ECONOMIC HISTORY AND THE ENVIRONMENT: NEW QUESTIONS, APPROACHES AND METHODOLOGIES

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Contents

Summary

Ecological economics is enabling economic and environmental historians to enhance their respective understanding of economic growth, by placing it in a broader perspective of biophysical interactions between nature and society. In this paper, several ongoing researches and historical debates are examined from this standpoint such as the missing role of energy carriers in GDP growth, the socio-metabolic profiles of past and present societies, the pre-industrial 'Smithian' responses to 'Malthusian' traps, the role of efficient land-use in breeding livestock to increase agricultural yields, the reasons the Industrial Revolution began in a high wage and cheap energy economy, the first globalization as a socio-metabolic watershed, and the question of whether there was a general crisis of biomass energies at the coming of fossil fuels era. Research discussing long-term socio-metabolic transitions may contribute to our understanding of how economic growth actually occurred, and which ecological impacts affected the Earth's life-support systems. Equally, these projects leave room for the institutional settings or ruling actors needed to explain why growth has happened and by whom. Far from naturalizing history, the use of ecology in the explanation of human history historializes ecology.

1. Introduction

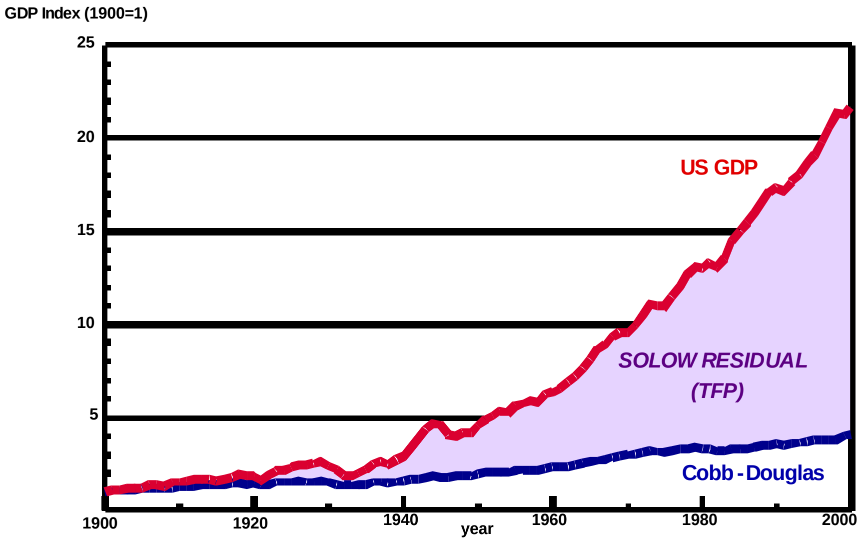
If all the research done in the well-established scientific field of economic history had to be summed up in one word it would be 'growth'. The main subject, if not the single issue, studied by economic historians is when, where, and why economic growth has taken place. In doing so, there has been a greater tendency to rely mainly or exclusively on mainstream economics as an analytical foundation. One of the earliest criticisms raised by environmentalists decades ago, and later by environmental historians is that mainstream economists, and some economic historians, have not only set aside the role played by natural resources in past and present economic growth, but have also ignored the increasingly powerful and global environmental impacts of economic growth on the planet's ecological life-support systems.

Yet the misunderstanding between mainstream economics and environmental sciences goes beyond having ignored "external" inputs and outputs that can simply be reintegrated into current macroeconomic growth analysis. As many specialists have recognized, economists have found profound and persistent problems in the explanation of long-term economic growth. These difficulties originated at the beginning of the neo-classical analytical approach. Ironically, mainstream economists intended to become the analytical physicians of the social sciences precisely as they discarded 'land' and other natural resources as relevant factors within economic theory. Interestingly enough it was also in this period when history ceased to be the basic background within economics. From then onwards the standard neo-classic growth model assumed that the final value added flows of GDP are directly produced from labor and capital alone, without specifying a role for energy flows, which were only considered to be consumable intermediates.

2. The Missing Role of Useful Work from Energy Carriers in Economic Growth

According to these neoclassical analytical assumptions, technological progress becomes exogenous and natural resource consumption is seen as a consequence, not a driver, of economic growth. Perhaps it is not so surprising that the first generation of macroeconomists who accounted for growth by means of a Cobb-Douglas production function using capital and labor as the only relevant factors, couldn't fully explain no more than a small level of growth in GDP, because the results left a large, increasing residual (Figure 1). Labeling this unexplained residual "total factor productivity" (TFP), and considering it to be the contribution of technical progress to economic growth, has become common practice. However as Robert Solow stresses, by calling it "*the measure of our ignorance*", TFP has become an exogenous factor not taken into account by the standard growth theory.

A second wave of "endogenous growth" theories has attempted to overcome this analytical *cul-de-sac*. Nevertheless, instead of reintroducing the material and energy layers that embody and activate capital assets or enhance labor capacities, the endogenous growth theorists came from a different angle. They looked towards increasingly symbolic and immaterial dimensions, such as the role played by 'human capital' endowment in long-term economic growth, and other social and cultural aspects. This approach has inspired a wide range of interesting and valuable historical research on the economic history of education, literacy and numeracy, book printing, skill premiums in the labor markets, the long-term effects of the European Marriage Pattern characterized by late weddings resulting in independent households based on a single nuclear family, and "a million of mutinies" in the everyday life of a large fraction of people which, according to Jan Luiten Van Zanden and Tine De Moor is needed for income growth to occur in any society, ranging from nutritional standards and height increases, to the rise of contractual arrangements on weddings seen as a direct token of 'girlpower' and an indirect indicator of the habit to negotiate all sorts of business in life.



Source: Ayres, R.; Eisenmenger, N.; Krausmann, F.; Schandl, H. and Warr, B. (2009): "Energy use and economic development: A comparative analysis of useful work supply in Austria, Japan, the United Kingdom and USA during 100 years of economic growth", presented to the Q2 session on *Energy, climate change and growth: perspectives from economic history* of the 25th World Economic History Congress, Utrecht, The Netherlands. The following three-factor Cobb-Douglas production function has been used: $Y_t = A_t(H_tK_t)^{\alpha}(G_tL_t)^{\beta}(F_tR_t)^{\gamma}$, where Y_t is output at time t, a function of K_t, L_t, R_t as inputs of capital, labour and natural resources; A_t is "total factor productivity" or the "Solow residual"; H_t, G_t, F_t are the coefficients of factor contribution taken from its revenue share in the income distribution of GDP —in this case as 0.70 for *L*, 0.26 for K, and 0.04 for the rest. According to the constant returns to scale assumption required by this function, $\alpha + \beta + \gamma = 1$.

Figure 1. Explained share of the actual GDP growth of the United States economy during the 20th century, and the Solow residual obtained by a conventional Cobb-Douglas production function.

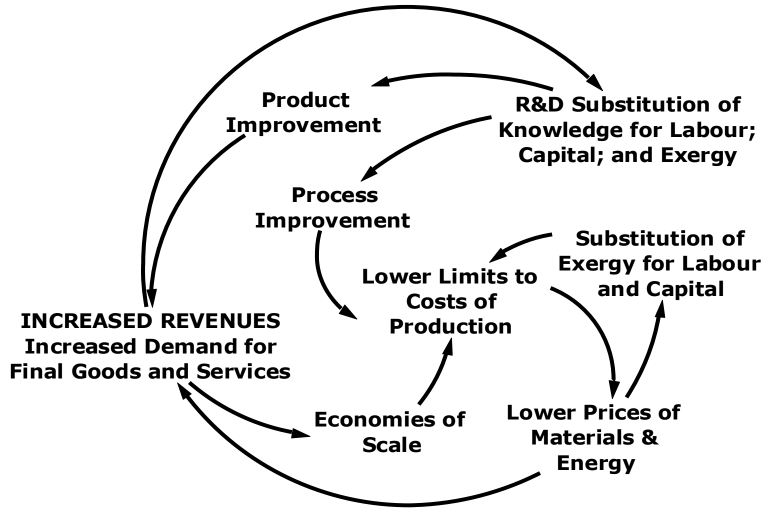
There has also been a renewed interest in studying the role played by income or wealth inequality, social public spending, and socio-institutional settings in the long-term economic performance of nations. When income inequality approaches the maximum permitted by available wealth and the need to reproduce the labor force at a subsistence level, societies often get caught in a 'worlds apart' lock-in state: the great majority of people cannot change the situation, and the privileged minority do not want to. This explains why the agrarian class structure, the social conflicts that arise within it, and the kind of institutional changes fostered by social and political struggles are so important for historical processes of economic development.

All these socio-institutional settings and human capabilities raise important questions that deserve to be studied in their own right. They have more than likely played a key role, considering them as results as well as crucial factors, that help explain *why* economic growth has taken certain directions in only some places and in only certain periods, and *by whom*. Also, if we apply here the distinction put forward by Amartya Sen and Martha Nussbaum between economic growth and human development, taking into consideration all these important questions may significantly help explain historical human development as an individual and collective increase in freedom of choice and 'empowerment'. Nevertheless, it is doubtful that this can ever fill the Solow residual gap to explain *how* economic growth takes place. After several decades of endogenous growth analyses, the growth engine remains a black box.

Although the historical process of human development has always included many social, institutional and symbolic dimensions, we should wonder if the empowerment of human capabilities, and the enhancement of individual and social choices, could ever be attained without relying on a greater amount of energy power able to move increasing amounts of physical flows in a wider global scope. According to both qualitative and quantitative historical evidence, physical and energy resource flows have always been a major factor in increasing the aggregated production of goods and services. A recent contribution to a never-ending debate, the Bob Allen book on *The British Industrial Revolution in Global Perspective*, has again stressed the role played by the supply of cheap coal as a driving force for the beginning of modern economic growth in England.

Several economic and environmental historians have studied this link between coal and the British Industrial Revolution, or underlined the role played by the increasing access to fossil fuels for other regions of the world to industrialize and converge with developed nations. All these studies reaffirm what Nicholas Georgescu-Roegen wrote many years ago in *Energy and Economic Myths*: "*Now Economic history confirms a rather elementary fact-the fact that great strides in technological progress have generally been touched off by a discovery of how to use a new kind of accessible energy. On the other hand, a great stride in technological progress cannot materialize unless the corresponding innovation is followed by a great mineralogical expansion.* [...] *This sort of expansion is what has happened during the last one hundred years*".

The failure to explain how the growth engine actually works is relevant from an environmental standpoint because the energy flows or material throughputs moved by the economy all over the planet are put aside. The principal ways through which the economy affects the ecosystems are exactly these same energy and material flows. Moreover some recent developments made by Robert Ayres and Benjamin Warr seem to open a promising new way to address the unsolved problem of the long-term growth accounts, without encountering the Solow residual. This approach considers economic growth as an open multi-sector processing system of materials, energy and information, which moves forward in a perpetual disequilibrium, beginning with the extraction of natural resources and ending with the consumption and disposal of wastes. Since the Industrial Revolution, radical innovations in energy conversion technology have been among the most potent drivers of growth and structural change, which have put in motion much positive feedback by means of reducing energy costs. The substitution of increasingly cheap mechanical, thermal and chemical useful work (or 'exergy') for increasingly expensive human labor and capital has played a key role as a driver of economic growth (Figure 2).

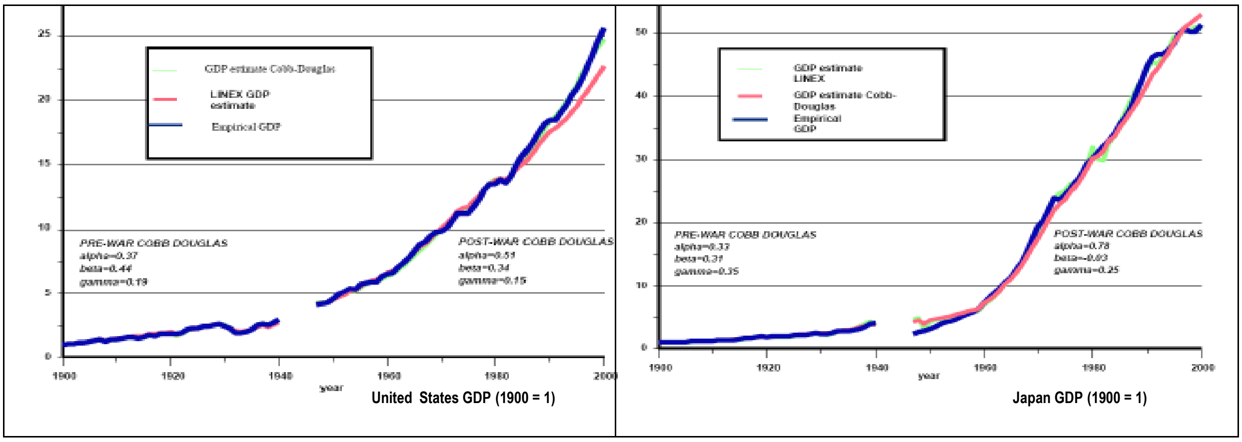


Source: Ayres and Warr Ayres R.U., Warr B. (2009),*The Economic Growth Engine*: *How Energy and Work Drive Material Prosperity*, Edward Elgar, Cheltenham.

Figure 2. The substitution of exergy for labor and capital seen as the key factor of lowering costs and increasing revenues in the virtuous cycle driving historical economic growth.

Considering that this evidence strongly suggests that 'exergy' (or the useful work actually performed by all energy converters which empower human labor and capital goods at its disposal) should be taken as a factor of production, Robert Ayres and his collaborators have been able to almost fit the empirical GDP historical series of the United States, Japan and other countries during the 20th century by including the useful work performed by all energy converters after discounting energy loses, together with the standard labor and capital factors, either in a conventional Cobb-Douglas or in a linear-exponential (LINEX) production function where all factors become mutually dependent, and where empirical elasticities do not equal cost share (Figure 3):

It is too early to tell if this new way to account for the long-term economic growth, just now being opened from an ecological economics standpoint, will consolidate and gain acceptance among the majority of mainstream economists and economic historians. For the moment, even admitting the increasing relevance of environmental global concerns, mainstream developing economists and economic historians continue to consider primary energy as only another input or intermediate good that can always be substituted in the market. All of this explains why there is a growing suspicion among ecological economists and environmental historians that ignoring the environmental impacts of economic growth comes from the same analytical foundation that has forgotten the role played by natural resources in human economy and ecology, and both seem to be tightly related to the persistent inability by mainstream economists to fully explain how economic growth actually works.



Source: Ayres, R.; Eisenmenger, N.; Krausmann, F.; Schandl, H. and Warr, B. (2009): "Energy use and economic development: A comparative analysis of useful work supply in Austria, Japan, the United Kingdom and USA during 100 years of economic growth", presented to the Q2 session on *Energy, climate change and growth: perspectives from economic history* of the 25th World Economic History Congress, Utrecht, The Netherlands. The following LINEX production function has been used:

$$Y_t = U \exp\left\{ a\left(2 - \left(\frac{L+U}{K}\right)\right) + ab\left(\frac{L}{U} - 1\right)\right\}$$

which includes capital (K), labour (L) and useful work (U). Considering that there is an apparent inconsistency between very small factor payments directly attributable to physical resources –especially fossil fuels— and the obvious importance of final useful energy (or exergy) as a factor of production, this approach abandons the neoclassical assumption that the productivity of a factor of production must be proportional to the share of that factor in the national income. Alternatively, it considers that available useful work, either mechanical, chemical or thermal, multiplies the joint productivity of any combination of capital and labour throughout all value-added stages of the whole set of production chains (Ayres, 2001:817-838; Ayres and Warr, 2005:181-209 and 2009). Therefore, the neoclassical identification of marginal productivities with factor shares is here replaced by a statistical assessment of the equation parameters. For the United States and Japan, $a = 0.12$. For the United States $b = 3.4$, and for Japan $b = 2.7$ b = 2.7. It corresponds to $Y = K_{0.36} L_{0.08} U_{0.56}$ (i.e., useful work performed by energy sources could explain as much as 56% of actual GDP growth experienced during the 20th century, while growth of capital stock would account for 36% and 8% would come from the increase in labour capabilities).

Figure 3. The explanatory capacity of a LINEX or Cobb-Douglass production function which includes useful work together with labour and capital, confronted with the historical GDP series of the United States and Japan (1900-2000)

3. From Economic History To Social Metabolism And Beyond

The rise of ecological economics is enabling economic and environmental historians alike to share and, at the same time, enhance their respective long-term understanding of economic growth by placing it in a broader perspective of biophysical interactions between human economies and natural systems in the biosphere. This socio-metabolic approach has been summarized by the Institute of Social Ecology in Vienna (IFF) as follows: «*The central theme underlying this research is the notion that most, if not all, global sustainability issues have to do with the fact that about two-thirds, if not three-quarters of the world population are currently in the midst of a rapid transition from agrarian society to the industrial regime. This transition is fundamentally changing societal organization, economic structures, patterns of resource use and so on, thereby probing the limitations of the planet Earth in many ways, among others by using up* *exhaustible resources, altering global biogeochemical cycles, depleting diversity and degrading Earth's ecosystems*». A new set of questions, methods and accounts arise from this, focus on the main socio-ecological transitions experienced in the interplay between nature and societies:

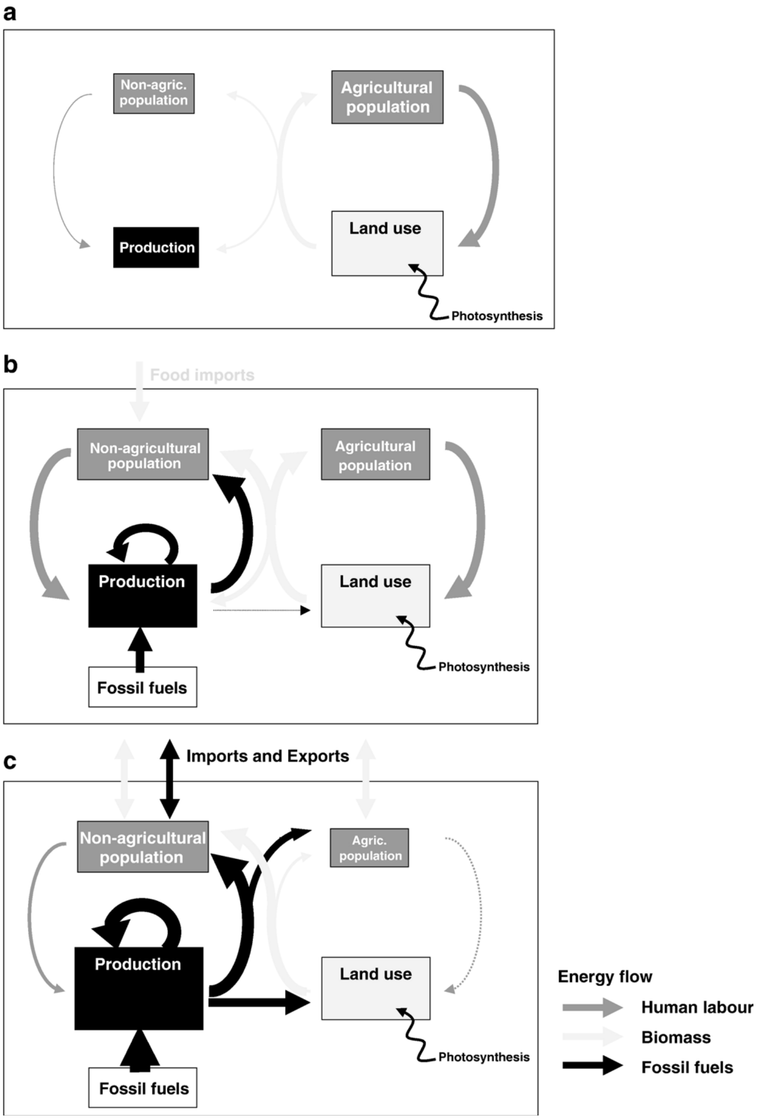
1. Was there a 'characteristic metabolic profile' of agrarian societies? Was such a metabolic profile connected to, and dependent on, certain land-use patterns?
2. What happened when these socio-ecological agrarian regimes started to change? Which were the major drivers of change? Which pressures upon the environment gained momentum with industrialization and urbanization based on burning cheap fossil fuels, and which pressures receded? Which changes within natural systems could be observed during the socio-ecological transitions?
3. How much did the course of the socio-ecological transitions depend on the historical context, either local, regional or worldwide? Do common patterns exist?
4. How does the interplay between different spatial scales and levels of society work and interact with nature? Does globalization matter?

This approach has led to detailed quantitative studies of the energy and biophysical flows that link human economic activities with their ecological foundations, opening new ways of accounting: Material and Energy Flow Analysis (MEFA), the reconstruction of energy balances of economic systems and sectors, the estimation of energy returns on energy inputs (EROI), the study of nutrient and water cycles, the extent of the human appropriation of the ecological net primary production (HANPP) or the historical evolution of ecological footprints. These have established themselves as leading lines in current research. There have also been attempts within the European Union to standardize these methods of ecological-economic accounting in established systems of National Accounts.

As the IFF scholars have written, «*In this way, industrialization appears as a process of continuous increases in labor productivity and energy efficiency as well as growing industrial output resulting in continuous economic growth. Besides impelling social change and creating material wealth it has fundamentally changed the human domination of the Earth's ecosystems and brought along a plethora of environmental problems. A major claim of ecological economics is to broaden our understanding of economic processes and how they are embedded in nature by taking a biophysical perspective which conceptualizes economic processes also as natural processes in the sense that they can be seen as biological, physical and chemical processes*. […] *In this context, a historical understanding of the long-term development of society-nature interactions is of vital importance*. […] *We understand the industrialization process as a qualitative transition which transforms the agrarian socio-ecological regime into an industrial regime thereby establishing a distinct and fundamentally new pattern of society-nature interaction and material and energy use*».

The following scheme (Figure 4) summarizes the key features of the two last main socio-ecological transitions from a solar land-based socio-metabolic regime (a) towards the coal stage of industrialization, combined with a set of 'advanced organic agricultures' which optimized traditional low-input agrarian systems (b); and then to a new stage of the oil and electricity driven technologies of the second Industrial

Revolution that fuelled mass production and consumption, together with a reversal in the traditional relationship between the agricultural and non-agricultural sectors (c), by means of massive fossil energy subsidies for all economic activities and transport which fostered a boom in worldwide trade.



Source: Krausmann F., Schandl H., Sieferle R.P. (2008). "Socio-ecological regime transitions in Austria and the United Kingdom", *Ecological Economics*, 65, pp. 187-201.

Figure 4. The changing relation of energy, land and labor during the stages of the socio-ecological transitions

Perhaps the most interesting feature of this socio-metabolic approach is that it establishes a clear and accountable link between local and regional environmental problems with regards to the input side of nature-society interaction, based on resource-use together with related land-use changes; and from the output side, with local and global environmental problems derived from polluting emissions along the economic throughput chains. As the IFF scholars have put it, «*Taking a biophysical view it* *becomes evident that it will not be possible to accomplish global industrialization without an alternative pathway for the metabolic transition. Scarcity of oil and gas will increasingly become an issue and declining energy prices, a major precondition for the industrialization of the industrial core, are unlikely to prevail for latecomers. Before energy scarcity and rising energy prices become a major problem, the world is faced with rising greenhouse gases in the atmosphere contributing to global warming and destabilization of the world climatic system to a large and unknown extent*. [...] *In the light of the historical process, the need for a new, sustainable, industrial socio-ecological regime with lower per capita material and energy turnover and a lower share of non-renewable energy and materials becomes a vital need for the global system*».

One of the aims of this broader ecological-economic perspective is to explore the connections, on all levels, between value-added flows in the market sphere, and the biophysical and energy flows or climatic suitability that sustain them from their ecological base. Measuring the energy and material dimensions of what GDP growth actually means for natural systems can provide us with new answers to previous questions regarding what triggers economic growth, what growth in fact involves, and what consequences it has for both social and natural environments. This standpoint connects the understanding of economic growth with the new studies on Global Warming and Climate Change which, during the last thirty years, have enhanced the focus on climate history. The IPCC concern about Global Warming has led to a development of new indicators and methodologies that have had a dramatic impact on all areas of knowledge, especially in a long-term historical perspective. Many recent studies have broadened the methodological possibilities open to climate historians, aimed at understanding the evolution of climate and its impacts on past and present times.

Moreover, the analysis of biophysical flows linking economic performance with the carrying capacity of ecosystems necessarily leads to the study of changes in terrestrial land covers by human land-uses. Together with pollution and bio-invasions, this changing face of the Earth by human landscapes is precisely the main origin of the crisis of biodiversity at present. Putting together biophysical flows moved by human societies with the land-use changes made by them leads to the study of Global Change, a crucial meeting point for all scientific disciplines interested in the sustainability of human-nature interaction.

This emerging socio-metabolic perspective does not entail prior assumptions concerning the causal direction in the ecological-economic interaction or phenomena. The common attitude among practitioners of the emerging 'sustainability science' is a cautious, multidimensional and transdisciplinary approach which, from a co-evolutionary background, can admit that sometimes the driving forces originate from within the economic sphere and leave their ecological footprint on the surrounding environment; whereas in other cases researchers highlight the role played by the availability of energy, water, raw materials or climatic conditions and variability, either as a limiting factor or as a source for economic growth. Neither does such an approach entail the making of any deterministic presumptions; rather it is dependent on the type of enquiry being undertaken and on its historical or geographical scope.

When environmental historians seek to discover the ecological impact of economic growth, usually from a short or medium-term perspective, they typically adopt market or state economic forces as the main driving force. But by adopting a long-term, comparative historical perspective, they also raise questions about the role played by the availability of energy, land, water and raw materials in accounting for historical economic growth processes or catching-up paths. On occasion, both approaches can be adopted simultaneously within the same research strategy, as Astrid Kander demonstrates in her study of the long-term relationship between energy, economic growth and greenhouse emissions in Sweden since the beginning of the 19th century – a research strategy that has been adopted within a broader comparative analysis between different countries and regions of the world undertaken by the members of the Energy-Growth and Pollution Network and the Institute of Social Ecology.

Whereas it is true that all these new perspectives and methods provided by ecological economics and environmental history are greatly expanding the toolbox of economic historians, it is no less true than among scholars devoted to the study of past organic economies there was already a long tradition of taking bio-geographic, agro-ecological, energetic and landscape factors into account. However, their explanatory relevance has tended to decrease with the shortening of the time perspective from which economic historians seek to understand the present. The practitioners of prehistory and ancient, medieval or early modern history have never failed to analyze changing environmental conditions as a key dimension to understanding the evolution of any human society. Nevertheless, until recently, their presence has tended to vanish between the historians devoted to modern and contemporary times.

This growing lack of interest cannot be attributed to the loss of relevance of such environmental factors, as it is in very recent times when the impact of human societies on the face of the Earth has become more intense, global and dangerous. The reason is ideological, and derives from a way of seeing reality that has characterized the two major socio-economic visions of the 20th century. Within the mainstream approach to these two great visions, natural environments were considered as a set of restrictions and limitations that development would overcome. By seeing economic growth as "liberation" of environmental constraints, the relevance of their study was considered inversely proportional to the degree of technological progress. Hence the explanatory weight of environmental factors was seen to decrease with the time-distance to the present covered by the analysis, in open contradiction with the degree of human degradation of Earth's ecosystems. Thus, this long-lasting Faustian vision of the modern Unbound Prometheus has paid a learned ignorance to the environmental dimension, until the obvious signs of a global ecological crisis have forced many to rethink. Since it is impossible to summarize within this text all lines of research which are currently changing the old visions of economic growth that formerly remained disconnected from environmental constraints and effects, we will take only a few relevant issues and ongoing debates as examples to illustrate the new emerging trends.

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Gabriel Jover Avellà is doctor in early modern economic history and professor of economic history at the University of Girona. He teaches courses on economic and environmental history. His research is focused on agrarian and environmental history from the 17th to the 19th centuries. He uses official statistics and private accounts written by farms or big estates in the island of Majorca to analyze the changes experienced in labor demand and supply related with land-use and agricultural changes in Mediterranean organic agro-systems. His aim is to reconstruct long-term historical series on economic as well as biophysical flows in traditional agrarian societies where large estates which hired wage laborers were predominant, like in the Majorca Island.