TI 2008-058/3

Tinbergen Institute Discussion Paper

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Maria Francesca Cracolici[1]

Miranda Cuffaro[2]

Peter Nijkamp[1,3]

[1] *Free University Amsterdam;*

[2] *University of Palermo;*

[3] *Tinbergen Institute.*

Tinbergen Institute

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Tinbergen Institute Amsterdam
Roetersstraat 31
1018 WB Amsterdam
The Netherlands
Tel.: +31(0)20 551 3500
Fax: +31(0)20 551 3555

Tinbergen Institute Rotterdam
Burg. Oudlaan 50
3062 PA Rotterdam
The Netherlands
Tel.: +31(0)10 408 8900
Fax: +31(0)10 408 9031

ANALYSIS OF SPATIAL DISPARITIES BY A STRUCTURAL EQUATIONS MODEL

Maria Francesca Cracolici[*], Miranda Cuffaro[†] and Peter Nijkamp[*]

*Department of Spatial Economics
Free University
Amsterdam
The Netherlands
cracolici@feweb.vu.nl
pnijkamp@feweb.vu.nl

[†]Department of National Accounting and Analysis of Social Processes
University of Palermo
Palermo
Italy
cuffaro@unipa.it

pn276mcmc

Abstract

This paper presents a new analytical framework for assessing spatial disparities among countries. It takes for granted that the analysis of a country's performance cannot be limited solely to either economic or social factors. The aim of the paper is to combine relevant economic and non-economic (mainly social) aspects of a country's performance in an integrated logical framework.

Based on this idea, a structural simultaneous equation model will be presented and estimated in order to explore the direction of the causal relationship between the economic and the non-economic aspects of a country's performance. Furthermore, an exploration of the trajectory that each country has registered over time along a virtuous path will be offered. By means of a matrix persistency/transition analysis, the countries will be classified in clusters of good/bad performance.

One of the most interesting conclusions concerns the inability of most countries to turn the higher educational skills of the population into greater economic performance over time. In addition, our analysis also shows that making an accurate picture record and formulating related policy aiming at environmental care is highly desirable. It is surprising that only a few countries have reached a favourable economic and environmental performance simultaneously.

Keywords: Socio-economic well-being, living standards, structural simultaneous equation model

JEL-classification code: P46

1. Introduction

The measurement of a country's welfare is one of the most critical and highly debated issues in economic research. The snappy title of Davidson's book highlights one of the most relevant and debated topics of the recent literature: "*You can't eat GNP*" (Davidson, 2000). This publication addresses the hypothesis that GNP (or GDP) per capita can not be considered as the only indicator of the performance of a country because it does not capture the overall well-being of population.

Nevertheless, it has become rather common to rank the performance of countries or regions by assessing their levels of development (or growth) in terms of GDP. But this approach has often been strongly criticized. As the World Bank has written: "*The basic objective of development is to create an enabling environment for people to enjoy long, healthy and creative lives. But it is often forgotten in the immediate concern with the accumulation of commodities and financial wealth*" (World Bank, 2001, p. 9).

The conventional economic view has frequently prompted much criticism based on the observation that "*people derive utility or well-being not merely from the command over income alone*" (Neumayer, 2003, p.276). This observation takes for granted that the standard GDP index is unable to capture the real inequalities among countries in terms of the different – sometimes contrasting – dimensions of the well-being of populations. GDP is at best only a partial measure (or proxy) of a multi-dimensional welfare concept incorporating both the economic and the non-economic aspects of human life (see Sen, 1985, 1987; Khan, 1991; Dasgupta, 1990).

Since the 1990s however, there have been some new attempts in the literature to come up with more appropriate indicators. The first is the World Bank's Human Development Index (HDI), a composite indicator based on GDP per capita, life expectancy at birth, and the adult literacy rate (UNDP, 1990). These features represent, respectively, three main aspects of an individual's life, viz. access to resources; health conditions; and the opportunity to enjoy a basic education.

Although the HDI is the most frequently used indicator for measuring the development differentials among countries, it has been much criticized, in particular regarding its simple weighting of each variable, and the high correlation between GDP and certain crucial background variables.

In 2005 a special issue of the *Review of Income and Wealth* was entirely dedicated to 'Inequality and Multidimensional Well-being', while in 2007 one of its calls for papers was mainly addressed to specific related themes, such as: measuring well-being from objective and subjective perspectives, constructing macro indicators of well-being, measuring economic well-being among regions, and so forth.

In 2001 an original and stimulating study (Hobijn and Franses, 2001) drew economists' attention to the need to extend the evaluation of a country's performance to

encompass relevant measures of living standards. In so doing, they have thus readdressed the spatial convergence issue – so prominent in the economic growth literature – and presented evidence that convergence in GDP does not necessarily imply convergence in living standards, the latter being defined by daily calorie supply, protein calorie supply, infant mortality, life expectancy at birth, and so forth.

In our view, and in agreement with the above-mentioned literature about the need to follow a multidimensional approach to the analysis of national or regional well-being, the assessment of a country's performance cannot be limited solely to either the economic or the non-economic aspects. Both aspects must be considered simultaneously, and within a consistent framework.

More specifically, the level of GDP in a country is viewed as its ability to provide its inhabitants with proper opportunities to enjoy good economic, social, and environmental conditions of life. An increase in per-capita GDP is considered as a basic prerequisite for improvement in the living standards of a population, viz. better health services, more secure livelihoods, greater access to education, better working conditions, security against crime, more satisfying leisure time, a healthy and sustainable environment, etc. On the other hand, better living standards constitute a good basis to enhance productivity and, in turn, GDP.

In the light of these considerations, in the remainder of this paper we shall propose a simultaneous equation system to take into account various relevant aspects, economic and non-economic, related to the living conditions of the population. In the literature, these aspects are often also called, respectively, economic and non-economic well-being (see, e.g., Osberg and Sharpe, 2005; McGillivray, 2005; McGillivray and Shorrocks, 2005). The main idea is to identify a cycle where an increasing amount of GDP per capita (i.e. the economic dimension of a country's performance) produces a higher level of non-economic aspects, viz. better health conditions, longer life prospects, higher percentage of educated population, balance between work and free time, etc. Similarly, if a country has a high level of non-economic well-being factors it is more able to manage its resources in order to increase its income and productivity. Consequently, it seems plausible to hypothesize that there exists a bidirectional relationship between the economic and non-economic dimensions of country performance, and this question will be further analysed in the present paper.

Using a simultaneous equation model, we explore whether there is a bidirectional causal relationship between the economic and the non-economic aspects that characterize country performance, and how strong the intensity of this mutual causality is.

To this end, we have designed a simultaneous equation model (SEM), where each relevant dimension of well-being is represented by an explanatory equation, and where each equation contains both endogenous and exogenous variables. By means of our SEM, we can control the possible endogeneity problem between economic and non-economic variables. The model is based partly on both the conventional production function theory and partly on the most recent empirical literature on economic growth. Using an extensive database, the

model is estimated for 64 countries for the period 1980-1999; the sample involves mainly developing countries, but it has also been implemented for a few developed countries.

After a brief literature review presented in Section 2, a first attempt to build an operational framework for the analysis of country performance is provided in Section 3; our empirical model and the data used are also presented there. Empirical results and some concluding remarks are presented in Sections 4 and 5, respectively.

2. The Multifaceted Performance of a Country.

The economic analysis of regional growth and its distribution already has a long history and dates back to the early work of Solow (1956), where he argues that, in a neoclassical economic world, the growth rate of a region (measured in per capita income) is inversely related to its initial per capita income, a thesis which offers an optimistic perspective for poor regions. This convergence idea has attracted much attention and has prompted interesting qualitative research on evolving convergence versus persistent disparities (see, e.g., Barro and Sala-i-Martin, 1992).

This stream of research has dominated the economic analysis of a country's welfare, though recently a new approach, involving also non-economic aspects of a country's well-being is emerging. Concerning the latter, some economists consider GDP per capita as a very limited measure of the level of a country's well-being, because it does not consider the consequences of economic development on the lives of people (e.g. air, sea and water pollution, increases in certain rare diseases, congestion, cost of urbanization, etc.); nor does it capture the real-life conditions of populations (UNDP, 1990; Hobijn and Franses, 2001; Neumayer, 2003; Marchante and Ortega, 2006).

In 1973 Kuznets made this challenging assertion: "*The most distinctive feature of modern economic growth is the combination of a high rate of aggregate growth with disrupting effects and new problems*" (Kuznets, 1973, p.257). This statement implies that the national accounting framework should be expanded so that it considers both certain costs (i.e. pollution, urban concentration, commuting, etc.) and positive returns (i.e. better health, greater longevity, more leisure, less income inequality, etc.).

In the light of these suggestions, the economic literature has proposed different measures of a country's performance. The one most widely used is the HDI based on a concept of human development which involves both an economic dimension, measured by GDP per capita, and a dimension linked mainly to social aspects, measured by life expectancy and the literacy rate. It has been inspired by Sen's development theory, according to which a country's development is a matter not only of long-run economic growth but also of opportunities for people, in both the high and the low growth cycle (Sen, 1984).

Yet, after the first Report on HDI (UNDP, 1990), many criticisms were made of the index. Indeed, it has sometimes even been considered a redundant indicator that provides little

additional information on inter-country development levels with respect to traditional GDP (McGillivray, 1991; Desai, 1991; Dasgupta and Weale, 1992; Sagar and Najam, 1998). Nevertheless, the framework for calculating the index has remained substantially unchanged in UNDP's subsequent annual reports; only a few corrections have been made to take account of gender differentials or income distribution.

The specific literature of the 1990s comprised a number of critical proposals for the improvement of the HDI. For example, since the indicators of the three dimensions of HDI were closely correlated, a principal component method was proposed in order to use a linear combination of these indicators (Noorbakhsh, 1998; McGillivray, 1991).

Further, Sagar and Najam (1998) proposed a more in-depth revision of HDI involving multiplication of the three component variables instead of using their arithmetic average, a logarithmic treatment of GDP, and the incorporation of an inequality measure into the index. In fact, only the second Report calculated the distribution-adjusted HDI for 53 countries (UNDP, 1991, pp.17-18), and this was available until 1994, although since that year the distribution-adjusted HDI has been omitted.

Notwithstanding its limitations, the HDI is particularly relevant to developing countries, where the basic dimensions depicted by the three indicators have not yet been fully accomplished. By contrast, regarding the developed countries, a decent standard of living, longevity, and primary education have already been achieved by most people. Consequently, multiple significant and suitable indicators, which take account of the different aspects of living appear to be necessary.

Recently, in fact, Marchante and Ortega (2006), in a study conducted to measure the quality of life and economic convergence across Spanish regions, have used an alternative augmented composite indicator (AHDI) in the context of HDI. In particular, they considered alternatively three different per-capita income measures (total personal income minus grants, GVA, and total disposable income) and six quality of life indicators (life expectancy at birth, the infant survival rate, the probability at birth of surviving to the age of 60, the adult literacy rate, the mean years of schooling of the working age population, and the long-term unemployment rate). Moreover, they applied an averaged arithmetic mean scheme with (arbitrary) weights for the variables transformed by an achievement index.

Cuffaro et al. (2008) analysed the performance of Italian regions by using both different categories of consumption expenditure as proxies of the economic aspects of well-being, and indicators of health and diet conditions, education, labour market, etc. as proxies for the social aspects of well-being. Their analysis showed that it was possible for high levels of economic well-being to coexist with a high level of non-economic well-being.

Furthermore, since the 1980s – after the creation of the United Nations World Commission on Environment and Development – some economists have highlighted that the environment, like the social aspects of life, is an essential element of well-being or country performance. In 1989 Daly and Cobb, proposed the ISEW, viz. the first Index of Sustainable

Economic Welfare; it attempted to integrate the economic aspects of an economy, as depicted by the conventional national accounting, with the social (i.e. income distribution inequality) and the environmental (i.e. air and water pollution) aspects.

ISEW was criticized very soon (see, e.g., Neumayer 1999, 2000) for the arbitrary selection of its component variables and for the method of aggregation and construction. After that, various indices, such as the Living Planet index, the Ecological Footprint, the Environmental Performance Index and so forth, were proposed (see, e.g., Bohringer and Jochem, 2007).

At present, there is a big debate among ecological economists concerning the appropriate way to define a multidimensional index of sustainability, combining the economic, social and environmental aspects of human life (Pulselli et al., 2006; Distaso, 2007). Actually, the assessment of the environmental aspects is very important in developed countries where growth and technological progress may become 'uneconomic', worsening the life of citizens, by, for example, air and water pollution. Even in developing countries the policies towards environmental problems constitutes a plus point for those governments. Moreover, considering this feature in a multidimensional measure of country performance could produce a more significant ranking of territorial areas.

Although a number of efforts have been made to obtain a more comprehensive index of multidimensional well-being or country performance, many methodological issues still need to be explored more deeply, concerning how to integrate the above-mentioned different aspects in a unique measure (i.e. a composite indicator).

The above considerations indicate that many dimensions should be considered for the analysis of a country's performance. So, how are these dimensions linked? To this end, an operational framework including the economic and the non-economic (social and environmental) aspects of country performance will now be presented in Section 3. It is a first attempt to provide a conceptual and structural framework for the analysis of country performance. The empirical model will also be presented.

3. A Conceptual Scheme for the Analysis of a Country's Performance

3.1 Introductory remarks

In our view, an endeavour to combine the economic and the social aspects of a country's performance and to link static and dynamic analysis requires a general framework like the one depicted in Figure 1. This has been inspired by Sen's development theory, according to which a country's development is a matter not only of long-run economic growth but also of opportunities for people, in both the high and the low growth cycle (Sen, 1984).

<<Insert figure 1 about here>>

In this scheme, both the economic and the non-economic aspects of a country contribute to its performance. By introducing the time dimension, we can refer to income growth (i.e. the improvement in living conditions) and to human development (i.e. the improvement in non-economic aspects of living).

As a rule of thumb, we expect a strong relationship between both economic and non-economic aspects, between income growth and human development. As far as we know, there are no empirical studies about the first relation, and there are only few studies about the second one. While some economists (Zuvekas, 1979) have found that economic growth and human development are unrelated, some others have found strong support for the opposite hypothesis.

Mazumdar (2000) found evidence that in the middle- and low-income countries there is one-way causal relationship between the two phenomena[1], but only up to a certain level of income, after which growth and human development move independently. The results, as highlighted by the author, vary with respect to both the three different indicators of human development and the different income level clusters. In particular, for the low and middle-income countries human development precedes economic growth, that is, low social development implies low labour productivity and in turn low income.

Moreover, Ranis et al. (2000) demonstrated an 'iterative process' between the improvement in human development and economic growth "*as a necessary but not sufficient condition for achieving such improvements*". They conclude that "*economic growth itself will not be sustained unless preceded or accompanied by improvements in human development*" (p. 213).

In agreement with the previous empirical evidence, we define an operational scheme based on the argumentation that, in the long run, the causal relationship between the economic and the non-economic aspects may reveal two paths: high levels of economic well-being contribute to high levels of non-economic well-being through households, firms and the public sector. It does so through households because they spend a higher proportion of their income on education, health and culture; through firms because they devote a higher proportion of their profits to create a safer labour environment, to finance R&D to control pollution, etc.; and through the government because it allocates a higher proportion of its resources to education, health, and the environment. Conversely, high levels of non-economic well-being contribute to high levels of economic well-being through various channels. For example, high levels of health and education raise the productivity of workers, facilitate the acquisition of skills, and promote technological progress and ICT usage. In their turn, these factors help to significantly increase the level of output (and also its composition), exports, and per capita disposable income.

[1] The test is performed by using three single linear equations between GDP per capita (as a standard measure of economic growth) and, respectively, life expectancy at birth, infant survival rate, and adult literacy rate; the latter three variables are proxies for human development.

More specifically, a high level of economic well-being should support the formation of a high level of such human capabilities as improved health or knowledge. Improving human capabilities means increasing the efficiency of the use made by people of their own capabilities for work or leisure (UNDP, 1997). In synthesis, the performance of country is defined by a cycle, viz. a bidirectional path that moves both from the economic dimensions to the non-economic ones and from the non-economic dimensions to the economic ones.

So, how should we measure the economic and the non-economic aspects of a country's performance?

3.2 The economic and the non-economic aspects

In our analysis, the economic dimension of country performance, viz. the access to economic resources – as argued by UNDP (1997) – is evaluated by the traditional GDP per capita. We hypothesize that the ability of a country to satisfy the basic needs of population comes from the opportunities and the efficiency to manage its human, material, and natural capital. From a theoretical point of view, the latter are inputs of the GDP production process.

In the long run, the capacity of the economy to grow fast pushes up the non-economic aspects of a country. Regarding these, very little attention has been paid to which particular indicators have to be chosen. Indeed, it is not immediately obvious at the outset, because the decision also depends on the main features of the countries analysed: for instance, whether they are developed or developing.

Many studies do not devote much attention to this problem. For example, the indicators chosen by Hobijn and Franses (2001) – who analyse both developed and developing countries simultaneously – can well discriminate between the two groups of countries, but they fail to take account of different levels of well-being within developed countries. In fact, when measured on these indicators (viz. daily protein, calorie supply, infant mortality rate, and life expectancy at birth) developed countries are quite homogeneous. Later, Neumayer (2003) criticized the previous authors and tested (on the same data set used by Hobijn and Franses) for convergence with different indicators of well-being, namely life expectancy, infant survival, education enrolment, literacy, and telephone and television availability. The wider range of indicators considered offsets the bias due to the analysis of developed and developing countries simultaneously. As a matter of fact, Neumayer reached different results compared with those of Hobijn and Franses that suggest strong evidence of convergence most of the indicators.

More recently, Giles and Feng (2005), analysing 14 OECD countries, considered five measures of well-being: namely, life expectancy, the Gini index of income inequality, the poverty rate, the tertiary education participation rate, and carbon dioxide ($CO_{2)}$ emissions.

Also, MacGillivray (2005) for a selected number of developing countries examines a number of indicators, including measures of poverty, inequality, health status, education status, gender bias, empowerment, governance, and subjective well-being. He found that most

of the commonly used indicators are highly correlated to income and, as a consequence, they are not able to give any more information than income can. Moreover, he raises the problem of the possible endogeneity between income and non-economic indicators.

In the light of the aforementioned literature, we think that the choice of indicators should be based on the main characteristics of countries (viz. developed or developing; low, medium or high income, etc.), and on their capacity to catch the relative heterogeneity among countries, but avoiding possible redundant statistical information. Obviously, in order to perform significant comparisons between countries, there would have to be wide agreement on the chosen indicators.

In particular, as our analysis concerns a relevant share of developing countries, we think that, in line with the literature, the main dimensions of non-economic well-being should be related to long life prospects (i.e. life expectancy at birth), health (i.e. infant survival rate as the inverse of infant mortality rate), and education (i.e. literacy rate) status.

In relation to the first indicator, as Ram and Schultz (1979, p.402) pointed out "*the satisfaction (utility) that people derive from a longer life span must be substantial*"; linked to this one, there is the infant survival rate, which, if it is very high, tends to raise the life expectancy. Finally, the literacy rate is "*a direct measure of achievement, one basic sign of human beings' minimum education*" (Mazumdar, 2000, p.301).

In addition to these dimensions, we think that the quality of the environment is worth considering when measuring country performance. As ecological economics points out: "*The economic system is a subsystem of the system which is the environment. The economy depends upon the environment, what happens in the economy affects the environment, and changes in the environment affect the economy. Regarded as two systems, the economy and the environment are interdependent*" (Common and Stagl, 2005, p.218).

The well-known Kuznets curve (EKC) predicts pollution increases until a certain level of income (viz. $5000-$8000), as developing countries "*grow first and clean up later*". A recent paper (Dasugpta et al., 2006) demonstrates that this argument is incorrect and find evidence that an environmental governance is also possible for developing countries. More specifically, their results suggest that policy actions are sufficient to reduce air pollution significantly, even in those cities of overcrowded and poor countries. This is an important result that makes it possible to take the environment into account when assessing developing countries' well-being.

An empirical model of country performance, including the economic and the non-economic aspects will be proposed in Section 3.2. By using a simultaneous equation model, we verify if a bidirectional relationship exists between the economic and the non-economic dimensions for 64 countries in the world for the years 1980-1999.

3.3 Model and data

To define the model and to choose the key variables to include in it, the guidelines from the most relevant literature quoted above have been followed. In particular, by means of a simultaneous equation model (SEM), an empirical application of the operational scheme has been performed. By using SEM, we attempt to arrange and to combine in a synthetic and structural way the suggestions from the literature, in order to capture the effects of the relationship between the economic and the non-economic aspects that charactize country performance, viz. the simultaneous relationships between the economic and the non-economic aspects of country well-being (see Figure 1). As far as we know, this approach is the first attempt to arrange the different dimensions of country performance, controlling for endogeneity.

The endogenous variables in our SEM are gross domestic product (*gdp*), literacy rate (*li*), life expectancy (*le*), and pollution indicator (*pol*).

We use as exogenous variables the following: working age population at t-1 as a proxy for labour input (*labour-1)*; the share of gross capital formation at t-1 (*capform-1*) in GDP, as a proxy for material capital input; telephone mainlines (*telp*) as a proxy for technology progress; television set availability (*tels)* as a proxy for information diffusion, which indirectly affects *gdp*, and directly the literacy rate (*li*) and life expectancy (*le*); educational enrolment to primary, secondary and tertiary school (*ee*) as a determinant of the literacy rate and indirectly of *gdp*; the urbanization rate (*urb*), as a determinant of pollution in terms of emission of CO_2.

We assume that the exogenous variables are determining the endogenous variables by the following equations system.

$$gdp_{it} = \alpha_1 + \beta_{11} labor_{-1it} + \beta_{12} capform_{-1it} + \beta_{13} telp_{it} + \beta_{14} le_{it} + \beta_{15} li_{it} + \varepsilon_{1it}; \quad (1)$$

$$li_{it} = \alpha_2 + \beta_{21} gdp_{it} + \beta_{22} ee_{it} + \beta_{23} tels_{it} + \varepsilon_{2it}; \quad (2)$$

$$le_{it} = \alpha_3 + \beta_{31} li_{it} + \beta_{32} tels_{it} + \beta_{33} gdp_{it} + \varepsilon_{3it}; \quad (3)$$

$$pol_{it} = \alpha_4 + \beta_{41} gdp_{it} + \beta_{42} urb_{it} + \beta_{43} tels_{it} + \varepsilon_{4it}. \quad (4)$$

Clearly, the explanatory structure of the above SEM is co-determined by data availability. The first equation – according to production theory – captures the variables that are likely to influence the GDP production process, i.e. the exogenous variables previously described and the endogenous ones *le* and *li* that affect the productivity and, consequently, the

rise of income[2]. The *gdp* as an economic dimension directly affects the country performance, but also indirectly, through its effect on the explanation of other endogenous variables.

The next two equations (2 and 3) describe the non-economic dimensions of country performance, viz. social features, while equation (4) aims to describe the environmental dimension. In equation (2), the literacy rate (*li*) is explained by gross domestic product (*gdp*), education enrolment to primary, secondary and tertiary school (*ee*), and television set availability (*tels*). Equation (3)[3] links life expectancy to gross domestic product (*gdp*), education level (*li*) and information level; it is plausible to hypothesize that increasing the level of *gdp*, *li* and *tels* increases the prospects for longer life and better health conditions, i.e. might positively affect life expectancy.

The last equation links pollution (*pol*) measured by the emission of CO_2 to the production of GDP and to the level of urbanization (*urb*). It should be noted that the production of *gdp* cannot be expanded infinitely without some negative external effects on the environmental equilibrium of a country. So one can discriminate between 'good or desirable output' and 'bad or undesirable output' (i.e. pollution); the notion that desirable and undesirable outputs are jointly produced is called 'null jointness' (Shepard and Färe, 1974). Bad outputs could be considered in a production function, as in Färe et al. (1994) or in Cracolici et al. (2006); conversely, as in Welsch (2007), it could be inserted in the production function as a quasi-input[4]. On the other hand, this quasi-input is strictly correlated with the level of output, the urbanization or concentration of activities, the number of motor vehicles and electricity production from oil, etc.

The SEM composed of equations (1)-(4) constitutes a schematic, but clearly non-exhaustive, efficacious representation of the multifaceted nature of a country's performance.

Because of heteroskedasticity problems, all the variables have been transformed into logs; this allows us to interpret the results in terms of elasticities. We have next used in our econometric analysis a 2-stage least squares (2SLS) estimation method based on instrumental variables (IV) for panel data (Hsiao, 2003), i.e. an equation-by-equation robust estimation approach. The 2SLS IV estimation method allows us to obtain consistent results, while it also has the advantage over a system estimation (e.g. a 3SLS estimation method) in that if one equation is misspecified it will not spill over and contaminate the estimation results for the other equations. Moreover, the 2SLS IV method lets us use different and suitable instruments for each equation.

To implement the model we use data from World Bank (2001). In particular, the analysis concerns the year from 1980 to 1999. As not all countries and not all variables have

[2] Because of the existence of correlation problems between *labour* and *capform* and the other exogenous variables, time lags have been used.

[3] It should be noted that equations (1) and (3) included, as a first step, the endogenous variable infant survival (*is*); but, after a diagnostic statistical analysis it has been removed because of the strong correlation between *is*, $labor_{-1}$, and *telp*.

[4] It should be noted that, as a first step, *pol* was been inserted in Equation (1) as quasi-input; but it caused strong bias in the estimates and, consequently, it has been removed.

data availability over the period analysed, we made an appropriate choice of either countries or variables. Hence, we use observations at five-year intervals, around 1980, 1985, 1990, 1995 and 1999. In most cases, these are an average of five annual observations centred on the year indicated. Section 4 contains a discussion of the results obtained.

4. Empirical Results

The empirical results that originated from the simultaneous equation model are reported in Table 1. Regarding the economic dimension, the estimates of equation (1) highlight that *gdp* is positively linked to life expectancy (*le*), the share of working age population ($labour_{-1}$), and the proxy for capital stock ($capform_{-1}$), and the proxy for technological progress (*telp*). As expected, the elasticity of output (*gdp*) with respect to labour is higher than it is to the stock of capital ($capform_{-1}$).

<<Insert Table 1 about here>>

Furthermore, it should be noted that the sum of input coefficients of the production process – including *telp* as proxy for technological progress – is almost equal to 1 highlighting constant returns of scale. Among the endogenous variables, the coefficient of the literacy rate is not significant, a phenomenon that could be related to the features of the majority of countries included in the sample, which presents a low level of human capital quality, i.e. a level of the literacy rate not sufficient enough to affect the production of GDP.

Instead, the *gdp* significantly affects the literacy rate of a country, as shown by the coefficient equal to 0.679. Thus, there exists only a unidirectional relationship from *gdp* to *li*, i.e. *gdp* precedes *li*. Life expectancy (*le*) has a strong and significant effect on *gdp*, it has a coefficient equal to 0.472; on the other hand, *gdp* also has a positive and significant effect on life expectancy (β_{33}=0.114). In synthesis, the estimates from equations (1) and (3) show a bidirectional relationship between *gdp* and *le*.

If we now turn to the literacy rate, we find, as expected, that the estimates show a positive sign for all the estimated coefficients. In particular, *li* is affected by education enrolment (*ee*), and by the proxy for information diffusion (*tels*); these variables represent significant coefficients equal to 0.185 and 0.064, respectively. The high value of the constant coefficient indicates that some other variables could influence the explanation of *li*.

Regarding equation (3), the estimates highlight that *le* is mainly explained by *gdp*, and weakly by *tels*. In contrast to our poor expectation, the coefficient of the literacy rate is not significant. In the light of this finding, we can say that the non-economic dimensions are strongly explained by income per capita, but, as said above, the inverse relationship is not always true.

Finally, regarding the environmental dimension, there exists a positive relationship between *gdp* and *pol*, i.e. a marginal increase of *gdp* produces an almost proportional increase of production of CO_2. Among the other variables, as expected, it is relevant to mention the effect of urbanization on *pol*; in fact it is reasonable to believe that a high urbanization rate directly and indirectly affects the level of pollution through an increasing use of urban transport, high consumption of energy, electricity, and water, etc.

The coefficient of *tels* has a negative and significant sign, indicating that the information acts positively on the decrease of pollution.

In conclusion, a bidirectional causality relationship exists between *gdp* and life expectancy (*le*), while only a unidirectional one exists between *gdp* and *li*. Why does *li* not affect *gdp*? For developing countries, this factor is likely to be connected to the composition of the population characterized by low educated people employed in low productivity and traditional sectors (i.e. agriculture) which weakly affect the production of *gdp*. For developed countries, the unidirectional relationship may reflect the inability of countries to adequately employ their human capital with a high level of education and skills. Thus, in the long run, this could lead countries – with a high level of *gdp* and *li* – to have a poor *status*, i.e. low *gdp* and *li*.

The positive and significant effect of *gdp* on all social and environmental dimensions highlights that a good level of the economic dimension is a basic condition to achieve a good social-enviromental performance.

Actually, the estimates from the model give us relevant information on the 'average behaviour' across countries and over years. If we want to obtain more detailed information for each country at each time point, it would be useful to explore growth rates of economic (i.e. *gdp*) and social-environmental performance (i.e. *le*, *li* and *pol*). For this aim and in order to obtain a dynamic interpretation of our empirical results, we classify the countries in four groups:

i) *High high* (HH) – countries with a rate of economic and social-environmental growth greater than the average value;

ii) *Low high* (LH) – countries characterized by a growth rate of *gdp* lower than the average value and a social or environmental performance (i.e. *le*, *li* and *pol*) greater than the average value;

iii) *High low* (HL) – countries characterized by a growth rate of *gdp* greater than the average value and a growth rate of social or environmental performance lower than the average value;

iv) *Low low* (LL) – countries characterized by a growth rate of *gdp* and social or environmental performance lower than the average value.

Table 2 shows the clustering of countries in the four groups according to growth rate of *gdp*, and *le*, *li* and *pol*, respectively. With respect to *gdp* and *le*, we note that the number of

countries with an excellent performance (i.e. the group H-H) is increasing over the time; it passes from 11 – at the first time point – to 27 at the last time point. In contrast, it is interesting to observe the number of countries with a bad performance (i.e. the group L-L) decreases over time, declining from 22 to 7. All this is the expression of the bidirectional causality relationship between *gdp* and *le* highlighted by the simultaneous model, i.e. a high rate growth of *gdp* supports the expectancy of a longer life, but, conversely, a lower rate growth of *le*, i.e. the worst human health conditions, causes a country achieve lower growth and productivity in terms of *gdp*. Further, the countries included in the cluster HL decrease by of about 50 percent while the countries in the cluster LH increase over time.

Regarding the relationship between *gdp* and *li*, the clustering of the countries does not highlight a clear relationship between the two variables as was obtained from the simultaneous equation model; the number of the clusters is almost stable over time for the HH and the LH ones, while the number of countries increases weakly in the HL cluster and decreases in the LL one.

With respect to *gdp* and *pol*, only the cluster LL shows a significant change in the number of countries included in it, while we note the number of countries is almost stable in the clusters HH, HL and LH. In particular, we expected an increase of units in the HL cluster and, in contrast, a decrease of units in HH one, if countries with high growth rate of *gdp* had audited the environmental damage associated with economic growth.

In the light of these results, it would be interesting to trace the performance of each country in terms of growth rates for the period analysed, viz. 1980-1999. Tables 3 and 4 summarize the movements of countries from the start period (1980-1985) to the end period (1995-1999). In particular, Table 4 can be interpreted as a matrix of the transition/ persistency status of countries. In fact, the main diagonal shows the persistency status of countries with respect to their beginning status (i.e. HH, LH, HL and LL); on the contrary the units above and below the main diagonal indicate the countries that move from a certain start status to a different end status.

Regarding the relationship between *gdp* and *le* and *li*, respectively, we can say that a unit follows a virtuous path if it moves directly from the cluster LL to HH or LH; that means reaching a good economic performance matches social goals. Further, a country follows a virtuous path just as much if it moves from status HL and LH to HH. With respect to the first path (from HL to HH), a territorial unit is able to manage its economic growth efficiently in order to increase its social development. Concerning the second path, i.e. from LH to HH, a country exploits the good conditions of its people in terms of a high level of education and high health conditions to contribute to increase its economic growth.

In particular from Table 4, we note that the number of countries following a virtuous path is greater with respect to *le* (30) than to *li* (10). This result, already highlighted by the estimates of our model, confirms the bidirectional causal relationship between *gdp* and *le*. In

other words, a high level of life expectancy has been an easier goal to reach for many countries, while a high level of education is a more difficult goal to achieve.

Relating to *gdp* and *pol*, a country proceeds along a virtuous path if it moves from the cluster HH to HL, but also from LL and LH to HL. In fact, it is important for both developed and developing countries to reach an economic growth process by monitoring the level of pollution through specific actions. From Table 4, we can count only 10 countries that have a virtuous status, i.e. the monitoring of environment has been a difficult problem to manage for the majority of countries. The polarization of countries in the clusters HH (20 countries) and LL (26 countries) indicates that a high level of economic growth implies a social cost in terms of environmental damage; on the other hand, a low economic growth is not likely to imply environmental damage.

5. Conclusion

We have proposed a rational scheme in which future research on economic, social, and environmental performance of countries can be positioned and nested. By using a structural simultaneous equation model, we have estimated the intensity of causal relationships among economic, social and environmental variables, and we have controlled for endogeneity.

Obviously, our scheme is not exhaustive and additional aspects could be considered as well (e.g. ones related to income inequality, quality of diet, time and leisure, etc.). Nevertheless, at this moment, our analysis is a new attempt to integrate the economic, social, and environmental aspects of countries' performances simultaneously.

By using a simultaneous equation model, our attempt represents a novel methodological approach to analyse a multidimensional phenomenon on such as country well-being, traditionally treated by means of statistical multivariate methods or composite indicators.

The estimations show that *gdp* is a basic condition to obtain a good social performance: a high level of *gdp* permits inhabitants to have a longer life expectancy and to achieve a higher level of education. But the other side of the coin is that high levels of *gdp* increase the level of pollution. In particular for developing countries, this insight implies that policy makers have to pay attention to controlling and monitoring the negative effects of economic growth on the environment.

Furthermore, the empirical analysis reveals a strong bidirectional relationship between *gdp* (the economic performance indicator) and one of the social performance indicators, life expectancy.

In contrast, a unidirectional relationship between *gdp* and *li* has been found. This result could be related to a slower response of *gdp* to human capital changes, viz. a higher quality level of human capital does not turn immediately into a higher level of *gdp*.

As our empirical analysis has mainly concerned developing countries, we may hypothesize that the countries analysed have not reached the minimum threshold that permits them to move from an economy characterized by a low productivity level to a country characterized by a high productivity level .

Finally, the results obtained show that life expectancy does not serve to distinguish between the countries, while the literacy rate and CO_2 emissions are better able to capture the differences between countries in terms of their social and environmental dimensions. In particular, with respect to the literacy rate a similar result has been obtained from McGillivray (2005).

From a policy point of view, the above result indicates that, for most of the countries that were examined, more efforts should have been made to improve their social and environmental performance, viz. in order to increase the level of the literacy rate and to control the CO_2 emissions. More specifically, in agreement with several strands of the literature, the policy response to spatial inequality or disparity could be based on:

- supply-side policy of a Keynesian nature, with a pronounced interest in public spending in less privileged regions;
- growth pole strategies, with a clear emphasis on a concentrated growth impulse in a few designated place or areas;
- infrastructure policy, with the aim of creating the necessary physical conditions (e.g. improvement of accessibility) in order to enhance the competitive capabilities of regions;
- self-organizing policy, where regions are encouraged to get their acts together on the basis of their own indigenous strength with a limited role of governments;
- suprastructure policy, in which regions are provided with favourable R&D conditions, educational facilities, knowledge centres, and the like, in order to create the conditions for self-sustained development.

In summary, our paper has tried to investigate and explore country performance regarding all aspects, economic and non-economic, simultaneously. Further, as the results obtained from the model give us insights into the average behaviour of countries over time, a matrix of persistency and transition status has been made. This analysis confirms the empirical results derived from the model, and highlights the inability of most countries, over time, either to turn the higher educational skills of their population into greater *gdp* or to improve the level of education in order to move from a low productivity economy to a higher productivity one.

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Table 1. Estimates from the 2SLS IV Simultaneous Model

Variables	*gdp*	*li*	*le*	*pol*
labour$_{-1}$	0.695	-	-	-
	(0.043)			
capform$_{-1}$	0.128	-	-	-
	(0.008)			
Telp	0.124	-	-	-
	(0.000)			
li	0.030	-	0.015	-
	(0.663)		(0.383)	
le	0.472	-	-	-
	(0.067)			
Gdp	-	0.679	0.114	0.890
		(0.000)	(0.000)	(0.000)
Ee	-	0.185	-	-
		(0.001)		
Tells	-	0.064	0.006	-0.043
		(0.000)	(0.021)	(0.002)
Urb	-	-	-	0.402
				(0.003)
Constant	1.725	-4.300	3.245	-7.704
	(0.029)	(0.000)	(0.000)	(0.000)
R^2	0.812	0.521	0.665	0.769

Table 2. Clustering of countries regarding the growth rate of *gdp*, *li*, *le*, *pol*

	HH	LH	HL	LL
		gdp_li		
1985/1980	17	16	11	20
1990/1985	18	13	10	23
1995/1990	12	17	16	19
1999/1995	16	15	18	15
		gdp_le		
1985/1980	11	14	17	22
1990/1985	15	16	13	20
1995/1990	25	19	3	17
1999/1995	27	23	7	7
		gdp_pol		
1985/1980	20	10	8	26
1990/1985	14	9	14	27
1995/1990	14	8	14	28
1999/1995	22	13	12	17

gdp is gross domestic product; *li* is the literacy rate; *le* is the life expectancy; *pol* is the emission of CO_2.
HH economic and social-environmental growth greater than the average value; LL economic and social-environmental growth lower than the average value; LH growth rate of *gdp* lower than the average value and social or environmental performance greater than the average value; HL growth rate of *gdp* greater than the average value and social or environmental performance lower than the average value.

Table 3. Movements of countries over time relating to cross-tabulated growth rates of *gdp* and *li, le* and *pol*

		gdp_li				*gdp_le*				*gdp_pol*			
		1985/ 1980	1990/ 1985	1995/ 1990	1999/ 1995	1985/ 1980	1990/ 1985	1995/ 1990	1999/ 1995	1985/ 1980	1990/ 1985	1995/ 1990	1999/ 1995
1	Algeria	HL	LL	LH	HH	HH	LH	LH	HH	HL	LL	LL	HL
2	Argentina	LL	LL	HL	HL	LL	LL	HH	HH	LL	LL	HL	HH
3	Brazil	LL	LL	HL	LL	LL	LL	HH	LH	LL	LL	HL	LH
4	Burkina Faso	HL	LL	LL	HL	HL	LL	LL	HL	HL	LH	LL	HL
5	Burundi	HL	LL	LL	LL	HL	LL	LL	LH	HH	LL	LL	LH
6	Cameroon	HH	LH	LH	HH	HH	LH	LL	HL	HH	LL	LH	HL
7	Central African Republic	LL	LL	LL	LL	LL	LL	LL	LL	LH	LL	LL	LL
8	Chile	LH	HH	HL	HH	LH	HH	HH	HH	LL	HH	HL	HH
9	China	HH	HH	HH	HH	HL	HL	HL	HH	HH	HL	HH	HH
10	Colombia	LH	HL	HL	LL	LL	HL	HH	LH	LH	HL	HL	LL
11	Congo, Dem. Rep.	LL	LL	LL	LL	LL	LL	LL	LL	LL	LL	LL	LL
12	Congo, Rep.	HH	LH	LH	LH	HL	LL	LL	LL	HL	LH	LL	LL
13	Costa Rica	LH	HL	HL	HH	LL	HL	HH	HH	LL	HL	HH	HL
14	Cote d'Ivoire	LL	LL	LL	HL	LL	LL	LL	HL	LH	LL	LL	HH
15	Cyprus	HH	HH	HH	HH	HL	HL	HL	HH	HL	HH	HL	HH
16	Ecuador	LH	LH	LH	LH	LL	LL	LH	LH	LH	LL	LH	LL
17	Egypt, Ar. Rep.	HL	HL	LL	HL	HH	HH	LH	HH	HH	HL	LL	HH
18	El Salvador	LL	LL	HL	LL	LH	LH	HH	LH	LL	LH	HH	LH
19	Gambia, The	LL	LL	LL	HL	LH	LH	LH	HH	LL	LL	LL	HL
20	Ghana	LL	LH	LH	HH	LH	LH	LH	HL	LH	LL	LL	HL
21	Greece	LH	LH	LH	HH	LL	LH	LL	HH	LH	LL	LL	HH
22	Guatemala	LL	LL	HL	LL	LL	LH	HH	LH	LL	LH	HL	LH
23	Honduras	LL	LL	LL	LL	LH	LH	LH	LH	LL	LH	LH	LH
24	Hungary	HH	LH	LL	HL	HL	LL	LL	HH	HL	LL	LL	HH
25	India	HL	HL	HL	HL	HH	HH	HH	HH	HH	HH	HH	HH
26	Indonesia	HH	HH	HH	LH	HH	HH	HH	LH	HH	HH	HH	LL
27	Iran, Islamic Rep.	HL	LH	HH	HH	HH	LH	HH	HH	HH	LH	HL	HH
28	Israel	HH	HH	HH	LH	HL	HL	HH	LH	HH	HL	HH	LL
29	Italy	HH	HH	LH	LL	HL	HL	LL	LH	HL	HL	LL	LL
30	Jamaica	LH	HL	LL	LL	LL	HL	LH	LH	LL	HH	LL	LH
31	Japan	HH	HH	LH	LH	HL	HL	LL	LH	HL	HL	LL	LH
32	Kenya	LH	HH	LH	LH	LH	HL	LL	LL	LL	HH	LL	LL
33	Korea, Rep.	HH	HH	HH	HH	HL	HH	HH	HH	HH	HH	HH	HH
34	Kuwait	LL	HH	HL	LL	LL	HH	HH	LH	LL	HL	HH	LL
35	Madagascar	LL	LL	LL	LL	LL	LL	LH	LH	LL	LL	LL	LL
36	Malawi	LL	LL	LL	HL	LL	LL	LL	HL	LL	LL	LL	HL
37	Malaysia	HH	HH	HH	LH	HL	HL	HH	LH	HH	HH	HH	LH
38	Mali	LL	LL	LL	HL	LH	LL	LL	HL	LL	LL	LL	HL
39	Malta	HH	HH	HH	HH	HL	HL	HH	HH	HH	HH	HL	HH
40	Mauritius	HL	HL	HL	HL	HL	HH	HH	HH	HH	HH	HH	HH
41	Mexico	LH	LH	LH	HL	LL	LL	LH	HH	LL	LL	LL	HH
42	Morocco	HL	HL	LL	HL	HH	HH	LH	HH	HH	HL	LH	HH
43	Nepal	HL	HL	HL	HL	HH	HH	HH	HH	HH	HL	HH	HH
44	Nicaragua	LL	LL	LL	HL	LH	LH	LH	HH	LL	LH	LL	HH
45	Oman	HH	LH	LH	LH	HH	LH	LH	LH	HH	LL	LL	LL
46	Pakistan	HL	HL	HL	LL	HH	HH	HH	LH	HH	HH	HL	LH
47	Paraguay	LH	LH	LH	LH	LL	LL	LH	LH	LL	LH	LH	LL
48	Peru	LH	LH	HH	LH	LH	LH	HH	LH	LL	LL	HL	LH
49	Philippines	LH	HH	LH	LH	LL	HH	LH	LH	LL	HH	LH	LH
50	Rwanda	LL	LL	LL	HH	LH	LL	LL	HH	LH	LL	LL	HL

51	Senegal	LL	LL	LL	HL	LH	LH	LH	HH	LL	LL	LL	HL
52	Singapore	HH	HH	HH	HH	HL	HL	HH	HH	HL	HH	HH	HH
53	South Africa	LL	LL	LL	LL	LH	LH	LL	LL	LH	LL	LL	LL
54	Sri Lanka	HL	HL	HL	HL	HL	HL	HH	HH	HH	HL	HH	HH
55	Swaziland	LH	HH	LH	LL	LH	HH	LH	LL	LL	HL	LL	LL
56	Syrian ArHL Republic	LL	LL	HL	HL	LH	LH	HH	HH	LH	LL	HL	HL
57	Thailand	HH	HH	HH	LH	HL	HH	HL	LH	HH	HH	HH	LH
58	Trinidad and ToLHgo	LH	LL	LL	HL	LL	LL	LH	HH	LH	LL	LH	HH
59	Tunisia	HH	LL	HL	HH	HH	LH	HH	HH	HH	LL	HL	HH
60	Turkey	HH	HH	HH	LH	HL	HH	HH	LH	HH	HL	HL	LH
61	Uruguay	LH	HH	HH	HH	LL	HL	HH	HH	LL	HL	HL	HH
62	Venezuela, RB	LH	LH	LH	LH	LL	LL	LH	LH	LL	LL	LH	LL
63	Zambia	LL	LL	LH	LH	LL	LL	LL	LL	LL	LL	LL	LL
64	Zimbawe	LH	LH	LH	HH	LL	LL	LL	HL	LL	LH	LL	HL

gdp is gross domestic product; *li* is the literacy rate; *le* is the life expectancy; *pol* is the emission of CO_2.
HH economic and social-environmental growth greater than the average value; LL economic and social-environmental growth lower than the average value; LH growth rate of *gdp* lower than the average value and social or environmental performance greater than the average value; HL growth rate of *gdp* greater than the average value and social or environmental performance lower than the average value.

Table 4. Persistency/transition matrix from 1980 to 1999

gdp_li

⟶	HH	LH	HL	LL
HH	7	8	1	1
LH	5	6	2	3
HL	2	0	7	2
LL	2	1	8	9

gdp_le

⟶	HH	LH	HL	LL
HH	7	3	1	0
LH	6	3	2	3
HL	8	7	1	1
LL	6	10	3	3

gdp_pol

⟶	HH	LH	HL	LL
HH	11	5	1	3
LH	3	0	3	4
HL	3	1	2	2
LL	5	7	6	8

gdp is gross domestic product; *li* is the literacy rate; *le* is the life expectancy; *pol* is the emission of CO_2.
HH economic and social-environmental growth greater than the average value; LL economic and social-environmental growth lower than the average value; LH growth rate of *gdp* lower than the average value and social or environmental performance greater than the average value; HL growth rate of *gdp* greater than the average value and social or environmental performance lower than the average value.

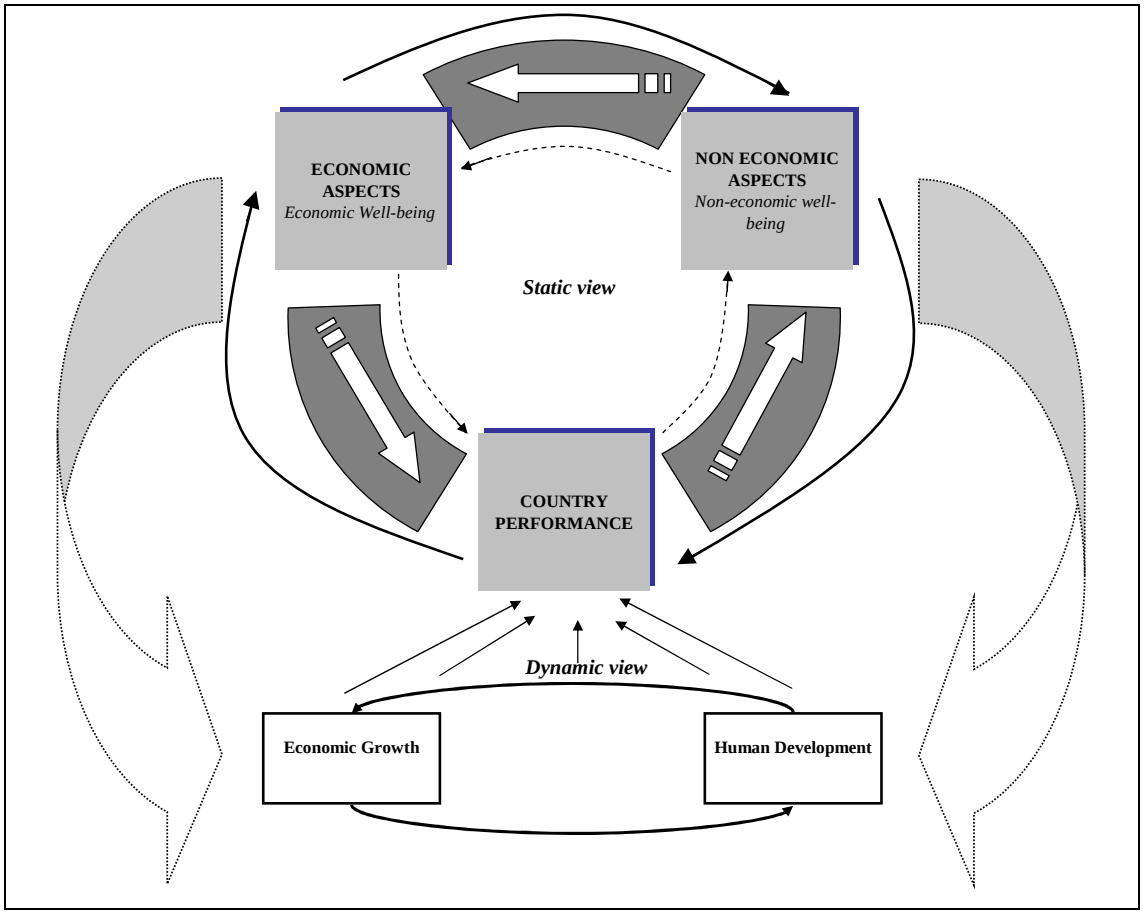

Figure 1. Operational scheme for the assessment of economic and non-economic performance of countries