Values and technologies for sustainable happiness: A cross-development analytical model

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June 2011

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Abstract

This paper develops an analytical model to calculate the amount by which individuals are expected to modify their values (the relationship between lifestyle and happiness, as measured by subjective well-being, SWB) and to adopt innovative technologies (to increase the sustainability of production and consumption, measured by the ecological footprint, EF) to allow current and future generations to achieve sustainable happiness (the pursuit of happiness that does not exploit other people, the environment, or future generations). The paper also examines the dependence of these changes on an individual's concern for future generations and on their country's current state of economic development. Individuals in developed countries can change their values by showing greater concern for future generations as well as by adopting new technologies, thereby reducing the required change in values and achieving sustainability at a high SWB. In contrast, individuals in developing countries must rely solely on technological innovation (and to a greater extent than in developed countries), and their concern for future generations is less relevant, with sustainability achieved at a low SWB. Finally, maximising the concern for future generations will make individuals in developing and developed countries coincide in terms of their potential to substitute values for technologies or vice versa, but not in terms of their potential to achieve sustainable happiness.

Keywords

Sustainability, happiness, values, sustainable technologies, model, well-being, ecological footprint

1. Introduction

Concerns about the trajectory of development and its harmful impacts on all life on the planet, including life that has yet to be born, have been outlined for many years (e.g., WCED, 1987). These concerns have led many to advocate a shift from a materialistically oriented to a less materialistic worldview (e.g., UN, 1993) or to a new welfare economics of sustainability (i.e., approaches to measuring well-being that provide an alternative to equating per capita consumption with welfare; see Gowdy, 2005). Others have advocated technological progress (e.g., IPCC, 2007) or post-normal technologies, which involve stakeholder engagement and interaction with those who possess more traditional forms of expertise in order to co-produce knowledge about sustainability (see Frame and Brown, 2008).

The concept of *sustainable happiness* (i.e., the pursuit of happiness that does not exploit other people, the environment, or future generations) was developed to draw attention to the consequences, both positive and negative, of how individuals, communities, and nations pursue happiness (O'Brien, 2008). In other words, the goal is to achieve happiness (as an end), but constrained by the (subjective) happiness or (objective) resources of others.

Moreover, de Vires and Petersen (2009) advocated a shift from welfare to capabilities and functions or to human-scale development in order to achieve a constructive resolution of the tension between objective and subjective notions of the sustainability and quality of life, by combining individual values and cognitive maps in *worldviews* translated into model-based narratives or scenarios. In other words, this means seeking sustainability based on values and beliefs: the tension between ends and means remains, but the distinction between objective and subjective disappears.

Finally, Sabau (2010) suggested *sustainability as a principle* of social continuity on Earth (i.e., to understand our rights and duties in light of the solidarity chain that links our fate to those of nature and of our fellow humans). In other words, this means aiming at sustainability regardless of happiness: the tension between ends and means also disappears in this approach.

The purpose of the present paper is to develop an analytical model to address the following questions: *To what extent* should we change our values (in particular, the relationship between lifestyle and happiness, as measured by subjective well-being, SWB) or introduce new technologies (in particular, those that promote sustainable production and consumption, as measured by their ecological footprint, EF) to allow people in current and future generations to achieve sustainable happiness? *To what extent* do these changes in values (materialistic vs. non-materialistic) and technologies (sustainable vs. non-sustainable) depend on the current state of economic development of a country and on concerns for future generations?

To better grasp the relationship between lifestyle and happiness, consider the possibility of different values that are capable of producing the same happiness level from different consumption patterns. For example, in order to reach their workplace on the other side of the city, an Italian worker who uses a 1500 cc gasoline-powered car could achieve the same level of utility as another worker who uses a 1000 cc car if the latter is more concerned about the use of the car while the former is more concerned about the social status revealed by the car. Similarly, different values can produce different happiness levels from similar consumption patterns. For example, if the Italian worker uses a 1500 cc car in the United States, they would achieve a smaller happiness level than in Italy because American cars are larger, on average, than in Italy.

To better capture the relationship between production and sustainability, think of different technologies that lead to different sustainability levels for similar consumption patterns. For example, the CO_2 emissions by a 47-kW electric car (i.e., one equivalent to a 1000 cc gasoline engine) are smaller than those of a 1000 cc gasoline-powered car if the electric car can be recharged using a sufficiently high proportion of clean energy. Similarly, different technologies can lead to the same sustainability levels from different consumption patterns: for example, the electric car's CO_2 emissions would be similar to those from a 50 cc gasoline-powered motorcycle (i.e., equivalent to 2.3 kW) if the proportion of clean energy used to recharge the electric car is sufficiently large.

To better grasp the meaning of changes in values, think of a consumer who receives the same level of utility from the 1500 cc and 1000 cc gasoline-powered cars after adopting a less materialistic worldview. To better capture the impact of technological changes, think of a consumer who would move from a 1000 cc gasoline-powered car to an equivalent 47-kW electric car if technological innovation made this feasible.

In other words, I will assume based on these examples that science and technology can make significant potential contributions to help implement sustainability policies (see Huesemann and Huesemann, 2008). To do so, I will quantify to what extent a fundamental change in values can replace scientific research and technological innovation in order to achieve sustainability, and to what extent changes in societal values and policies depend on a fair distribution of income between current generations and on just treatment of future generations and the environment that will sustain them.

Note that it is beyond the scope of this paper to address the following additional questions: Can individuals be educated or trained (see Solomon, 2010) to make better choices about sustainable happiness? Which policies could contribute (see Hellstrand et al., 2009) to sustainable happiness?

Moreover, two main groups of actions can favour individual sustainability (which is only partially depicted by EF). First, consumers can directly choose consumption patterns based on less pollution emissions and resource use and can indirectly choose production technologies through their product choice. Second, producers can directly implement less manufacturing and more service industries and technologies that emit less pollution or use less resources. For the sake of simplicity, the abovementioned examples and the examples in the following sections will refer to "consumers" rather than "individuals" based on the assumption that consumers can choose economic *structures*, production technologies, and consumption *patterns*. The distribution of global sustainability among countries (i.e., sustainability of human activities in a world that is seen as a system composed of interdependent economic, social, and environmental sub-systems), linked to import decisions by consumers, will be disregarded (Kissinger and Rees, 2010).

Finally, although several factors can affect individual happiness (which is only partially represented by SWB), for the sake of simplicity, the abovementioned examples and the examples in the following sections will refer to "utility" instead of "happiness", based on the assumption that happiness linked to income arises from consumption and related freedoms rather than from social structures or ethical principles. The utility that arises from objective *uses* of goods or services will be distinguished from utility arising from subjective sources such as social *status* by disregarding global sustainability, which characterises goods or services.

The recent literature on sustainable development, which is relevant for this study, can be summarised in two main questions: What is sustainable development? How can it be achieved?

As regards the first question, it is possible to envision a shift from a definition of sustainability to an epistemological foundation for the theoretical framework of sustainable development based on different *categories* and independent *concepts* (i.e., ethical paradox, natural capital stock, equity, eco-form, integrative management, utopianism, political global agenda). This shift highlights sustainability as an unresolved and fluid paradox, which can simultaneously inhabit different and contradictory environmental ideologies and practices (Jabereen, 2008). Next, it is possible to envision a shift from a definition of sustainability to scientific sustainability *principles* (i.e., biophysical limits, societal welfare and development, irreducible minimum needs, system complexity). This shift leads to sustainability as an attempt to bring together scholars from different backgrounds and disciplines in order to create an integrated thesis (Quental et al., 2010).

As regards the second question, Hellstrand et al. (2009) emphasised that politicians must address the distributional issues within and *between nations* by stressing the drawbacks for nature and society that result from the pressure that society puts on nature. Thus, economic and ecological policies must address the restrictions on ecological sources and sinks that underlie sustainable development. Solomon (2010) stressed that environmental law and environmental education will not succeed in *poor countries*, where the government's overwhelming priority is placed on economic development; however, environmental ethics must be the force that drives the adoption of environmental priorities by other disciplines.

In this study, I will adopt a *familiar* definition of sustainable development (i.e., social and economic development defined in terms of happiness within ecological sustainability limits defined in terms of ecological footprints), and will explore this definition within a normative approach (see Baumgartner and Quaas, 2010). My goal is to assess the potential substitutions between economic and ecological policies (here, represented by technological innovation) and environmental ethics (here, represented by value changes) and the role of these substitutions in achieving sustainable development. In so doing, I will distinguish between developed countries and developing countries because of the different constraints they face.

2. Methodology

2.1. The constraints with current values and technologies

In this paper, I measured sustainability using EF values, which represent the relationship between the use of natural resources by individuals, organisations, or nations and the carrying capacity of the biosphere that sustains this use. Other indicators of the sustainability of current consumption could have theoretically been chosen (see Brand, 2009), but I chose EF because of the high data availability. I referred to EF values for 141 countries provided by Bagliani et al. (2008). The originality of the present study does not rest on the use of original data; using other indicators would not change the approach and the insights it provides. Next, I measured happiness using SWB values, which represent an index that combines each person's responses to questions about happiness and life satisfaction. Again, although other definitions of happiness would be theoretically consistent with the model developed in this paper (see Deci and Ryan, 2008), I chose SWB because of its high data availability. I considered SWB values for 88 countries provided by Inglehart et al. (2008). The originality of the present study does not rest on the use of original data; using other indicators would not alter the approach and the insights it provides.

To simplify the model development, I assumed that each individual is expected to produce the same sustainable EF per year. This is set at the current value (the value in or around 2006 based on the available data), although this EF might not be the future equilibrium value with a larger world population that has a longer life expectancy.

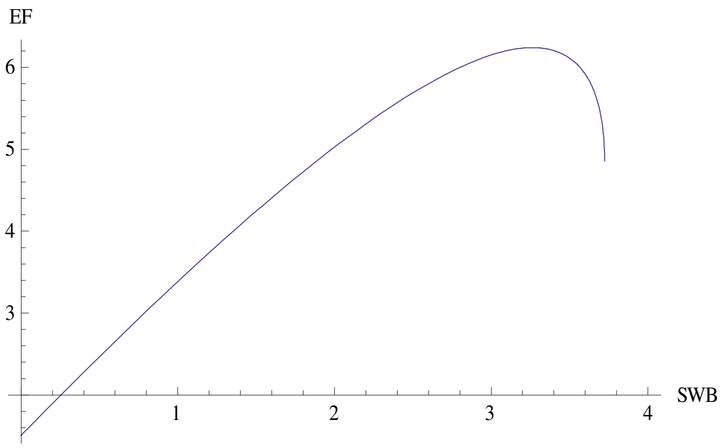

Figure 1. Ecological footprint (EF) as a function of subjective well-being (SWB). The SWB is measured by combining a life satisfaction index (on a 10-point scale) with a happiness index (on a 4-point scale), with equal weight given to each variable (i.e., SWB = life satisfaction – 2.5 happiness) so that SWB can range from the maximum score of 7.5 to negative scores (Inglehart et al., 2008). The EF is measured in global hectares, with country values from around 2006 ranging from 0.52 for Bangladesh to 11.87 for the United Arab Emirates (White, 2007).

Finally, each individual is assumed to *theoretically* refer to the same world "achievement function" that defines the ability to transform EF into SWB. This is obtained as a stochastic production function based on average data per country, with variability observed both in SWB and in EF among individuals and among countries. In this analysis, EF and SWB for each individual were normalised with respect to their current (in or around 2006) values by setting those values to 1, and expressing all changes as a proportion of that baseline value. Thus, EF and SWB are normalised with respect to their current values. However, I differentiated between individuals in developed and developing countries with respect to the part of the developed "achievement function" that is feasible for them to implement in *practice*.

Table 1. The dataset used to calculate happiness (subjective well-being, SWB) and sustainability (ecological footprint, EF). Source for GNI, GDP, car use and car production: www.nationmaster.com. Countries are indicated using the ISO 2-letter country codes (www.iso.org/iso/country_codes).

Country	Happiness (SWB)	Car use per 1000	Gross national income per capita, PPP, current international USD	Gross domestic product per capita, PPP, current international USD	Car production per 1000	Sustainability (EF)
AU	2.95	541	33947	36997	16	6.56
BG	-0.77	312	4083	4515	0	3.11
BR	3.25	147	4953	5904	9	2.15
CA	3.74	386	36737	39145	44	7.61
CH	3.91	520	57400	53283	0	5.15
CL	2.37	100	6977	8682	0	2.33
CN	1.61	19	2100	2151	1	1.64
CO	4.19	38	3483	3938	0	1.28
DE	2.68	546	37317	36570	62	4.55
ES	2.45	486	27443	28712	55	5.36
FI	3.35	459	41263	41084	8	7.64
FR	2.54	495	36900	36907	55	5.36
IN	0.85	10	867	908	1	0.75
IT	2.07	593	32117	32529	20	4.15
JP	2.46	362	38433	34680	68	4.35
KR	1.34	237	19020	19637	56	4.05
MD	-0.85	82	1027	1004	0	1.27
MX	4.48	149	8737	9039	10	2.56
NL	3.65	440	43103	42697	11	4.39
NO	3.78	447	68953	73289	0	5.85
NZ	3.8	608	25810	28660	0	5.94
PL	2.38	359	8470	9359	7	3.29
RO	-0.33	164	5073	6037	3	2.35
RU	0.53	197	5957	7143	7	4.41
SE	3.72	462	45843	45191	27	6.07
SI	2.18	494	19730	20242	64	3.42
TR	2.94	84	7150	7672	0	2.06
UA	0.3	125	2020	2400	1	3.19
UK	3.68	458	41313	41337	27	5.59
US	3.52	457	45853	44608	17	9.59
UY	2.83	151	5563	6144	1	1.92
YU	0.26	202	3893	4223	1	2.28
ZA	2.4	101	5363	5545	6	2.29

In particular, by combining the world relationship between EF and income developed by Bagliani et al. (2008) (i.e., $0.9585 + 0.4y - 0.00757y^2$) with the global relationship between SWB and income developed by Inglehart et al. (2008) (i.e., $-0.276 + 0.2y - 0.0025y^2$), where y stands for per capita income in thousand USD, the global constraint that represents the relationship between EF and SWB can be derived as EF ≥ EF(SWB) (Figure 1). This represents the smallest EF value that each individual can produce, on average, for alternative values of SWB.

To better understand the meaning of the relationship between SWB and EF, it is helpful to eliminate the effect of differences in income, which affects both variables. To do so, I first identified 33 countries for which consistent per capita data from around the year 2006 were available on SWB, car use, gross national income (GNI), gross domestic product (GDP), car production, and EF (Table 1). Note that the Pearson's correlation coefficient between GNI and car use equaled the world average (i.e., 0.80; Table 2), and that the Pearson's correlation between GDP and car production was smaller than the world average (i.e., 0.35 rather than 0.62). The relationship between SWB and income refers to the happiness obtained from a consumption activity (i.e., it is an increasing concave-down function), but many other factors affect happiness (e.g., ethical principles, social structures, income distribution, trends in these and other parameters).

Table 2. Pearson correlation matrix calculated using the data in Table 1. SWB, subjective well-being; GNI, gross national income; GDP, gross domestic product; EF, ecological footprint.

	Happiness (SWB)	Car use	GNI	GDP	Car production
Car use	0.40				
GNI	0.58	0.80			
GDP	0.58	0.81	1.00		
Car production	0.14	0.47	0.37	0.35	
Sustainability (EF)	0.46	0.78	0.80	0.81	0.35

Let us approximate consumption activities using data on car use, since data is readily available and since cars create both environmental impacts (EF) and utility (SWB). The Pearson's correlations between SWB and car use, SWB and GNI, and SWB and car production are 0.40, 0.58, and 0.14, respectively (Table 2). Linear regression coefficients show that a 1% increase in car use and car production would produce increases of 0.40% and 0.07% in SWB, respectively (Table 3). This is reasonable, since a car is a single consumption good, and happiness is more closely related to car use than to car production. Note that the relationship between EF and income refers to sustainability from a combination of both consumption factors (e.g., consumption patterns) and production factors (e.g., economic structures). Let us approximate the economic structure using car production data. The Pearson's correlations between EF and car production, EF and GDP, and EF and car use are 0.35, 0.81, and 0.78, respectively (Table 2). Linear regression coefficients show that a 1% increase in car use and car production would produce increases of 0.67 and 0.14% in EF, respectively (Table 3). This is reasonable, since sustainability is more likely to be affected to a greater extent by car use than by car production, whereas income from production enhances sustainability by favouring technological innovation (Table 3). Also note that in the context of the present study greater happiness requires an increase in consumption and that an increase in consumption implies smaller sustainability (i.e., happiness reduces sustainability). Here, I have assumed that an average relationship can be identified for the world, excluding factors other than income that affect happiness and sustainability; for example, I have disregarded the effects of sustainability on happiness. Note that the 0.39% increase in EF implied by a 1% increase in SWB approximately amounts to 47% (i.e., 40% plus the 7% impacts of car use and car production on SWB) of the 0.81% of the impacts that arise from car use (67%) and car production (14%) on EF (Table 3).

To better understand why individuals in developing countries, in practice, *implement* the lowest part of the *same* theoretical "achievement function" (based on world empirical data), think of an Indian consumer who cannot afford a 1500 cc gasoline-powered car, and who can only afford a 150 cc gasoline-powered motorcycle. Even if the consumer is more concerned about the *uses* obtained from the vehicle than about the social *status* provided by the means of transportation, they will never reach the utility level achieved by the Italian consumer who uses a 1500 cc gasoline-powered car; for example, the Indian faces difficulties carrying their spouse and two children on the motorcycle, let alone the family's luggage. However, it would be possible to shift to a 100 cc motorcycle if uses similar to those provided by the 150 cc motorcycle could be obtained from it, and to obtain a 4.7-kW electric motorcycle (i.e., equivalent to a 100 cc gasoline motorcycle), if this became feasible.

Table 3. Linear regression coefficients for the primary variables. These values represent the increase in subjective well-being (SWB) and sustainability (EF, the ecological footprint) for every 1% increase in the independent variable. GNI, gross national income; GDP, gross domestic product. To explain the relationship between EF and SWB, I used linear regressions with no interactions between independent variables, and did not consider issues related to omission of variables.

		Dependent variables (% change per 1% change in the independent variable)	
		Happiness (SWB)	Sustainability (EF)
Independent variables	Happiness (SWB)	—	0.39
	Car use	0.40	0.67
	GNI	0.41	0.48
	GDP	0.42	0.50
	Car production	0.07	0.14
	Sustainability (EF)	0.54	—

Note that EF ≥ EF(SWB) is a constraint that faces each individual, but it does *not* equal the macro-level relationship between happiness and sustainability, unlike in the country rankings by NEF (2006), the linear regressions by Zidansek (2007), or the ranked data correlations by Moffat (2008). Also see Engelbrecht (2009) for macro-level relationships between happiness and natural capital, Bonini (2008) for macro-level relationships between life satisfaction and environmental conditions, and Welsch (2007) for macro-level relationships between SWB and pollution. Neither does this constraint represent a causal link between greater happiness and greater sustainability; too many variables other than per capita national sustainability might affect per capita national happiness, including the states of economic development (Veenhoven, 2005), democracy (Welsch, 2003), social tolerance (Haller and Hadler, 2006), or ethics (Zagonari, 2011), for it to be possible to identify relationships or causal links between happiness and sustainability.

Moreover, the application of a single theoretical global stochastic constraint (Lothgren, 1997), calculated by fitting average values per country properly weighted by population size, cannot account for the variability of EF(SWB) among individuals in different countries even if the constraint is split into separate parts for developed and developing countries. For example, compare a happy and sustainable person in a low-income country with an unhappy and unsustainable person in a high-income country. To obtain specific *quantitative* results, one should apply a different "achievement function" for each individual, or at least a different constraint for all individuals in a given country or a different "achievement function" for all individuals in the same group of countries. In practice, the reference to a global constraint is sufficient to provide *qualitative* insights.

Finally, EF ≥ EF(SWB) is a theoretical constraint that faces each individual, *not* a representative individual, with people in developed and developing countries differentiated in terms of the practical implementation; this avoids issues related to the relationship between representative individuals and the environment (Dasgupta, 1998).

2.2. The constrained maximisation problem

The benefits of material progress are accompanied by psychological costs related to the sense of purpose, autonomy, identity, belonging, and hope (Eckersley, 2007); materialism or consumerism breed dissatisfaction, depression, anxiety, anger, isolation, and alienation rather than happiness (Kasser, 2002). In the present analysis, I will introduce a parameter (α) to depict the magnitude of the shift towards non-materialistic values. Think, for example, of a consumer who comes to attach the same utility to 1500 cc and 1000 cc gasoline-powered cars as a result of the adoption of a less materialistic worldview. This parameter represents a shifting of the constraint EF(SWB) to the right along the SWB axis.

Moreover, it is important to create enough pressure from public opinion that the environmental standards will be raised regularly in order to ensure sustainability (Moran et al., 2008). To account for this phenomenon, I will introduce a parameter (β) to depict the magnitude of the introduction of environmentally sustainable technologies. Think, for example, of a consumer who moves from a 1000 cc gasoline-powered car to an equivalent 47-kW electric car if technological innovation makes this feasible. This parameter represents a shifting of the constraint EF(SWB) downwards along the EF axis.

Finally, I have assumed that happiness increases significantly with increasing wealth in developing countries, whereas most people in developed countries experience a reasonable material standard of living that lets them explore other values such as sustainability or concern for future generations. I will distinguish between individuals in developed and developing countries by assuming that each individual, by modifying their values and technologies, cannot improve their current status by more than δ times, so that their current status is crucial. Think, for example, of an Indian consumer with a 150 cc gasoline-powered motorcycle who comes to disregard the low social *status* attached to this vehicle by focusing on the *uses* it permits; consequently, the consumer becomes happier, although only to a finite extent δ, since the uses obtained from a motorcycle will never be similar to the uses obtained from a car. In other words, income constrains both the consumer's happiness (only some uses are feasible) and their sustainability (only some technologies are affordable). This amounts to disregarding the variability of EF and SWB between individuals within the categories of developed and developing countries.

Let us assume that each individual tries to:

$$\text{Maximise}_{SWB,\,EF}\ IUF = [\alpha\ SWB^{(1-\varepsilon)} - [1/(\alpha\ \beta)]\ \gamma\ EF^{(1-\varepsilon)}]^{1/(1-\varepsilon)}$$

Subject to the following constraints:

$$EF \geq EF(SWB)$$
$$SWB \geq 0,\ IUF \leq \delta\ IUF(0),\ EF \leq \zeta,\ EF \geq 0$$

With

$$\alpha \geq 1,\ \beta \geq 1,\ \gamma \leq 1,\ \delta \geq 1,\ 0 \leq \varepsilon \leq 1$$

Where IUF stands for the intergenerational utility function and IUF(0) represents its (interpersonal cardinal) current value; α is the relationship between the level of consumption and SWB ($\alpha > 1$ means that individuals achieve a greater SWB for a given consumption than is feasible today); β is the relationship between consumption and EF ($\beta > 1$ means that individuals obtain a greater level of consumption per unit of EF than is possible today); γ represents the relative importance of intergenerational SWB ($\gamma < 1$ means that the SWB of future generations is less important to the individual than the SWB of the current generation); δ represents the potential increase in the IUF for the current individual by shifting to new values (e.g., away from materialism) and adopting new technologies (e.g., towards environmentally sustainable technologies); ε (i.e., the inequality aversion of Atkinson's inequality index; Cowel, 1995) depicts the aversion of the current individual to unequal welfare distribution between generations ($\varepsilon = 0$ means no aversion, $\varepsilon = 1$ means absolute aversion); and ζ depicts the sustainable EF for the current individual.

To better understand the meaning of the intergenerational inequity aversion, observe that IUF is a constant elasticity of substitution utility function, where SWB of current generations is combined with SWB of future generations, which in turn depends on EF under the assumption that values (α) and technologies (β) prevailing for current generations also apply to future generations. If ε is close to 0, then it can be assumed that perfect substitution exists between current SWB and future SWB (or alternatively, between current SWB and EF). In contrast, if ε is close to 1, then it can be assumed that there is no acceptable substitution between current SWB and future SWB (or alternatively, between current SWB and EF): in order to achieve sustainability, one must rely solely on technological innovation.

Note that the model is normalised with respect to the current individual ($\alpha \geq 1$, $\beta \geq 1$) to obtain *general qualitative* conclusions for different individuals living in developed and developing countries, although large variability is observed in α, β, γ, and ε. To depict physical, human, and social capital constraints, countries are differentiated in terms of the potential increase in the IUF; that is, each individual can at most achieve δ times the current IUF(0), and a worsening in current sustainability conditions is represented in terms of a possible decrease in ζ (that is, each individual should require at most ζ global hectares (gha) of productive land to sustain their level of consumption).

Moreover, EF ≥ EF(SWB) is a static constraint and EF ≤ ζ is a dynamic constraint, although changes in α and β could be used to describe the dynamics of the achievement function. Only long-run equilibria are considered in this analysis.

Finally, since indifference curves in the plane (SWB, EF) (i.e., combinations of SWB and EF that provide the same level of IUF) are increasing (i.e., an increase in EF must be compensated for by an increase in SWB), each individual will achieve a corner solution.

2.3. No solutions with current values and technologies

The graphical representation of constraints for the maximisation problem depicted in section 2.2, at current values ($\alpha = 1$) and using current technologies ($\beta = 1$), with γ set at 0.1 to obtain a positive IUF for positive SWB, and at the current average per capita world sustainability ($\zeta = 1.8$; WWF, 2006), leads to the conclusion that the only solution is at EF = 1.8 and SWB = 0.15 (Figure 2); however, this is an unacceptable solution because of the small SWB value.

Note that changing γ would modify the slope of the indifference curve for a given IUF level and that imposing stricter sustainability conditions by decreasing ζ would decrease the SWB at the solution, but neither change would alter the results qualitatively.

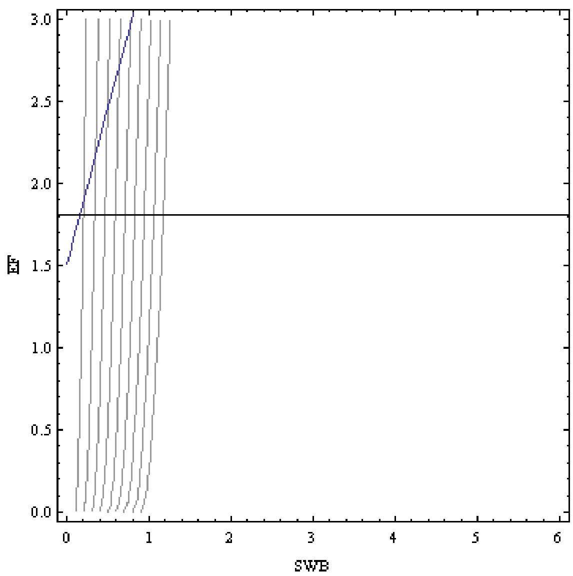

Figure 2. The constraint EF ≥ EF(SWB) (dark diagonal line), the constraint EF ≤ 1.8 (horizontal line), and indifference curves (pale lines) with IUF in [0,1], for α = 1, β = 1, γ = 0.1, and ε = 0.5. EF, ecological footprint; SWB, subjective well-being; IUF, intergenerational utility function; α, the relationship between consumption and SWB; β, the relationship between consumption and EF; γ, the relative intergenerational SWB; ε, the aversion of the current individual to intergenerational inequity.

The graphical representation of the constraints for the maximisation problem depicted in section 2.2, together with the values of EF and SWB that characterised 33 countries in or around 2006 (White, 2007; Inglehart et al., 2008), leads to the conclusion that only the Republic of Moldova has a feasible combination of EF and SWB, but with SWB < 0 (Figure 3). This is not surprising, since a traditional agricultural society still prevails in the Republic of Moldova, as depicted by the lack of car production and the use of 82 cars per thousand people.

Note that replacing data on SWB (for which negative values might exist) with data on life satisfaction (for which only positive values are possible) would not alter the insights qualitatively; this is because the inverted-U shape of the relationship between EF and income has a stronger influence on the outcome than the concave-down relationships between SWB or life satisfaction and income.

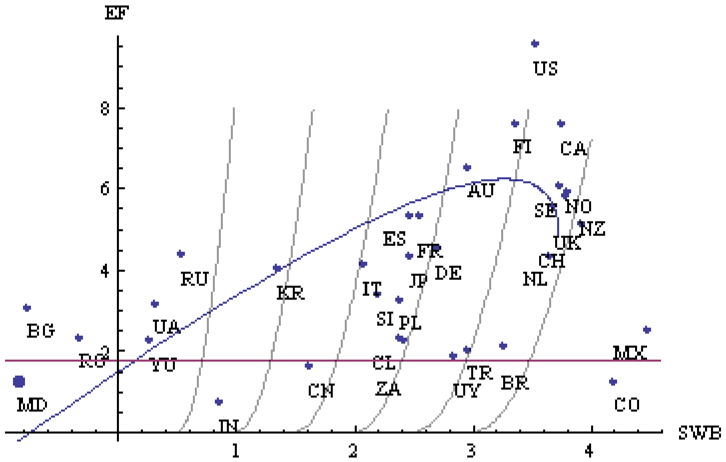

Figure 3. The constraint EF ≥ EF(SWB) (dark curved line), the constraint EF ≤ 1.8 (horizontal line), and the indifference curves (pale lines) shown for IUF = 0.5 (left) to IUF = 3 (right) at intervals of 0.5, for α = 1, β = 1, γ = 0.1, and ε = 0.5. Points representing 33 countries in terms of their EF and SWB values in or around 2006 were obtained from White (2007) and Inglehart et al. (2008). The Republic of Moldova (MD) is highlighted by a larger point. EF, ecological footprint; SWB, subjective well-being; IUF, intergenerational utility function; α, the relationship between consumption and SWB; β, the relationship between consumption and EF; γ, the relative intergenerational SWB; ε, the aversion of the current individual to intergenerational inequity. Country names are defined using the ISO 2-letter country codes (www.iso.org/iso/country_codes).

Moreover, the depicted constraint is obtained by combining the fitting curves presented by Bagliani et al. (2008) for EF vs. income and by Inglehart et al. (2008) for SWB vs. income in order to use the largest coverage of countries, while the points presented in Figure 3 refer to only the 33 countries for which I could obtain consistent data (in or around 2006) for both EF and SWB.

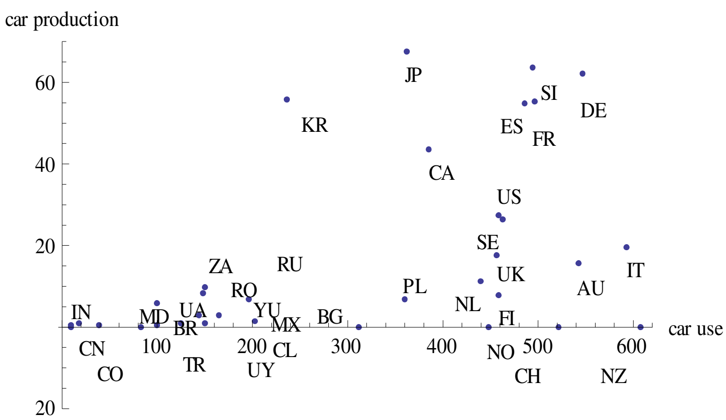

Figure 4. The 33 countries in terms of their car production and car use per 1000 people. Except for the Latin American countries (BR, CL, CO, MX, UY), using a car production of 2 cars per thousand and a car use of 304 per thousand (i.e., half the highest value observed in NZ) as thresholds identifies four groups of countries: producers and consumers (AU, CA, DE, ES, FI, FR, IT, JP, NL, PL, SE, SI, UK, US), consumers but not producers (CH, NO, NZ), producers but not consumers (KR, RO, RU, ZA), and neither consumers nor producers (BG, CN, IN, MD, TR, UA, YU). Country names are defined using the ISO 2-letter country codes (www.iso.org/iso/country_codes).

Finally, Figure 3 reveals the expected groups of countries, with former members of the Soviet Union on the lower left, Latin American countries on the lower right (together with Turkey and South Africa), Catholic Western countries in the middle, Protestant Western countries on the upper right, and China and India in the lower middle. The position of countries in the EF–SWB plane can be explained by referring to their car production and use. Except for Latin American countries (BR, CL, CO, MX, UY), where social determinants are likely to be crucial, the most sustainable and happy countries use but do not produce cars (e.g., CH, NO, NZ), the least sustainable but happy countries produce but do not use cars (e.g., RU, RO, ZA, KR), the happier but less sustainable countries both use and produce cars (e.g., US, DE, FR, ES), and the least happy but more sustainable countries do not use and do not produce cars (e.g., BG, IN, CN, MD, UA, YU, TR) (Figure 4).

2.4. Solutions with changed values and technologies

The lack of acceptable solutions to the constraint-maximisation problem depicted in section 2.2 and described in section 2.3 leads to the following inequality problems:

$$\text{Find } \alpha \text{ and } \beta \text{ such that}$$
$$[\alpha\, SWB^{(1-\varepsilon)} - [1/(\alpha\, \beta)]\, \gamma\, EF^{(1-\varepsilon)}]^{1/(1-\varepsilon)} \leq \delta\, IUF(0)$$
$$EF = EF(SWB)$$
$$EF = \zeta = 1.8$$

If $\gamma = 0.1$, alternative values for ε (e.g., $\varepsilon = 0.01$, $\varepsilon = 0.5$, and $\varepsilon = 0.99$) will characterise alternative scenarios for each numerical solution, while applying the same value of δ (e.g., $\delta = 5$) to different current levels of IUF(0) will distinguish between developed and developing countries in the analysis presented in section 3.

To better understand the meaning of these conditions, note that the first condition represents indifference curves, in which current happiness and sustainability are combined; the second condition depicts the feasible relationship (due to values and technologies) between EF and SWB; and the third condition measures the current sustainability level.

Note that depicting β as a decision variable amounts to implicitly assuming that production processes are driven by consumers. Moreover, the "achievement function" is met with equality (i.e. EF = EF(SWB)), since I have referred to a global average constraint: countries below the EF(SWB) curve do not completely exploit the environmental capacity that is available to them, which is consistent with their achieved happiness level. Finally, the sustainability condition is met with equality (i.e. EF = 1.8), since I have disregarded the distribution of the sustainability burden among the world's countries: each country is expected to achieve sustainability.

3. Results

Figure 5 displays the solutions to the inequality problems depicted in section 2.4 for developed countries (i.e., IUF is assumed to be within [10,15]). This figure provides the solutions for α and β at $\varepsilon = 0.01$, $\varepsilon = 0.5$, and $\varepsilon = 0.99$. Figure 6 presents a solution to the constrained maximisation problem depicted in section 2.2 at the specified values of α, β, and ε (i.e., EF = 1.8 and SWB = 5.55). To exclude complex solutions, the following condition must be met: $\beta < 3.46806/\alpha$.

Figure 7 presents the solutions to the three inequality problems depicted in section 2.4 for developing countries (i.e., IUF is assumed to be within [0,5]). This figure provides the solutions for α and β at $\varepsilon = 0.01$, $\varepsilon = 0.5$, and $\varepsilon = 0.99$. Figure 8 presents a solution to the constraint-maximisation problem depicted in section 2.2 at the specified values of α, β, and ε (i.e., EF = 1.8 and SWB = 2.05). To exclude complex solutions, the following condition must be met: $\beta < 3.46806/\alpha$.

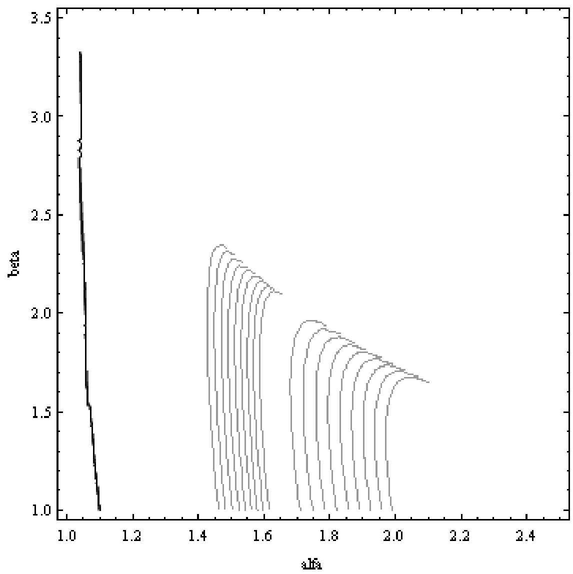

Figure 5. Solutions for EF = max EF = 1.8 and SWB = max SWB from EF(SWB) = 1.8, for developed countries with IUF in [10,15]; the solution on the left is for ε = 0.99, and the solutions in the middle and right are for ε = 0.5 and ε = 0.01, respectively. To exclude complex solutions, the following condition must be met: β < 3.46806/α. EF, ecological footprint; SWB, subjective well-being; IUF, intergenerational utility function; α, the relationship between consumption and SWB; β, the relationship between consumption and EF; ε, the aversion of the current individual to intergenerational inequity.

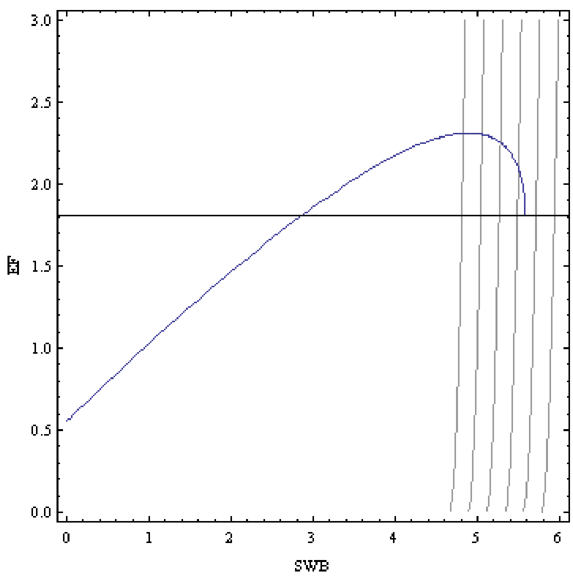

Figure 6. The constraint EF ≥ EF(SWB) (dark curved line), the constraint EF ≤ 1.8 (horizontal line), and the indifference curves (pale lines) with IUF in [10, 15] for α = 1.5, β = 1.8, γ = 0.1, and ε = 0.5. EF, ecological footprint; SWB, subjective well-being; IUF, intergenerational utility function; α, the relationship between consumption and SWB; β, the relationship between consumption and EF; γ, the relative intergenerational SWB; ε, the aversion of the current individual to intergenerational inequity.

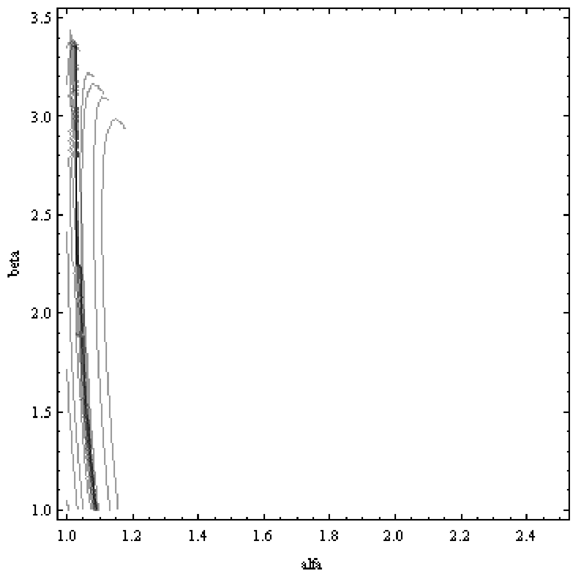

Figure 7. Solutions for EF = max EF = 1.8 and SWB = max SWB from EF(SWB) = 1.8 for developing countries, with IUF in [0,5]. The solutions on the left of the dark vertical line are for ε = 0.99, the dark vertical line is for ε = 0.5, and solutions on the right of the dark vertical line are for ε = 0.01. To exclude complex solutions, the following condition must be met: β < 3.46806/α. EF, ecological footprint; SWB, subjective well-being; IUF, intergenerational utility function.; α, the relationship between consumption and SWB; β, the relationship between consumption and EF; ε, the aversion of the current individual to intergenerational inequity.

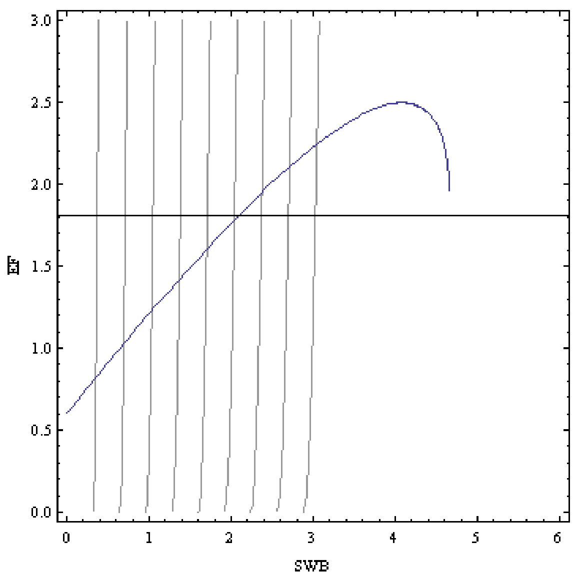

Figure 8. The constraint EF ≥ EF(SWB) (dark curved line), the constraint EF ≤ 1.8 (horizontal line), and the indifference curves (pale lines) for developing countries, with IUF in [0, 5], α = 1.25, β = 2, γ = 0.1, and ε = 0.5. EF, ecological footprint; SWB, subjective well-being; IUF, intergenerational utility function; α, the relationship between consumption and SWB; β, the relationship between consumption and EF; γ, the relative intergenerational SWB; ε, the aversion of the current individual to intergenerational inequity.

The main insights from this analysis can be summarised as follows. Individuals in developed countries can substitute changed values for new technologies, and a greater concern for future generations can reduce the magnitude of the required change in these values. Individuals in developed countries can achieve sustainability at a higher SWB when the constraint EF(SWB) is decreasing. Sustainable happiness seems to be *achievable* for individuals in developed countries with a reasonable magnitude of change in values ($\alpha = 1.5$, which means 50% more happiness from the same consumption pattern or the same happiness for a less-frequent consumption pattern, such as buying a new car every 3 years rather than every 2 years), a feasible level of technological innovation ($\beta = 1.5$, which means a 33% reduction in use of resources or emission of pollutants for the same consumption bundle, such as the combination of 11% of energy obtained from renewable sources, an 11% gain in energy efficiency, and an 11% reduction of CO_2 emissions) at a plausible level of concern for future generations (an intermediate value of intergenerational inequality aversion). Individuals in developing countries must rely solely on technological innovation (and to a greater extent than in developed countries), and the magnitude of the concern for future generations has little effect. Individuals in developing countries will achieve sustainability at a lower SWB when the EF(SWB) constraint is increasing. Sustainable happiness seems to be *unachievable* for individuals in developing countries, as it requires an unfeasible level of technological innovation ($\beta = 3$, which means 66% less use of resources for the same consumption bundle). Assuming the maximum concern for future generations makes individuals in developing countries coincide with individuals in developed countries in terms of the potential achievement of sustainable happiness.

4. Discussion

The main limitations of the analysis presented in this paper can be summarised as follows: Human rights and land degradation are neglected. As a result, the applied EF could be an inadequate measure of social and environmental sustainability (Fiala, 2008). National boundaries are implicit in the model, but the applied EF should be improved to account for cross-border trades of goods (Kitzes et al., 2009). By using EF as a measure of sustainability, the model implicitly assumes that all greenhouse gases that mankind produces need to be sequestered or eliminated (Venetoulis and Talberth, 2008), but by normalising the current EF to 1 for each individual, the model mitigates problems that result from this assumption by changing this to a calculation that estimates the reduction in current emissions. The model is implicitly static because it is based on EF, but the introduction of β makes it possible to depict differences in technological progress among countries (Mulder, 2007). Individuals with an intrinsic value orientation (i.e., personal growth, self-acceptance, relationships, physical fitness, and community involvement) are less materialistic and more inclined to engage in environmentally friendly behaviour than individuals with an extrinsic value orientation (i.e., financial success, social recognition, image, and popularity). An increase in α could therefore imply an increase in β (see also Brown and Kasser (2005) for a micro-level relationship between SWB and ecologically responsible behaviour due to intrinsic values and mindfulness). Individuals will never undertake sustainability behaviours as long as responsible behaviour is framed in terms of self-sacrifice, which is assumed to detract from happiness. Instead, an increase in β should be thought to lead to an increase in α (see also Ferrer-i-Carbonell and Gowdy (2007) for a micro-level relationship between SWB and environmental awareness about ozone depletion and biodiversity loss, with concern about positive environmental features having positive effects on SWB). The current limits on sustainable lifestyle choices and livelihoods are disregarded. Consumers sometimes cannot affect β, which is chosen by stakeholders with vested interests in unsustainable policies and practices. Differences in the constraints that affect each individual are disregarded. The analysis could be improved by specifying a different achievement function for each country to achieve more specific quantitative results. In examples data for only one parameter (cars) have been used. In future research a composite index that includes more parameters (e.g., cars, food, accommodation) could be developed, although the analytical approach would not change. The path to long-run equilibria in sustainable happiness as a result of the potential impacts of education or other social policies is neglected. In future research, the simultaneous dynamics of α and β, with potentially multiple and different transition paths for developed and developing countries, could be analysed.

5. Conclusions

In this study, I adopted a *familiar* definition of sustainable development, in which social and economic development is defined in terms of happiness within ecological sustainability limits, which are in turn defined in terms of ecological footprints. The analysis was conducted within a normative approach (see Baumgartner and Quaas, 2010) in order to assess the potential substitution between economic and ecological policies (here, represented by technological innovation) and environmental ethics (here, represented by changes in values), with the goal of achieving sustainable development. This was accomplished by distinguishing between developed and developing countries.

The main findings can be summarised as follows. Sustainable happiness seems to be *achievable* for individuals in developed countries with a reasonable level of value change, a feasible degree of technological innovation, and a plausible level of concern for future generations. In the example discussed in this paper, an Italian consumer can shift from a 1500 cc gasoline-powered car to a 1000 cc gasoline-powered car, and then to an equivalent 47-kW electric car, with a large absolute increase in sustainability and at high level of happiness.

Moreover, sustainable happiness seems to be *unachievable* for individuals in developing countries because it requires an impractical level of technological innovation. In the example discussed in this paper, an Indian consumer can shift from a 150 cc gasoline-powered motorcycle to a 100 cc gasoline-powered motorcycle, and then to an equivalent 4.7-kW electric motorcycle, with a small absolute increase in sustainability and at low level of happiness. In other words, to achieve the same absolute sustainability achieved by the Italian consumer, the Indian consumer must rely on technological innovation to a greater extent.

Finally, maximising the concern for future generations will make individuals in developing and developed countries coincide in terms of their potential to achieve sustainable happiness and in terms of their potential to substitute values for technologies or vice versa. In the example discussed in this paper, based on the assumption that there is no acceptable substitution between SWB and EF, both Italian and Indian consumers must rely on technological innovation only to achieve a given level of sustainability, although the Italian consumer achieves it at a higher level of happiness than the Indian consumer.

The optimistic results for developed countries (i.e., sustainable happiness is achievable) are outweighed by the pessimistic results for developing countries (i.e., sustainable happiness is unachievable) for two main reasons: first, because of the inequity between these groups of countries, which places the burden of sustainability of happiness largely on developing countries, and second, because of the global unsustainability, if the analysis is expanded to account for the distribution and dynamics of the world's population as well as life expectancy, which differ between developed and developing countries.

Note that the equity would be smaller if technological change were assumed to affect the population and per capita affluence (Huesemann and Huesemann, 2008), since developing countries should rely on technological innovation to a greater extent. Next, global sustainability would be less likely if green consumption patterns were assumed to be not self-enforcing and not locked in permanently (Buenstorf and Cordes, 2008), since eventual global sustainability would only be temporary.

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