

A study of Sustainability: Developing a holistic approach towards the scope and impact of change

Few authorities deny the prospect of global warming, and with it, the role of manmade CO². The earth's recognised carrying capacity is thought to be less than a quarter of 1997's emission levels and international policy reports that CO² reduction should be in the order of 90% (Ball *et al* 2008). Whilst third world countries, including India, have ratified the Kyoto agreement, their emissions were too low to make any cuts viable (Johnson, 2007), which augments the size of the problem because growing emission levels from developing countries undermine reductions made elsewhere. If the findings of some scientists are proved to be correct, it would suggest that the degree of change required to achieve sustainability will be in the order of a paradigmatic change.

Resource depletion is an associated problem. Western Societies depend upon oil for transporting 95% of all goods including food. Demand for oil is forecasted to increase beyond supply within the next ten years (Leggett, 2006). There is no ethical argument that would counter other societies from matching the lifestyle of the average American, but should this happen, it is argued that we would need five planets the size of Earth to supply all of the resources (Groc, 2007). Arguing against this, some economists suggest that price rises will minimise the effect of resource depletion by reducing demand and justifying more expensive methods of production or extraction and prompt research and development into new technologies to replace the goods in short supply (Beckerman, 1995) A guiding ideology incorporated in the Rio Declaration is the precautionary principle, (Dresner, 2002) which states that "when there are threats of serious irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation" (United Nations Economic Commission for Europe, 1990 cited in Dresner, 2002). Thus economic theory suggesting a problem might be averted should not be sufficient grounds to ignore other remedial action and issues of this magnitude should not be left to market forces to remedy in their own time.

For the purposes of this paper, sustainable development should be seen to embody making whatever changes necessary to allow civilisations to survive with dignity within earth's carrying capacity. Thus It is recognised that sustainability is a multifaceted issue, involving numerous stakeholders competing for different outcomes to satisfy their disparate needs and form an interdependent network of relationships that is vulnerable to change. It is thus evident that the question of sustainability is that of a complex problem, whereby inappropriate action could yield unintended consequences that render them at best ineffective and at worst, detrimental to progress towards a sustainable future.

This paper adopts a systems approach so that a more holistic approach can be revealed. It does this by reviewing various theories across a range of disciplines including social and technological determinism, long wave theory and normative stakeholder theory substantiated through empirical studies. The aim is to expose the interrelated factors that are causal to what is perceived as a 'messy' problem in an attempt to expose the web of factors that constitute this messy problem. A systems approach involves ascertaining all of the components of a problem and identifying the relationships between them to develop an understanding of causal chains; thus identifying potential drivers of change as well as the scope of the resultant impact.

Technical Determinism or Social Construction

There are opposing schools of thought regarding the manner in which societies change over time, namely technological determinism and social constructionism. These are two ends of a continuum, between which there are a range of positions represented in *Fig 1*. Social constructivist's argue that society controls choice and thus constructs the technology that is adopted and the manner in which it is used. Critical of overgeneralisations Hacking (1999) identifies flaws with social construction. He argues that the abstraction of a theory from empirical evidence when it does not appear to be substantiated with evidence of applicability at a general level suggests that social constructionism can only be useful in particular

instances where it can be seen to operate. However, the purpose of this paper is to identify the agents of change that have operated in the past in order to collate and assess the multiple causes of change.

Hacking (1999) argues that the role of technology in shaping societal change must be identified. He recognises that the artefact is the “product of human knowledge” and links that knowledge to the priorities and choices made within the arena of research. However, he argues that once developed, technologies have a limiting effect upon the scope of further research because, firstly, the dominant technology can blind the researcher to viable alternatives, and secondly, new technologies spur the development of new materials that materially alter the environment and knowledge construction.

At the other end of the continuum, are those that believe societal structures are determined by technology, claiming that the development of technology is autonomous and cause societies to adapt accordingly (Chandler, 2000), thus pointing to technology itself as the driver of change. Taken at an extreme level, proponents of the concept refer to the ‘technological imperative’, claiming that there is a moral duty to advance new technologies in order to extract the maximum possible level of benefit from them (*ibid*). Thus the technological imperative would augment the autonomy ascribed to technology. If the concept of technological determinism is upheld, any societal attempt to change would be considered futile because in doing so, society would be attempting to limit the autonomy of technological developments.

In seeking to assess the role of technology in paradigm changes, De Bresson (1987) and Hacking (1999) ascribe much development as driven by Governments protecting their national interests. These technologies however are transferred to the business sector, where they may not be the best solution for the role they fulfil. Technology transfer is also a key issue when assessing the scope of change in developing countries. Because of the competitive advantage that can be ascribed to technologies that minimise the use of resources including labour, the developed world is reluctant to transfer expertise, forcing emerging nations to either use more inefficient technologies or delay their development.

Between these contrasting views are numerous other positions, which highlight alternative drivers to change. De Bresson (1987) & Heilbroner (1994) maintain that whilst technology is a core driver, it is itself shaped by social and economic forces. Mackenzie & Wajcman (1993) identify empirical evidence that highlights the manner in which social structures such as the perception of value and risk determine what is considered to be economically viable and thus produce markedly different technological solutions in different cultures. They also consider it essential to recognise the role of political intervention in the shaping of technology. There is a wealth of empirical evidence to support this, from the implementation of the Kyoto protocol to the governmental decision to focus of industry in Singapore onto tourism in order to enable the country to compete in the international arena (Mehmet & Tahiroglu, 2003)

Society can influence the shaping of structures at a grass roots level. Bruland (1985 in Mackenzie and Wajcman, 1993) argues that machinery was introduced to replace manual labour as a direct result of labour disputes. Grass roots activities also shape technological progress and employ new technologies to wage successful campaigns (The ‘Economist 2008). The use of the media is a further determinant in shaping societal structures. In this case, the identification of causality is not so straightforward. Whilst it is clearly possible to impart information using the media, either in the form of advertisement, or more subtly with the message embodied in programme content, measuring the impact on desired behaviour is less clear (Meirick 2006). Research suggests that media influence will entrench prior opinion rather than persuade the viewer to adopt a new perspective (Oliver *et al*, 2008). Thus, on its own, media coverage devised to orchestrate a change in societal attitudes and practices is not sufficient, but it can add impetus to change that is initiated by other factors. It should also be recognised that media may involve inaccuracies that are nevertheless influential. For example, investigating the cause of the recent rise in both oil and grain prices, Engdahl (2007) identified that the published explanations emanating from the US government were at variance with the facts revealing the role of hidden agendas in the shaping of innovation. Whilst such agendas could be fuelled by financial expedience that is deemed unpalatable and

thus not politic for publication, they could also be fuelled by a greater level of self interest and thus not for the public good.

Thus it has been argued that technology and numerous factors within society influence societal change. However, Gendron (2003) argues that technology and society are no longer the only determinants of social structures. She identifies an increasing awareness of the threat posed by environmental degradation that is beginning to influence business managers in their choices. Latour (2005) suggests that as illustrated in *fig 1*, the factors that have the capacity to shape structures within society form an interconnected network and thus should not be viewed in isolation of each other. From a systems perspective, this would indicate that each factor can be viewed as an element that can be controlled, because a change in one of them would influence others, amplifying its effectiveness.

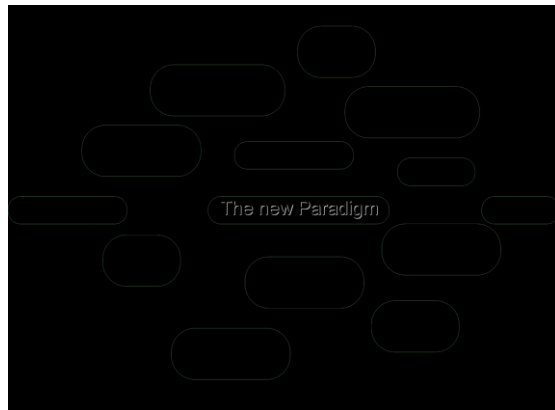


Fig 1 The web of factors that can determine the manner of change

A review of Theories relating to Paradigm change

Historically, technical change has been linked to economic cycles, and associated theories reveal something of the dynamics of such change. Kondratieff observed that paradigmatic changes have occurred at approximately 50 year intervals and have linked these changes to peaks and troughs of economic growth and recession (Tarascio, 1988). Kondratieff's observations have been developed into what is now referred to as long wave theory which has been largely overshadowed by economic theory concentrating on short and medium term cycles (O'Hara, 1994, Silverberg & Verspagen, 2003). Thus much of the literature relating to long waves is dated, but considered of relevance to this paper because it facilitates understanding the components of change in the order of magnitude that is required to move into a sustainable trajectory.

In an historical study Kondratieff found a link between cycles of innovation and technological change and economic cycles of growth and recession leading to a new technological paradigm. *Fig. 2* illustrates the features that Kondratieff identified occurring in each cycle. He argued that financial hardship put pressure on agrarian societies survival, which in turn cleared the way for innovations to be considered. The upswing in economic prosperity was accompanied by a change in the techno-economic paradigm facilitated by the innovations of the previous wave as they became diffused. Associated with this came wars and revolutions as nations competed for markets and materials (Tarascio, 1998). The centre of growth for each upswing could be a different country because the most prosperous were likely to suffer the greatest in a collapse and thus not be able to re-emerge with their former strength (Fisher, 1998).

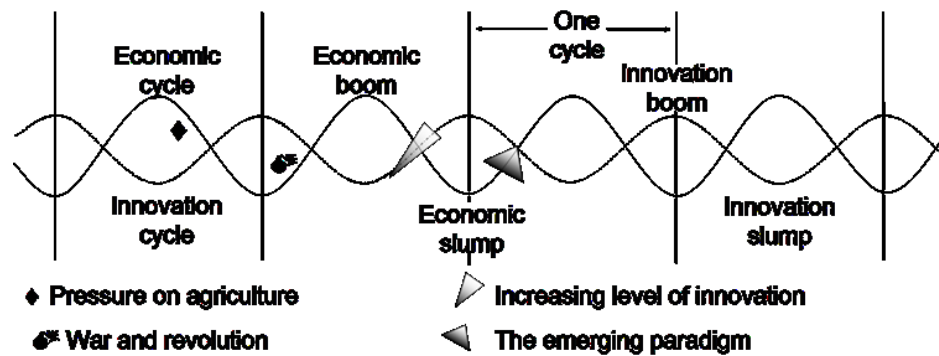


Fig 2: Kondratieff's observations in diagrammatic form

Empirical evidence dating back to the mid 1700's appears to confirm the existence of long waves nevertheless some theorists argue that because subsequent economic performance has not matched the 50 year cycle, their relevance in the Post War II economy is undermined (Fisher 1998). However this is not sufficient to disprove the theory because during that period, long waves have been observed falling between 40 and 60 year cycles. Whilst it is evident that changes of paradigm are not new, it could be argued that since the 1970's, globalisation has developed to the point that the interdependency of societies has increased the impact of such change. Fig 2 represents the cycles with a fixed level at which the peaks and troughs occur. Whilst this is not an established fact it could be argued that globalisation and the associated interdependency of nations could amplify events, increasing the rise and fall of recession signifying that the depths of each successive recession are deeper and the economic boom is greater, which would result in a greater destabilising effect on the economy

Business Cycles

Schumpeter isolated profit as the link between long waves and business cycles. He argued that innovations were causal to economic upturn but treated both innovation and government action as externalities. Innovations included the development of new products that, once accepted by the market, became profitable because they could be marketed at a premium enabling investment and growth (O'Hara, 1994). This was exacerbated by employment required for the installation of new plant (Freeman & Perez, 1988, in Dosi, 1988). Perez and Freeman make the point that such growth is balanced by the tendency to finance innovation through increased debt, fuelling the need for future growth (Perez, 1983, in Freeman, 1986). As other businesses copied the new ideas, over production occurred fuelled by mass production and economies of scale tended to occur, which coupled with competition forced prices down, leading to recession until the next range of innovations could lift the market again (O'Hara, 1994) (Freeman & Perez, 1988, in Dosi, 1988). Process innovation, which tends to occur later in a product's life cycle involves labour saving methods that can herald the recession (Freeman & Perez, 1988, in Dosi, 1988). Peled, (2001) noted inertia in the system, explaining that industries prefer to use tried and tested processes. In potentially delaying investment in new plant, it could be argued that such inertia increases the amplitude of the cycle because inefficiencies would need to be sufficient to overcome the inertia before any change is instigated. Fig 3 is a systems map of the long wave system from the perspective of business, and includes a key question raised - that of the character of innovation, and whether or not it clumps, and thus causes long waves to occur.



Fig 3: A systems map of the components of the long wave in relation to Business Cycles

The role of innovation

Ohara (1994) suggested most theorists disagree that innovations clump, and thus discredit the hypothesis that they trigger the upswing in the economy and therefore seek a different explanation. Three are identified: Firstly, the term innovation is used to embody process and product focussed developments as well as new ways of structuring organisations (Ohara 1994) and in this context, they are seen to occur throughout the cycle. However, Mensch, Freeman and Perez differentiated between the types of innovation, noting they varied at different stages of the cycle. Thus, as shown in *fig 4*, the change in style of innovation is seen to drive different stages of the business cycle, whereby radical product focussed innovation is illustrated by the solid line, and the process focussed innovation stemming from the need to maintain profitability is represented by the broken line. Mensch believed that the innovations spawn further innovation during the period of economic boom as industry concentrated on exploiting the new technologies. Improvement innovations gradually become less radical until their ability to make profitable change is negligible (Troub 1981).

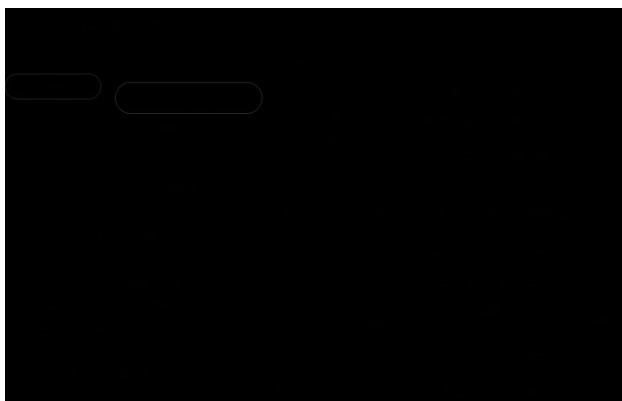


Fig 4 An Influence map showing the impact of innovation of the long wave system from a business perspective.

Secondly is the issue of the timing of the innovation. Perez (1983) believed that process innovations begin to occur towards the end of the upswing and are diffused in the form of equipment by the time the depression occurs. The significance of this is that the new cluster of product focussed innovations are developed using the established technology regarding production plant, which is not necessarily the most effective manner of production, and thus the peak of the next wave occurs when the potential efficiency that can be achieved with the

old technology is exhausted. Ansoff's industry life cycle (*fig 5*), which shows a loss during its emergence stage followed by a dramatic growth in profitability during its growth phases which drop to a plateau during maturity before fading away during decline helps to substantiate her argument.

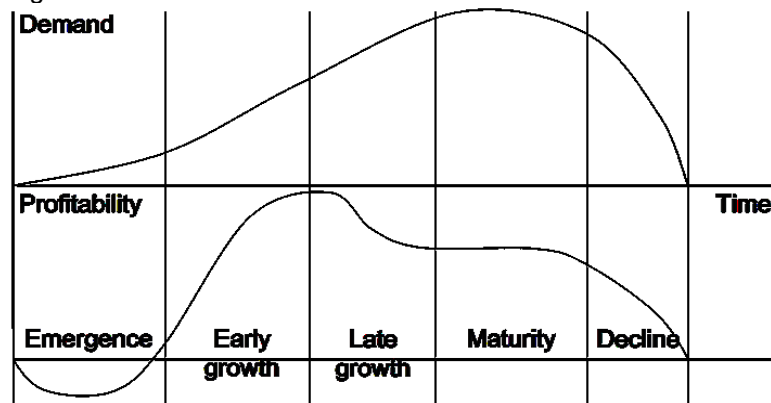


Fig 5: The Industry Life cycle. (Ansoff *et al* 1976)

Finally, De Bresson, (1987) argued that whilst innovations tend to be incremental they could also be cumulative. Thus identification of the innovation may be of lesser import to the issue of their role in paradigm change than the degree of change they yield. De Bresson also noted that the more radical changes leading to a paradigm change occurred when the potential efficiencies within a system had been attained and maintains the motivation of profitability as a core driver of the upswing and downswing.

Coombes & Kleinknecht (1983, in Freeman 1986) argued that the move from product focused innovation to process innovation only occurred in newer industries and concluded that the older industries, being in their mature stage had already adopted all feasible process based improvements. The implication of this is that the paradigm adopted in each long wave is largely influenced by new industry. Whilst Freeman observed that a new paradigm consists of technologies that have been proved to be effective in the preceding one (Freeman, 1992), Perez intimates that there is an element of chance that determines which innovations dominate a new paradigm, dependent on the timing of the innovation. She noted that the organisations that suffer the least during the downswing are those in their infancy and their apparent resilience attracts investment that enables them to develop into the growth stage that heralds the new paradigm and associated rise in the economy. (Perez, 1983 in Freeman, 1986)

Fig 6 maps the role of innovation to the economic cycle and shows that process focussed innovation should be considered part of the system because they not only affect the system, but are driven by it themselves. However, the stimulus for product innovation is not identified Thus innovation is seen to be a necessary element driving long waves but is not considered sufficient, because, as shown in Fig 4, the links between innovation and the inflow if investment and between innovation and the growth in outputs and employment has not been established (Rosenberg and Frischtak 1983 in Freeman, 1986).



Fig 6 The impact of innovation on the economic cycle

The technological and social sub systems

Broadening the scope of factors driving long waves, Perez postulated that there were two sub systems at work; the technological and the social, as shown in *fig 7*. She believed that new technology is uneconomic until society changes. She argued that society's natural hesitance in adopting a new technology increases the lag between the innovation being developed and the upturn in the market. For instance: In order to embrace the paradigm emerging in the 4th wave, that of low cost energy and mass production, society needed educating and advertisements, retail outlets & planned obsolescence were introduced. This caused widespread spending and the subsequent expansion (Perez, 1983, in Freeman, 1986). Perez and Tylecote both recognised that society was an intrinsic part of the system during the downswing. The period, illustrated by the broken line initiated by process development, is typified by a drop in earnings as redundancies occur when industry seeks localities with a lower wage demand in order to bring about economies to maintain profitability. Thus a mismatch is created between those who profit from developing new technologies and the wealth of those working in production meaning that the larger sector of society has less disposable income with which to purchase goods, further exacerbating the downswing (*ibid*) (Ohara 1994).

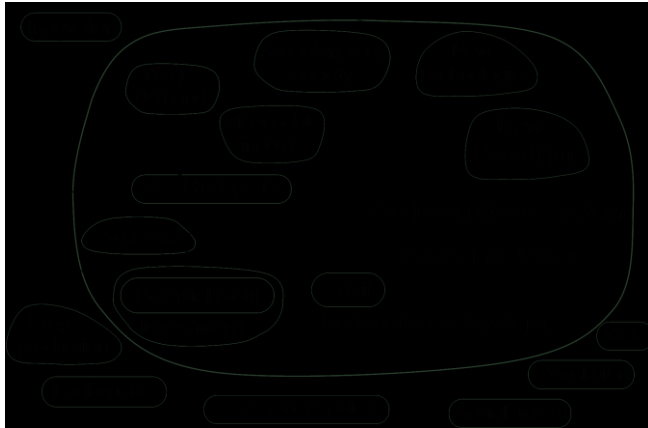


Fig 7 An influence map showing the role of the technological and social sub systems

The Role of Governments and Institutional Change.

Having identified the implication of the growing disparity of wealth, Perez also recognised the role of governments during the resultant period of downswing and recession whilst they seek to stabilise the economy and promote growth (Ohara 1994). Perez considered that the upswing could only take hold once there was a sufficient degree of congruence between the technological and social systems and Tylecote maintained that it required regulation in order to control the mismatch. (*ibid*).

Empirical evidence suggested that each upswing had been preceded by a change in legislation rendering a sphere of activity profitable for the entrepreneur. Whilst such change of property rights had no doubt been prompted by innovation, they enabled the entrepreneur to profit at a level that compensated for the associated risk. (Anderson, 2006) (Kingston, 2006) Whilst legislation was a necessary, it was not considered a sufficient forerunner to change, as on each occasion, it was associated to a change of institutional structure. For instance the introduction of property rights led to the wealth and security that enabled investment in other ventures including factories. Similarly, the limited liability act is identified as being the forerunner of the larger Corporation and Trademark Registration act which facilitated the birth of the brand.

Thus we see in *Fig 8* that whilst the potential for financial profit remains a key driver of the long wave, it is facilitated by multiple factors including innovation, legislation and changes in institutional structures.



Fig 8 an influence map including the role of legislation and new institutions

Determinants of the Character of an Emerging Paradigm

A key question of interest to this paper is the determinant of the paradigm that emerges with the new upswing. Kondratieff believed that it was not possible to determine the nature of an emerging paradigm. Similarly, as related in this paper, some theorists also allude to the role of technology in shaping change. De Bresson (1987) suggested that the innovations preceding a paradigm change occurred after potential efficiencies of the existing system had been exhausted, thus suggesting that the new paradigm embodied the radical change necessary to achieve efficiencies that were not possible with the preceding one. This is supported by Freeman's observation that the new paradigm includes the technologies that had proved their efficiency in the preceding one. However, Perez's view that industries that are emerging prior to the downturn are the ones that dominate the upturn could suggest that they also influence the new paradigm. Thus it is apparent that the seeds of the new paradigm are in place before it emerges and thus the possibility exists for it to embody efficiencies that enhance profitability. It is argued in this paper that whilst structures are in place with the purpose to encourage a reduction in environmental dependency, the subsequent paradigm would include a step towards the desired goal.

The Position of the Stakeholder

This paper has shown that one of the major determinants in shaping the techno-economic paradigm is business, which seeks to maximise profits in order to benefit their shareholders. Thus environmental sustainability is not a primary consideration, and will not be pursued if it results in a loss of competitive advantage (Steger *et al*, 2006). However, it has made the point that shareholders are not the only stakeholders of business, and the remainder, including the environment, the employee and society all create demands that, if met, could reduce profits. Thus business can only satisfy one set of stakeholders at the expense of the requirements of another. Regulation has to a certain extent developed a minimum standard designed to protect stakeholders, and these can lead to incremental change that over the passage of time has made a significant difference. However, most of this change has been in the arena where the stakeholder has been the most active through the development of campaigns and the use of the media. (Crane & Matten, 2004) This may be because business responds to three stakeholders, the shareholder, the customer and the employee as each of these has the ability to influence their financial position, and thus any change in their opinion with respect to the need for sustainable practice will be echoed in business, (*ibid*) raising the effectiveness of education of society.

Steger *et al* identify four groups of stakeholders that have the power to change organisational behaviour and relate them to the degree by which they focus on environmental issues. Firstly, there are the 'challengers', including NGO's and consumer groups that seek transparency and social and environmental responsibility. Secondly 'bystanders' are entities that hold power, such as governments and unions. These groups seek to maintain a level playing field for competition, and in the EU, have already developed relatively high standards and thus are currently not considered by Steger *et al* to be interventionist. The group that embodies the key players within business, including organisations and consumers is labelled 'incrementalists', the name reflecting natural evolution that has occurred over time. This group does not see the need for regulation. Finally, the media is seen to be distinctively

different. The media does not have a direct interest in events, but it is their role to inform society of events. Thus they broadcast opinion expressed by others and as such are seen to hold significant power to influence others. Even if, as identified by Oliver *et al* (2008) the media does not change opinion, its power lies in the threat that it could do so. This view of stakeholder relationships would suggest that any change towards greater levels of sustainability would be slow, as governments do not see the need for further action and the consumer group changes in an evolutionary rather than radical fashion, and the consumer is unlikely to adopt change that provides a lesser level of utility without some form of intervention from regulatory authorities. Whilst education is seen to be a driver of change within society, it should be recognised that this embodies the transfer of indigenous knowledge as well as knowledge creation that can be stimulated through government grants. The mode of education is also critical, as leaving it to institutions where the time lag between learning and implementation is unlikely to result in a reduction in resource use at a rate that will meet the emerging countries needs.

The scope and impact of change

In long wave theory paradigm change is secondary to economic cycles. However, the focus of this paper is to assess the factors that will influence a change in paradigm, and thus the economic cycle is a secondary issue. *Fig 8* provides an influence map in which paradigm change is the primary issue. In order to limit the components within the map, the subsystems have been represented at a generic level, and thus it should be assessed in conjunction with the previous maps.



Fig 8 An influence map showing factors that can be controlled by society relating to paradigm change.

Fig 8 should be viewed in conjunction with *figs 6 & 7* for the full level of detail to be represented. The actions that are considered to be those which are the most effective in driving through change are represented by the arrows in bold. The impact of change is represented by arrows with broken lines, and the influence between the societal sub system and political action is represented as a dotted line. This representation is differentiated because it is a relationship that has particular qualities. Governments seek to represent the sector of society that gave them their mandate for a limited period of years and their scope of action is limited by that mandate.

The entities within the Business and Economic cycle are not viewed as principal drivers of change. Steger classifies this group as incrementalists, and long wave theory would suggest that the core focus of their activities is driven by economic expedience. Thus, appropriate change emanating from the business sector would follow other changes that render such action profitable. The diagram would suggest that business is influenced by a change in paradigm that feeds back into the cycle of change.

Thus the primary driver of change is seen to be the activity of governments. However, with respect to driving society towards sustainability, Steger has classified this group as bystanders, suggesting that they require stimulus from elsewhere to spur action. It is recognised that Globalisation is at the heart of the current paradigm, and the first countries to legislate in a manner that could damage their competitive position are likely to undermine their economic stability. (Le Veness & Fleckenstein, 2003). Thus intergovernmental agreements such as the Kyoto Agreement is likely to yield more effective action as it would enable and prompt government action whilst still preserving competitiveness. Once the focus of change is established, the diagram shows feedback loops that will carry it through into subsequent paradigms, augmenting the change.

Conclusion

This paper has reviewed theories from a systems perspective with the view to developing a map of the factors that lead to paradigm change. The nature of change is determined by not only technology and society, but the environment, together with an interconnected web of individual positions ranging from national interest to personal gain, using instruments as varied as political intervention and the media.

Examination of long wave theory reveals a number of interlinked issues. The role of entrepreneurs is a consistent feature of both economic upswings and downswings, but the trigger that enables the downswing to move to the upturn appears to involve legislative change that leads to new business structures. These are in turn driven by core business concepts, including the life cycle of an industry and of products and lead to changes in not only the economic cycles but also in the change of technological paradigms. Coupled with this is the role of society which needs to respond to the activities of business to render them profitable. Wealth disparity that occurs as businesses seek to cut costs undermine the profitability of business contributing to the downturn. A review of stakeholder theory revealed that business is sensitive to those that can influence their profitability. Corporate stakeholders are constantly seeking efficiencies that lead to competitive advantage which is a theme evident in studies of long wave theory. It is suggested that government action, whilst effective has currently achieved high standards in the EU and views economic prosperity as a higher priority. Thus the key activity campaigning for sustainability rests with grass roots activists and NGO's.

A relationship map representing all of these components highlights the influence that governments wield over the system, but identifies their current 'bystander' status. The feedback loops suggest that once change is instigated, provided society accepts the need for it and adopting the changes does not undermine profitability, the changes will carry on through to subsequent paradigms, augmenting the degree of change achieved.

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