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Navarro Espigares (José Luis), Martín Segura (José Aureliano), « Les investissements verts et les systèmes de santé durables »

Résumé – Cet article est consacré à la durabilité des systèmes de santé sous l'angle de la réduction de la demande de services de santé. La coopération entre secteurs est essentielle pour améliorer la santé publique et réduire la demande de soins. Ce travail analyse la manière dont les investissements verts affectent la durabilité de la santé et des systèmes de santé. Il établit ainsi le lien réciproque entre l'impact financier des investissements dans des technologies vertes et le coût des soins.

Mots-clés – Investissement vert, durabilité, systèmes de soins

Navarro Espigares (José Luis), Martín Segura (José Aureliano), « Green investments and sustainable healthcare systems »

Abstract – This work addresses the healthcare systems sustainability objective from the perspective of reducing the demand for health services. Cooperation across industry sectors is a crucial issue in achieving healthier populations that demand less health care. This research work poses the question: how are green-investments affecting health and healthcare systems sustainability? Thus, we will relate the financial impact of investments in eco-efficient technologies with healthcare costs and vice versa.

Keywords – Green investment, sustainability, healthcare systems

GREEN INVESTMENTS AND SUSTAINABLE HEALTHCARE SYSTEMS

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INTRODUCTION

To increase the sustainability of health systems is one of the four main objectives of the European Programme "Health for Growth". The reason why EU emphasises sustainable health systems is based on four main challenges: an ageing population of the EU Member States, more effective but also more expensive health technologies, the need for progress in prevention of chronic diseases, and the global and cross-border health threats.

The current moment, just after one of the deeper economic crises, represents both a threat and an opportunity to design health systems for the future. In the context of advanced economies, an area in which health expenditures are rapidly increasing, concern about their financial sustainability urges a new orientation. Most experts agree that sustainability is unlikely to be achieved through incremental changes.

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Transformative solutions will be needed–solutions that require cooperation across industry sectors and governments.

Most governments have serious difficulties in attributing health policies to the economic crisis. These difficulties include troubles in measuring the impact of the crisis on health systems and health due to the absence of national analysis and evaluation, time lags in international data availability and time lags in effects; troubles in disentangling the impact of the crisis itself from the impact of health system responses to the crisis; and troubles in systematically providing information on each health system's readiness to face a crisis (The European Observatory on Health Systems and Policies, 2015).

Despite all these issues, we know that the generalised response of national health authorities has been based on austerity (Karanikolos *et al.*, 2013), and that the combination of fiscal austerity with economic shocks and weak social protection is what ultimately seems to escalate health and social crises in Europe.

To achieve a sustainable health system for the future, societies must reshape demand for health services, reducing the burden of disease by helping people stay healthy and empowering them to manage their health. Health systems can encourage people to develop healthier habits, incentivise healthier consumption, and develop an environment and infrastructure that facilitate population health.

This work addresses the healthcare systems sustainability objective from the perspective of reducing the demand for health services. Cooperation across industry sectors is a crucial issue in achieving healthier populations that demand less health care.

Frequently, proposals in favour of promoting cooperation between the health sector and the business sector have had a limited scope and this cooperation constraint its objectives to some specific targets such as public-private partnership (Majestic, 2009, Easton, 2009). At other times, the proposed policies has constrained to environmental policy actions driven directly from the health sector (Feyerherm, Tibbits, Wang, Schram and Balluff, 2014). This time, our proposal goes further–our proposal suggests environmental actions promoted by the business sector and seeking its own profit.

This research work poses the question: how are green-investments affecting health and healthcare systems sustainability? Thus, we will explore the financial impact of investments in eco-efficient technologies on healthcare costs.

To answer this question we will visit a sequence of arguments that lead us to conclude on the urgent need for a firm commitment in favor of green investment as a radical innovation for the sustainability of health systems. Part of our arguments will support the review of literature, but some will rely on econometric models that start from the previous estimate of the index of environmental impact (IPAT) (Ehrlich and Holdren, 1971, Commoner and Barry, 1972) for 205 countries for 52 years (1961-2012). These models will ratify two key relationships aimed at our main concern. The first one relates environmental degradation and health. The second one links environmental degradation to R&D investments. Finally, by using environmental damage as a connection element, we associate green investments with sustainability of health systems.

Our main goal is to make explicit the relationship between green investment and the sustainability of health systems, using the reduction in demand for health care as causal connection.

The development of our argumentation start from four basic relationships that we will try to ratify either by arguments obtained from the literature, or by statistical testing provided by econometric models.

The four basic relationships are the following:

1. Impact of economic activity on environment
2. Impact of environmental issues on health conditions
3. Impact of health conditions on health systems sustainability
4. Impact of green investments on health systems sustainability

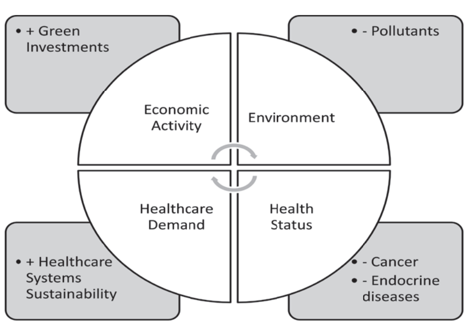

FIG. 1 – Impact's sequence.

The influence of economic activity on the environment as the starting point of the sequence of impacts is important, because it allows us to introduce the consumption equation (IPAT) and the separation of it in its determinants. Among these factors, environmental efficiency is included–a key element that will be conditioned by green investments.

Thus, a system of economic activities supported by green investments will generate fewer pollutants, which will alleviate the incidence of oncological diseases, reducing the demand for health care and strengthening the financial sustainability of health systems.

The next section is devoted to the methodology and presents the main hypotheses defended in the work. The third section offers a summary of what the literature says about four main relationships, which are the following: impact of economic activity on environment, impact of environmental issues on health conditions, impact of health conditions on health systems sustainability, and impact of green investments on health systems sustainability. The results section is focused on costs of some diseases and the opportunity to finance the transition towards a green economy. Finally, we will present some conclusions oriented to policy action.

I. METHODS

From the methodological point of view, this work combines a literature review with econometric panel data models.

The conclusions reached in this paper are the result of the confrontation of arguments. It is not part of the objective of this work to ratify or empirically demonstrate through econometric models all the causal relationships in the hypotheses. Our methodological objective is to find in the literature the arguments that support the relationships drawn from the assumptions. Strictly speaking, our hypotheses cannot be regarded as such, since there is no demonstration, but instead as proposals that aim to confirm the arguments.

A proposition is similar to a hypothesis, but its main purpose is to suggest a link between two concepts in a situation where the link cannot be verified with an experiment. The proposal is based largely on previous research, reasonable assumptions, and existing correlative evidence.

However, in the development of this work, dialectical development has been combined with empirical developments based on econometric panel data models.

Likewise, econometric models do not attempt to determine the causal relationship that underlies them. The objective of these models is to note that the aggregate behaviour of the countries during the period studied coincides with that indicated in our initial propositions.

By means of a literature review and some empirical estimations, we will offer arguments in support of the following sequence of hypotheses:

- Economic activity impacts on the environment.
- Environmental issues have relevant effects on health conditions.
- Health conditions are a crucial factor in the sustainability of health systems.
- Green investments can relieve environmental issues.
- Green investments can be a help in health systems sustainability.

First, we will present what specialised literature says about these relationships. The review of the literature carried out is not a systematic review. It does not attempt to be considered an exhaustive review of each of the relationships listed above. In this case, each of these relationships has enough content for an independent work in its own right. The intention is merely corroborative and supportive. We will search, in the specialised literature, for arguments that ratify the consistency of relationships stated as intermediate and necessary steps that will take us up to the final one, i.e., the connection of green investments with the sustainability of health systems.

Then, with data provided by the World Bank, we will calculate the Ehrlich and Holdren index for all countries in the world, during the period 1961-2012. This index represents the impact on the environment resulting from economic activity. It combines three variables–the population number, the consumption per capita (affluence), and the technology factor.

Next, by means of a panel data econometric model, we will study the association between this index and mortality rates. In accordance with Amartya Sen (2008), mortality rate will be used as a proxy variable representing the health status of the population.

In our research, we have made a first econometric estimation through panel data techniques, because this technique allows us to deal with two-dimensional (cross sectional / times) series.

As Baltagui explains (2013), these models have some advantages over cross-sectional models or time series, because within them there is no limit to the heterogeneity of the data. Thus, they provide more informative data, more suitability to study the dynamics of change, plus they are better for detecting and measuring some effects, allowing the study of more complex models of behaviour and minimising the bias resulting from the use of total aggregate data. The model utilised in this case would be the following:

$$Y_{it}= \beta_1+ \beta_2 X2it+\beta_3 X_{3it}+\mu_{it} \mid i=1,2,\ldots,N; t=1,2,\ldots,T$$

The estimate would depend on the assumptions we make about the error term. First, we might consider that the coefficients of the slopes of the b variables are constant for all the regressions we calculate in each country, but the independent coefficients, or the intersection, vary for each of these populations, with the subscript being variable, and the model would be the following:

$$Y_{it}= \beta_{1i}+ \beta_2 X_{2it}+\beta_3 X_{3it}+\mu_{it} \mid i=1,2,\ldots,N; t=1,2,\ldots,T$$

This regression model is called fixed effects or least squares dummy variable.

In contrast to this method of calculation, there is another important method called random effects, or error component model. The basic idea of this method is that, instead of considering the constant term fixed for each population or person, there is supposed to be a random variable with mean equal to β1 and a random error term ε_i with a mean value of zero and constant variance. In this way, the intercept value for a single traverse unit (State in this case) is expressed as:

$$\beta_{1i}=\beta_1+\varepsilon_i$$

And the model looks like this:

$$Y_{it}= \beta_1+ \beta_2 X_{2it}+\beta_3 X_{3it}+\varepsilon_i+\mu_{it} = \beta_1+ \beta_2 X_{2it}+\beta_3 X_{3it} +\omega_{it} \mid$$
$$\omega_{it}= \varepsilon_i + \mu_{it}, i=1,2,\ldots,N; t=1,2,\ldots,T$$

where the error term w_{it} would consist of two components, e_i would be the individual specific error component, and m_{it} being the one already discussed that combines time series and cross track error component; hence the name of the error components model, because the model error term has two components (but more components can be considered also, for example, the temporal component).

From these two methods, in accordance with the data we have, the most suitable one for the objectives sought is the fixed effects in which, as we said, the coefficients of the regression equation remain fixed for all countries, but the constant terms are different for each. These different constant terms represent the difference in each country in addressing the studied issue. The reasons for using this calculation procedure and not the random effects model and without biasing the test performed is to ensure the statistical goodness of it. We can specify that we are working with all countries, not with a sample of them.

In our research, we have made a first econometric estimation through panel data techniques, because this technique allows us to deal with two-dimensional (cross sectional / times) series. The data have been collected over time (1961-2012) and for the same individuals (205 countries). In summary, regarding the approach, we chose the fixed effect model because, in our opinion, this is the most adequate one when the interest is only focused on drawing inferences about the examined individuals (countries). This approach assumes that there are unique attributes of individuals (countries) that are not the results of random variation and that do not vary over time.

We will also relate the environmental index with green investments, i.e., investments that enable economic growth and at the same time improve the environment.

By means of the previous relationships, we will discern the impact of green investment on the environmental index and the association of this index with the health of the population.

II. LITERATURE REVIEW

IMPACT OF ECONOMIC ACTIVITY ON ENVIRONMENT

As the United Nations Environment Programme (UNEP) Annual Report (2002) stated, the growing attention to issues of sustainable consumption is a natural outcome of decades of work on cleaner production and eco-efficient industrial systems. It represents the final step in a progressive widening of the horizons of pollution prevention–a widening which has gone from a focus on production processes, to products (eco-design to lower product impacts), then to product-systems (incorporating transport logistics, end-of-life collection and component reuse or materials recycling), and to eco-innovation (new products and product-systems designed for win-win solutions for business and the environment).

Action focused on consumption has highlighted the need to address the creation of new systems of production and consumption, systems that might be truly sustainable, environmentally and economically.

The UN Report includes the consumption equation from Ehrlich and Holdren (Ehrlich and Holdren, 1971). This equation describes the relationship between population, consumption and environmental impact in approximate terms as the following:

$$TEI = P \times UC/pc \times EE^{-1}$$

Where TEI is total environmental impact, P is population, UC/pc is (average) units of consumption of products and services per capita, and EE is the environmental efficiency of the production–use and disposal of those units.

This equation makes it easy to visualise the importance of considering levels of consumption of goods and services (per capita) and the resources used (and waste generated) to produce those goods and services.

It is from such an equation that the concept of *Factor 4* emerges–that is, the level of change in EE that can be achieved through technical and organisational improvements (cleaner production, product re-design, etc.).

If the intent is to reach some specific level of Total Environmental Impact (e.g., for CO2 production) in a given period, then estimates of the likely population growth over that period, as well as the likely rise in the average level of consumption per capita (from development, GDP growth, etc.), will define the factor of improvement in Environmental Efficiency necessary to compensate for this rise.

Factor X and dematerialisation are two relevant concepts also included in this UNEP Report.

This technical improvement in the environmental/resource efficiency of production and products is encapsulated in two widely used concepts: Factor 4 (also Factor 10, Factor 20, etc.) (Weizsäcker, Lovins, Lovins, 1998) and dematerialisation.

Factor 4 refers to cutting in half the total material input into the economy while doubling wealth and welfare.

Dematerialisation is more a general approach which proposes a progressive and significant reduction in material throughput in the economy, i.e., reducing material flows in production and products, while maintaining (or increasing) value.

Both of these concepts suggest a shift in the economy towards an increasing value for natural capital: "Natural capital includes all the familiar resources used by mankind: water, minerals, oil, trees, fish, soil, air… it also encompasses living systems." (Weizsäcker, Lovins, Lovins, 1998).

"Dematerialisation" and "factor X", like the umbrella term "eco-efficiency" are strategies for dissociating the economy from resource-use and waste-production.

After the initial formulation of the consumption equation, it was better known under a different formula, the IPAT equation. This equation represents environmental impact, (I), as the product of three variables, (1) population, (P); (2) affluence, (A); and (3) technology, (T). The IPAT equation and related formulas were born, along with the modern environmental movement, circa 1970.

IPAT is an identity simply stating that environmental impact (I) is the product of population (P), affluence (A), and technology (T).

$$I = PAT$$

Although generally credited to Ehrlich, Commoner also plays an important role in the formulation of the IPAT equation. Commoner's work in his popular 1974 book, *The Closing Circle* [Commoner, Corr, and Stamler (1971)], became the first to apply the IPAT concept with mathematical rigour.

In order to make the three factors that influence I, environmental impact, operational, Commoner defined I as "the amount of a given pollutant introduced annually into the environment." His equation, published in a 1972 conference proceedings (Commoner, 1972), is the following:

$$I = Population \times \frac{Economic\ good}{Population} \times \frac{Pollutant}{Economic\ good}$$

Used in this way, the equation takes on the characteristics of a mathematical identity. On the right-hand side of the equation, the two Populations cancel out, the two Economic goods cancel out, and what remains is: I = Pollutant.

$$I = \cancel{Population} \times \frac{\cancel{Economic\ good}}{\cancel{Population}} \times \frac{Pollutant}{\cancel{Economic\ good}}$$

His main value, then, is to estimate the contribution of each of the three terms to total environmental impact.

Pollution = (population) × (production/capita) × (pollution emission/ production)

The concepts of the IPAT equation are at the core of the emerging field of industrial ecology in the 90's. Industrial ecology has been described as the "marriage of technology and ecology" and examines, on the one hand, the environmental impacts of the technological society, and, on the other hand, the means by which technology can be effectively channelled towards environmental benefit (Graedel, Allenby, 1995, Graedel, 2000).

In conclusion, this equation and its different interpretations underline the relevant impact of economic activity on environment. Technology, although associated with both disease and cure for environmental harm, is a critical factor in environmental improvement (Chertow, 2000). This emphasises the role of innovation (technological and social) in improving environment.

Regarding the role of service activities, the EIPRO project (Environmental Impacts of Products) reflects the concern about the impact of products on the environment in the framework of the EU-25. In June 2003 the European Commission adopted a Communication on Integrated Product Policy (IPP). The idea behind this policy is to reduce the environmental impacts of products and services throughout their life cycles (European Commission, 2003). The EIPRO Report (2006) pointed out that shifting from a "material society" to a "service society" in itself may not be the panacea it is sometimes thought to be. It shows that there are many service-related categories (healthcare, restaurants, etc.) among the top 60-percentiles of environmental impacts. This reflects that what is sold as a service is, in most cases, an "envelope" around a set of products generated *via* a life cycle of very material-oriented production processes.

Nevertheless, the three main priorities–housing, transport, and food–are responsible for 70 % of the environmental impacts in most categories, although accounting for only 55 % of the final expenditure in the 25 countries that currently make up the EU. At a more detailed level, priorities are car and most probably air travel within transport, meat and dairy within food, and building structures, heating, and (electrical) energy-using products within housing. Expenditures on clothing, communication, health care, and education are considerably less important (Tukker and Jansen, 2006).

The transition to a low-carbon economy is more and more urgent in specifically addressing climate change, one of the main manifestations of environmental damage. Even more than facilitating climate action, aligning all policies with a low-carbon economy can contribute to a broader reform agenda for greener, more resilient and inclusive growth, including more progressive tax codes, pro-growth long-term infrastructure investment, and energy and transport systems that support cleaner air, better health and a more diversified energy supply. Thus, the low-carbon economy strategy reinforces some of the intermediate goals to achieve the healthcare systems sustainability, more pro-growth long-term infrastructure investment, and energy and transport systems that support cleaner air and better health.

IMPACT OF ENVIRONMENTAL ISSUES ON HEALTH CONDITIONS

In 1974 the Lalonde report *A New Perspective on the Health of Canadians* (Canadian Government, 1981) pointed out the existence of the so-called counter-forces which constitute the dark side of economic progress. They include environmental pollution, city living, habits of indolence, the abuse of alcohol, tobacco and drugs, and eating patterns. The report emphasised that physicians, surgeons, nurses and hospitals together spend much of their time in treating ills caused by adverse environmental factors and behavioural risks. It confirmed that self-imposed risks and the environment are the principal or most important underlying factors in each of the five major causes of death between age one and age seventy. So, unless the environment is changed and the self-imposed risks are reduced, the death rates will not be significantly improved. It presented the first proofs and measures on the total effect of air pollution on health, establishing a direct cause-and-effect relationship between air pollution and sickness.

The report introduced the term "Health Field". The term "health care system" is limited to the system by which personal health care is provided. The term "health field" is much broader and includes all matters affecting health. Health field can be broken down into four broad elements: human biology, environment, lifestyle, and health care organisation. These components have different importance in relation to the major problems of health: human biology (27 %), *environment* (19 %), lifestyle (43 %), and health care organisation (11 %).

The environment category includes all those matters related to health which are external to the human body and over which the individual has little or no control. Individuals cannot, by themselves, ensure that foods, drugs, cosmetics, devices, water supply, etc., are safe and uncontaminated; that the health hazards of air, water and noise pollution are controlled; that the spread of communicable diseases is prevented; that effective garbage and sewage disposal are carried out; and that the social environment, including the rapid changes in it, do not have harmful effects on health.

The Lalonde approach can be considered innovative because it includes some social determinants of health into the concept of environmental conditions. In this sense it referred to economic deprivation, social change, new technologies, and the pursuing of private pleasure instead of common good.

Finally, it concludes that future improvements in the level of health of Canadians lie mainly in improving the environment, moderating self-imposed risks, and adding to our knowledge of human biology.

With Lalonde's Report a new line of research was opened and it continues nowadays. Currently, the World Health Organisation (WHO) promotes a number of studies on the relationship between environment and health.

Outdoor air pollution is a major environmental health problem affecting everyone in developed and developing countries alike. WHO estimates that some 80 % of outdoor air pollution-related premature deaths were due to ischemic heart disease and strokes, while 14 % of deaths were due to chronic obstructive pulmonary disease or acute lower respiratory infections; and 6 % of deaths were due to lung cancer.

Some deaths may be attributed to more than one risk factor at the same time. For example, both smoking and ambient air pollution affect lung cancer. Some lung cancer deaths could have been prevented by improving ambient air quality, or by reducing tobacco smoking.

An assessment by WHO's International Agency for Research on Cancer (IARC) (2013) concluded that outdoor air pollution is carcinogenic to humans, with the particulate matter component of air pollution most closely associated with increased cancer incidence, especially cancer of the lungs (Raaschou-Nielsen *et al.*, 2013). An association also has been observed between outdoor air pollution and increase in cancer of the urinary tract/bladder.

Ambient (outdoor air pollution) in both cities and rural areas was estimated to cause 3.7 million premature deaths worldwide per year in 2012; this mortality is due to exposure to small particulate matter of 10 microns or less in diameter (PM), which cause cardiovascular and respiratory disease, and cancers.

People living in low- and middle-income countries disproportionately experience the burden of outdoor air pollution with 88 % (of the 3.7 million premature deaths) occurring in low- and middle-income countries, and the greatest burden in the WHO Western Pacific and South-East Asia regions.

The latest burden estimates reflect the very significant role air pollution plays in cardiovascular illness and premature deaths– much more so than was previously understood by scientists.

Most sources of outdoor air pollution are well beyond the control of individuals and demand action by cities, as well as national and international policymakers, in sectors like transport, energy waste management, buildings, and agriculture.

In addition to outdoor air pollution, *indoor smoke* is a serious health risk for some 3 billion people who cook and heat their homes with biomass fuels and coal. Some 4.3 million premature deaths were attributable to household air pollution in 2012. Almost that entire burden was in low-middle-income countries as well.

The "WHO Air quality guidelines" (2006) offer global guidance on thresholds and limits for key air pollutants that pose health risks. The Guidelines apply worldwide and are based on expert evaluation of current scientific evidence for the following:

– particulate matter (PM)
– ozone (O)
– nitrogen dioxide (NO)
– sulphur dioxide (SO), in all WHO regions.

The OECD Environmental Outlook to 2050 (2012b) pointed out some environmental issues that are not well managed, are in a bad or worsening state, and which require urgent attention:

– Substantial increase in SO2 and NOx emissions in key emerging economies.
– Increase in premature deaths linked to urban air pollution (particulates and ground-level ozone).
– High burden of disease from exposure to hazardous chemicals, particularly in non-OECD countries.

The paper from Lim *et al.* published in (2012) estimated deaths and disability-adjusted life years (DALYs, sum of years lived with disability [YLD], and years of life lost [YLL]) attributable to the independent effects of 67 risk factors and clusters of risk factors for 21 regions in 1990 and 2010. They estimated exposure distributions for each year, region, sex, and age group, and relative risks per unit of exposure, by systematically reviewing and synthesising published and unpublished data. They used these estimates, together with estimates of cause-specific deaths and DALYs from the Global Burden of Disease Study 2010, to calculate the burden attributable to each risk factor exposure compared with the theoretical-minimum-risk exposure. These calculations incorporated uncertainty in disease burden, relative risks, and exposures into estimates of attributable burden.

Among other findings this article highlights that in 2010 the three leading risk factors for global disease burden were high blood pressure (7.0 % [95 % uncertainty interval 6.2–7.7] of global DALYs), tobacco smoking including second-hand smoke (6.3 % [5.5–7.0]), and alcohol use (5.5 % [5.0–5.9]). In 1990, the leading risks were childhood underweight (7.9 % [6.8–9.4]), household air pollution from solid fuels (HAP; 7.0 % [5.6–8.3]), and tobacco smoking including second-hand smoke (6.1 % [5.4–6.8]). However, in most of sub-Saharan Africa, childhood underweight, household air pollution, and non-exclusive and discontinued breastfeeding were the leading risks in 2010, while household air pollution was the leading risk in south Asia.

Although, fortunately, both risk factors related to air pollution (Household Air Pollution and Ambient Particulate Matter Pollution) show a decreasing trend between 1990 and 2010, these two factors in sum represent in 2010 13.6 % of total global disability-adjusted life-years lost.

Air pollution is already known to increase risks for a wide range of diseases, such as respiratory and heart diseases. Studies indicate that in recent years exposure levels have increased significantly in some parts of the world, particularly in rapidly industrialising countries with large populations. The most recent data indicate that 223,000 deaths from lung cancer worldwide resulted from air pollution[3] in 2010.

The specialised cancer agency of the World Health Organization, the International Agency for Research on Cancer (IARC), announced in 2013 that it had classified outdoor air pollution as carcinogenic to humans[4]. After thoroughly reviewing the latest available scientific literature, the world's leading experts convened by the IARC Monographs Programme concluded that there is sufficient evidence that exposure to outdoor air pollution causes lung cancer. They also noted a positive

3 http://www.iarc.fr/en/publications/books/sp161/index.php
4 The summary evaluation was published by The Lancet Oncology online on Thursday, 24 October, 2013.

association with an increased risk of bladder cancer. Particulate matter, a major component of outdoor air pollution, was evaluated separately and was also classified as carcinogenic to humans.

Volume 109 of the IARC Monographs evaluations is based on the independent review of more than 1000 scientific papers from studies on five continents. The reviewed studies analyse the carcinogenicity of various pollutants present in outdoor air pollution, especially particulate matter and transportation-related pollution. The evaluation is driven by findings from large epidemiologic studies that included millions of people living in Europe, North and South America, and Asia (Loomis *et al.*,2013).

In 2004, after the recognition that air pollution might have an impact on cardiovascular disease, the UK Department of Health asked the Committee on the Medical Effects of Air Pollutants (COMEAP) to advise on the possible effects of outdoor air pollutants on cardiovascular disease in the UK. The Committee formed a Sub-Group which reviewed the literature in detail and drafted a report. The Committee on the Medical Effects of Air Pollutants undertook an extensive review of the evidence for these effects, to assess possible mechanisms and identify areas for future research. In 2006, eighteen months later, it published a report in which the state of the art in all respects was presented–short and long terms effects as well as the confirmation that modest reductions in exposure will result in significant health gains.

The principal conclusions of the report are that clear associations have been reported between both daily and long-term average concentrations of air pollutants and effects on the cardiovascular system, reflected by a variety of outcome measures including risk of death and of hospital admissions; these associations are likely to be causal in nature; and, although it is not possible to be certain which components of the ambient pollution mixture are responsible for these effects, it is likely that fine particles play an important role (Straif, Cohen, Samet, 2013).

Another relevant environmental issue related to health is the exposure to chemical pollutants, the so called endocrine disrupters. The 2013 Berlaymont Declaration on Endocrine Disrupters[5] expressed the concern of 89 scientists actively engaged in endocrine disrupter research. This Declaration gathers the conclusions of the scientific convention

5 The 2013 Berlaymont Declaration on Endocrine Disrupters. (89 signatories) Available at http://www.ipcp.ch/IPCP_Berlaymont.html.

organised by the European Commission to discuss forthcoming policy initiatives for endocrine disrupters.

The Declaration confirms the concern about the prevalence increase of endocrine-related diseases, higher than it has ever been. The disease burden continues to increase in the EU and globally. Evidence is strengthening that environmental factors, including chemical exposures, play a role in these phenomena.

Some recent reports–from the European Environment Agency, a European Commission funded report, and an assessment conducted under the auspices of the World Health Organisation and the United Nations Environmental Programme[6]–have pointed out the incremental prevalence of endocrine-related diseases in the European Union and globally:

- In some EU Member States, large proportions of young men have semen quality so poor that it will seriously affect their chances of siring children.
- There is a dramatic rise in breast cancer in Eastern and Southern European EU Member States.
- With the exception of high prevalence countries such as The Netherlands and Austria, all EU countries are experiencing strong rises in prostate cancer. Similar trends exist for other hormonal cancers, including those of the testes, endometrium, ovaries, and thyroid.
- Neurobehavioural disorders, and thyroid diseases and disorders affecting brain development, represent a high and increasing paediatric disease burden in countries where these disease trends have been followed.
- The prevalence of obesity and its comorbidity factors, type 2 diabetes and metabolic syndrome have increased dramatically in almost all EU Member States.

6 European Environment Agency [2012], *The impacts of endocrine disrupters on wildlife, people and their environment*, the Weybridge +15 report. http://www.eea.europa.eu/publications/the-impacts-of-endocrine-disrupters – Kortenkamp A., Martin, O., Faust M., Evans R., McKinlay R., Orton F., Rosivatz E. [2012], *State of the art assessment of endocrine disrupters*, DG Environment project contract number 070307/2009/550687/SER/D3. http://ec.europa.eu/environment/chemicals/endocrine/pdf/sota_edc_final_report.pdf – UNEP WHO [2013], *State of the science of endocrine disrupting chemicals – 2012*, (Editors: Bergman A., Heindel J.J., Jobling S., Kidd K.A., Zoeller R.T. http://www.unep.org/pdf/9789241505031_eng.pdf

Finally, these scientists call on the European Commission to implement a regulatory regime that classifies endocrine disrupters by using weight-of-evidence approaches and to develop a targeted research strategy for endocrine disrupting chemicals (EDCs) as part of Horizon 2020.

In economics terms, the cost of air pollution has been estimated by the OECD (OECD, 2014). The cost of the health impact of outdoor air pollution in OECD countries, both deaths and illness, was about USD 1.7 trillion in 2010. Available evidence suggests that road transport accounts for about 50 % of this cost, or close to USD 1 trillion. The economic cost of the health impacts of outdoor air pollution in China and India combined is larger than the OECD total–about USD 1.4 trillion in China and about USD 0.5 trillion in India in 2010. There is insufficient evidence to estimate the share of road transport in these figures, but even if it is less than half, it nonetheless represents a large burden.

HEALTH SYSTEMS SUSTAINABILITY AND HEALTH CONDITIONS

In accordance with the Ladonde Report (1974), economic progress has brought to us an evident improvement in the health status of the population, but also some problems such as environmental pollution, city living, habits of indolence, the abuse of alcohol, tobacco and drugs, and non-desirable eating patterns. These counterforces have been at work to undo progress in raising the health status. Thus, they constitute the dark side of economic progress.

Nevertheless, from a different point of view, health is not just a value in itself. It is also a driver for growth. Only a healthy population can achieve its full economic potential. The health sector is driven by innovation and a highly qualified workforce. The healthcare sector is one of the largest in the EU. It accounts for approximately 10 % of the EU's gross domestic product and employs one in ten workers, with a higher than average proportion of workers with a tertiary-level education.

Health therefore plays an important role in the Europe 2020 agenda. In its Communication (European Commission, 2011b) of 29 June 2011 "A budget for Europe 2020" the Commission stressed that "promoting good health is an integral part of the smart and inclusive growth objectives for Europe 2020. Keeping people healthy and active for longer has a positive impact on productivity and competitiveness. Innovation in healthcare helps take up the challenge of sustainability in the sector in the context of demographic change", and action to reduce inequalities in health is important to achieve "inclusive growth".

All these reasons explain why, from the public and institutional perspective, sustainability of health systems is a permanent concern. The financial crisis has further highlighted the need to improve the cost-effectiveness of health systems. Member States are under pressure to strike the right balance between providing universal access to high-quality health services and respecting budgetary constraints.

In this context, the European Commission considers that supporting Member States' efforts to improve the sustainability of their health systems is crucial to ensure their ability to provide high quality healthcare to all their citizens now and in the future. And, with this aim, in 2011 it launched the Health for Growth Programme (2011b). This Programme has four objectives and three of them maintain a close alignment with our hypotheses. They are to encourage innovation in healthcare, to increase the sustainability of health systems, to improve the health of EU citizens, and to protect citizens from cross-border health threats.

In this line, the Budget for Europe 2020 assigns the funding distribution for the health objectives (€2.75 billion). Most of the financial resources go to the Food Safety Programme (€ 2.2 billion), clearly oriented to cope with health problems derived from endocrine disrupting chemicals.

Not only are there institutional instances where concern is shown about sustainability of healthcare systems, but also private economic agent are alarmed about this worry. The World Economic Forum (WEF, 2013a) considers that health systems sustainability is unlikely to be achieved through incremental changes. Instead, transformative solutions will be needed–solutions that require cooperation across industry sectors and governments, and thereby challenge the current boundaries of healthcare.

The WEF Report stresses the differences between "healthcare system" and "health system". Both are often used interchangeably, but there is an important distinction between them. The healthcare system describes the institutions, facilities, and actors involved in delivering healthcare services. This report refers to healthcare system activities as supply-side. The health system denotes a much wider range of institutions and actors beyond the traditional so-called health sector, including actors who directly or indirectly influence and affect health in a society (e.g., food and beverage companies).

The health system is regarded as having a more balanced focus on both supply and demand, with demand referring to policies and services aimed at encouraging healthy lifestyles and preventing disease. Pushing the boundaries of the healthcare system to include a wider ecosystem of influences on health pushes stakeholders to better consider the demand side and questions the way in which governance of health is currently organised.

That demand side perspective is crucial for our aim in warning about the impact of environment on health and health systems sustainability.

The Forum explored the fundamental influences on healthcare expenditure, creating a simple conceptual model of demand and supply elements.

Growing demand for healthcare is driven primarily by four factors: an ageing population, an explosion of so-called lifestyle diseases, a rise in public expectations, and a lack of value-consciousness among healthcare consumers.

On the supply side, the cost of care continues to rise, while resources are not allocated in the best way. The rise in unit costs is driven by the advent of new therapies and technologies, together with innovative strategies that focus on better outcomes rather than lower costs. This is compounded by poor allocation of resources in a healthcare delivery system often closed to change (because of vested interests), and an incentive structure that does not always reward value creation.

With the aim of identifying critical uncertainties, by means of interviews with experts, the Forum identified 20 drivers of change for health systems grouped into five dimensions. One of these five dimensions was the "environmental", and it includes four key drivers: climate change, pollution and toxicity, incidence of infectious diseases, and population sanitation.

Health systems sustainability concern has also been treated from a more theoretical Economics perspective. The apparently unrelenting growth in the GDP-share of health spending (SHS) has been a recurrent issue of policy concern. Recent studies raise the question about the existence of an equilibrium limit (Ehrlich, Yin, 2013). This issue has been left open in the latest dynamic models, which take income growth and population aging as given (Hall, Jones, 2007). Ehrlich and Yin developed a human capital-based endogenous growth model treating these variables as endogenously determined. Their model expands the basic elements of the endogenous growth models of Lucas (1988), Becker *et al.* (1990), and especially Ehrlich and Lui (1991) and Ehrlich and Kim (2007) to integrate health and life expectancy as a basic endogenous variable in addition to fertility and human capital formation.

The conclusion of their analysis also puts an emphasis on investments in children's survival to adulthood as yielding high social return because they protect, and thus induce, investments in the knowledge component of human capital, which promotes economic growth. By the same token, policies that induce larger investment in education increase the motivation to protect this investment by investing in life protection and adopting a healthier lifestyle, which promotes the probability of survival to older age. By contrast, the analysis indicates the limitations of health financing policies that encourage the use of remedial care services covered by reimbursement insurance policies. These policies encourage excessive use of remedial medical services at the expense of the more individually and socially productive life protection and preventive medical care.

Although health issues generate direct costs for healthcare systems, most studies calculate the economic burden of illnesses in terms of value of a statistical life. This methodology is based on the sum of money each individual is willing to pay for a given reduction in the risk of premature death, for example from diseases linked to air pollution. An OECD study (2012a) carried out a meta-analysis that analyses the largest database to date containing all Stated Preferences studies that have been prepared around the world and that estimate adult value of a statistical life (VSL) in environmental, health and transport risk contexts. This study proposes a range for the average adult VSL for OECD countries of USD (2005-USD) 1.5 million-4.5 million, with a base value of USD 3 million. For EU-27, the corresponding range is USD 1.8 million-5.4 million (2005-USD), with a base value of USD 3.6 million. Adjustments for VSL in specific countries should be applied with the difference in Gross Domestic Product (GDP) per capita to the power of an income elasticity of VSL of 0.8. The results achieved by the

OECD showed rather a large range for VSL estimates according to risk category, environmental, health, or traffic accident. Higher values of VSL have been obtained for environmental and traffic risks. Nevertheless, among these three categories of risks, median values are more similar than average values, indicating a greater dispersion in values obtained from environmental and traffic contexts.

IMPACT OF GREEN INVESTMENTS ON ENVIRONMENT

In 2012, the OECD published a definitional paper (Inderst, Kaminker, Stewart, 2012) that aims to provide a comprehensive review of the concepts and definitions related to "green" investments (also variously referred to as "clean", "sustainable", and "climate change" investments) that are currently used. The paper examines how "green" investments are defined across different asset classes (equities, bonds and alternative investments), as well as providing some estimates of the size of these investments. The paper concludes that, given the lack of consensus on the usage and definition of the term "green", the most productive approach could be to take an open and dynamic attitude towards definitions and standards, with international institutions and governments adopting a "governance approach to green investment". That open and dynamic approach to definitions and standards would be more effective for some strategies (i.e. green growth, climate change policy, etc.). The science and the general understanding of the environment, climate change, and resource scarcity are evolving as are clean technologies, which are being developed and scaled-up to deal with these challenges.

Green "investment" is a very broad term. It can be stand-alone, a sub-set of a broader investment theme or closely related to other investment approaches such as SRI (socially responsible investing), ESG (environmental, social and governance investing), sustainable, long-term investing, or similar concepts.

As an example, the IMF has provided a macroeconomic definition of green investment. A recent IMF Working Paper by Eyraud *et al.* (2011) refers to green investment as "the investment necessary to reduce greenhouse gas and air pollutant emissions, without significantly reducing the production and consumption of non-energy goods". It covers both public and private investment. There are three main components of green investment. These are low-emission energy supply (including renewable energy, bio fuels and nuclear), energy efficiency (in energy supply and energy-consuming sectors), and carbon capture and sequestration (including deforestation and agriculture).

Investors' attention to climate change, resource efficiency and green issues in general, has been rising in recent years and investor initiatives in this respect are growing in support. The paper provides some indications on the market volume of green investments. It is important to note that green investment has traditionally been mostly embedded within a broader approach. In fact, the current investment volumes in ESG/SRI assets, estimated at over USD 10 trillion, are a multiple of those in "pure" green investments (estimated in the tens or hundreds of billions, depending on the definition).

In recent years, the debate has not been focused on the impact of green investment on the environment. Instead, green investments are considered to be the only ones viable for achieving economic growth. Economic growth and sustainability are interdependent–you cannot have one without the other–and greening investment is the prerequisite to realising both goals.

Dramatic upgrades in technology, skills, policies and business models, along with an aligned public consciousness, are needed for the transition to a green growth pathway. Infrastructure investment required for sectors such as agriculture, transport, power and water under current growth projections stands at about US$ 5 trillion per year to 2020 (WEF, 2013b). Additional investment needed to meet the climate challenge–for clean energy infrastructure, sustainable transport, energy efficiency and forestry–is about US$ 0.7 trillion per year.

Considerable progress has been made in transitioning to green growth. Global investment in renewable energy in 2011 hit another record; up 17 % in 2010 to US$ 257 billion. This represented a six-fold increase from 2004 and was 93 % higher than in 2007, the year before the global financial crisis. Global agricultural productivity growth rates are exceeding overall population growth rates, and, since 1990, more than 2 billion people have gained access to improved drinking water sources. Energy efficiency is widely recognised as providing economic opportunities and improved environmental security, while the fuel efficiency of vehicles has more than doubled since the 1970s.

Such progress, however, remains inadequate. Progress in green investment continues to be outpaced by investment in fossil-fuel intensive, inefficient infrastructure. The challenge will be to enable an unprecedented shift in long-term investment from conventional to green alternatives to avoid locking in less efficient, emissions-intensive technologies for decades to come.

The Green Investment Report (WEF,2013b) introduces several interesting definitions related to our objectives:

– Green growth: growth that eradicates poverty and reduces inequality, while combating climate change and respecting a range of other planetary boundaries.
– Green investment: a broad term closely related to other investment, approaches such as socially responsible investing (SRI) and sustainable, long-term investing. As in the case of most green investment, it is necessary to retrofit existing infrastructures and develop new ones.
– Infrastructure can be defined as the basic physical and organisational structures and facilities needed to operate a society or enterprise that enables economic growth and facilitates the everyday life of citizens. Infrastructure can refer to transport (vehicles, roads, rail), water, energy, and telecommunications.
– Green infrastructure: infrastructure that enables economic growth and at the same time improves the environment (quality of air, health of citizens), helps conserve natural resources, reduces emissions, and enables adaptation to climate change. Green infrastructure could include renewable and low-carbon power plants, sustainable and low-carbon vehicles and transport, and energy-efficient, climate-resilient buildings.

From a perspective more focused on health, the report *Transport for Health: The Global Burden of Disease from Motorized Road Transport* (Global Road Safety Facility, 2014) underscores the urgent need for green investments to spread improvements in transport pollution and safety across world regions. Road injuries now rank as the world's eighth-leading cause of death and the number-one killer of young people ages 15 to 24.

Pollution from vehicles is the cause of 184,000 deaths globally, including 91,000 deaths from ischemic heart disease, 59,000 deaths from stroke, and 34,000 deaths from lower respiratory infections, chronic obstructive pulmonary disease, and lung cancer. While the disease burden attributed to ambient air pollution has declined among richer regions such as Western Europe and North America, over the last 20 years it has risen sharply in South Asia and East Asia.

The report concludes that road injuries are a major contributor to the Global Burden of Disease. Thus, rapidly scaling up road safety programs alongside the expansion of transport is vital for saving lives while promoting development. Mitigating the health risks requires a long-term investment strategy to build the capacity of national institutions, so they can actively manage safety and mobility performance through targeted interventions. Its final recommendation is a systematic approach and a long-term investment strategy, rather than isolated efforts with specific interventions.

Housing is another field in which green investments are needed. Residential buildings contributed close to 18 % of direct carbon dioxide emissions from energy combustion in 2008, with 11 % due to household use of grid electricity and district heating, and the remainder due to emissions at household level (e.g. cooking and heating with gas, coal, oil, etc.) (WHO, 2011). At the same time, indoor smoke from solid fuel combustion is the eighth most important risk factor in burden of disease and is responsible for 2.7 % of the global burden of disability-adjusted life years (WHO,2004).

Savings from system-wide efficiency gains from green investment are estimated in 450 billion USD or a 14 % in potential (Kennedy, and Corfee-Morlot, 2013). So USD 44 trillion additional investments to decarbonise the energy system in line with international climate goals will yield savings of USD 71 trillion by 2050 (International Energy Agency, 2014).

Recent international reports have recognised the insufficient volume of green investments, and a debate about the reasons has been opened. Regarding solar and wind energy international investment, the focus of this analysis has been put on "local-content requirements". Through the last two decades, most governments in developed countries have incentivised green investments in the solar-photovoltaic and wind-power industries but accompanied with the rise of local-content requirements to support local growth and employment.

Now, in a post-crisis recovery context and in a context of global value chains, new empirical evidence shows that local-content requirements can hamper international investment in solar- and wind-energy generation in the country that adopts them and globally as well. In addition, local-content requirements have mixed or negative impacts on local job creation, value added and technology transfer in solar photovoltaic and wind energy when the full value chain is taken into account. To avoid negative impacts, policy makers should design domestic incentive measures that do not differentiate between domestic and international investors (OECD, 2015).

The low-carbon transition strategy also shows an insufficient amount of investment to achieve a global infrastructure and technological transformation. It will require the mobilising of all sources of public and private sector investment and finance, including institutional investors. Governments need to use their scarce resources to trigger large-scale private sector investment in activities otherwise unlikely to attract sufficient private funding.

USD 93 trillion in assets were held by institutional investors such as insurance companies, investment funds and pension funds in OECD countries in 2013; and only 1 % of large pension fund assets were allocated directly to infrastructure projects of all types in 2013. Allocation to green infrastructure investment was estimated to be much smaller, at only 3 % of that 1 % share (OECD, 2015c).

The International Energy Agency (IEA) (2014) estimates that a cumulative investment of USD 53 trillion in energy supply and efficiency will be needed by 2035 to achieve the goal of keeping global warming below 2ºC. This is only about 10 % more than the USD 48 trillion that would be needed in the sector irrespective of climate change.

There are different sources of traditional financing for infrastructure green investments: governments, companies, households, banks and other financial institutions, and financial markets. Although the public sector has traditionally taken the lead in long-term investment in public goods, particularly in infrastructure projects, most OECD governments have had to tighten their budgets in the aftermath of the 2008 financial crisis, and Public investment per capita in 2012 fell in 15 out of 33 OECD countries, compared to 2007.

Currently there are a number of misalignments in policy domains, such as finance, taxation, trade policies, and innovation, as well as in three specific sectors: electricity, urban mobility, and land-use. The key message in this transition is the urgent necessity to align all policies in scaling up finance for long-term investment in infrastructure and shifting investments towards low-carbon alternatives (OECD, 2015a).

Finally, after reviewing the evidence shown by the literature, it is appropriate to point out again the critical points of this research. The remaining problem is the permanent financial difficulties and the threat to health systems' sustainability induced by an excess in the healthcare demand, which in turn generates a growing supply of more and more expensive services. Despite the strength of the arguments and conclusions reached in the above studies, it is not possible to observe a strong and determined commitment to green investments, with a sufficient importance to allow for the qualification of the phenomenon as a process of radical innovation.

III. RESULTS

A way to connect environmental problems and their root causes, according to the aforementioned IPAT equation, would be through the above scheme to make environmental degradation dependent on the number of people, the average of resources used by each person (measured by the GDP per capita) and the amount of environmental pollution per unit of resource (which could be measured by the number of tons of CO2 per capita released into the atmosphere). Thus, in developing countries, the size of the population and the resulting degradation are often the most decisive factors. However, in developed countries, the main components are the high level of resource utilisation and the pollution generated.

With data provided by the World Bank, we have calculated the Ehrlich and Holdren index for all countries in the world (1961-2012). Then we compared the results, country by country, with mortality rates and R&D investments. Mortality rates, according to Amartya Sen (Sen and Kliksberg, 2008), give the best picture of health and disease levels in a population. We have also employed R&D investments in our comparison to reflect the efforts made by economic agents to improve the situation, by putting technological innovations in the service of sustainability.

We have made a first econometric estimation through panel data techniques. For this we used the data provided by the World Bank, from 1961 until 2012, such as GDP per capita, total tons of greenhouse gases that are released into the atmosphere per unit of consumption and total population, for each of the 205 countries registered. With these three variables, and following the Ehrlich and Holdren design, an index of environmental impact was built. Once this index was developed, we built a first model to analyse the relationship between the environmental impact index and mortality rates. This model ratifies a positive and significant relationship between index environmental impact and the mortality rate, indicating the harm that environmental damage is causing on mortality.

Dependent Variable: MORTALITY				
Method: Panel Least Squares				
Sample (adjusted): 1961 2012				
Periods included: 52				
Cross-sections included: 205				
Total panel (unbalanced) observations: 8368				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
INDEX_IMPACT	4.17E-10	1.26E-10	3.318459	0.0009
C	9.995998	0.027939	357.7751	0.0000
	Effects Specification			
Cross-section fixed (dummy variables)				
Period fixed (dummy variables)				
R-squared	0.840410	Mean dependent var		10.03761
Adjusted R-squared	0.835373	S.D. dependent var		5.628845
S.E. of regression	2.283865	Akaike info criterion		4.519846
Sum squared resid	42307.29	Schwarz criterion		4.735820
Log likelihood	-18654.04	Hannan-Quinn criter.		4.593604
F-statistic	166.8470	Durbin-Watson stat		0.180549
Prob(F-statistic)	0.000000			

FIG. 2 – Mortality Model.

This model ratifies the impact of resource consumption on the environment and also the effects of the environment on health, as established in the literature.

In a second estimate, we analysed the relationship between the calculated environmental impact index and global investments in R&D. In accordance with the definition given by the WEF (2013b), R&D investments has been utilised as proxy variable of green investment, understood in a broad sense.

Dependent Variable: RSDV				
Method: Panel Least Squares				
Sample (adjusted): 1961 2012				
Periods included: 52				
Cross-sections included: 205				
Total panel (unbalanced) observations: 8368				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
INDEX_IMPACT	2.82E-10	2.14E-11	13.19228	0.0000
C	0.113991	0.004754	23.97937	0.0000
	Effects Specification			
Cross-section fixed (dummy variables)				
Period fixed (dummy variables)				
R-squared	0.416135	Mean dependent var		0.142141
Adjusted R-squared	0.397707	S.D. dependent var		0.500709
S.E. of regression	0.388588	Akaike info criterion		0.977634
Sum squared resid	1224.763	Schwarz criterion		1.193608
Log likelihood	-3833.422	Hannan-Quinn criter.		1.051392
F-statistic	22.58170	Durbin-Watson stat		0.453008
Prob(F-statistic)	0.000000			

FIG. 3 – Research and Development Investments Model.

These results indicate that a positive and significant relationship is also observed, between these two variables. Thus, in general, those countries with greater environmental problems allocate more resources in R&D investments.

The consistency of this relationship has been proved by means of a co-integration analysis. Since the low p-values were obtained, the panel unit root tests did not indicate the presence of unit roots. Therefore, the null hypothesis of no co-integration of the variables within each country and over time is rejected with a confidence level of 95 %. Because the presence of co-integrated variables is observed, we can say that this relationship is compact in the long term and not spurious.

Panel unit root test: Summary				
Series: D(MORTALITY)				
Sample: 1960 2013				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 9				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin and Chu t*	-236.580	0.0000	202	10406
Null: Unit root (assumes individual unit root process)				
ADF – Fisher Chi-square	6340.80	0.0000	202	10406
PP – Fisher Chi-square	7070.83	0.0000	202	10504
Panel unit root test: Summary				
Series: D(INDEX_IMPACT)				
Sample: 1960 2013				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 10				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				

Levin, Lin and Chu t*	-58.8170	0.0000	193	7460
Null: Unit root (assumes individual unit root process)				
ADF – Fisher Chi-square	3497.17	0.0000	193	7460
PP – Fisher Chi-square	4825.51	0.0000	193	7665
Panel unit root test: Summary				
Series: RESID				
Sample: 1960 2013				
Exogenous variables: Individual effects				
Automatic selection of maximum lags				
Automatic lag length selection based on SIC: 0 to 8				
Newey-West automatic bandwidth selection and Bartlett kernel				
Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin and Chu t*	-7.02438	0.0000	204	8029
Null: Unit root (assumes individual unit root process)				
ADF – Fisher Chi-square	599.821	0.0000	204	8029
PP – Fisher Chi-square	631.944	0.0000	204	8150

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

FIG. 4 – Unit Root tests (mortality/Impact index).

Once having ratified the existence of a positive relationship between the environment index and mortality rates, our main concern is to quantify the effect of green investments on health systems sustainability, i.e., a quantification of healthcare costs reductions derived from the use of a technology with a higher level of eco-efficiency.

We based our analysis on two main environmental issues, air pollution and endocrine disrupting chemicals. The relationship between health systems sustainability and environment improvements is totally circular. Environmental improvements reduce premature deaths and health costs, and funds liberated from healthcare can be dedicated to green investments.

The economic analysis works with data obtained from the literature review carried out in the previous section.

Economic cost of diseases can be calculated by two different methodologies. The first one is based on determining the theoretical value of DALYs lost due to environmental causes. The second one is based on computing the healthcare costs, direct plus indirect.

The literature estimates that additional investment needed to meet the climate challenge—for clean energy infrastructure, sustainable transport, energy efficiency and forestry—is about US$ 0.7 trillion per year.

Furthermore, in accordance with the Global Burden of Disease Study for 2010, household air pollution plus ambient particulate matter pollution are responsible for 6.6 million DALY lost annually. If we adopt US$ 30,000 as the DALY unit value, the result is US$ 0.2 trillion per year, almost the third part of the needs for additional green investments.

From a different factor related to environment, the EU estimates health savings up to 31 billion per year possible from reducing EDC exposures. Out of an estimated cost of around EUR 0.636 trillion for endocrine diseases, if EDCs contribute to only 2-5 % of the total health costs from endocrine-related chronic diseases, an EU policy change such as the phasing out of these hazardous substances and promoting safer alternatives could save Europeans up to €31 billion each year in health costs and lost productivity.

To give a context to these figures, total healthcare expenditure in the European Union (EU28) in 2010 represented 9.5 % of GDP (OECD, 2013), or €1,166 billion (Eurostat, 2012). The healthcare bill for chronic disease is €700 billion. These figures do not include indirect health costs.

Finally, we will focus our attention on cancer, one group of diseases closely related to air pollution and EDC, and with a great economic impact.

The total economic impact of premature death and disability from cancer worldwide was $895 billion in 2008. This figure, which does not include direct costs of treating cancer, represents 1.5 percent of the world's GDP.

Using a formula accepted by public health researchers and economists to measure the global burden of disease, there were 83 million years of "healthy life" lost due to death and disability from cancer in 2008.

The top three cancers that account for the highest number of healthy life years lost were lung cancer (15.5 percent), stomach cancer (9.6 percent), and liver cancer (8.6 percent).

The top three cancers that caused the most economic impact globally were lung cancer ($188 billion), colon/rectum cancer ($99 billion), and breast cancer ($88 billion). All of them are closely related to air pollution and EDC exposition.

Cancer causes the highest economic loss of all of the 15 leading causes of death worldwide. The economic toll from cancer is nearly 20 percent higher than heart disease, the second leading cause of economic loss ($895 billion and $753 billion, respectively).

The US National Cancer Institute, with methodology based on cost of treatments, estimated for 2010 an annual cost of US$ 124 billion for all types of cancer, of which more than US$ 12 billion correspond to lung cancer.

Cancer cost the EU €126 billion in 2009, with health care accounting for €51.0 billion (40 %). Across the EU, the healthcare costs of cancer were equivalent to €102 per citizen, but varied substantially from €16 per person in Bulgaria to €184 per person in Luxembourg. Productivity losses because of early death cost €42.6 billion and lost working days €9.43 billion. Informal care cost €23.2 billion. Lung cancer had the highest economic cost (€18.8 billion, 15 % of overall cancer costs), followed by breast cancer (€15.0 billion, 12 %), colorectal cancer (€13.1 billion, 10 %), and prostate cancer (€8.43 billion, 7 %) (Luengo-Fernandez *et al.*, 2013).

This study also has a methodology based on costs. In a population-based cost analysis, authors evaluated the cost of all cancers and also those associated with breast, colorectal, lung, and prostate cancers. The study takes into account country-specific aggregate data for morbidity, mortality, and healthcare resource use from international and national sources. It includes healthcare costs from expenditure on care in the primary, outpatient, emergency, and inpatient settings, and also drugs. Additionally, the costs of unpaid care provided by relatives or friends of patients (i.e., informal care), lost earnings after premature death, and costs associated with individuals who temporarily or permanently left employment because of illness were also considered.

Although there is much evidence of health and economic losses derived from the traditional economic model based on carbon and fossil combustibles, in 2013 governments in developing and emerging economies spent 548 billion USD for supporting fossil fuel consumers (4 times renewable energy support) and 55-90 billion USD support in OECD countries for consumption and production of fossil fuels (OECD, 2015c). Current government policy is not supportive enough to accelerate green infrastructure investment. Green growth development and green investments require progress and accelerated implementation efforts. Work to enhance understanding of complementarities and trade-offs between economic, environmental, and social goals should be a priority area in governmental agendas.

CONCLUSIONS

Currently most developed countries accept that healthcare systems must be adapted to their functioning, to demographic changes, and to growing demand for care, making the best use of innovative health technologies. Health system reforms have to guarantee universal access to high-quality care and improve the efficiency and financial sustainability of the health systems.

Throughout this work, a positive and statistically significant relationship between environmental impact index and both mortality rate and R&D investment has been ratified. In addition, a number of specific pieces of evidence were found in the literature endorsing all the propositions stated in the methodological section. Several international reports quantify and exhibit figures regarding the magnitude of green investments and the amount of additional investment to advance towards a green economy model.

Regarding the relationship between green investments and healthcare sustainability, estimates showed that the required additional green investment amount necessary every year to follow the green growth track is lower than the cost of a few illnesses and lower than the cost of DALY lost and premature deaths occurring annually.

One of the most relevant contributions of this work is the innovative approach to healthcare systems sustainability from the demand side. This unusual perspective offers an impacting contrast with most research proposals that typically suggest reforms based on efficiency gains derived from the supply side (efficiency gains and reduction of resources devoted to the health sector).

Another specific contribution is the link established in this work between green investments and healthcare sustainability. Generally, the literature presents the strength of green investment impact on health, but not on healthcare system sustainability. This relationship adds a new social perspective to green growth strategy.

In order to guaranty the financial sustainability of health systems, it is necessary to reduce the incidence of preventable diseases. Cancer, heart disease, diabetes, respiratory, mental, and other chronic diseases represent great suffering to citizens and come at a huge cost to society and the economy. In addition, most of these diseases maintain a growing tendency along with environment deterioration, climate change, and unhealthy lifestyles.

Greening global economic growth is the only way to satisfy the needs of today's population and up to 9 billion people by 2050. Nowadays, despite signs of increasing private finance into clean energy and other green investments, there remains a considerable shortfall in investment. Closing this gap is a collective task and one that we can support from public sector finances. Public finance, linked to smart, enabling policies, has a critical role to play. Given the scarcity of public funds, governments' contributions to closing the gap will depend on their effectiveness in mobilising private investment.

Within the framework of green growth policies, we have presented green investments, an economic and environmental tool, as complementary to a social objective, the sustainability of healthcare systems.

Three limitations must be also pointed out. The first one is related to the causal relationship among contaminant agents and health issues. These relationships are in constant evolution. Every day, scientists discover new causes of diseases related to environment. Thus, an infra-estimation of the impact of environmental causes on health can be supposed. The second one is related to the scarcity of data about green investments. Only a few international reports presume to estimate the amount of money devoted to that aim, but there are no official and accurate statistics based on uniform criteria. Finally, the third limitation relates to the impact of green investments on the environment. Most studies are based on a limited number of estimates with a limited scope, the majority attributed to the energy sector. So, the evidence is limited in this aspect.

From the point of view of policy implications, the results support the need for inter-sector cooperation. Green investment is a broad term closely related to other investment approaches, such as socially responsible investing (SRI) and sustainable, long-term investing. So its benefits are global and could liberate a huge amount of money from health systems.

Up to now, signs from governments have not been clear. In recent years, in OECD countries support for fossil fuel production and use amounted to between USD 45-75 billion per annum. Developing and emerging economies provided over USD 400 billion in fossil fuel consumer subsidies in 2010. Alongside these contradictory behaviours, governmental support for "green" behaviour (e.g. ecological farming techniques) must be part of the policy mix, although such green subsidies should be periodically reviewed and eventually phased out once the green practices have become well accepted.

In general, the implementation of effective green growth policy mixes will depend on political leadership and on widespread public acceptance that changes are both necessary and affordable. In this sense, promoting green investments in all sectors can greatly reinforce the sustainability of healthcare systems as well. Reciprocal support between public and private sectors is crucial in the achievement of this new societal challenge, which is the innovation for sustainable growth and welfare. In contrast to the traditional choice supporting competitive strategies, this decisive proposal in favour of cooperation adds a distinctive character to this work.

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