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ANALYSIS

Measuring sustainable development: Some empirical evidence for France from eight alternative indicators

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ABSTRACT

This paper presents results from a time-series analysis of eight measures of development and/or sustainability for France. The measures chosen are green national net product, Genuine Savings, ecological footprint, Indicator of Sustainable Economic Welfare, Genuine Progress Indicator, Pollution-sensitive Human Development Indicator, Sustainable Human Development Indicator and French Dashboard on Sustainable Development. A theoretical description of each index highlights their advantages and drawbacks, underlining the fact that no indicator is perfect and no one can give an exhaustive view of sustainable development. Therefore, the analysis of various indicators is necessary to evaluate sustainable development with accuracy. Empirical results of measures of well-being show that French development was improving between 1990 and 2000. Concerning sustainability, indicators support different conclusions. It seems that French development was weakly sustainable but unsustainable in the strong sense over the period examined.

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1. Introduction

In 1992, the United Nations Conference on Environment and Development in Rio de Janeiro underlined the limitations of gross domestic product (GDP) as a measure of sustainable development for a country. Indeed, “common indicators such as gross domestic product and measures of different resources or pollution flows do not assess the sustainability of economic systems” (paragraph 40.4 of Agenda 21). This article also points

out that “sustainable development indicators must be constructed in order to form a useful basis for decision making”. Therefore, since the beginning of 1990, measures aiming at completing the GDP and limiting its supremacy have been built.

This paper lies within the framework of development of indicators of sustainable development. In fact, whereas alternative and competitive measures have been created, none of them is perfect: each index is based on a specific definition and so takes into account only some aspects of sustainable

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development. Therefore, it is important to begin with a definition of sustainable development. In this paper, I used the widespread definition of the Brundtland Report (*Our common Future*, 1987): “sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It aims at assuring the on-going productivity of exploitable natural resources and conserving all species of fauna and flora”. In my view, two key ideas are expressed in this definition: i) concern for the well-being of future generations and ii) recognition of the bi-directional impacts between economic activity and the state of the environment and natural resources. In this context, sustainable development takes into account human development (in terms of welfare) and sustainability of such development (in terms of condition on the stock of capital). Within this broad definition, two main approaches can be described: weak sustainability and strong sustainability. Although these two views define development as a non-declining level of well-being for future people, the requirement for sustainability is different. Weak sustainability only requires a non-declining combined stock of all capital. It is then possible to substitute between human, man-made and environmental capital. In this approach, natural capital is not different from other resources. The aim is to keep the stock of total capital constant or increasing, whatever the combinations of the three types of capital are. On the contrary, strong sustainability gives an essential position to natural capital. It is a different form of capital without which human life cannot exist. Strong sustainability requires the maintenance of environmental functions and critical natural capital needed for the life of ecosystems. Therefore, models of strong sustainability incorporate real world constraints on the possibility of substitution between man-made, human and environmental capital. Contrary to weak sustainability that focuses on maintaining a combined stock of capital intact, strong sustainability deals with specific environmental functions that ought not to be undermined by economic activity and possible ecological limits to growth.

In this context, an indicator of sustainable development must assess human development (i.e. is welfare non-declining?) and sustainability (i.e. is the stock of total capital (weak sustainability approach) or natural capital (strong sustainability view) intact?). However, no single measure does a perfect job at reflecting sustainable development per se. Therefore, it is necessary to look at different indicators of development and sustainability to give a better valuation of the sustainable development of a country. This paper presents results from time-series analysis of eight measures for France. Whereas the green national net product, the Genuine Savings and the ecological footprint are indicators of sustainability, The Indicator of Sustainable Economic Welfare, the Genuine Progress Indicator and the two “green” Human Development Indicators measure national welfare. The French Dashboard on sustainable development is an imperfect assessment of both concepts of sustainable development (i.e. well-being and sustainability). This paper adopts the same methodology as the one used by [Hanley et al. \(1999\)](#).¹ These authors

calculate seven alternative indicators for Scotland. Whereas the measures are supposed to assess the same phenomena, their results lead to opposing views of the national sustainability. The main aim of my paper is to draw a parallel between the eight measures to determine whether the indexes show a trend towards sustainable development. In other words, what are the results concerning the sustainable development of France emerging from the connection between the eight indicators? To sum up, this article attempts to highlight that the study of a single measure is not sufficient to assess the sustainable development of a country and policies based on the conclusion of only one indicator should not be implemented because the empirical results could be misleading.

The remainder of this paper is divided into four sections. Section 2 deals with indicators of sustainability and Section 3 with measures of welfare. Section 4 presents the French Dashboard on sustainable development, an assessment of sustainable development per se. Sections 2, 3 and 4 have the same structure. Firstly, they give a description of each kind of indicator by focusing on the theoretical basis and practical problems. Then, empirical results for France are presented. Finally, Section 5 concludes by confronting opposite trends and presenting missing indicators and research prospects.

2. Measures of sustainability

2.1. Green national net product

2.1.1. Theoretical description

Gross national product (GNP) is the traditional measure of economic performance and is implicitly used to assess national development and welfare. GNP measures the value of goods and services produced by domestically owned factors of production. This indicator takes into account human capital imperfectly but does not integrate natural capital. The first step to compute green national net product (gNNP) is to work out national net product (NNP) by subtracting depreciation of physical capital from GNP. Then, many adjustments are necessary to obtain gNNP. These modifications are derived from a neoclassical model of growth with a constant rate of discount and are linked to specific environmental variables (exhaustible resources, renewable natural resources, pollution flows, discoveries) (see [Hamilton, 1994](#) and [Hanley, 2000](#) for a review of the different optimal adjustments). Note that there is not a consensus among economists concerning the reasons for those modifications and on the techniques used to compute them.

Another point of disagreement is the interpretation of gNNP. According to some authors (e.g. [Solow, 1993](#); [Hartwick, 1990](#)), gNNP is a measure of the Hicksian income, i.e. it represents the maximum amount of possible consumption during a period that does not reduce the possibilities of future consumption. In this context, if gNNP is rising and superior or equal to current consumption, the studied country will be sustainable. Note that an increase of gNNP means that the maximum level of sustainable consumption is improving ([Hanley, 2000](#)). On the contrary, a falling gNNP is a sign of unsustainability in the sense that the maximum amount that can be consumed without undermining productive capacity is

¹ Note that only five indicators are identical between Hanley's paper and mine (green GNP, genuine savings, ISEW, GPI and ecological footprint). The three other measures studied are two green HDI and the French Dashboard on sustainable development.

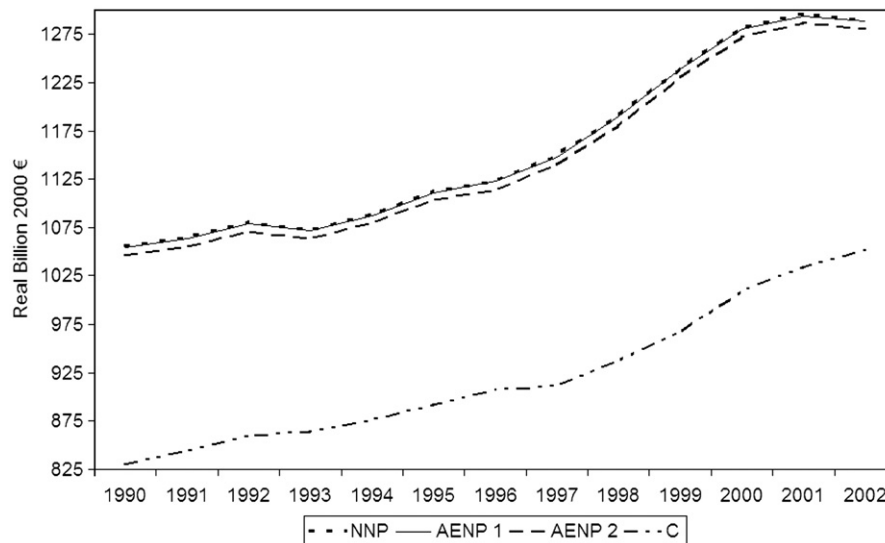


Fig. 1 – AENP 1 and 2 for France (1990–2002).

deteriorating. On the other hand, other authors doubt the ability of gNNP to be an indicator of weak sustainability (e.g. Asheim, 1994; Pezzey and Toman, 2002b, 2005). According to them, an instantaneous measure of gNNP does not indicate if a country is on a path of sustainable growth: the entire time path of gNNP must be assessed. This result is linked to the method of computation of the Hotelling rents for natural capital (that is, the difference between price and marginal cost). Even if the prices used were the optimal prices resulting from the theoretical model, this would not mean that gNNP is a measure of the Hicksian income because sustainability is not an efficiency problem but rather an equity one (Hanley, 2000). Therefore, gNNP would be the “true” measure only if sustainable prices were used. However, only current prices are available for empirical work and these prices are neither optimal nor sustainable (Pezzey and Toman, 2002a, 2005). To compute an exhaustible gNNP, other data are missing. For example, since most marginal costs are not available, average costs are used instead and few pollution flows are included in the estimated gNNP because of the lack of data on abatement costs.

To apply this indicator to France, we used the framework of Hartwick (1990) which suggests subtracting depreciation of all kinds of natural capital, valued with their Hotelling rents, and pollutant emissions valued at marginal abatement costs (cf. Appendix A for the expression of gNNP).

2.1.2. Empirical results for France

Data used to estimate a green national net product (gNNP) for France come from various sources (cf. Appendix B for a detailed presentation of the sources and methodology). Briefly, over the period 1990–2002, Hotelling rents from energy (oil, gas and coal), minerals (copper, lead, zinc, silver and gold), forests² and the costs of air pollution have been deducted from national net product (NNP).

Given the facts that data on marginal production costs were not available for many resources and that partial data have been used, we refer our estimation to *approximate environmentally-adjusted national product* (AENP) as in Hanley et al. (1999). Note also that four different AENP have been estimated. AENP 1–3 and AENP 2–4 are different because of the valuation of marginal damages from dioxide carbon [CO₂] emissions: AENP 1 and 3 are based on the global marginal social cost of a ton of carbon emitted as estimated by Fankhauser (1994) (20 \$ in 1995); whereas AENP 2 and 4 are built with an average value of 100 € per ton of carbon in 2000, taken from the Boiteux and Baumstark Report (2001). AENP 3 and AENP 4 take into account the cost of three other air pollutants (nitrogen oxide [NO_x], sulphur dioxide [SO₂] and particulate matter [PM₁₀]) estimated by the average cost of a kilogramme of pollutant in 1998. These costs stem from the work of Rabl and Spadaro (2001).

Fig. 1 shows NNP, AENP 1, AENP 2 and current consumption (C) and Fig. 2 NNP, AENP 3, AENP 4 and C in real billion euros (of 2000). I would like to develop two comments on those graphs. First of all, for the whole period, the four AENP are always less than NNP. This indicates that environmental depreciation in any year has a negative impact on NNP. This influence varies according to the method of valuation and number of pollutants examined. Secondly, the four AENP have been rising for the whole period (except in the last year), indicating that the maximum level of sustainable consumption is improving. The comparison with current consumption shows that the four AENP are always higher than current consumption. These elements can be interpreted as a sign of national weak sustainability (cf. Section 2.1.1.). Nevertheless, note that pollution recorded in the AENPs is far from exhaustive: for example, overfishing, water pollution and loss of biodiversity are not included because of lack of data. This implies that the “true” gNNP would be lower than the AENPs shown in Figs. 1 and 2. Therefore, any conclusions about the weak sustainability of France should be used with caution.

² Note that Hotelling rents from forest resources are added to NNP for France because natural regeneration is higher than wood extraction.

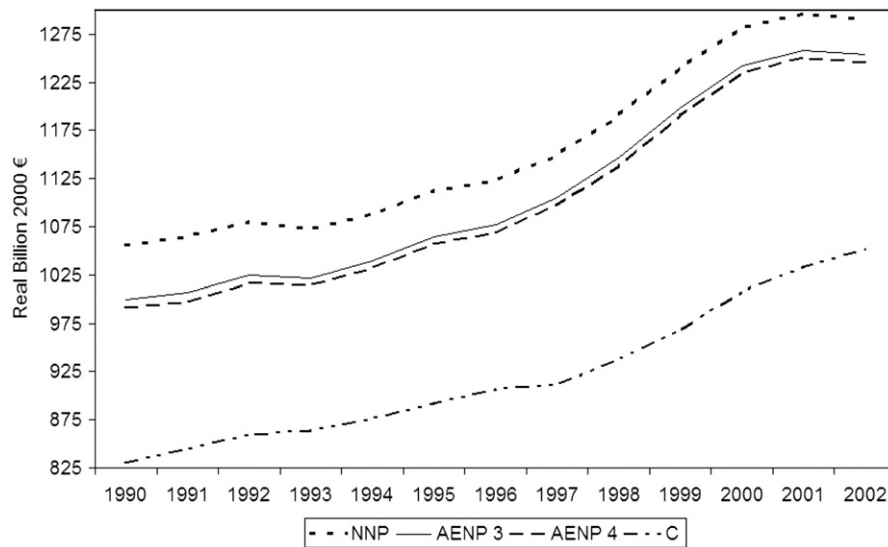


Fig. 2 – AENP 3 and 4 for France (1990–2002).

In conclusion, results for AENP support the idea that France was weakly sustainable for the period 1990–2002. However, given the fact that no AENP estimates the “true” measure of gNNP, this outcome is not very reliable and should be used carefully.

2.2. Genuine Savings

2.2.1. Theoretical description

Genuine Savings (GS) stems from a theoretical model of maximization of a social welfare function, discounted at a constant rate, under hypothesis of constant population and perfect substitution between all kinds of capital (Hamilton and Clemens, 1999; Neumayer, 2004). Within this framework, it can be shown that the economy is unsustainable if its GS is inferior to zero (Pezzey and Toman, 2002b). GS is an extension of the Hartwick rule³: an economy is sustainable if savings are superior to the aggregated depreciation of human, man-made and natural capital⁴ (Pearce and Atkinson, 1993). Based on the following operational specification, the World Bank computed GS for 140 countries in 2004:

GS = Gross national savings – fixed capital consumption + education expenditures – value of natural resources depletion – value of damages caused by pollutants (carbon dioxide and particulate matter).

Empirical results show that OECD countries as well as East and South Asia never had negative GS during the period 1980–2000; whereas many African nations and the Middle East had negative value for this indicator during this same period (World Bank, 2005). Therefore, according to GS, most devel-

oping countries, dependent on natural resources exploitation, are unsustainable whereas results for developed nations do not indicate unsustainability.

Note that this indicator is a measure of weak sustainability. Indeed, the condition for sustainability in the theoretical model is non-declining consumption and total stock of capital on the optimal development path. Therefore, this requirement does not integrate a constraint on natural capital. There are no limitations on the substitution between human, man-made capital and environmental capital. In this context, this indicator does not take into account irreversibility or threshold effects. Moreover, problems appear during the switch from the theoretical definition to the operational one. Firstly, the theoretical model supposes that the economy follows an efficient growth path. Therefore, prices used in the GS computation must be the optimal and sustainable prices (as for gNNP computations). However, only current prices are available for empirical work and these prices are neither optimal nor sustainable (Pezzey and Toman, 2005). Since empirical values of GS are estimated with incorrect data, conclusions on national sustainability based on this indicator must be used carefully. Secondly, methods used to compute natural resource depletion and damages from pollution are criticized. Neumayer (2000) uses an alternative method to assess resource depletion (El Serafy method⁵) and this change has an impact on the value of GS: for countries with substantial reserves, GS changes from a negative to a positive value, transforming conclusions on the sustainability of those countries. Thirdly, GS is overestimated because only damage from carbon dioxide and particulate matter are subtracted. Other environmental fields like biodiversity, water and soil are not included because of a lack of data, although these fields are important to assess national sustainability. To conclude, GS seems to be a partial and flimsy indicator of weak sustainability.

³ The Hartwick rule requires that rents from natural resource extraction must be re-invested in physical capital to maintain the amount of total capital at the same level (or a higher one). See Hartwick (1977).

⁴ Note that this indicator is closely related to gNNP. In fact, GS can be roughly defined as the difference between gNNP and current consumption. See Pezzey and Toman (2002b) for a precise technical description.

⁵ The El Serafy method values the “user cost” of resource extraction. It indicates the share of the resource receipts that should be considered as capital depreciation (see Neumayer, 2004 for a detailed presentation).

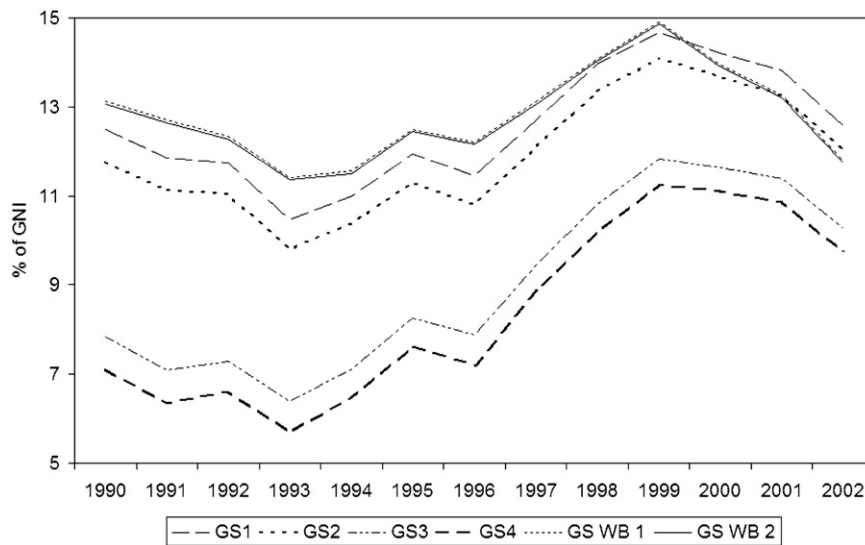


Fig. 3 – French Genuine Savings 1990–2002.

2.2.2. Empirical result for France

Fig. 3 shows six different GS over the period 1990–2002.

GS WB 1 and GS WB 2 are taken from the World Bank. GS WB 2 takes into account damage from particulate matter contrary to GS WB 1 that only deals with damage from CO₂ emissions (Bolt et al., 2002).

To estimate GS, I used the formula of the World Bank (cf. Section 2.2.1). GS1 to GS4 are computed with data from the French statistical institute (INSEE) for gross national savings, fixed capital consumption and education expenditures. The valuation of rents from energy, forests and minerals is the one used to estimate the AENP (cf. Section 2.1.2 and Appendix B). I also used different assessments of environmental damage (like for the AENP, cf. Section 2.1.2 and Appendix B). In this context, GS1 and GS2 only incorporate damage from CO₂ emissions whereas GS3 and GS4 also take into account damages from NO_x, SO₂ and PM₁₀. Moreover, to monetize damages from CO₂ emissions, the value of Fankhauser (1994) is used to compute GS1 and GS3 whereas the value of the Boiteux and Baumstark Report (2001) is used to estimate GS2 and GS4.

Firstly, Fig. 3 indicates that the value of the French GS is always higher than zero within the period, whatever index is examined. Therefore, France seems not to be unsustainable during the period in the weak sustainability sense. However, given the problems and limitations of this indicator (cf. Section 2.2.1.), this conclusion must be used carefully. Secondly, the graph shows that the use of different assessments for environmental damage affects the value of the index. Indeed, the gap between GS 1 and GS 2, and between GS 3 and GS 4 is due to a different valuation of marginal damages from CO₂ emissions. In a similar way, the difference between GS1 and GS 3, and between GS 2 and GS 4 is explained by the incorporation of damages linked to NO_x, SO₂ and PM₁₀ emissions. In this context, the choice of data sources and methods of valuation affects empirical results and so the conclusion. Concerning my estimation of Genuine Savings, the conclusion about sustainability does not change. However, the pollution recorded is far

from exhaustive. The estimated values of GS are imperfect and so overestimate the “true” value of the measure. Therefore, any inference about weak sustainability based on this indicator must be used with caution.

To conclude, the positive value of GS cannot be interpreted firmly as a sign of weak sustainability (Pezzey and Toman, 2005) because GS is a “one-sided indicator of sustainability” (Atkinson et al., 1997). Nevertheless, empirical results corroborate the idea that France is not unsustainable.

2.3. A physical indicator: ecological footprint

2.3.1. Theoretical description

The ecological footprint was first proposed and developed by Rees and Wackernagel (1994) and Wackernagel and Rees (1996). Its objective is “to translate all the ecological impacts of human activity into the area required to produce the resources consumed and to assimilate the wastes generated under the predominant management and production practices in any given year” (Neumayer, 2004). The ecological footprint is a physical indicator of sustainability expressed in land units. It compares human consumption of natural resources with planet Earth’s ecological capacity to regenerate them and absorb the corresponding waste. The ecological footprint is defined as the amount of biologically productive land area required to support the consumption of a given population. If the ecological footprint is higher than the existing land area, current consumption is not sustainable since the carrying capacity⁶ of the land is exceeded. In other terms, economic activity, responsible for the ecological footprint, is unsustainable. Empirically, energy, food and timber consumption per capita are transformed in terms of land area needed to produce these amounts. The sum is then compared with the amount of available productive land area per capita.

⁶ The carrying capacity defines the extent of disruptions that can be absorbed by a system based on a locally stable equilibrium before shifting to another one.

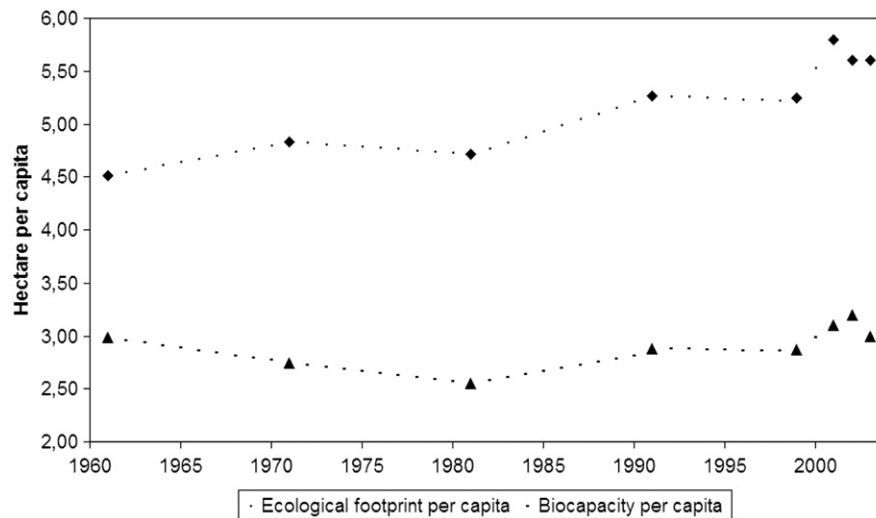


Fig. 4—Ecological footprint in France (1961–2003).

Whereas this indicator is appealing and widespread, it is not perfect. I present below three main limitations. Firstly, the ecological footprint construction is problematic because heterogeneous data are transformed into land units. Conversion methods are criticized. For example, not all the aspects of economic activity can be integrated into the index because of the lack of means of conversion into physical units (Neumayer, 2004). Secondly, the ecological footprint can be seen as an indicator of weak sustainability whereas proponents present it as a measure of strong sustainability. Although this indicator focuses on the environmental constraint on development, it does not include irreversibility or threshold effects. In fact, even if the ecological footprint is lower than the carrying capacity of the ecosystem, it is possible that some critical ecological thresholds have been exceeded. There are no constraints on the substitution between different kinds of natural capital. In this context, it should not be regarded as an indicator of strong sustainability. The last but not the least limit, is the lack of specific policy proposals based on ecological footprint analysis. If the goal is to reduce the ecological footprint to fit within the carrying capacity of the land, advocates of this indicator do not propose detailed policy advice. Nevertheless, the ecological footprint gives a general policy recommendation that is to reduce the rate of resource throughput. This could lead to more precise policy proposal concerning resource use efficiency and means to respect regenerative and waste assimilative capacities of resource stocks.

2.3.2. Empirical result for France

Only partial data were available for this indicator: for the years 1961, 1971, 1981, 1991, 1999 and 2001, data of the ecological footprint and biocapacity have been taken from WWF “Living Planet Reports”; for the years 2002 and 2003, data come from the National Footprint Accounts 2005 and 2006 published by the Global Footprint Network. Data on total national population have been taken from the French statistical institute (INSEE) to compute ecological footprint and biocapacity per capita. Values of these two indicators have been estimated for

the missing years by a linear approximation (using an average annual growth rate). Fig. 4 shows the trends of the ecological footprint (superior line) and biocapacity per capita (inferior line) between 1961 and 2003. Note that bold points on Figs. 4 and 5 represent real values whereas dotted lines represent estimated values of the indicators.

First of all, during the studied period, the ecological footprint per capita was always higher than the individual biocapacity. This means that the carrying capacity of land in France has been exceeded. Therefore, the French economic activity is unsustainable. This result also appears on the graph of the ecological deficit that is the difference between biocapacity and ecological footprint (Fig. 5). During the period, the ecological balance was always negative. Moreover, the French environmental deficit is widening. This is mainly due to the growth of the ecological footprint which is explained especially by the rise of the energy footprint (i.e. the land needed to absorb national CO₂ emissions) (WWF, 2002). The downward trend of the ecological deficit suggests that France is not on a sustainable growth path. On the contrary, according to the ecological footprint, France is unsustainable and continues to grow at the expense of the environment. This country could be sustainable in the future only if a considerable slow down in the rate of resource use occurs in order to reduce the ecological footprint to fit within the biocapacity.

The connection of results from the three measures of sustainability leads to opposite conclusions. Indeed, the estimates of gNNP and GS support the idea that France was weakly sustainable between 1990 and 2002 but empirical results for the EF call this conclusion into question.

3. Measures of welfare

3.1. GPI and ISEW

3.1.1. Theoretical description

Some authors attempt to correct GDP by integrating not only ecological but also social and political variables. The Indicator

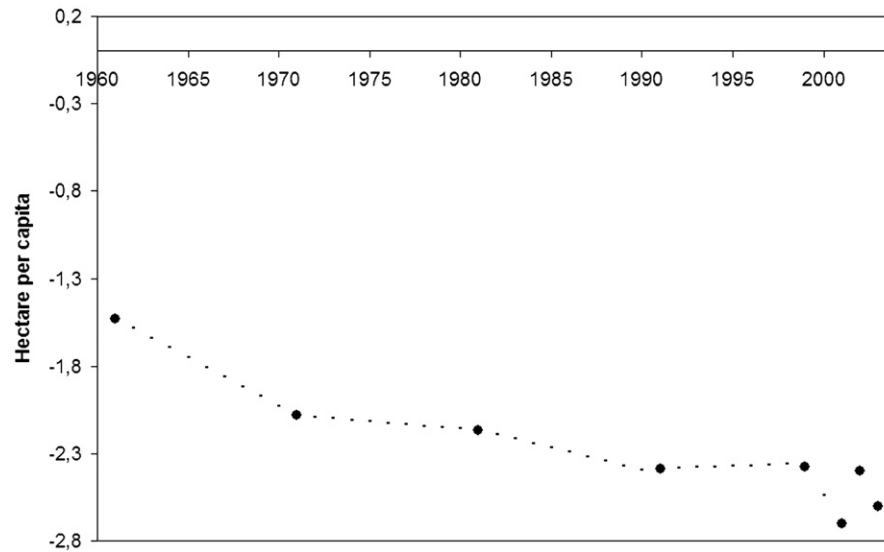


Fig. 5 – Ecological deficit in France (1961–2003).

of Sustainable Economic Welfare (ISEW) (Daly and Cobb, 1989)) that became the Genuine Progress Indicator (GPI) (Cobb et al., 1995), belongs to this group of measures. From personal consumption expenditures adjusted for income inequality, the general idea is to add contributions to welfare and/or sustainability (e.g. household labour and voluntary work) and to subtract losses (e.g. cost of environmental damages). Differences between the ISEW and the GPI are due to the revision of the methods of computation and concern the treatment of public and private defensive expenditures on health and education and also the incorporation of cost estimates of welfare losses (e.g. loss of leisure time, under-employment). Note that the ISEW/GPI is not strictly an indicator of sustainable economic welfare since the incorporation of the cost of environmental degradation is not sufficient to indicate sustainability or otherwise. In this context, a rise of the ISEW/GPI means that national economic welfare is improving. Therefore, the policy recommendation is to ensure that those indexes are not decreasing. Estimates of ISEW and GPI show a decrease of these indicators during the last twenty to thirty years, unlike the still rising GDP. These opposite trends support the “threshold hypothesis” (Max-Neef, 1995): there is a point beyond which economic growth does not improve economic welfare but deteriorates it. Consequently, empirical results indicate that development is worsening in the studied countries. The application of these measures to France is another test of the threshold hypothesis.

Two main limitations appear during the construction of these indicators. Firstly, it seems that no theoretical basis supports them: environmental and social adjustments do not seem to come from a theoretical model but depend on *ad-hoc* justifications. Yet, Lawn (2003) constructs a theoretical framework to support the ISEW/GPI based on the Fisherian concept of income. This paper explains the different step of computations of these indicators and gives a theoretical foundation to environmental and social adjustments. However, ecological and social costs and benefits must be monetized and yet this step is tricky since mone-

tization techniques are criticized. Therefore, like the gNNP and GS, empirical results of ISEW and GPI depend on the choice of the valuation method. Finally, note that a sustainable development indicator should enable one to assess if a country is on a sustainable growth path. Indicators such as the ISEW and GPI do not give this indication since no benchmark value for a sustainable state exists. Although the GPI/ISEW does not give information on the national sustainability, they take into account environmental degradation and social conditions while assessing national development and welfare.

3.1.2. Empirical results for France

Data used to estimate the ISEW and GPI for France come from various sources (cf. Appendix C for a detailed presentation of the sources and methodology).

Fig. 6 shows ISEW, GPI and GDP per capita over the period 1990–2002. Two main comments can be developed. Firstly, it is striking that ISEW and GPI per capita always had a lower value than GDP per capita. Note also that, over the whole period, GPI per capita was inferior to ISEW per capita. This suggests that the incorporation of social, political and environmental variables in a traditional measure of development contributes to lower the value of this indicator. Therefore, it seems that a part of the growth of GDP of France between 1990 and 2002 occurred at the expense of environmental quality and social conditions. Secondly, two trends appear: a first one from 1990 to 1997 and a second one from 1997 to 2002. During the first period, ISEW and GPI per capita rose, as did GDP per capita. This indicates that the development of France improved during the period 1990–1997. During the second period, the trends were no longer similar. While GDP per capita continued to increase, ISEW and GPI per capita showed an unstable evolution, mainly due to significant changes in net investment position and net capital growth. This unstable trend suggests that the development of France was not regular over the period 1998–2002 and environmental, social and economic variables influenced it significantly.

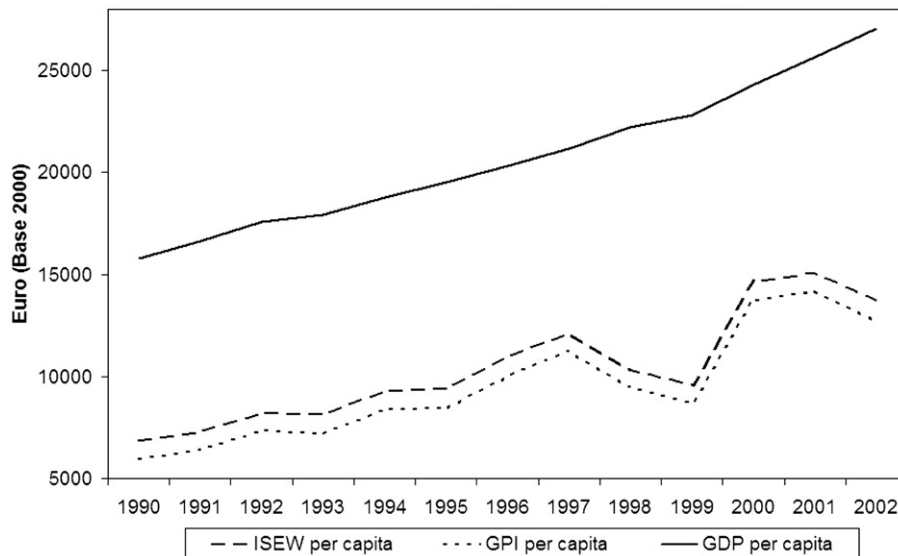


Fig. 6 – ISEW/GPI per capita in France (1990–2002).

To conclude on both indicators with respect to the threshold hypothesis, it seems that the trends of ISEW and GPI per capita do not support the threshold hypothesis for France between 1990 and 2002, contrary to other studies on European countries (Jackson and Stymne, 1996 for Sweden; Hanley et al., 1999 for Scotland). However, these papers computed ISEW or GPI per capita over a longer period. Therefore, an extension of the computations for France in previous years could supply a stricter verification of the threshold hypothesis.

3.2. A “green” extension of the Human Development Indicator (HDI)

3.2.1. Theoretical description

The “green” extensions of the HDI constitute the second indicator of welfare. The HDI, created by the United Nations Development Program in 1990, is a well-known global

measure of human development. It is composed of three variables (equally weighted): GDP per capita, life expectancy at birth and education level (measured by adult literacy and enrollment rates in education). Note that the validity of the HDI as an indicator of human development and well-being is still criticized. Critics are related either to the idea that the HDI is not reflecting human development accurately (Dasgupta and Weale, 1992; Hicks, 1997; Sen, 1997) or to the construction and technical properties of the index (Mac Gillivray, 1991; Srinivasan, 1994; Noorbakhsh, 1998). In this context, such critics also apply to the “green HDI”. I refer “green HDI” to attempts of incorporation of an ecological measure into the HDI (Desai, 1994; Lasso de la Vega and Urrutia, 2001; Costantini and Monni, 2004). Indeed, since economic and social variables are included, an environmental measure is missing in the HDI to be interpreted as a sustainable development indicator. Different methods of integration are used. As I compute the

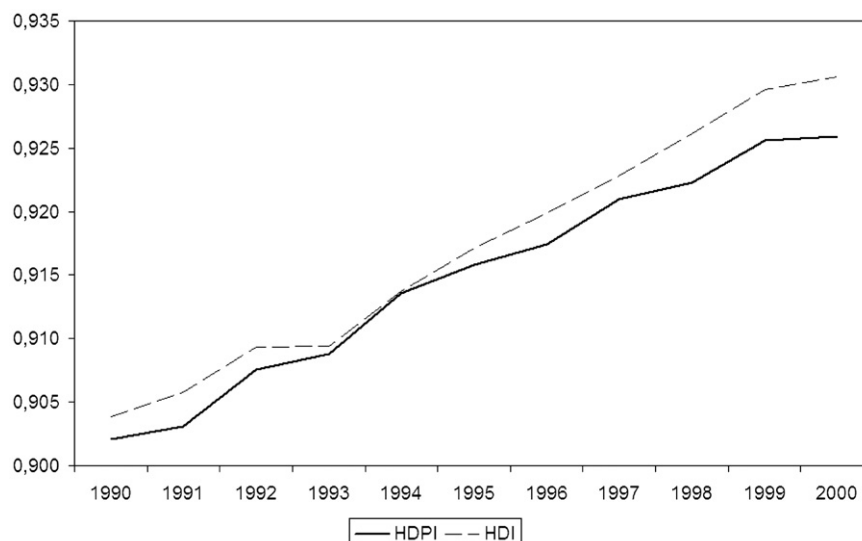


Fig. 7 – HDI and HDPI in France (1990–2000).



Fig. 8 – Gap between HDI and HDPI in France (1990–2000).

“green” extensions of Lasso and Urrutia and Costantini and Monni for France, I present briefly their methodology. Lasso and Urrutia include an environmental variable by penalising the income component of the HDI. They compute an environmental behaviour indicator (EBI) based on CO₂ emissions per capita and combine it with GDP per capita using the approach of Atkinson’s inequality index (cf. Appendix D for the exact expression of the indicator). Whereas Lasso and Urrutia keep the same economic and social variables, Costantini and Monni change the composition of the HDI to better assess human development in OECD countries. They include a fourth equally weighted variable in their “sustainable HDI” (SHDI) composed of three measures of environmental quality (for air, water and soil) (cf. Appendix E for the exact specification).

Even if these “green HDI” seem interesting to assess sustainable development, some limitations on their computation and interpretation can be underlined.⁷ Concerning the construction of these measures, the choice of the environmental variable and its exhaustiveness is important. In fact, a sustainable development indicator cannot be based on a specific measure of pollution. On the contrary, it must represent all environmental threats. Consequently, it is more relevant to use an aggregated and weighted ecological index (as in Costantini and Monni’s paper). Nevertheless, the weighting of the environmental variable in the HDI is another issue. The choice is between equal weights for each component or different ones. Note that the choice of weights is not without effect because it has an impact on empirical results. However, this step is not based on theoretical arguments and is totally arbitrary. Concerning the interpretation of the “green HDI”, note that these measures are not sustainable development indicators. Indeed, the incorporation of environmental

degradation is not sufficient to indicate sustainability or otherwise. Since a benchmark value for a sustainable state does not exist, the “green HDI” do not assess national sustainability. Nevertheless, they are better, yet imperfect, indexes of welfare and development than GDP because they take into account ecological and social elements.

3.2.2. Empirical results for France

Two extensions of the HDI are applied to France.

To compute the French “Pollution-sensitive Human Development Indicator” (HDPI) (based on Lasso and Urrutia’s methodology), I used data from: the World Bank (GDP per capita in purchasing power parity), the French statistical institute INSEE (life expectancy), Human Development Reports of the United Nations and the French ministry of Education (adult literacy and school enrolment rate) and also the World Resource Institute (CO₂ emissions per capita). I worked out this indicator for the period 1990–2000 (cf. Appendix D for the exact specification).

Fig. 7 shows HDI and HDPI over the period 1990–2000. At first sight, both indicators increased during the decade. Note also that the value of the HDPI is less than that of the HDI. Therefore, the incorporation of an environmental variable into the HDI reduces its value. The study of the gap between these two measures provides some interesting results (see Fig. 8). Indeed, the difference decreased between 1991 and 1994 whereas it increased after 1994. This phenomenon can be explained by the trends of the different components and especially by the income and environmental variable. In fact, the time-series analysis of these two elements shows that environmental quality improved over the 1991–1994 period and worsened after 1994, whereas income per capita grew during the decade. In summary, as the “green” HDI increased over the period, it seems that human development in France is improving. Nevertheless, to draw a conclusion on the sustainability of this development would not be accurate since no benchmark value for sustainable development exists.

⁷ I present only general drawbacks of those “green” HDI. Nevertheless, specific and individual comments on their computation can be developed (e.g. the choice of the maxima and minima).

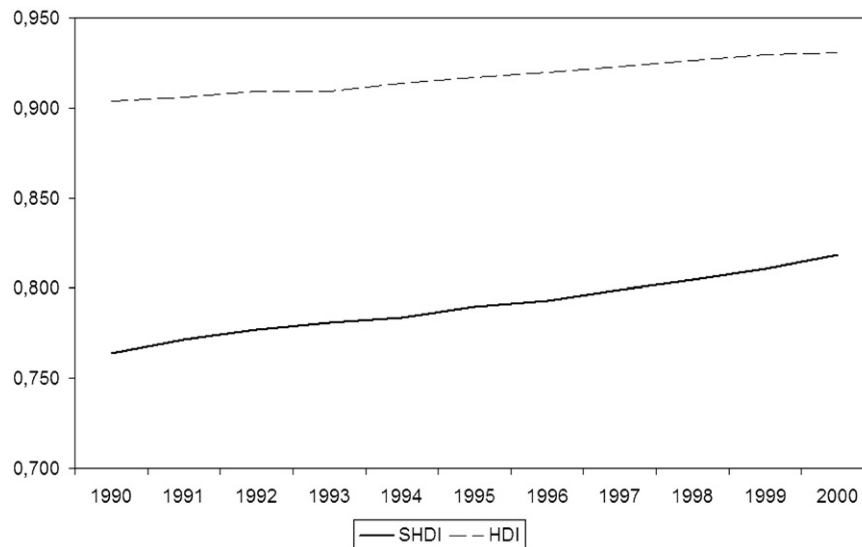


Fig. 9 – HDI and SHDI in France (1990–2000).

To calculate the “sustainable HDI” (based on Costantini and Monni’s approach), data come from: the French statistical Institute INSEE and the French ministry of Education (tertiary gross enrollment ratio), the United Nations economic commission for Europe UNECE (unemployment rate), the World Bank and INSEE (green national net product per capita), the European Environmental Agency and the World Resource Institute (air, water and soil pollution). This “green HDI” is also computed for the period 1990–2000 (see Appendix E for the precise formula).

Fig. 9 shows the French HDI and SHDI over the decade. There is an upward trend for both measures. One can observe that the value of the SHDI is lower than that of the HDI. In comparison with the HDPI, the gap between the indexes is larger. Therefore, the incorporation of an environmental measure and the change of other variables have a negative impact on the level of the indicator. In short, as the SHDI has increased, but at a lower level, it seems that human development has improved in France between 1990 and 2000. However, no relevant conclusion on sustainability can be deduced from this indicator.

Before concluding, Fig. 10 presents a different SHDI. SHDI is the one presented above whereas SHDI 1 to SHDI 4 were computed using respectively EANP 1 to EANP 4 described in Section 2.1 and Appendix B. This graph shows that the indicator is affected by the change of the value of green national net product. The conclusion concerning the development of France on the period is not contradicted since all the SHDI are increasing. Nevertheless, this example underlines that the choice of variables and sources of data to compute an indicator affect empirical results and so the conclusion. In this context, any inference about development or sustainability based on an indicator must be used with caution because of the data uncertainties and incompleteness.

To conclude on the indicators of welfare, the three measures give the same result, namely the improvement of human development in France between 1990 and 2000.

4. The French Dashboard on sustainable development

The French Dashboard on sustainable development is a non-monetary measure composed of non-aggregated indicators. It is interesting because it has the advantage of avoiding the difficult step of aggregation and monetization of environmental and social items. Moreover, the French Dashboard on sustainable development can be viewed as an indicator of sustainable development per se since it gives information on welfare and sustainability.⁸

4.1. Theoretical description

To construct the dashboard, France used United Nations’ works. Indeed, in 1995, the commission on Sustainable Development defined a list of 134 indicators divided into four groups (economic, social, environmental and institutional) and published in 2001 a methodological report in order to guide countries in constructing dashboards. The construction of the dashboard was based on the Pressure-State-Response (PSR) model. France has changed the framework proposed by the United Nations: it separates 10 modules (grouped in 5 themes) relevant to assess the sustainable development of a country and insists on the links between them. In this context, France adopted a list of 45 indicators in 2004 (Ayong Le Kama et al., 2004) and chose 15 key measures (cf. Appendix F). These main measures aim at “broadening the description of growth by integrating a human dimension and environmental pressures, establishing the state of resources to transmit to future generations and giving some information on inter/intra-generational equity” (IFEN, 2003).

This set of measures is interesting because it can give a more exhaustive view of the sustainable development of a country. Nevertheless, it can be difficult to have a global and clear picture

⁸ Therefore, I cannot present it in Sections 2 or 3.

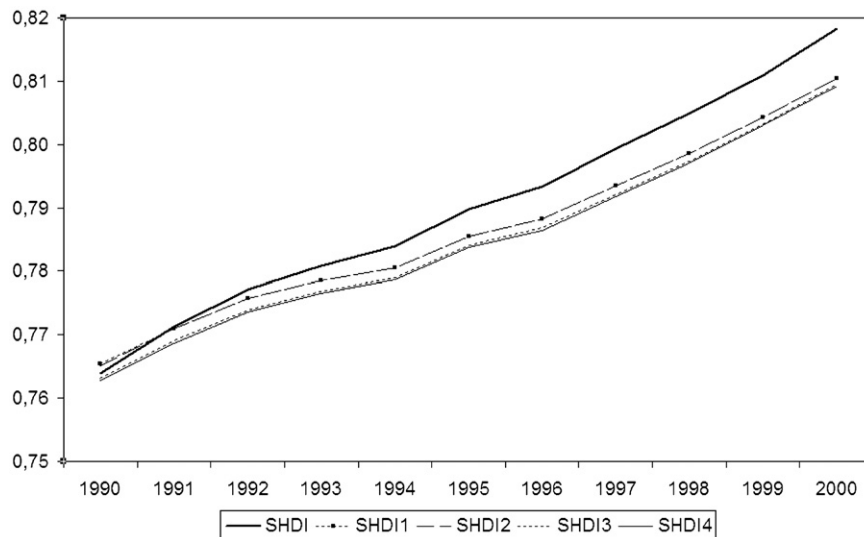


Fig. 10 – Alternative computations of the SHDI for France.

with a dashboard because of the number of data and information, sometimes at odds, to examine. Moreover, contrary to the ISEW and GPI, this kind of indicator is not a substitute for GDP but rather a complement. Indeed, some of the indicators of the dashboard can be integrated in an economic model to evaluate the precise consequence of a given policy. But, the dashboard of sustainable development cannot take the role of benchmark of GDP in macroeconomic models, contrary to the aggregated measures ISEW/GPI. Nevertheless, it can still be useful to give some relevant information on specific aspects of sustainable development.

4.2. Empirical results for France

In this section, I will focus on the significant trends of the 15 key indexes⁹ (cf. Appendix F) to assess the sustainable development of France. These measures are presented with the three-pillar framework of sustainable development, so they are grouped in economic, social and environmental sets. Three main results can be underlined. First, in the economic domain, the trends show positive GS, a relatively stable employment rate and rising R&D expenditures over the past ten years (Ayong Le Kama et al., 2004; IFEN, 2003), suggesting that some resources needed for sustainable development are present in France for current and future generations. Nevertheless, in the environmental field, empirical results for five indexes indicate that French production and consumption modes put considerable pressures on the environment. However, the trend of CO₂ emissions compared with that of GDP does not support this conclusion. It shows a decoupling between GDP and CO₂ emissions¹⁰ over the 1990–2000 period, suggesting that economic growth has, during this decade, increased without

increasing air pollutant emissions. Therefore, ecological key indicators give an ambiguous picture of environmental effects of economic growth. This result also appears with social indicators. Some variables of human development are improving (life expectancy and mortality rates) whereas others indexes of national and international equity are worsening (expenditures for development assistance, public debt) or relatively stable (long-term unemployment rate and proportion of households below the poverty line) (Ayong Le Kama et al., 2004; IFEN, 2003).

This brief description of the important results based on the dashboard on sustainable development illustrates the advantages and drawbacks of this kind of indicator. Whereas it gives useful information on specific element of sustainable development, it is difficult to synthesize and obtain a clear conclusion for the situation of France. According to the 15 key indicators, it seems that French development is increasing but not sustainable because environmental quality is worsening for some aspects and some threats exist on inter/national intra/intergenerational equity.

5. Conclusions and prospects

This paper has presented data concerning the evolution of eight indicators of development and/or sustainability for France. A theoretical description of each index has highlighted their advantages and drawbacks, underlining the fact that no indicator is perfect and no one can give an exhaustive view of sustainable development. Therefore, the study of a single measure is not sufficient. The analysis of various indicators is necessary to evaluate sustainable development with accuracy. Concerning the development of France, empirical results for ISEW/GPI and the two “green HDI” indicate that French development was improving between 1990 and 2000. However, even if these indexes take into account, yet imperfectly, social conditions and environmental deterioration to assess national well-being, they cannot evaluate national sustainability. Therefore, indicators of sustainability are necessary to complete the study of sustainable development in France. Results show that trends of the various measures do not support the same

⁹ Note that I do not present the 15 graphs for the sake of brevity. These figures can easily be found in Ayong Le Kama et al. (2004) and IFEN (2003).

¹⁰ Note that the reduction in CO₂ emissions per unit of GDP can be due in part to the importation of “dirty” goods from poor countries into rich nations (pollution haven hypothesis). In this context, the empirical decoupling occurring in the developed country does not indicate a better environmental performance.

conclusion about the sustainability of France. Indeed, while the imperfect computations of AENP and GS uphold the idea that French development was weakly sustainable, the analysis of the EF path and the French Dashboard on sustainable development support the opposite idea. Given this different empirical evidence, it seems that French development is weakly sustainable. In this view, the requirement for sustainability is a non-declining combined stock of total capital. If the condition for sustainability is stronger, i.e. the maintenance of environmental functions and critical natural capital, it seems that French development is unsustainable in the strong sense.

Note that to estimate each indicator, I attempt to respect the theoretical framework at best. However, given the availability of data, some variables are either approximated or omitted. Therefore, any change of variables or method of assessment leads to significant modification of empirical results and so conclusions. I underlined this effect for three indicators, namely gNNP, GS and SHDI. In this context, the analysis can be completed either by focusing on the sensitivity of indicators to any change in their computations or by calculating missing indicators of sustainability. Indeed, ecological measures such as the net primary productivity, environmental space and material flows are not estimated. Another missing indicator is the sustainable national income (SNI) (Huetting and De Boer, 2001) that combines physical values and a monetary valuation. This measure can be defined as the “maximum attainable level of production and consumption, using the technology of the year under review, whereby the vital functions, which is possible uses, of the physical surroundings remain available forever”. The SNI was estimated for the Netherlands with a general equilibrium model by Gerlagh et al. (2002) and Hofkes et al. (2004). Therefore, it is possible to collect new empirical evidence about the sustainability of France by computing the ecological measures aforementioned and estimating a French SNI. This additional information on the sustainability of France can either support or invalidate the conclusion of this paper about the weak sustainability of French development and its unsustainability in the strong sense.

Acknowledgments

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Appendix A. Expression of the green national net product estimated for France

$$gNNP = C + \dot{K} - \sum_{i=1}^n (p_i - Cm_i)(R_i - g_i) - \sum_{j=1}^m b_j(E_j - d_j)$$

With gNNP: green national net product

C: total consumption and $\dot{K}$: net investment (so $C + \dot{K}$ is national net product)

R_i : production or extraction of resource i

g_i : growth of the resource i ($g_i=0$ for non-living resources)

p_i : the market price of the resource i

Cm_i : the marginal cost of production or extraction

b_j : the marginal cost of abatement of the pollutant j

E_j : emission of pollutant j

d_j : the natural dissipation of pollutant j ($d_j=0$ for pure cumulative pollutants)

Source: adapted from Hamilton and Clemens (1999).

Appendix B. Sources and methodology for EANP

Net national product is estimated by the subtraction of depreciation of fixed capital (INSEE data) from gross national product (United Nations data). Real values of gross national product have been obtained using the French GDP deflator (INSEE data).

Hotelling rents from energy have been estimated with data of various sources. Annual productions of oil, natural gas and coal (in kTep) come from the French Research Institute on Energy. Data for oil (\$ per barrel) and gas prices (\$ per billion BTU) have been taken from the British Petroleum Statistical Review of World Energy of 2006 and prices for coal from the World Bank. Marginal production costs have not been found. I used average costs taken from the World Bank for gas (\$ per TJ) and coal (\$ per ton). For oil, I found partial data on average production costs (\$ per barrel) for the years 1990, 1994, 1998 and 2000 (French Oil Institute via CNRS). Missing data have been estimated with an annual average growth rate. Prices and production costs have been converted into \$ per ton using conversion factors from the British Petroleum Review of World Energy.

French wood production (in cubic meters) has been taken from the Food and Agriculture Organization (FAO) of the United Nations. Natural regeneration (in cubic meters) and prices (\$ per cubic meter) come from the World Bank. A rental rate of 40% is assumed, as used by the World Bank for Genuine Savings computations. This provides unit rents and costs (\$ per cubic meter). I used this methodology because I did not find detailed data on prices or average/marginal costs.

French mineral productions (copper, lead, zinc, gold and silver) have been taken from various U.S Geological Survey Mineral Yearbooks. Average annual prices for copper, zinc, gold and silver have been derived from INSEE monthly data and prices for lead is a world average (World Bank data). Since marginal/average extraction costs have not been found, I used average costs published by the World Bank.

Finally, damages from air pollution have been calculated with four different methods. For AENP 1 and 3, I estimated the cost of total CO₂ emissions using the value of 20 \$ per ton of carbon in 1995 (Fankhauser, 1994). This has been deflated for missing years using the French GDP deflator. For AENP 2 and 4, I used the figure of the Boiteux and Baumstark Report (2001), 100 € per ton of carbon in 2000. This also has been deflated for other years using the French GDP deflator. For AENP 3 and AENP 4, in addition to the cost of CO₂ emissions, I took into account the damage cost of three other air pollutants (NO_x, SO₂ and PM₁₀). Total NO_x and SO₂ emissions come from the European Environmental Agency (EEA) and total PM₁₀ emissions from the Interprofessional Technical Centre (CITEPA).

Although marginal damage costs have not been found, average costs have been studied by [Rabl and Spadaro \(2001\)](#). Those estimated costs value external damage costs on health, buildings and harvests. Note that the effects on health are the most important. [Rabl and Spadaro \(2001\)](#) estimate the cost of a

kilogramme of NO_x, SO₂ and PM₁₀ at respectively 16 €, 10.5 € and 15.4€ in 1998. Those costs have been deflated for missing years using the French GDP deflator.

All data in \$ have been converted into € using an exchange rate from Eurostat.

Appendix C. Sources and methodology for ISEW and GPI

- The French ISEW by variable:

Variables (Sources)	Computations
Personal Consumption (INSEE)	
Distribution inequality (World Inequality Income Database of the United Nations)	I use Gini's coefficient.
Weighted Personal consumption	= Personal consumption/(1+Gini coefficient)
+ Services from domestic labour (INSEE)	I use data from two national time-use studies (1986, 1999) to estimate the time-use for domestic labour (childcare, housework). I monetize this time by multiplying it by a time-varying wage rate (the SMIC, minimum guaranteed income).
+ Services from consumer durables (INSEE and Williams, 1998)	The flow of services from durable goods is calculated using the average lifetime of the goods (taken from Williams, 1998) and the value of expenditures on them in each period. The flow of services from each good is assumed to be equal in each period of its life.
+ Services from roads	Not integrated because of lack of data
+ Public expenditures on health and education (OECD and Education Ministry)	As some of the expenditures on health and education must be regarded as defensive, "the ISEW does not include all government expenditures on health and education, but takes only half of the expenditures on health and education as a non-defensive contribution to welfare" (Jackson and Stymne, 1996)
- Consumer durables (INSEE)	This includes consumption of cars, television sets, washing machines, refrigerators and freezers, furniture, carpets and textile.
- Defensive private expenditure on health and education (INSEE)	As for public expenditures, the ISEW assumes that only one half of private expenditures on health and education contribute to welfare.
- Cost of commuting (INSEE)	I use data from two national time-use studies (1986, 1999) to estimate the time-use for travelling to and from work. I monetize this time by multiplying it by a time-varying wage (the SMIC).
- Cost of personal pollution control (IFEN)	This includes mainly expenditures for purifying and insulation of houses and purchase of waste containers.
- Cost of automobile accidents (National institute of road safety)	I use data on the annual number of accidents (divided into three classes: fatal accident, slight injury and serious injury). I apply a unit cost for each kind of accident (1,000,000 € per fatal accident, 150,000 € per serious injury and 22,000 € per slight injury). These costs are taken from the National Institute of Road Safety (2006) .
- Cost of water pollution (Water Agency)	I have decided to use the same methodology employed in the Swedish study, namely to scale the estimated costs of water pollution in the USA in 1972 according to the relative difference in GDP. Then, the cost estimate is spread over the period using an indicator for the quality of water (i.e. proportion of sites with an average to bad concentration of nitrates).
- Cost of air pollution (European Environmental Agency (EEA) and Interprofessional Technical Centre (CITEPA))	Valuation of the annual emissions of SO ₂ , NO _x , carbon monoxide [CO], PM ₁₀ and volatile organics [VOC] is based on their marginal social costs. I compute average marginal social costs with the estimates of Rabl and Spadaro (2001) , Tellus (1991) and Pace (1990) . The marginal social costs of SO ₂ , NO _x , CO, PM ₁₀ and VOC are respectively: 5245.4 €/T, 8093.4 €/T, 969.5 €/T, 7264.57 €/T and 5762.3 €/T (1995 €).
- Cost of noise pollution (INSEE et Boiteux and Baumstark, 1994)	I use the number of people bothered by noise (about 40% of the whole population). I monetize these numbers by applying an individual cost of 137.2 € per person (in 1992) (taken from the Boiteux and Baumstark Report, 1994) increasing at the same rate as personal consumption.
- Loss of wetlands	Not integrated because wetlands represent only 3% of the French territory.
- Loss of farmlands (IFEN)	The IFEN assumes that 81,000 ha of farmlands have been destroyed each year for the period 1992–2003. So, I use this data to evaluate the cumulated physical losses. Then, I use the foregone benefits estimated by Daly and Cobb (1989) : 100 \$ per acre per year (in 1972), i.e. 397.19 € per acre per year (in 2000 €).
- Depletion of non-renewable resources (Energy Ministry)	I use the methodology employed by Jackson and Stymne (1996) . Data on annual consumption of coal, electricity, oil and gas are monetizing with a replacement

(continued on next page)

Appendix C (continued)

Variables (Sources)	Computations
- Costs of long-term environmental damage (Energy Ministry)	costs of 75 \$ per barrel of oil equivalent in 1988. Note also that this replacement cost increases by 3% each year.
- Costs of ozone depletion (UNEP)	Long-term environmental damage is taken into account by imposing an annual tax of 0.50 \$ (1972) (1.98 € (2000)) on each barrel of oil equivalent consumed from non-renewable energy sources. This tax is supposed to operate cumulatively. That is to say, the total cost in any year is taken to be equal to the cumulative energy consumption (from 1981 onwards) multiplied by the tax imposed.
+ Net capital growth (INSEE)	Data on production is used (because no information on consumption has been found). The unit cost of 5 \$ (1972 \$), 19.86 € (2000 €), per kilogramme is applied to cumulated production.
+ Net changes in international position (IMF via EconStats)	This variable accounts for capital formation net of both depreciation and the capital requirement (the capital growth necessary to maintain a constant level of capital per worker) flowing from an increase in the workforce. = $C_t - D_t$ with $D_t = B_{t-1} \times A_t$, where A is the change in number of people employed, B is the net capital stock (private capital only), C is the change in the net capital stock B and D is the 'capital requirement', while t denotes the year. = assets–liabilities

- Differences with the GPI:

Variables not included in the GPI

The variables “public expenditures” and “defensive private expenditures” are not taken into account to compute the French GPI. The GPI never includes these elements (Anieslki and Rowe, 1999).

Alternative computation

Costs of long-term environmental damage Long-term environmental damage is taken into account by imposing an annual tax of 1.45 \$ (1.58 € (2000)) on each barrel of oil equivalent consumed from non-renewable energy sources. This tax is supposed to operate cumulatively. That is to say, the total cost in any year is taken to be equal to the cumulative energy consumption (from 1981 onwards) multiplied by the tax imposed.

Additional variables

Variables (Sources)	Computations
+ Services of volunteer work (INSEE et Archambault and Boumendil, 1999)	I found data on the number of volunteer workers for the years 1991, 1993, 1996 and 2002. For missing years, I apply the proportion of volunteers in the population to the French total population. I assume that each participant gives 2.5 h per week to voluntary work, as Prouteau and Wolff (2004). I monetize the annual number of volunteer work using the SMIC.
- Cost of crimes (Research centre on law and penal institutions)	Over the period 1990–1996, I use estimated costs of stealing, tax evasion, customs frauds, economic offences, pimping and consumption drugs from Godefroy and Laffargue (1995) and Palle and Godefroy (1998). For the period 1997 to 2002, I compute the costs by applying the annual growth rate of crimes and offences to the previous estimated cost.
- Cost of divorces (INSEE)	I multiply the annual number of divorces by a unit cost (4204 € en 2000) representing expenditures for legal fees and counselling. This cost is an average between estimated costs of the three kinds of divorce.
- Cost of underemployment (INSEE)	I use the estimated number of people being in a situation of underemployment from the INSEE. Employment surveys indicate these people, for the most part, work for 20 h and want to have a full-time job. Therefore, I multiply their number by the number of additional hours they desire to work (15 h) and then by a time-varying wage rate (the SMIC).
+ Gain of leisure time (INSEE)	From two time-use studies, leisure time increases by 2 h per week (96 h per year) between 1986 and 1998. I assume this growth was equally distributed during the 12 years and is continuing at the same rate: a gain of 8 h of leisure time per year. I monetize this value using the SMIC.

Appendix D. Expression of the “Pollution-sensitive HDI”

$$HPDI = 1/3(H_1 + H_2 + H_3P)$$

With: $H_1 = \frac{LE-25}{85-25}$ where LE is life expectancy $H_2 = \frac{2}{3} \frac{AL}{100} + \frac{1}{3} \frac{ER}{100}$ where AL is adult literacy and ER is school enrollment rates
 $H_3P(\varepsilon) = \left[\frac{1}{2}(H_3)^{1-\varepsilon} + \frac{1}{2}(EBI)^{1-\varepsilon} \right]^{1/(1-\varepsilon)}$
 where $H_3 = \frac{\ln(GDP) - \ln(100)}{\ln(40,000) - \ln(100)}$ with GDP = gross domestic product per capita
 $EBI = 1 - \frac{CO_2}{60}$ with CO_2 = carbon dioxide emissions per capita
 ε is the degree of aversion to inequality and is fixed at 2 for computations.

Source: [Lasso de la Vega and Urrutia \(2001\)](#).

Appendix E. Expression of the “Sustainable HDI”

$$SHDI = 1/4 \left[\left(\frac{x_1 - 0}{100 - 0} \right) + \left(\frac{(100 - x_2) - 0}{100 - 0} \right) + \left(\frac{\log(x_3) - \log(40,000)}{\log(100) - \log(40,000)} \right) + \left(\frac{x_4 + x_5 + x_6}{100} \right) \right]$$

With:

x_1 : tertiary gross enrollment ratio

x_2 : unemployment rate

x_3 : green NNP per capita

$x_4 = 1 - \left(\frac{y_1 - 0}{0.03 - 0} \right)$ where y_1 is the air index: y_1 = tonnes per day per worker of nitrogen oxide, sulphur dioxide, ammonia, volatile organic chemicals and carbon monoxide.

$x_5 = 1 - \left(\frac{y_2 - 0}{0.55 - 0} \right)$ where y_2 is the water pollution index: y_2 = kg of organic water pollutant emissions per day per worker.

$x_6 = 1 - \left(\frac{y_3 - 0}{6,000 - 0} \right)$ where y_3 is the soil pollution index: y_3 = fertilizers, herbicides and insecticides used on arable land, kg per hectare.

Source: [Costantini and Monni \(2004\)](#).

Appendix F. The French Dashboard of sustainable development

• The structure of the Dashboard

Theme 1: Sustainable growth

Module 1: “Eco-efficient” growth

Module 2: Integrating the environment into the production structure

Theme 2: Critical heritage and resources

Module 3: Sustainable use of resources

Module 4: Maintaining and transferring our heritage

Theme 3: The spatial dimension and the global perspective

Module 5: Inequality and spatial distribution

Module 6: Relationships between France and the rest of the world

Theme 4: Satisfying the needs of the present-day generations

Module 7: Inequality and exclusion

Module 8: Behaviour reflecting dissatisfaction

Theme 5: The long-term and future generations

Module 9: Principles of responsibility and precaution

Module 10: Vulnerability and adaptability to unforeseen circumstances

Source: [Institut Français de l'Environnement-IFEN \(2003\)](#).

• The 15 key indicators

1. Life expectancy without disability (theme 2, Module 4)
2. Avoidable untimely mortality rate (theme 2, Module 4)
3. Artificial lands (theme 2, Module 3)
4. Contamination of inland waters by pesticides (theme 2, Module 4)
5. Overfishing (theme 2, Module 3)
6. Biodiversity: changes in the population of common bird species (theme 2, Module 4)
7. Genuine Savings (theme 5, Module 10)
8. Employment rate (theme 5, Module 10)
9. Research and Development expenditures (theme 5, Module 9)
10. Waste production and population (theme 1, Module 1)
11. CO_2 emissions and GDP (theme 1, Module 1)
12. Public debt (Theme 5, Module 9)
13. Proportion of households living below the poverty line (Theme 4, Module 7)
14. Long-term unemployment rate (Theme 4, Module 7)
15. Public expenditures for development assistance (theme 3, Module 6)

Source: [IFEN \(2003\)](#) and [Ayong Le Kama et al. \(2004\)](#).

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