# Measuring progress: A comparison of the GDP, HDI, GS and the RIE

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**Abstract** The current paper constructs a progress measurement appropriate for measuring multiple and different dimensions of progress. The paper is not meant to be a detailed discussion of the framework but rather a demonstrated application of the measure. The constructed resource-infrastructure-environment (RIE) progress measure employs a non-monetary evaluation adopting a weighting technique based on public opinion. The proposed index is assessed from a single summary standpoint. The aggregation method is evaluated via a z-score standardisation technique. The progress index is applied to three countries that are representative of different clusters. They are Australia (mid-industrialised nation), Mexico (emerging economy), and the US (highly industrialised nation). These selected countries provide an opportunity to highlight any divergences that may exist in their perceived economic strength. The results showed Australia as consistently having the highest levels of progress, closely followed by Mexico and then the US.

**Keywords** Measurement; Progress; Aggregation; Weighting

## 1 Introduction: Defining Progress

Defining progress is challenging. Its multidimensional nature makes establishing a universal criterion difficult since the term means different things to different people (Gurria 2007). In mainstream economics, progress has been defined as a term that involves an abundance of material possessions and resources possessing monetary or exchange value. The main focus of this definition was to collectively group income-generating assets. However, the term has constantly evolved to a point where it now can also confer the property of welfare and wellbeing. This move away from a market-centred definition to one that focuses on both social and economic progress (access to education and health care, environmental health, social relations, etc.) needs to be reflected in measurement (Soubbotina 2004).[1] In keeping with this, the current paper defines progress as the process of making advancements, within the limits of mankind's knowledge, in the social, economic and environmental spheres. This is further elaborated below.

Hence, the present paper's use of the term progress encompasses the more general concept of wellbeing, which echoes the sentiments of the human development index (HDI) with its notions of social and economic progress. The present paper divides progress into three key areas that can be drawn upon for its identification and determination:

1) *Resources*: comprises the machines, workers, money, land, raw materials and other things that a country can use to produce goods and services to make its economy grow (WB 2005).

2) *Infrastructure*: involves the basic facilities, services and installations needed for the functioning of a community or society. It includes roads, railways, canals, ports, airports and communications, and is manifested by its network structure, for instance, the road or rail network (Banister and Berechman 2000).

[1] The importance of human, social and environmental factors was acknowledged by the OECD (2007) World Forum on Statistics, Knowledge and Policy, 'Measuring and Fostering the Progress of Societies', held in Istanbul, Turkey, June 27-30. This is also reflected in the ABS (2002, 2004a, 2006) attempts to measure progress.

3) *Environment*: comprises the complex set of physical, geographic, biological, social, cultural and political conditions that surround an individual or organism and that ultimately determine the form and nature of its survival (WB 2005).

The link between policy and progress measurement means that the need to design appropriate policies to foster progress requires the monitoring of the three key areas outlined above, which form the basis of the resource-infrastructure-environment (RIE) index. These areas must then be converted into usable and understandable information necessary to evaluate alternative policy options. The current paper asserts that this can best be achieved via a non-monetary approach.

This paper will proceed by briefly outlining the context of the valuation approach used in the study as well as the established framework. This is followed with a justification of the treatment of data and the weighting technique. A comparison of the three countries in the study (Australia, Mexico and the US) is made with respect to the RIE, HDI, gross domestic product (GDP), and genuine savings (GS).

## 2 A Non-monetary Approach to Progress Measurement

Value is an essential concept encompassing every aspect of economics. Currently market value, which asserts that no value exists apart from price, is the predominantly held viewpoint. A non-monetary approach provides a valid and justifiable alternative theory of value that moves away from the acquisition of goods as a measure of affluence, to a concept that is truly reflective of the production value of the society we live in. Recently, non-monetary approaches to progress measurement have been undertaken by the new economics foundation with its happy planet index (HPI) (Marks et al. 2006), and the gross national happiness (GNH) initiated by the Centre for Bhutan Studies (Ura and Galay 2004). However, many national progress measures continue to use monetary measures.

In fact, the lack of a readily useable price for convenient evaluations for human, environmental and social concerns leads to the omission of their major impacts[2] and restricts debates to the economic bottom line.

The potential folly of monetary measures of progress is best illustrated by the parable of the broken window. The parable tells the story of incomplete accounting for unintended consequences. In the story, a little boy breaks a shopkeeper's window. After initially sympathising with the shopkeeper the onlookers conclude that the little boy is a public benefactor due to the economic benefits created for everyone. For instance, the broken window makes work for the glazier who can buy bread benefiting the baker, who will then buy shoes benefiting the cobbler, etc.[3]

However, the onlookers ignore the hidden costs. For example, the money the shopkeeper is forced to spend on the glazier cannot be spent elsewhere, for instance on a suit. Thus, the glazier's gain is the tailor's loss. Hence, instead of a window *and* suit, he has only a window. The onlookers therefore only see what is immediately visible to the eye. This fallacy is continually reaffirmed in traditional economic analysis. The parable of the broken window also serves to remind us that, as Hazlitt (1979) points out, in economics inevitable implications are not necessarily obvious implications.

There are, of course, differing interpretations of this parable. A relevant interpretation from this paper's perspective involves those from a Keynesian standpoint. It was Keynes who stressed that when a country is experiencing a period of dramatic resource underutilisation, the economically sensible thing to do might be to build totally useless pyramids. This would stimulate the economy, increase aggregate demand and encourage full employment.[4] Hence, *exchange-value* production (demand) occurs at the expense of *use-value* (need).

The pervasive nature of market value has led people to think in terms of money, where an increase means that they must be better off. As illustrated above, this is a

[2] An illustration of this can be seen in the work of Bilmes and Stiglitz (2006). Using standard economic and accounting frameworks, the authors assessed the *economic* costs of the Iraqi War. Even with such a narrow focus, their estimate was between US$1026bn to US$2239bn. This estimate occurs even *after* they omitted some of the most important costs of the Iraqi venture, as well as excluding costs borne by other countries, indirect costs such as the price of oil, and more importantly, the costs of the war to Iraq.

[3] It is an 1850 essay by Frederic Bastiat titled '*Ce qu'on voit et ce qu'on ne voit pas* (That Which Is Seen, and That Which Is Not Seen). The cost of repairing the window at the time was six francs.

[4] A similar scenario involves 'building palaces in the desert'.

flawed viewpoint. Furthermore, one also needs to consider the fact that monetary totals can rise yet people may not necessarily be better off. This, in part, is due to the peculiarity of the purchasing power parity (PPP).

To briefly illustrate, during the lengthy recovery from the depression, agricultural prices dropped sharply compared to industrial goods which experienced a minor drop. This factor, economists assumed, linked the prosperity of everyone to that of the farmer. Hence, a simple cure was identified: restore the price of agricultural products to parity with industrial products. This parity existed from 1909-1914, an era where farmers were prosperous. This perpetual preservation of prices however does not exist elsewhere. For example, a Chevrolet in 1912 cost $2,150. An incomparably improved Chevrolet in 1942 cost $907. However, adjusted for parity it would have cost $3720 in 1942 (Hazlitt 1979).[5]

Thus, what does this monetary measure tell us? Is society better off with a PPP? Can increases in wealth as measured by monetary values automatically be associated with improvement? Why are improvements in the cost of production (lower costs) ignored? And why is it that when agricultural prices are above parity, they are not brought down to parity? The point here is to demonstrate that the use of monetary values is not necessarily an ideal approach, but rather is subject to flaws. This provides further justification for the use of a non-monetary approach to measuring progress.

On a related issue, empirical evidence on the relationship between income and subjective measures of wellbeing performed by the seminal work of Easterlin (1974, 1995, 2001) as well as Oswald (1997), Frey and Stutzer (2000) and Blanchflower and Oswald (2004), found that the positive effects of extra income on quality of life are relatively small. This finding adds credence to the present paper’s assertion that monetary measures (increased monetary outcomes) do not necessarily portray factors important to progress.

Similarly, McGillivray (2005) states that the ability of the HDI, the most prominent non-monetary progress measure, to identify countries that show superior outcomes in

[5] The estimate made by Hazlitt (1979) is based on his assertion that had the price relationship between agricultural and industrial products contained any logic, then the notion of perpetually preserving price relationships should be extended to every commodity at that time relative to every other. This is what he did.

non-economic wellbeing to what their economic condition would suggest, is important if one accepts that there is more to wellbeing than what occurs in the economic sphere.

As the OECD (2007) World Conference established, while it is not possible yet to truly construct an adequate progress measure, it is still possible to do a lot better than current measures. The current reliance of equating progress in terms of a nation's GDP implicitly devalues the importance of factors such as natural capital (NC), unpaid work, knowledge and health (Cobb, Goodman and Wackernagel 1999), as well as social capital (SC) (Grootaert 1998). It also fails to distinguish economic activities that contribute to progress from those like crime and pollution that detract from it. The need for better measures is acknowledged.

With this in mind, this paper sets out to develop the aforementioned RIE index as a means to more accurately reflect the state of a nation's progress and provide a foundation for an alternative approach to progress measurement. This will greatly increase the chance of an informed, balanced debate and lead to more optimal outcomes for progress. The RIE index will be applied to three countries. The countries selected are representative of different clusters. The three countries are Australia (mid-industrialised nation), Mexico (emerging economy) and the US (highly industrialised nation). The choice of Mexico was partly due to their association with the OECD, which would minimise data collection issues.

## 3 Establishing the Conceptual Framework

The explicit identification of a conceptual framework is considered essential as it locates the researcher's stance amongst a vast number of perspectives, and prevents the eventual model from simply being an arbitrary collection of components (OECD 2005). Establishing a rigorous framework is especially important when developing a composite indicator (CI) since their theoretical underpinnings are not sufficiently developed (Freudenberg 2003).

Given its contentious nature, the use of a CI has long been debated. A brief review is provided below (see Zhou, Ang and Zhou 2010; OECD 2008; Saltelli 2007; Cherchye, Moesen, Rogge and van Puyenbroeck 2007; Saisana, Saltelli and Tarantola 2005; Freudenberg 2003; Booysen, 2002). The arguments for the use of CIs are:

- Ability to incorporate a set of complex multidimensional issues that reflect the nature of societies. Factors commonly included in progress measures such as social, political, environmental and economic can be captures along with the unconventional ones such as sustainability and welfare. This is regarded as one of the significant advantages of this approach.
- Providing a 'big picture' view of society that can be used to rank countries based on their performance on complex issues over time. This helps inform public debates which has long been seen as beneficial in attracting the interest of policymakers.
- Flexibility in construction allowing the possibility to add more information within the existing size limit and adapt to changing conditions, making them a powerful policy implementation tool.
- Ability to identify potential areas for action to be used to support policy initiatives. This feature enables interested parties to assess trends and measure the deviation that occurs from the optimal target.

The arguments against the use of CIs are:

- Poorly constructed CI can produce conflicting interpretations resulting in inadequate policy initiatives. This issue is common to all measures but is more important in the case of CIs due to the employed aggregation techniques.
- The construction of a CI requires judgements that deal with the selection of sub-indicators, choice of models, sensitivity of results to different weighting and problems of treating missing data. The degree of subjectivity in the construction of a CI is considered a major drawback.
- The selection of weights is a challenging task. The view of CIs as an ideological statement is disingenuous given that ideological incursion into economics is not unique to CIs. However, a transparent analysis based on sound statistical procedures could reduce some of these acknowledged problems.
- Construction of composite indicators is quite time consuming, particularly given the amount of data CIs require for its sub-indicators to meet a statistically

> significant criteria. This normally elicits an outcry from statisticians who resent CIs because all these large amounts of data are 'wasted or hidden behind a single number of dubious significance'. The irony is that despite the high level of aggregation required, it is the method of disaggregation that allows the articulation of effective policies.

Despite the debates surrounding the merits of applying CIs for measurement purposes, the current study asserts that the difficulties a CI possesses in measuring multidimensional concepts are somewhat over-exaggerated (Hoskins and Mascherini 2009). These over-exaggerations are due to the perpetuation of certain 'common fallacies', which also apply to currently used measures as well. These fallacies have been addressed by the World Economic Forum (WEF 2005, p. 19) as detailed below.[6]

1. *The concept is too abstract*. Although the study of progress is an abstract concept, abstractness does not equate to non-measurement, for instance, the GDP. Furthermore, the abstract concepts of inflation and stock market performance have not stopped the widespread use of the consumer price index, and the all ordinaries index respectively. This is the nature of constructivism.
2. *The concept is too multi-faceted*. The fact that a multi-faceted measure will contain variables and indicators that possess complex causal structures are not a reason for inaction. If anything, such indicators can help unravel causality by strengthening the empirical nature of policy debates. It is also a key justification for the current study to attempt an alternative progress measurement.
3. *The concept covers too wide a range of issues.* The dimensions included in this paper cover a wide array of issues: social, political, cultural, environmental, economic, etc. that are embedded in the progress concept. This makes the need for a broad measure even stronger.
4. *There is no common unit of measurement*. Here, the transformation techniques employed to achieve a common unit of measurement will bias the results, masking most of the analytical work. To limit this, it is important that variables are made

[6] WEF (2005, p. 19) limit their concerns to addressing the misunderstandings of measuring environmental sustainability; however the multidimensional nature of that topic makes it relevant to this discussion.

comparable on a cross-national level using GDP, or people, or populated land area. This is the preferred method when dealing with such a variety of data.

For measuring macroeconomic behaviour, CIs are not the only form of measurement available to researchers. For instance, when the Australian Bureau of Statistics (ABS) (2002, 2004a, 2006) decided on its preferred measure of progress it narrowed the alternatives to three broad possible measurements: (i) single value approach; (ii) accounting framework; and (iii) suite-of-indicators approach. Firstly, the single value approach combines several indicators representing areas such as health, economy, etc. into a single CI. Although useful, this measure has the tendency to oversimplify a complex system and give potentially misleading signals. Secondly, the employment of an accounting framework presents different dimensions (social, economic and environmental) into one unified system of accounts based on a monetary valuation, as is the case with the Dutch system of economic and social accounting matrices and extensions. This approach however is not only complex, but also presents with difficulties when determining the links and the effect these have on progress. This extension of monetary value based national accounts reinforces the reification of economic statistics and also results in a narrow conception of progress. Finally, there is the suite-of-indicators approach, which relies heavily on quantitative indicators, and is favoured by the ABS. It sets out key aspects of progress side-by-side and discusses the link between them (ABS 2002, 2004a, 2006).

The use of a CI however remains the most realistic way to approach progress measurement. It is reflected by the range of organisations that continue to adopt CIs as an attempt to convey ideas about areas previously judged unworthy of economic measurement. Below are some examples of the many existing CIs**:**

- gross domestic product;
- consumer price index;
- all ordinaries index;
- human development index;
- physical quality of life index; and
- environmental sustainability index (ESI).

The examples listed above, which comprise two prominent progress measures (HDI and physical quality of life index), establish the CI as a valid and appropriate approach to measuring multidimensional concepts such as progress. This is also supported by OECD (2004).

Prior to establishing the framework it needs to be explicitly stated that this paper is not a detailed discussion of the conceptual framework but rather a demonstrated application of the RIE progress measure.[7]

Having established a definition of progress, and strongly justified the use of a CI above, the next step is to address issues of epistemology. If one accepts that knowledge is standpoint dependent, then one stops looking for ultimate truths and causes. Consequently, multidimensional concepts such as progress will always give rise to a number of different theories or explanations.

Given the conceptually complex nature of the problem, this paper adopts an interdisciplinary approach that is similar to the 'overdetermination' approach proposed by Wolff and Resnick but used in a different context.[8] This interdisciplinary approach adopts the view that all aspects of life of societies are determined by their constant interaction with one another and rejects the idea that some aspects of life are static. Such an interdisciplinary approach requires that the proposed alternative framework be aware of, and incorporate when necessary, diverse disciplines and techniques utilised beyond econometrics.

## 4 The Resource-Infrastructure-Environment Framework

To reflect this interdisciplinary approach, the proposed framework will be structured to enable the use of a CI, which has been used by a variety of organisations (national and international, including statistical offices). It is used to communicate information

[7] For a comprehensive presentation and justification of the conceptual framework refer to Natoli and Zuhair (2007, 2009).

[8] Wolff and Resnick (1987) adopt Althusser's concept of overdetermination regarding social formation. The term was first used in a social scientific context by Freud; however Althusser used it as a critique of classical Marxism's determinism. His intention was to create space for a non-economist and non-reductionist analysis. Wolff and Resnick transform it into a post-structuralist version of Marxian theory.

regarding the standing of countries in areas such as the economy, environment, society and technological development (Saisana, Saltelli and Tarantola 2005).

As part of this interdisciplinary approach, a broad set of interconnected theories that suggest that knowledge is at least as much a human construction as a discovery is employed (Danforth 2005). Adopting an interdisciplinary approach has the strength of accommodating multiple views as reflected in the literature on progress. In particular, the framework was based on a thorough progress literature review focusing on issues integral to national progress. This is deemed useful because it attempts to encompass both collective activity and individual experience, areas that reflect progress creation’s myriad of determinants and social processes, to construct a meaningful representation of progress creation.

The most pertinent of these different theoretical approaches were chosen for integration into the RIE framework. They are: resources, capabilities, intellectual capital (IC), environmental sustainability, SC and institutions. These approaches, either on their own or in combination, have emerged in various fields from mainstream welfare economics to heterodox economics and all share interdisciplinary characteristics. These interdisciplinary characteristics permit the inclusion of a mixture of inputs and processes; outputs and outcomes; and stocks and flows.

Specifically, the framework is structured around the explicit acknowledgement that country wise differences in resource endowments, infrastructure, technology, laws, attitudes and behaviours, institutions, environment, etc. all impact on the types of progress opportunities that can arise. This interdisciplinary outlook embraces a combination of an individualistic and social approach and examines the adaptation of an individual or a society to a number of external constraints.

The RIE framework modifies and builds on the framework outlined in Maskell and Malmberg (1999), which examines how firms locate and build their competitiveness via a regional analysis. In particular, the modifications to Maskell and Malmberg’s work involve changing their firm level regional analysis to a country-based analysis and incorporating possible international effects. Given this, the localised capabilities consist of a country’s infrastructure and built environment; accessible natural resources; specific institutional endowment; and available knowledge and skills.

In Maskell and Malmberg's framework, resources are defined as those available either internally or through import from regions, whereas institutional endowment is purposefully defined broadly. It encompasses all the rules, practices, routines, habits, etc. associated with the internal supply of capital, land and labour. It also includes the moral beliefs, political traditions, culture, religion and other basic values that characterise the country. The institutional endowment dimension therefore interacts with all the dimensions in the progress model such as the country's infrastructure and physical environment, its natural resources (environment) and its human resources (knowledge and skills). These factors constitute a country's localised capabilities, and can either accelerate or retard the potential progress of a country depending on the types of interaction that occur (Maskell and Malmberg 1999).

The RIE progress framework will be split into the three key areas outlined earlier, which comprise a country's resources, infrastructure, and environment (RIE). Traditionally in economic analysis, the identification of three areas such as resources, infrastructure, and environment is subject to a three-pillar model which treats the areas as separate and independent of each other. However, as Lehtonen (2004, citing Le Bot 2002) argues, such a construction produces a false consensus by continuing to detach the economic from other context forms, such as social. Instead, what is required is an explicit acknowledgement of interdependency in the framework. Any given theme can overlap with one or more other themes and exhibit multiple relations with others in the form of simple causation or a varying degree of complex interactions. This interdependency reflects the idea that economic process is not some closed mechanical process, but rather an open system where there is constant interaction between the components. The structure of the framework incorporates the three main areas which will then be broken into themes, and dimensions. In all, there are seven themes and 23 dimensions. Table 1 defines the hierarchy of the RIE framework.

[**Insert Table 1 here**]

The three identified areas: resources, infrastructure and environment are then divided into their respective themes. For example, resources are divided into three themes: human, natural and generated. These themes are then subdivided into dimensions. The dimensions are considered the fundamental building blocks to the proposed progress model. Table 2 below lists the areas, themes and dimensions of the RIE framework.

[**Insert Table 2 here**]

## 5 Normalisation of the Data and Reverse Transformations

Having established a progress framework, the next step was to treat the data and establish an appropriate weighting technique. When selecting a suitable normalisation approach, both the data properties and the objectives of the index need to be taken into account (Ebert and Welsch 2004). The intention of the RIE index is to reward countries that perform well in dimensions considered highly important to progress, rather than reward average scores across all the indicators. Hence, the present paper employed the standardised (z-score) normalisation procedure to transform the data. The standardised approach (z-scores) calculates the average value and the standard deviation across countries. Widely used in CIs, it transforms the value into a common scale (the ratio of the difference between the raw indicator value and the average divided by the standard deviation, with a mean of zero and a standard deviation of one) (Saisana and Tarantola 2002; Freudenberg 2003; Nardo et al. 2005a).

Any bias introduced by this approach will be corrected by adopting a suitable differential weighting scheme and aggregation method (Nardo et al. 2005b). As it is a multi-year analysis (1990-2004), the z-score standardisation is calculated with 1990 as the initial time point. Furthermore, unlike the GDP, the RIE index does not assume that all its variables automatically increase progress. For instance, an increase in infant mortality cannot be said to increase progress. This acknowledgement requires the introduction of a process known as ‘reverse’ transformation. As the name suggests, a reverse transformation applies the opposite standardised z-score technique. That is, the observation must be subtracted from the mean then divided by the standard deviation (WEF 2005).

Given that different factors are relevant to different countries in their pursuit of progress, identifying ‘negative’ variables is not an easy task since determinations can be quite disputable and culturally dependent (Munda 2005). Acknowledging this, the current paper presents a list of variables chosen to undergo a reverse transformation that is summarised in Box 1 below.

[**Insert Box 1 here**]

## 6 Weighting Techniques

The choice of a weighting technique is arguably the most difficult task in the construction of a CI. According to Ebert and Welsch (2004), there are no underlying scientific relationships, or prescribed rules, for weighting and aggregating the data, due to the problem of incommensurability.

One can either apply equal weights or a differential weighting scheme, which gives greater weight to dimensions that possess greater theoretical or evidence based importance to the issue at hand. The uncertainty surrounding weights however does not imply that any selection is therefore arguably the right one. Although subjective in nature, the task of assigning weights should still be analytically sound, transparent, and consistent with the research’s objective (Saisana and Tarantola 2002).

According to Sharpe (2000), co-founder of the Index of Economic Wellbeing (IEWB), weights can come from several sources: the personal views of the researcher(s) who developed the index, eg. IEWB; societal views estimated through public opinion polls, surveys or focus groups, which Sharpe regards as the preferred approach; and statistical techniques based on factor analysis to determine the significance of each variable for changes in the overall index, eg. Index of Social Progress. A more common approach is to weight each variable equally. This paper will summarise the more popular weighting methods.

*Equal weights*: After data normalisation is completed, equal weights is the most frequent practice employed in assigning weights. Babbie (2004) claim that equal weights should be the rule and that differential weighting techniques are appropriate if there are *convincing* reasons to do so. Moreover, others favour equal weights due to its neutrality, and also due to the absence of any objective widely applicable differential weighting approach, which makes for unreasonable comparisons between countries (WEF 2005). Finally, there is also the belief that all dimensions do, in fact, contribute equally (Saisana and Tarantola 2002).

In practice, parsimony remains an important factor in its continued popularity. However, claims for choosing equal weights based on parsimony grounds are not entirely accurate, given that the normalisation method that precede it helps influence the outcome (Saisana and Tarantola 2002).

Two key problems this paper encounters with equal weighting lies in the fact that recognised global impacts may be assigned too little weight and can be overpowered by other measures. Additionally, equal weighting is an arbitrary and inappropriate technique to gauge society's concerns. Its advantage of neutrality is not enough reason to explicitly ignore society's concerns.

An alternative avenue for assessment lies in the allocation of differential weights, based on their contribution to the areas they represent. In decision theory literature, this differential weighting is normally referred to as symmetrical importance (Munda 2005). This view is supported by international bodies such as the OECD (2003).

This method is also open to criticism, due to the heavy reliance on personal judgement, more so since a change in the specified weights allocated to each variable can significantly alter research outcomes (Saisana and Tarantola 2002). To overcome this one may choose differential weights based on either statistical models or participatory processes (if longitudinally consistent). Statistical models are perceived as being neutral since they rely on the data, and include data envelopment analysis and distance to targets.

*Data envelopment analysis*. This is a very flexible technique that can be used in a wide range of areas. Through the use of linear programming, an efficiency frontier is produced to act as a benchmark to measure the performance of a given set of countries (Allen et al.

1997).[9] According to Storrie and Bjurek (2000) it is the data, via the set benchmarks that determine the weights. The construction of the benchmark normally follows three assumptions: (i) weights are strictly positive; (ii) no priorities given, thus countries are not discriminated against that perform best in any single dimension thus ranking them equally; and (iii) an assessment of comparative efficiency (convexity of the frontier) through the use of linear programming is feasible (Allen et al. 1997; Nardo et al. 2005a).

Therefore, the set of weights of each country depends on their position or distance, with respect to the benchmark (efficiency frontier), a benchmark that normally corresponds to an ideal point. Thus, different distances result in different weights.

Critics of this approach argue that the overwhelming empirical nature of this technique means that outcomes will not be able to provide a suitable policy direction for a country to be able to improve its situation (Saisana and Tarantola 2002). Furthermore, the benchmarking technique allows different countries to identify unique benchmarks making cross-country comparison impossible (Melyn and Moesen 1991). Hence, the method is undesirable for the present study.

*Distance to targets*. The HDI employs this technique as part of its international development strategy and is seen as an alternative to a cost-benefit approach. Here, global or universal targets based on performance criteria are set for all countries to achieve. The weighting in this technique is realised by dividing the values by the corresponding target values, which are expressed in the same units. The goal of the HDI is to minimise the cost of attaining the target. The targets are easy to understand and can also reflect political necessity, such as mobilising political support or use for policy goals (Griffin and McKinley 1992). However, given the comprehensive nature of the RIE index, the task of establishing numerous international targets is infeasible. Hence, this approach is not considered appropriate.

Aside from statistical techniques, another avenue to determining different weights is based on participatory approaches involving public or expert judgement. Unlike statistical weights, participatory approaches can reflect policymaking concerns and/or

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[9] As Allen et al. (1997) point out, that the use of linear programming to assess comparative efficiency was originally proposed by Farrell, but operationalised and popularised by Charnes, Cooper and Rhodes (1978).

budget constraints (WEF 2005). The current study will review the two most commonly used approaches.[10]

*Expert judgement via budget allocation*. Under this scenario, experts are gathered to attribute weight to the indicators that are placed before them. Experts are each given *X* amount of points to distribute across the indicators based on importance. Agreement amongst experts, however, is not common, especially regarding progress measurement. This technique is best suited for models that possess relatively low number of indicators, roughly 10-12, and is normally conducted with *a priori* knowledge of national goals. The downside to this is that the weighting scheme will not necessarily reflect the importance of each variable, but rather the need for political intervention (Saisana and Tarantola 2002; Nardo et al. 2005a).

*Public opinion*. This method seeks feedback from the public via public opinion polls. The polls focus on levels of concern rather than the allocation of *X* amount of points. Although this technique is *cheap and easy* to use, which is one reason why it has been commonly used for many years on a range of matters, due consideration needs to be given to the persons who will be affected by resultant policies (Saisana and Tarantola 2002). In fact, the idea of incorporating the general public into the policy processes has been more and more recognised by the multi-criteria community (Munda 2005).

However, not everyone is convinced by this approach. Many consider this approach to be unworthy due to a preconception that the public evaluates issues – particularly environmental – on an irrational basis. However as Parker (1991) claims, such accusations are baseless given that many case studies dealing with environmental threats have shown that weights based upon public opinion are fairly consistent across both time and space.

Potential biases of this approach include how some participants may exert undue pressure on the others. Furthermore, focus groups are not a representative sample of population, and thus social preferences should not be derived from it. Instead, a plurality

[10] Another two participatory approaches, although less popular, are the analytic hierarchy process and conjoint analysis.

of ethical principles seems the only dependable way to obtain weights in a social framework. Additionally, this method may allow scientists to absolve themselves of any responsibility for the result (Munda 2005).

The contentious nature of a weighting scheme is not surprising. Ideally, as Munda and Nardo (2005a) point out, weights must be context-dependent, reflecting the political, social, and economic priorities, as well as the development strategies a country has chosen to pursue.

With this in mind, and given the highly contentious nature of this area, the approach of the present paper is to adopt a differential weighting scheme based on opinion polls. Specifically, it will apply the survey developed by the Canadian Policy Research Network (CPRN), which involves extensive citizen participation in identifying priorities for Quality of life Indicators. The strength of this approach is that weights based on public opinions are fairly consistent across both time and space, as evidenced by many case studies (Parker 1991).

Since 1995, CPRN has played a leading role in public policy in Canada. In 2001, Michalski reported on the individual questionnaire responses on the importance of factors contributing to quality of life in Canada ($n = 342$). Twenty-two factors were ranked on a scale from 1 (not important) to 7 (extremely important) shown in Table 3 below. Rankings were done prior to and following a public dialogue process (Michalski 2001).

[**Insert Table 3 here**]

Using figures from the pre-dialogue column from the above table, the results showed that the participants consistently rated health programs, a clean environment, and the education system as the most important factors for quality of life. Other factors, such as secure employment, low poverty, unemployment rates, and low crime rates were rated a level below, whereas the economy (economic growth) was another level below this (Michalski 2001).

From this, a weighting allocation system was devised. Primarily, the factors in the survey were assigned to the relevant dimensions in the RIE index (see Table 4 below).

[**Insert Table 4 here**]

For example, the factor health program was assigned to the health; food consumption; and access to essential services dimensions. The factor clean environment was assigned to the dimensions: land and agricultural use; energy production and use; water; fisheries; biodiversity; air quality; greenhouse gas emissions; and conspicuous consumption. While the factor economic growth was assigned to the dimensions: knowledge diffusion; brain drain/gain; financial, machinery; ICT; transportation; and population.

The next step involved assigning scores to the factors that reflected the proportional differences. Under this, the factor with the lowest proportion (g*overnments* with 5.62) was assigned 1 and the factor with the highest proportion (*clean environment* with 6.44) was assigned 10. The entire rankings are shown in Table 5 below. The scores of the dimensions were then computed from the scores assigned to the factors. The weights of the dimension were standardised to fit a [1, 10] scale.[11]

[**Insert Table 5 here**]

The next section will briefly review the main aggregation techniques as well as a justification of the aggregation technique employed by the current study.

## 7 Aggregation Techniques

Many major international organisations such as the OECD, European Union, WEF and the International Monetary Fund, are increasingly employing CIs in many areas (Nardo et al. 2005b). As Cherchye (2001) states, the main reason for this is to facilitate the benchmarking and ranking of countries according to some aggregated dimensions. There are three main aggregation techniques to accomplish this: (i) *additive methods*; (ii) *geometric aggregations*; and (iii) *non-compensatory multi-criteria analysis*.

[11] For a more detailed analysis of the weighting procedures refer to Natoli and Zuhair (2007, 2009).

(i) *Additive methods*. These can be a simple additive aggregation which sums the country's rank in each of the indicators, based on ordinal information. Similarly, one can use nominal scores to calculate how many indicators lie above and below a designated threshold, and obtain the difference. Both approaches are simple to use and insensitive to outliers. However, they make no absolute value or interval level analysis (Nardo et al. 2005b; Munda and Nardo 2005a).

The most used additive approach is the linear aggregation method. It is however a restrictive technique with regard to the form of the variables, specifically this surrounds the quality of the variable and the measurement unit – which should be the same. An additive aggregation function is said to exist only when indicators are preferentially independent. This requirement of independence, which is of itself a difficult condition to achieve, suggests that assessments are made at the variable's marginal levels which are then added to determine a total value. It also implies full compensability, allowing poor performances to be offset by good performances in other indicators (Nardo et al. 2005b; Munda and Nardo 2005b).

(ii) *Geometric aggregations*. Like linear aggregation, weights are expressed as trade offs, however the variables need not possess the same measurement unit. In fact weighted geometric aggregation is ideal for data that is strictly positive with different ratio-scales, which include many environmental variables (Ebert and Welsch 2004). Although less compensatory than linear aggregation, an absence of conflict amongst the variables is still preferred.

Normally when assigning weights, more weight is given to an indicator considered being of more significance to the index. Both the linear and geometric approaches employ the use of substitution rates, where variables are expressed as intensities. Thus, substitution rates are employed that are equal to the weights of the indicators up to a multiplicative coefficient. Consequently, weights reflect the substitution rate as opposed to the variable's importance leading to a compensatory logic. Thus a poor result in one dimension can be counterbalanced by an above average result in another dimension.[12]

The majority of progress measures employ either a linear or geometric aggregation method, however according to Podinovskii (1994) a CI that intends to employ differential weights to variables based on their importance should adopt a non-compensatory aggregation procedure. This not only avoids complete compensability but also implies a theoretical guarantee that weights are used with the meaning of symmetrical importance, where variables are used with an ordinal meaning (Munda 2005; Bouyssou 1986).

(iii) *Non-compensatory multi-criteria analysis*. This approach is designed to resolve acknowledged conflict existent between variables. It does this by employing a discrete multi-criteria approach that incorporates the lack of preference independence (Munda 1995; Roy 1996). Here, a pair-wise comparison of countries across all indicators is performed. This is then ranked from best to worst in a complete pre-order by a mathematical formulation (Condorcet-type of ranking procedure).

According to Munda (2005), the main drawback to this method is that when many countries are involved in the analysis, the number of permutation calculations rises exponentially making it computationally costly. This would seem to make the adoption of this aggregation technique impractical for future analyses across many nations.

Furthermore the limitation of the geometric mean, which only applies to positive numbers, does not reflect the nature of the RIE index data set. Therefore, the use of the weighted geometric mean would result in unsatisfactory mean properties (Ebert and Welsch 2004).[13] As a result, the current study adopts the weighted arithmetic mean method to aggregate the values of the RIE index.

The next section presents the results from the RIE index single summary standpoint. The RIE index ranking results illustrate the preferred ordering of the countries compared to the resulting order of the GDP PPP per capita, the HDI and the GS.

[12] This substitution rate dilemma is found in most environmental impact assessment studies where most aggregations follow the linear rule and weights are attached according to their relative importance idea (Funtowicz, Munda and Paruccini, 1990).

[13] Although the strength of the weighted geometric mean lies with its better theoretical properties that can lead to less information loss (Zhu and Ang 2009; Zhou et al. 2006), it is often used on data transformed by the linear normalisation method. The weighted arithmetic method is often linked with the z-score transformation which was the method employed in this study.

## 8 Results and Discussion

The results of the comparison between the four measures are given in Table 6 below.[14]

[**Insert Table 6 here**]

A valid interpretation of the RIE results indicate that for almost the entire time period (1990-2003), Australia is the country with the highest level of progress, followed by Mexico and the US. However, in the final year (2004) Mexico outperforms both Australia and the US to record the highest level of progress. In comparison, the ordering of the GDP PPP measure offers different results to that of the RIE. Here, the US outperforms both Australia and Mexico respectively over the trend period. The HDI results differ again. Overall Australia finishes on top; however it swaps places with the US on two occasions with Mexico placed last throughout. The results of the GS are strikingly similar to the GDP with the exception of 2004, where Australia finishes higher than the US. Following is some general discussion of the order results.

Given that all four indicators adopt diverse frameworks reflective of their respective epistemological standpoints, the differing results are not altogether surprising. For instance, according to the GDP PPP figures obtained from the OECD (2006), the US and Australia outperformed Mexico on average by a ratio of 3.80:1 and 2.90:1, respectively. The HDI results, on average, show that Australia is ranked in the top 5 of all nations, whereas the US is ranked between 5 and 10. A sizeable disparity then emerges to Mexico whose results tend to range from 45 to 53. The results of the GS show that the US and Australia outperform Mexico on average by a ratio of 4.70:1 and 2.24:1 respectively.

The only consistency between the three other measures is that Mexico is placed last for all observations over the time period. Interestingly, these outcomes add support to the criticism aimed towards the HDI and the GS which claimed that both measures are heavily GDP dependent (Dijkstra and Hanmer 2000; McGillivray and White 1993; Cahill 2005). Furthermore, if one considers the GDP as an unreliable indicator of progress, an assertion the current paper holds, then the results of the HDI and the GS are unreliable.

[14] The GPI was not included as no results for Mexico are available.

The conflicting results reinforce the present paper's contention that: (i) a monetary measure is an inefficient approach to valuing progress; and (ii) that a non-monetary measure like the HDI needs to adopt a comprehensive approach, via framework and variables, to more accurately value progress and to avoid its ordering being usurped by one or two variables, primarily the GDP.

### *8.1 An Overview of the RIE Standardised Results*

Given the multi-year status of the analysis, the initial time point (1990) was used as a reference point. Consequently, the value zero signifies the average 1990 score of the three countries combined. The results of the standardised RIE index and the GDP for Australia, Mexico and the US are presented in Figures 1 and 2 below, with identified trends discussed in section 8.2. The standardised score (y-axis) signifies a country's movement from the 1990 combined average score.

[**Insert Figure 1 here**]

[**Insert Figure 2 here**]

For the majority of the observation period, Australia outperforms Mexico, with the US a distant third. The general trend for Australia is upward (rising from 0.133 in 1990 to 0.179 in 2004) however it is not monotonic. There are noticeable changes in direction over the period, for instance it seems that progress reaches its peak in 2000.

Furthermore, the periods 1992-1994 and 1995-1997 exhibit a similar spike pattern. That is, sharp increases followed by a sharp decrease to the point where the overall gain during these two periods are only slight. This is followed by gradual increases until the year 2000. Overall, the period 2001-2004 has progress decreasing with a particular sharp drop for the year 2002.

The general trend for Mexico is distinctly upward (rising from 0.016 in 1990 to 0.202 in 2004). It experiences the largest improvement in progress. In 2004 (the final observation) it actually surpasses Australia. A further breakdown of the results shows a sharp rise occurring in the years 1990-1992 before a steadier pattern emerges. There is however a marked decrease that occurs in 1996, reducing progress back to its 1991 level. This is followed by quite sizeable annual increases from 1997-1999. For the next 3 years a spike pattern (sharp increase followed by a sharp decrease) emerges resulting in a slight overall increase. The final two years show fairly strong growth resulting in Mexico recording its highest level of progress.[15]

The general trend for the US is upward (rising from -0.150 in 1990 to -0.107 in 2004) however this statement, although factual, hides the true nature of US progress over this period which can be categorised into 3 distinct phases. Between the years 1990-1996 the overall progress change is minimal, with a noticeable drop that occurs in 1993 countering the small yearly increases. The next distinct period 1996-2000 shows progress decreasing at a constant rate which is contrary to the trends for Australia and Mexico. The final phase 2000-2004 illustrates a marked turnaround in the US fortunes, with progress rising sharply. Following are some general discussion of these standardised results of the RIE index.

### *8.2 Assessing the Trends of the RIE*

Table 7 presents the trends for the RIE areas and enables the current study to identify these trends within and between nations.

[**Insert Table 7 here**]

The resource results for Australia demonstrate it to be a strong contributor to Australia's progress, averaging 0.142, with a consistent increase from 1990 to 2000 (0.107 to 0.174) before a sizeable drop in the final period (0.174 to 0.108). This is mainly attributable to

[15] A supposed paradox is said to occur with the trend of Mexicans fleeing their home country to the US. The present paper claims that this is due to a fixation on notions of *perceived* progress, or material wealth, as opposed to an adherence to a comprehensive conception of progress.

the decrease in the natural resource theme. As expected, the infrastructure results for Australia act as a solid contributor to progress (0.008 to 0.035). The RIE area, environment, exhibits some variations although is consistently positive with an average score of 0.016.

A discussion point arising from the Mexican and US results centre on the sizeable dip in progress that occurred in 1996 and 1993 respectively. These are reviewed below. Generally, the Mexican resource results display a solid average score of 0.050, with solid increases throughout the entire period (0.003 to 0.077) reflecting constant improvements across all three resource themes. Infrastructure however, constitutes Mexico's worst performing area with an average negative contribution of -0.036, and with little improvement over the time period (-0.039 to -0.031). The environment area represents Mexico's strongest contributor to progress with a 0.111 average, more than double the resource average contribution. In fact, even in 1996 where a sizeable drop occurs (0.061), it still is Mexico's highest contributor to progress in this time period.

A potential reason for the sizeable dip in Mexico's progress may be the economic crisis that occurred in 1994. Unlike the RIE index, the GDP PPP figures show a decline in the 1995 data. One reason for this could be that financial data movements can be assessed readily, whereas socio-economic data has a longer lag effect. Specifically, the conspicuous consumption results for Mexico tend to fluctuate with an initial increase (0.018 to 0.057) before a marked decrease in the period 1993 to 1996 (0.057 to 0.000). This decrease in conspicuous consumption during the period 1993 to 1996 is due to increases in the final consumption expenditure variable. This seems to mirror the financial crisis in Mexico where citizens were spending a greater part of their income on goods and services.

With the US result, the food consumption dimension recorded a dramatic fall in the period 1990 to 1993 (-0.055 to -0.075) which negatively impacted resource area contribution (see Table 7). Additionally, the land and agricultural use dimension experienced a one-off decrease in 1993. Another interesting aspect of the US results relate to the upsurge in progress from 2000 onwards due to large gains in the resource and environment area. These gains resulted from significant increases in the physical environment theme which allowed the environment area to increase from -0.056 to 0.000

between 2000 and 2004. Furthermore, despite the contribution from resources marking the worst performing area towards US progress (with a study average score of -0.155), the resource area experienced an increase in the final period (-0.204 to -0.173) which also enabled it to improve overall during this period.

The results presented above, specifically that of the US and Mexico, illustrate that the standardised RIE index does not appear to be strongly correlated with levels of income and production. In fact, it demonstrates that progress is not necessarily associated with high levels of income and production. By breaking the nexus between income, production and progress the RIE index is able to distinguish itself from measures such as the GDP, GS and the HDI.

This ‘breaking of the nexus’ is important since it reflects the current progress literature. Furthermore, it supports the empirical evidence regarding the effects of the link between income and subjective measures of wellbeing (Easterlin 1974, 1995, 2001; Oswald 1997; Frey and Stutzer 2000; Blanchflower and Oswald 2004). That is, that the positive effects of extra income on quality of life are relatively small.

Having distinguished itself from the three aforementioned measures, the next comparison involves the GPI. Interestingly, the RIE index results for Australia exhibit a similar pattern to the Australian GPI measure. Both portray overall increases but at a far slower rate than the GDP. However, this is where the similarities end. Given that the RIE index incorporates human resources while HC estimations are absent from the GPI, the present paper argues that the two measures are distinctly different in capturing progress. This viewpoint is reinforced by the ABS experimental estimates (2004b) pertaining to the stock of HC in 2001. The estimates, which were obtained using a lifetime labour income approach, showed that had the GPI allowed for HC estimation it would have dwarfed the costs imposed by the negative columns of the GPI. Ultimately, this would have revealed markedly different results to the RIE index.

The final general comparison is with the HPI, which like the RIE index is an attempt at a comprehensive non-monetary measure of progress. Although only a single observation of the HPI exists (with data mostly from 2004), a one-off comparison is still considered useful for the purpose of evaluation. Of the 178 countries assessed, the HPI had Mexico ranked 38, Australia 139, and the US at 150. The HPI ordering therefore is the same as the standardised RIE index result for 2004 (MAU), however there is a sizeable chasm in the magnitude of the results. The reasons for this vast difference can be attributable to the shortcomings of the HPI.

For instance, the HPI consists of three variables, making it quite a crude index to capture something as complex as progress. This narrow nature provides a limited scope for policy initiatives. Additionally, the HPI is not analytically sound given that two of the three variables it employs, ecological footprint and life satisfaction, are contested.

## 9 Conclusion

This paper presented the results of the RIE index, which reported different results to the GDP, the HDI and the GS. The overview had the US languishing in comparison to both Australia and Mexico who were in close proximity although Australia consistently recorded the highest levels of progress, apart from the final observation period (2004). A brief comparison was made with the GPI, where seemingly similar results proved to be somewhat different reflecting the broader nature of the RIE. The comparative results of the US and Mexico illustrated that it is possible to achieve high levels of progress without an excessive reliance on high levels of production and income.

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**Figure 1** RIE standardised index 1990-2004

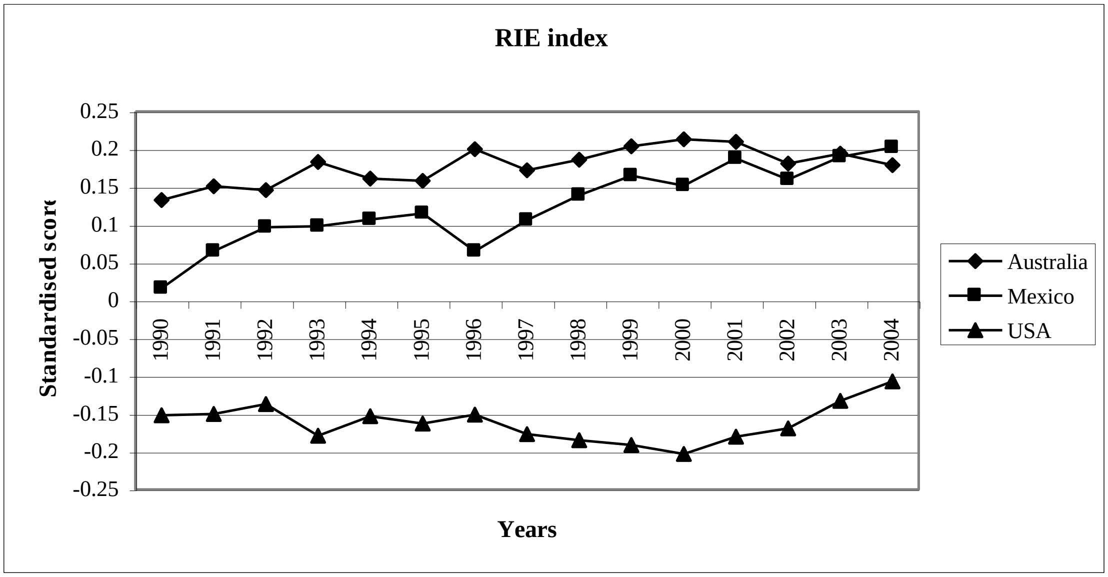


**Figure 2** GDP index 1990-2004

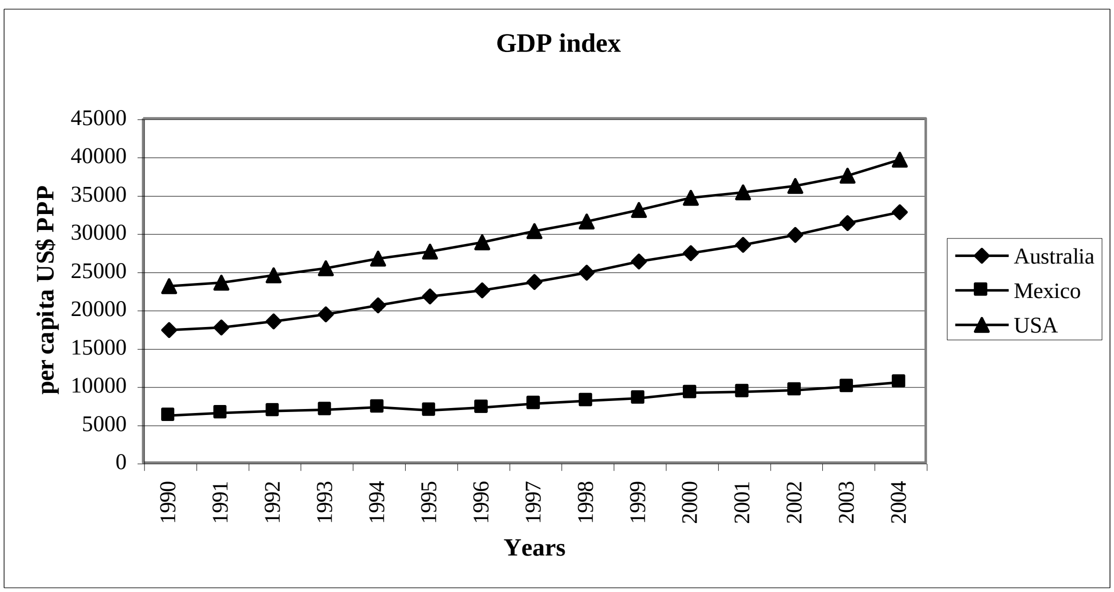

**Table 1** The RIE framework building blocks

| Hierarchy | Logic |
|---|---|
| Area | Three main areas that interact with the each other to create or deplete progress. |
| Theme | Breaks the areas into more manageable parts. A main focus area of the framework. |
| Dimension | Parts of the theme that provide the specific performance criteria of the themes. |

**Table 2** Components of the RIE framework

| **Area** | **Theme** | **Dimension** |
|---|---|---|
| **Resources** | **Human** | Health |
| | | Population |
| | | Food Consumption |
| | | Education & Training |
| | | Knowledge Renewal |
| | | Net Brain Gain |
| | **Natural** | Land & Agricultural Use |
| | | Energy Production and Use |
| | | Water |
| | | Fisheries |
| | | Biodiversity |
| | **Generated** | Financial |
| | | Physical Capital |
| **Infrastructure** | **Information & Communications Technology (ICT)** | ICT Access |
| | **Transportation** | Transportation Efficiency |
| **Environment** | **Physical** | Air Quality |
| | | Greenhouse Gas Emissions |
| | | Conspicuous Consumption |
| | | Built Environment |
| | | Access to Essential Services |
| | **Socio-cultural** | Social Connectedness |
| | | Institutional Quality |
| | | Economic Security |

**Box 1** List of 'reverse' transformation variable

| Variable |
|---|
| Infant mortality rate (per 1,000 live births) |
| Total calories intake (calories per capita per day) |
| Total fat intake (grammes per capita per day) |
| Sugar consumption (kilos per capita) |
| Pupil/teacher ratio primary (students per teacher) |
| Fertilizer consumption (100 grams per hectare of arable land) |
| Tractor use intensity (hectares per tractor) |
| GDP per unit of energy use (2000 US$ PPP per kg of oil equivalent) |
| Electric power consumption (kilowatt-hours per capita) |
| Water withdrawal (% of internal water resources) |
| Fish captures – primary product (% of world total) |
| Fish consumption (kg per capita) |
| Threatened mammal species (% of mammal species) |
| Threatened bird species (% of bird species) |
| Market capitalisation of listed companies (% of GDP) |
| Stocks traded – total value (% of GDP) |
| Real interest rate (%) |
| Sulphur oxide emissions (kilograms per capita) |
| Nitrogen oxide emissions (kilograms per capita) |
| Carbon monoxide emissions (kilograms per capita) |
| Carbon dioxide emissions (metric tons per capita) |
| Carbon dioxide emissions (% share of world total) |
| Daily organic water pollutant emissions (kg per 1,000 people) |
| Ecological footprint (hectares of biologically productive land required per capita) |
| Defensive expenditures (US$ million per 1,000 people) |
| Average number of occupants (per household) |
| Income inequality measure (Gini coefficient) |
| Youth unemployment rate (% labour force ages 15-24) |
| Divorce rate (per 100 marriages) |
| Prisoners – convicted adults (per 100,000 people) |
| Suicide rates (per 100,000 people) |
| Adult unemployment rate (% of 25-54 year olds) |
| Long-term unemployment (% of total unemployment) |
| Overwork hours (per person in employment) |
| Jobless households (% of total population) |
| Relative poverty rate (% of population) |
| Relative poverty rate among elderly (% of population aged 66 and above) |

**Table 3** Importance of factors contributing to quality of life in Canada

| Factors | Pre-Dialogue Mean Scores (S.D.) | Post-Dialogue Mean Scores (S.D.) |
|---|---|---|
| Clean environment | 6.44 (0.83) | 6.37 (0.85) |
| Health programs | 6.41 (0.94) | 6.42 (0.87) |
| Schools/colleges/universities | 6.38 (0.92) | 6.34 (0.87) |
| Low poverty rates | 6.27 (0.99) | 6.06 (1.10) |
| Secure employment | 6.22 (1.03) | 6.19 (1.00) |
| Low crime rates | 6.14 (1.05) | 5.94 (1.07) |
| Low unemployment rates | 6.06 (1.05) | 5.99 (1.09) |
| Social programs | 6.02 (1.17) | 6.01 (1.03) |
| Economic growth | 5.85 (1.22) | 5.80 (1.21) |
| Parks and recreational facilities | 5.75 (1.15) | 5.58 (1.20) |
| Housing programs | 5.73 (1.26) | 5.71 (1.25) |
| Non-profit and voluntary programs | 5.70 (1.24) | 5.67 (1.32) |
| Childcare or day-care programs | 5.67 (1.39) | 5.64 (1.26) |
| Welfare programs | 5.65 (1.34) | 5.74 (1.19) |
| Governments | 5.62 (1.27) | 5.65 (1.25) |
| Cultural diversity | 5.55 (1.35) | 5.32 (1.43) |
| Lower personal income tax rates | 5.27 (1.71) | 5.10 (1.75) |
| Arts and music programs | 5.18 (1.41) | 5.02 (1.50) |
| Private companies | 5.07 (1.25) | 4.82 (1.35) |
| The media | 4.79 (1.38) | 4.69 (1.50) |
| Religious organisations | 4.42 (1.69) | 4.33 (1.68) |
| Lower corporate tax rates | 4.20 (1.93) | 4.24 (1.92) |

*Source*: Michalski (2001, p. 52).

**Table 4** Assigning CPRN quality of life factors to RIE dimensions

| RIE dimension | Relevant CPRN Quality of Life Factor(s) |
|---|---|
| Health | Health programs |
| Population | Economic growth |
| Food consumption | Health programs |
| Education and training | Schools/colleges/universities |
| Knowledge renewal | Economic growth |
| Net brain gain | Schools/colleges/universities |
| Land and agricultural use | Clean environment |
| Energy production and use | Clean environment |
| Water | Clean environment |
| Fisheries | Clean environment |
| Biodiversity | Clean environment |
| Financial | Economic growth |
| Physical capital | Economic growth |
| ICT access | Economic growth |
| Transportation efficiency | Economic growth |
| Air quality | Clean environment |
| Greenhouse gas emissions | Clean environment |
| Conspicuous consumption | Clean environment |
| Built environment | Parks and recreational facilities & housing programs |
| Access to essential services | Health programs |
| Social connectedness | Low crime rates & social programs |
| Institutional quality | Governments |
| Economic security | Low poverty rates, secure employment & low unemployment rates |

**Table 5** Proportional scores of CPRN factors

| Original factor score | Proportional score |
|---|---|
| 5.620 | 1 |
| 5.711 | 2 |
| 5.802 | 3 |
| 5.893 | 4 |
| 5.984 | 5 |
| 6.075 | 6 |
| 6.166 | 7 |
| 6.257 | 8 |
| 6.348 | 9 |
| 6.440 | 10 |

**Table 6** Comparing the order of the RIE, the GDP and the HDI

| | 1990 | 1992 | 1995 | 1997 | 2000 | 2004 |
|---|---|---|---|---|---|---|
| **RIE** | AMU | AMU | AMU | AMU | AMU | MAU |
| **GDP** | UAM | UAM | UAM | UAM | UAM | UAM |
| **HDI** | UAM | AUM | AUM | UAM | AUM | AUM |
| **GS** | UAM | UAM | UAM | UAM | UAM | AUM |

*Notes*: A = Australia, M = Mexico and U = United States.

The GDP results are based on the GDP PPP per capita US dollar current prices obtained from OECD (2006). For the HDI, the 1990, 1995, 2000, and 2004 figures were obtained from the UNDP (2006). The 1997 figure was obtained from the UNDP (1999), and the 1992 figure was obtained from the UNDP (1994). The GS results were obtained from the WB (2007). The present paper selected the GS results that include PM10 damage (which is an air pollutant that causes damage to human health) as % of GNI PPP current international dollars and then obtained the GNI PPP per capita figures and applied it.

**Table 7** Standardised scores for the RIE areas

| | 1990 | 1993 | 1996 | 2000 | 2004 | Study Average |
|---|---|---|---|---|---|---|
| **Australia** | | | | | | |
| Resources | 0.107 | 0.152 | 0.177 | 0.174 | 0.108 | 0.142 |
| Infrastructure | 0.008 | 0.013 | 0.018 | 0.026 | 0.035 | 0.020 |
| Environment | 0.018 | 0.016 | 0.007 | 0.013 | 0.036 | 0.016 |
| **RIE Index** | **0.133** | **0.181** | **0.202** | **0.213** | **0.179** | **0.178** |
| **Mexico** | | | | | | |
| Resources | 0.003 | 0.019 | 0.040 | 0.066 | 0.077 | 0.050 |
| Infrastructure | -0.039 | -0.037 | -0.037 | -0.034 | -0.031 | -0.036 |
| Environment | 0.052 | 0.117 | *0.061* | 0.119 | 0.156 | 0.111 |
| **RIE Index** | **0.016** | **0.099** | **0.064** | **0.151** | **0.202** | **0.125** |
| **USA** | | | | | | |
| Resources | -0.112 | *-0.148* | -0.129 | -0.204 | *-0.173* | -0.155 |
| Infrastructure | 0.031 | 0.035 | 0.043 | 0.056 | 0.066 | 0.047 |
| Environment | -0.069 | -0.065 | -0.065 | -0.056 | *0.000* | -0.053 |
| **RIE Index** | **-0.150** | **-0.178** | **-0.151** | **-0.204** | **-0.107** | **-0.161** |