent datasets now include water pollution (Kellenberg 2008). Another issue is between emissions and concentrations. Only concentrations data were available for the first studies, whereas emissions data were required for testing the PHH. The EKC does not resist closer scrutiny through a more detailed theoretical model. Decomposing the relationship using the scale, technical and composition effect seems promising to understand the full effect than aggregating it all into a single curve. C&T conclude that the main driver of the relationship between trade and the environment is, as often, technical progress. Whether total factor productivity growth or Hicks or Harrod-neutral technical progress, it is key to understand the impact of trade on the environment. But technical progress is in essence a dynamic notion, and the next step is clearly to set a dynamic model, to see the impact of trade induced technical progress on the accumulation of factor endowments. Comparative advantage are fundamentally dynamic in an era where institutions, regulation and human capital play such a decisive role in trade patterns. The sources, the engines of growth will be different at different stages of development and so should be the impact of trade. This literature is centred on the relation between trade and the environment, which deterioration is usually represented by gas concentrations or emissions. Could this framework be adapted to the study of sustainability? The model presented have been designed to address specific issues regarding pollution and location of industries. Although the concept of “pollution” need to be adapted to fit into a capital-theoretic sustainability framework, parallels between approaches are obvious. Some issues linked with the H-O analysis still need to be addressed:

**The dynamics:** A static framework is not adapted<sup>8</sup> for the dynamic effects related to capital accumulation and technical progress. Bogmans and Withagen (2010) propose a HO-Vanek-Ramsey model inspired from C&T to address the issue, and highlight the role played by preferences and the discount factor.

**Factor intensity reversal:** In a dynamic Heckscher-Ohlin model (Stiglitz 1970) as factor endowments change through time, factor intensity reversal may occur: the general comparative advantage of the country change, because of the evolution of its factor endowments.

**Factor price equalisation:** C&T based their analysis on the canonical theorems of the Heckscher-Ohlin model, but they are based on factor price equalisation. If this condition is not verified (and it probably is not in the real world as factor endowments are too diverse) then the Stolper-Samuleson and Rybczynsky theorem do not hold anymore, and some of the theoretical conclusions of C&T as well. This scenario is investigated by Umanskaya and Barbier (2008) who show that a pollution heaven can appear in a country depending on the balance between environmental policy and relative wages. The lack of factor price equalisation makes the relative factor price ratios the key determinant of comparative advantage instead of the usual factor endowments. Bogmans and Withagen (2010) push that logic even further. In their model, factor price equalisation breaks down when pure rates of time preference are different across countries. This results in perfect specialisation for one country into either the dirty or the clean good (although only one country gets perfectly specialized).

Once those elements are taken into account, the literature on trade and environment would be a sound basis to see the impact of trade on sustainability. The last add-up needed is trade policy. Articles by Lee and Roland-Holst (1997) and Flaaten and Schulz (2010) address the challenges of trade policy in the context of environmental

<sup>8</sup>“We also worked within a static, perfectly competitive framework where [...] dynamic and strategic issues are entirely absent. This choices limited our methods and our results.” Copeland and Taylor (2003, p. 280)

externalities. They both conclude that tariffs can have a positive impact on environmental preservation. Lee and Roland-Holst (1997) show that trade liberalisation without an efficient tax system can lead to an increase in pollution emissions. Flaaten and Schulz (2010) promote export taxes when one sector rely on an open access natural resource, showing that they are welfare improving. Finally, the H-O motive for trade is not the only one, and some other models addressing other trade patterns could make a contribution to sustainability. Taste for Variety which is the basis for the Krugman (1980) of monopolistic competition is a challenge for sustainability. What to do of trade flows of goods that are similar? Could there be a trade-off between the utility gains of varieties available against the extra cost or provide a good which essential characteristics are already available? The Krugman model already has that economic trade-off embodied, but does taking into account comprehensive wealth change the picture?

## 4.2 Inequalities and environmental impacts: How does trade influence national environmental and social policies?

Using capital theory and ANS is a way to aggregate physical dimensions that would otherwise be incommensurable. However the relationships between some dimensions of sustainability included in the stocks of capital are not yet completely understood. For example, the impact of inequalities (which relate to both relative well-being and human capital accumulation) on environmental management (either natural capital preservation and accumulation or pollution) has received some attention but no definitive explanation. The founding paper by Boyce (1994) examines the impact of inequalities of income and power on environmental degradation. He finds that reduced inequalities result in lower environmental degradation. Clément and Meunié (2010), Heerink et al. (2001) and Scruggs (1998) explore this relationship from an empirical point of view, but there is to our knowledge no theoretical framework to explain the observed interactions. Scruggs (1998) proposes a political economy model to formalize the intuitions of Boyce. She concludes that the relation between inequalities and the environment is highly sensitive to the structure of preferences of agents in different income groups and to the institutional structure of their country. High inequality countries with low level of environmental degradation and the opposite are both possible: the existence of a strong causal relationship cannot be inferred from the model. Heerink et al. (2001) illustrate this by taking Boyce's opposite assumption. For countries where the environmental Kuznets curve (EKC) is verified, higher inequalities result in lower degradation. They focus on the household level, and find that an aggregation bias can result in misspecification of the EKC. Poor individual households are more affected by local pollution so they may be more sensitive than rich households to some local pollutants. Therefore, higher inequalities may result in lower environmental degradation when this effect dominates. Clément and Meunié (2010) work on the econometric specification of this relation. They also conclude that the relationship is probably nonlinear, different from poor to rich countries, from one pollutant to another. Water pollution, a local indicator of environmental degradation, is highly affected by inequalities in developing countries. The impact of inequalities is therefore real but non-linear. As we know from the standard Stolper-Samuelson theorem that international trade might foster inequalities, this issue should be taken into account.

A definition of sustainability supposes an articulated theory of well-being and ethical criteria (about intergenerational equity, inequalities, etc.). This defines some optimal trade relations between countries, relations compatible with each national agenda. Current sustainability approaches such as the GS assume that international trade is taken as given, countries take decisions individually according to national imperatives and adapt to international

trade. This vision is behind the argument of [Atkinson and Hamilton \(2002\)](#) amongst others that domestic policies should tackle environmental issues, and trade policy only trade issues. But economic policies are correlated, and studies have shown that environmental policy is sometimes set as a second best trade policy ([Cole and Elliott 2003a](#)). Trade relationships are usually unbalanced, and deficit countries (in terms of either capital or current account) are commonly considered responsible for those deficits. But recent works conducted by Dumas ([Dumas 2004, 2010](#)) in the context of the financial crisis cast doubt on that conclusion. From an accounting perspective, trade is a zero-sum game and creditor countries can only exist because of debtors countries. Dumas' argument is that capital inflows from creditors to debtors countries are the real origin of the crisis and the credit bubbles that appeared in several countries before the crisis. Therefore, the burden of adjustment after the crisis should be shared by debtors and creditors. Interactions between countries are critical to sustainability as crisis destroy a great part of accumulated wealth. A sustainable organisation of trade should be included into any attempt to define a path for sustainable development.

International trade impacts sustainability in two ways. It encourages the constitution or the depletion of a given capital stock through shifts in the country's terms-of-trade. But international trade can also favour the mobility of some forms of capital (human and produced capital mostly) through phenomena such as off shoring or the brain drain. The first modality of action is usually well documented, but the second one is usually neglected, apart from attempts to consider transboundary ownership. This aspect is related to the global supply chain. The global supply chain evolves permanently, following fears of interruptions (related to political or climatic uncertainties) and rising labour costs in emerging Asia. Some strategic resources (sometimes available in economically relevant quantities in only a handful of countries, such as rare earth in China) will create hubs in the global supply chain and raise issues of complementarity. Some elements of comprehensive wealth will be useless without those strategic resources. Countries will have a strong incentive to secure supplies of those resources, resulting in likely international trade tensions. The recent sustained raise in commodities prices, the crisis only temporarily slowed down, also indicate that absolute scarcity might become more common amongst exhaustible resources ([Krugman 2010](#)). Is this wave of Hotelling-type raises in prices the moment predicted by the Meadows report ([Meadows et al. 1972](#)) forty years ago? The growth of emerging economies is now part of the global equation and will weight on any country's trade, regardless of specialisation or market share. Interdependence is a reality and sustainability will require coordination and intelligent trade policy to overcome some potential shortages and keep speculation to reasonable proportions on strategic resources.

Some heterodox authors refute the logic of the comparative advantage and sometimes the neoclassical analysis as a whole. Their view of the impact of international trade is quite different. Daly ([Daly 1992, 1996](#)) once a partisan of free trade explains that as factors of productions are today internationally mobile (in violation of David Ricardo's assumption) the logic of comparative advantage is not valid any more. International trade in those conditions can only favour social and environmental dumping and overall gains from trade are not certain. In the same vein, [Schneider et al. \(2010\)](#) suggest that the global recession of 2009 had a very positive impact on carbon emissions, mostly because of the contraction of international trade. The authors consider this evidence that degrowth is the only way to achieve sustainability and international trade flows should be limited. [Rees \(2006\)](#) is even more pessimistic. In a demonstration based on the ecological footprint, he shows that international trade destroys local measures of environmental preservation and crush local producers. He argues for a local organisation of production integrated in ecosystem and for a reversal of globalisation as the only way to achieve sustainability.



Finally Tisdell (1994, 2000) criticise the World Trade Organisation (WTO) for its lack of concern for the environment, and calls for a better handling of environmental issues in trade negotiations. Overall, heterodox authors see the current organisation of international trade as an obstacle for sustainability. Hence the limited amount of existing literature. Those authors call for self-sufficient national economies and trading only goods and services not available inside national borders.

## 5 Conclusion

This article surveyed the literature on trade and sustainability. I show that in the theoretical literature on sustainability, the role of international trade is limited to the expectations linked to capital gains and the investment possibilities abroad offered by trade openness. Empirical studies have adjusted ANS to incorporate those insights, but as of today neither the theory of sustainability nor the leading indicator of sustainability reflect the true impact of international trade. The Heckscher-Ohlin analysis, as used by the literature on trade and the environment is a promising lead to gain further insight on the true extend of that impact. The literature on trade and the environment opened the way, highlighting that trade will affect the scale, the productivity and the composition of an economy. To use those insights in the sustainability literature, a dynamic framework is needed as capital accumulation and preservation is the core of sustainable development. The role of the institutions, partly reflected in the property rights debate should be better integrated, as it is likely to arbitrage the debate on inequalities and the environment. Finally, trade policy should be integrated and a clear ranking between domestic and trade policy is needed in a sustainable development strategy. The current limit of the research on international trade and sustainability lies in the tendency to assess sustainability either as if the world worked as a perfectly integrated economy or as if the world was a juxtaposition of essentially closed one. Realising that economies are as of today in between those extremes will allow us to better understand the role of international trade and hopefully design better sustainable development policies.

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