TECHNOLOGICAL CHANGE FOSTERING SUSTAINABLE DEVELOPMENT

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Abstract: This paper presents the concept of sustainable development in correlation with the technological development. It proposes a definition of the notion of technological paradigm. In the paper concepts from the evolutionary literature on technological change are applied to environment-saving technological change. Our objective is to examine the technology dimension in achieving a sustainable economy. It is argued that fundamental changes in production processes underpinned by alternative technological trajectories are necessary for achieving environmental sustainability. Finally we identify some factors that stimulate sustainable innovation.

1. INTRODUCTION

Sustainable development has been the subject of diverse definitions from a number of commentators. As a result, it has come to mean very different things to ecologists, economists, planners and politicians.

Ecologist researchers have developed two different streams of environmental modernisation theory. The first stream originate from environmental policy and sociology and focuses on techno-economic aspects [13] and reveals that technological innovations are important for relieving environmental burden in the industry.. The second stream has a wider focus and bases on social modernisation theory. [8], [19]

At the heart of the debate over the potential effectiveness of sustainable development is the question of whether technological change can reduce the impact of economic development sufficiently to ensure other types of change will not be necessary. Industrial leaders have recognised the importance of the environment in which they operate, and many have pursued a path of implementing voluntary initiatives to reduce the burden on the environment, taking a more proactive approach, addressing pollution prevention to stay ahead of legislation.

2. SUSTAINABLE DEVELOPMENT-CONCEPT

The subject of sustainable development ranks high on the legislative agendas of most governments, media coverage of the topic has proliferated and sustainability issues are of increasing concern to humankind. In today's society, there is a growing interest for. There are over 100 definitions of sustainability and sustainable development but the image most commonly used to describe sustainable development is that of three pillars, representing environmental protection, social development and economic growth, which together support the roof. Sustainability involves the simultaneous concern of economic prosperity, environmental quality and social equity in particular known as three bottom lines. Differences in interpretation mostly stem from how each of this three goals of sustainable development are emphasised. As sustainable development is historically a product of the environmental discussion, the focus has long been on strengthening the environmental pillar, perceived as the weakest of the three. The concern with balancing the needs of present and future generations – the intergenerational dimension – is also a point of difference. Many, for example, consider it to wrong to make assumptions about future human needs beyond basic biological ones.

Further, a few interpretations of sustainable development are discussed here. The first is that provided in the so-called Brundtland Report, which has had a great deal to do with the subsequent popularity of the term. We then take up, in order, the reaction of so-called deep ecologists; and the views of anti-development theorists, who see sustainable development as simply an ideological mask for old-fashioned development.

The term sustainable development first came to importance in 1987 when the World Commission on Environment and Development produced a report for the United Nations called "*Our Common Future*". This definition of sustainable development – "*development which meets the needs of the present without compromising the ability of future generations to meet their own needs*" – is commonly referred to as the "original" or "classic" formulation of the term. It is from this definition that most interpretations of sustainable development emanate [22]. Since the World Commission on Environment and Development Report of 1997 was published, corporate managers and management scholars have been grappling with the question of how and why corporations should incorporate environmental concerns into their own strategic decision making. And they have been assuming a positive role in furthering the cause of environmental protection, as opposed to being seen as an environmental problem. Today many companies have accepted their responsibility to do no harm to the environment.

The environmental ethics and sustainable development approach, believe that the protection of the environment is the most important aspect of sustainability. According to this theorist, the Brundtland Report tries to reconcile two irreconcilable objectives. One objective is to revive growth; the other is to avoid environmental degradation. What is wrong with this is that the "predominant" theory relied on in the Brundtland Report to assure the achievement of these objectives is *indefinite growth*. This is incompatible with a aim of living within natural limits, yet it is never categorically repudiated by the World Commission. But environmental degradation is not excluded by a minimalist approach to sustainable development. The objective of sustainable development is viewed by some economists and business groups as being only to preserve the environment to the extent that it is necessary for the maintenance of the economic system. For them future generations can be compensated for the loss of environmental resources by increased wealth and human capital with which to meet their needs. [1]

According to the critics of sustainable development, the notion of sustainability seems to be utopian. The term only serves to revitalize development, to give it another lease on life, by tying it to concerns for the environment. Sachs admits that what he calls "eco-developers" are in some sense distinguishable from traditional advocates of development--most obviously in their admission that there are environmental limits on production. However, "*What ties them nevertheless to the economic worldview is the failure to appreciate cultural limits to the predominance of production, cultural limits that render production less important and consequently relieve also environmental pressure.*" [21]

The paradigm of "sustainable development" can be viewed also as a new paradigm of technological development. The use of green technologies should be promoted, although technological optimism does not escape the need for fundamental social change and a shift in priorities. The institutional background and environmental instruments providing the right incentives play an important role in realizing the savings potential and/or the use of clean technologies. Given the medium-term goal of changing the proportions of capital, labour, and resources as well as the direction of technical progress, economic instruments have gained in importance, complementing environmental regulations. These instruments, such as taxation of inputs harmful to the environment, lead in the medium term to the deployment of other technologies which use less of these production factors, but perhaps require more know-how or labour. In spite of the undeniable diversity of technologies, of

the unpredictable nature of inventions and of the uncertain and risky nature of commercial innovations, there is a recognizable logic behind the main trends in technical change.
Achieving sustainable economic growth will require changes in industrial processes, in the type and amount of resources used, and in the products which are manufactured. In the recent years, designing specific aims for sustainability has become a strategic objective for the entire humanity. This process has to be adapted to each country, according to the demographical national particularities, to the natural environment particularities, to the built space etc. The essential meaning of sustainability can be reached only by finding the best endogenous pattern of reconciliation between man and nature. [4]
The first steps in the reconciliation with nature include:

- A thorough knowledge of the natural environment and of the interactions between the social and the economical system and the natural systems, the foreseeing of the consequences of these interactions on the short and the long term;
- The rational use of the natural resources, disregarding their origin;
- The prevention and the careful elimination of the environmental degradation, be it man-inflicted or provoked by natural causes;
- The harmonization of the immediate interests with the ones on the long term and the permanent interests of the human society in the use of the natural factors.

The tools of sustainable development like economic instruments, legislative measures and consumer demands are aimed at achieving technological changes. Lately, new improved and eco-friendly technologies have been designed, in the context of sustainability. By efficiently using sustainability, these technologies have been directed towards diminishing pollution, towards a better management of the water, soil and earth resources.

3. TECHNOLOGICAL PARADIGM AND TECHNOLOGICAL CHANGE

While the meaning and implications of “technological change” or “sustainability” have been interpreted in many ways, there is broad agreement on basic components that have important implications for environmental assessment design and practice. We propose a definition of the notion of technological paradigm related to the sustainability stream.
The questions of how technological change takes place in the economy and how to develop a technological policy are old issues of political economy, which have recently received new interest. Recent analyses have suggested a more articulate approach, using concepts and categories that have stressed the nature of the 'paradigm' of a technological system. [5]
A distinguishing feature of evolutionary theories on technological change stems from the used concept of technology. Technologies are not defined in terms of a stylised input-output relationship, but are seen as being linked with other technologies, economic activities and production and user practices and a whole range of institutions that form a technological system or regime [15]. From this point of view *technology* is then defined as a combination of tools and method to solve problems posed to human individuals and societies by their natural and social environment.
Technological paradigms are a classical concept in the literature on innovation and technological change. The literature on innovation and technological change is marked by three publications that explicitly built upon Thomas Kuhn ideas to analyzing technological change and introduced the term “technological paradigm”.
For Johnston (1972), the periodic nature of technological change was empirically outstanding. For him, a technological paradigm is “*a set of guiding principles generally accepted by practitioners in a particular field of technology*”. He distinguishes between paradigms as epistemological (“*a guiding framework for the development of technology*”), sociological (“*adherence to a paradigm constitutes membership to a community*”), and

psychological ("*technologists will tend to perceive the world through this framework*") concept.[14]

Granberg and Stankiewicz introduced the notion of "technological paradigms" for the analysis of generic technologies and elaborate in more detail than Johnston what kinds of activities are conducted in communities of technologist, namely technological research and functional analyses. For them, a technology can be understood in terms of the function it performs, the natural processes it exploits, and the design linking these into a functional whole, "*a "technological paradigm […] denotes a set of beliefs and opinions, held in common by a sizeable collectivity of practitioners, as to how 'their' technology ought best to be developed*" [11].

The concept of technological paradigms has been developed by Giovanni Dosi (1982) which has been highly influential in the field of the economics of technical change. The technological paradigm is defined by Dosi as a "model" and "pattern" of solution of *selected* technological problems, based on *selected* principles derived from natural sciences and on *selected* material technologies [7]. In contrast to Johnston, Dosi focuses more on the technology that underlies a paradigm. Although Dosi's definition of a technological paradigm itself is quite similar to the definition of Johnston, his work contains a much richer description of normal technological progress. Normal technological progress is driven by a combination of these fractions. Dosi's example is drawn from the case of semiconductors, where in order to perform a generic task (amplifying and switching electrical signals) a material technology is selected (silicon semiconductors), which uses specific scientific properties, in order to reach some economic maximization of performance.

Economics put the technological concept into a changing economic and organizational environment in which paradigms stepped into a balanced competition for survival. While there are no steadily competing paradigms in normal scientific change, technological "paradigms" were supposed to behave differently.

One of the key reasons why technological progress often proceeds along certain technological regime is that the established technology and design has already benefitted from all kinds of evolutionary improvements, in terms of costs and performance characteristics, from a better understanding at the user side, and from the adaptation of socio-economic environment to a certain type of technology in terms of accumulated knowledge, capital costs, infrastructure, available skills, production routines, social norms, regulations and life styles.[10]

Changes in technological paradigm may be associated with environmental improvements of the order of several magnitudes, not in the short term but in the longer term when the new system is optimised in ecological terms. Technological innovation can be of two types, incremental (focused on cost or feature improvements in existing processes, products or services, exploits existing technology, relatively minor changes of processes and products that occur more or less continuously) or radical (focuses on products, processes or services with unprecedented performance features, explores new technology, creates a dramatic change that transforms existing markets or industries, or creates new ones, discontinuous events). From an economic point of view, incremental change lies behind the general rate of growth of productivity, visible in the aggregate. Most of environmental technological change consists of incremental innovation of existing technologies and the diffusion of existing technologies that are integrated in existing production modes.

A radical innovation, by contrast, is the introduction of a truly new product or process. In other words, sustainable innovation involves risk but it also requires structure. While much can be achieved by "continuing to do better", it will be far more challenging and rewarding to learn how to [6]:

- Bring design, smart technologies and the "new economy" together to drive growth in ways that reflects changing concerns and values of a connected world;
- Support faster and more sustainable development in the developing nations involves risk but it also requires structure. While much can be achieved by "continuing to do better", it will be far more challenging and rewarding to learn how to;
- Bring design, smart technologies and the "new economy" together to drive growth in ways that reflects changing concerns and values of a connected world
- Support faster and more sustainable development in the developing nations.

As Mensch (1975) observe, due to the self-contained nature of the trajectories of incremental change, it is practically impossible for a radical innovation to result from efforts to improve an existing technology.[18],[23]

3. Drivers of environmental technological change

Today companies need to do much more than develop better, less expensive products and services than their competitors. They need to add features, improve performance and be able to quickly launch new products into the marketplace. Technological change was interlinked with institutional and social change: a shift in regulatory philosophy, pressures from environmentalists, growing environmental awareness at the supply and demand side, changing managerial perceptions, and the introduction of environmental management systems to address environmental problems.

Environmental innovations could in principle be defined in two ways: firstly by the effects of the innovation on the environment and, secondly, by the intention of the innovator to reduce the environmental impact of processes or products. Innovations that are not driven by a conscious intention to reduce environmental impact may nevertheless have this quality.

Environmental innovation can be defined as "*innovation that serves to prevent or reduce anthropogenic burdens on the environment, clean up damage already caused or diagnose and monitor environmental problems*" [12]. Most of environmental technical change consists of incremental improvements of existing technologies and the diffusion of technologies that are integrated in existing.

The deployment of technology systems involves several interconnected processes of change and adaptation:

- The development of adjacent services;
- The cultural adaptation to the logic of the interconnected technologies;
- The setting up of the institutional facilitators.

Of course, environmental innovations involve many areas of knowledge and many industrial sectors and may therefore be systemic and complex and also adaptation of the economic, cultural and institutional environment to the requirements of technology systems is not passive.

Even the power of consumers to influence technologies is limited the tendency for consumers to prefer ecological products has already become evident and cannot be avoid. Sustainability is nowadays far from only representing a slogan for an intelligent marketing campaign, but has become a primordial condition for the existence of a business on an extended period of time. In the case in which the consumers are willing to pay more for the "green" products [16], in the field of the retail selling there are traders who ask for a certificate (for example Tesco, Marks & Spencer) like the one given in England (through Carbon Footprint Ltd.) which would be a proof of the manner in which the products are obtained. In this way, in the future, the product label will also give information about the energy consumption and the CO_2 consumption during the production process of every

product. Moreover, regulations in this direction will be given starting with 2010. This will inevitably lead to a situation in which the pressure will be put upon the entire production chain up to the producers of machines and equipments, in what non-polluting products with low energy consumption are concerned. That makes some firms to introducing systematic environmental purchasing policies, and some are making specific demands on their suppliers for products that can be recycled.
Whilst consumers may influence packaging and some ingredients of products, they are usually unable to influence more hidden aspects of a product such as whether a retailer or manufacturer uses rail or road transport to transport their goods. Unfortunately they are unlikely to affect more fundamental production decisions that might lead to clean technology rather than end-of-pipe technologies. The end-of-pipe systems may involve treating water, air, noise and solid wastes. The Organisation for Economic Cooperation and Development, OECD, found that most investment in pollution control was being used for end-of-pipe technologies, with only 20 per cent being used for cleaner production[20]. A whole range of technologies are involved from the multitude of biological and chemical systems used for treating water, to filtration systems, cyclones and other barrier systems used for air, acoustic enclosures and baffles and various composting or disposal methods. However clean technologies are preferable to end-of-pipe technologies because they avoid the need to extract and concentrate toxic material from the waste stream and deal with it. [3]
Governments can be a key factor in many industry innovations. It encourage the development and implementation of clean technologies through the use laws and regulations which cannot be met without technological change or through the use of economic instruments which are meant to provide a financial incentive for technological change.

4. CONCLUSION

This paper did a survey some definitions of the concepts of sustainable development, and of technological paradigm and make the link between this based on pattern theory and formal concept analysis.
The definition of technological paradigm is theoretically appealing, for it captures some fundamental ideas of the philosophy of science such as Thomas Kuhn's, Dosi's or Johnston's thesis that scientific progress is paradigm-dependent. It also helps clarifying several key notions such as optimisation, and incremental and radical innovation.
The domain of sustainability comprises the theoretical frame for taking decisions in any situation in which there is a man / environment rapport, be it the natural, economical or the social environment. In this paper it has been argued that environmental sustainability requires eco-restructuring, that is the development of new technology systems offering dimension environmental improvements. This raises the question: how to achieve this?
New and sustainable technologies are possibly not initially fully competitive because they face barriers of entry such as economies of scale, institutional arrangements lack of information or regulatory frameworks in favour of the established technological regime. This implies a rationale for government intervention aiming to facilitate a transition process away from unsustainable technological regimes.
Eco-friendly technologies are improbable to appear from a sustainable development approach that looks for to incorporate the environment as part of the economic system and so to subordinate it to economic needs. There is a real require to value the environment apart from and above its input to the economic welfare, to see that environmental quality is irreplaceable.

The "Trend Chart on Innovation" launched as part of the European Commission innovation programme refers to three major categories of instruments for stimulating technological innovation [9] :

- Promoting an innovation culture includes measures to stimulate creativity, initiative, taking calculated risks and accepting a certain social, geographic and professional mobility;
- Setting up a favourable context for innovation targets promoting of the development of innovations, by stimulating both competition and cooperation, and providing better protection for intellectual and industrial property;
- Reinforcing the ties between research, innovation and markets through creation and spinning off of innovating companies, stimulation of cooperation with the public sector, private sector and education.

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