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IAMOT 2012 TAIWAN

Managing Technology-Service Convergences in the Post-Industrialized Society

March 18-22, 2012 · Hsinchu, Taiwan



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Chinese Society for Management of Technology (CSMOT), Taiwan, R.O.C.

Taiwan Academy of Management (TAOM), Taiwan, R.O.C.

IAMOT 2012, Hsinchu, Taiwan
Managing Technology-Service Convergences in the Post-Industrialized Society

PHILOSOPHY, THEORY, AND PRACTICE OF GREEN OPERATIONS MANAGEMENT

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ABSTRACT

This paper proposes a more profound discussion of the philosophical underpins of sustainability than currently exists in the MOT literature and considers their influence on the construction of the theories on green operations and technology management. Ultimately, it also debates the link between theory and practice on this subject area. The paper is derived from insights gained in three research projects completed during the past twelve years, primarily involving the first author. From 2000 to 2002, an investigation using scenario analysis, aimed at reducing atmospheric pollution in urban centres by substituting natural gas for petrol and diesel, provided the first set of insights about public policy, environmental impacts, investment analysis, and technological feasibility. The second research project, from 2003 to 2005, using a survey questionnaire, was aimed at improving environmental performance in livestock farming and explored the issues of green supply chain scope, environmental strategy and priorities. Finally, the third project, from 2006 to 2011, investigated environmental decisions in manufacturing organisations through case study research and examined the underlying sustainability drivers and decision-making processes. By integrating the findings and conclusions from these projects, the link between philosophy, theory, and practice of green operations and technology management is debated. The findings from all these studies show that the philosophical debate seems to have little influence on theory building so far. For instance, although 'sustainable development' emphasises 'meeting the needs of current and future generation', no theory links essentiality and environmental impacts. Likewise, there is a weak link between theory and the practical issues of green operations and technology management. For example, the well-known 'life-cycle analysis' has little application in many cases because the life cycle of products these days is dispersed within global production and consumption systems and there are different stakeholders for each life cycle stage. The results from this paper are relevant to public policy making and corporate environmental strategy and decision making. Most of the past and current studies in the subject of green operations and sustainability management deal with only a single sustainability dimension at any one time. Here the value and originality of this paper lies in its integration between philosophy, theory, and practice of green technology and operations management.

Introduction

This paper explores the links between philosophy, theory, and practice in green operations management. The globalisation of markets and production systems has created a new dynamic in the world economy that includes millions of people in the consumption patterns of Western countries (Prahalad and Hart, 2002). Nevertheless, the increasing rates of consumption could be threatening our natural environment and may put the World population in jeopardy due to the loss of biodiversity, insufficient energy supply, climate change, and pollution of fresh water resources, air and soil, among other causes (WRI, 2002).

Despite the continuous debate about the sustainability of the planet, a number of issues continue to be unexplored. The sustainable development concept is extensively used, but there is a great difficulty in translating it into practice for countries, cities, companies, and even to personal life styles. These problems are related to the complexity and uncertainty embedded in the design, implementation, and assessment of environmental strategies.

For example, the concept of sustainable development that is largely used in academic studies reads simply that "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). Very little attention is paid to the following paragraphs in the main document "Our common Future" also known as "The Brundtland Report". They supplement the section on the concept of sustainable development by adding the aspirations of human beings besides only meeting the basic needs.

> "The satisfaction of human needs and aspirations is the major objective of development. The essential needs of vast numbers of people in developing countries for food, clothing, shelter, jobs - are not being met, and beyond their basic needs these people have legitimate aspirations for an improved quality of life. A world in which poverty and inequity are endemic will always be prone to ecological and other crises. Sustainable development requires meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for a better life." (WCED, 1987)

The philosophical position in the Brundtland Report is that sustainable development implies limits – "not absolute limits, but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities" (WCED, 1987). However, although the concept of needs is discussed, it is not clear how to measure sustainability in different countries considering their unequal stages of development. It then becomes less tangible when the concept of sustainable development is cascaded to companies as the attempts of measuring sustainability of business are often inaccurate or too far from reality. Despite the broadness of the concept there are two main variables that are explicit in the document: essentiality (representing the 'needs' of human beings) and environmental impact, which should be minimised in order to guarantee that future generations have the same access to natural resources as we currently do.

With regard to the concept of need, Maslow's 'hierarchy of needs' as shown in Figure 1 has well been established in the psychology literature (Maslow, 1943). It can be considered for practical terms in business and societies as a way to define better the boundaries of essentiality.

The issues around environmental impact assessment are mostly considered from the series of ISO 14000 standards. Environmental impacts can be assessed based on four main characteristics: (1) the scale of the impact, (2) the severity of the impact, (3) probability of occurrence, and (4) durations of impact (ISO 14004, 2000). The scale of the impact can be considered as global, regional, local, confined, or isolated. Severity can vary from 'fatal' to 'harmless', while probability varies from 'high' to 'low' likelihoods. The duration of the impact can be considered irreversible, long-term (which takes time and great effort to recover the damage), or short-term (impacts that are easier and quicker to be reversed).

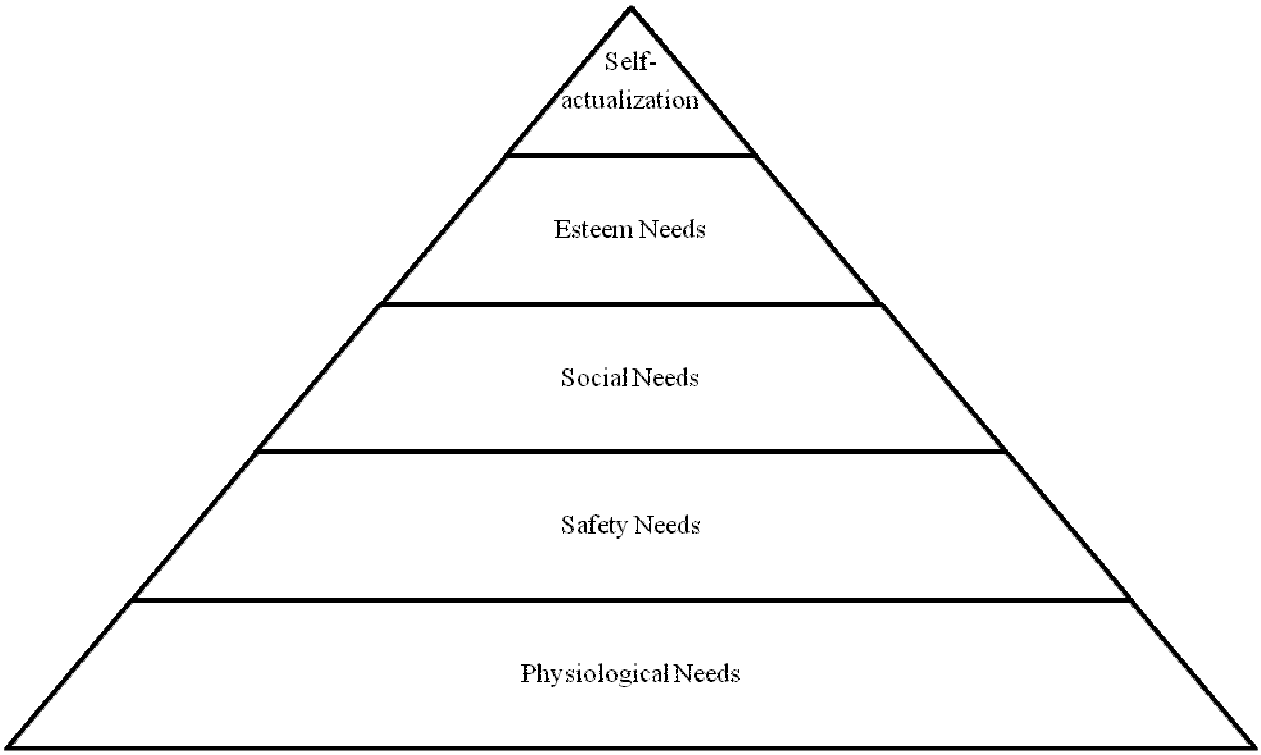

Figure 1 – Maslow's Hierarchy of Needs (Abraham-maslow.com, 2012)

Three other concepts are vital in the discussion proposed in this paper: the *environment*, *environmental aspect*, and *environmental impact*. These concepts can be extracted ISO 14004:

- *"Environment is the surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation"* (ISO 14004)
- *"Environmental aspects: element of an organization's activities, products or services that can interact with the environment"* (ISO 14004)
- *"Environmental impact: any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services"* (ISO 14004)

Without a debate about what should be the main drivers for action and the focus of the actions, the sustainability initiatives may not result from the primary objectives (e.g. conservation of the environment, social equality, and economic prosperity).

The next section will address the relevant literature related to the main thesis of this paper: the fragility of the link between philosophy, theory, and practice of green operations management.

Literature Review

First, this section presents a brief of philosophy of science and its link to theory and practice. It thendiscusses the philosophical aspects on the research of green operations management when building theories and assessing environmental practices.

From Philosophy to theory building to practice assessment

The philosophy of science deals with the fundamental questions for scientific research. It is concerned with issues related to the foundations of science, the formation of assumptions, use of methods, and lately the ethical implication of scientific discoveries. Encyclopaedia Britannica Online defines 'philosophy of science' as:

> " The branch of philosophy that attempts to elucidate the nature of scientific inquiry—observational procedures, patterns of argument, methods of representation and calculation, metaphysical presuppositions—and evaluate the grounds of their validity from the points of view of epistemology, formal logic, scientific method, and metaphysics" (Kitcher, 2010).

The fundamental question in philosophy of science is "What is reality made of?" (Lee and Lings, 2008). From this primary enquiry, the schools of thought in science have developed their axioms, theories, research methodology strategies, and investigation methods. The perception of what reality and knowledge are had a profound impact on the output of knowledge generation processes. Four different concepts have emerged on the basis of philosophy of science, namely: ontology, epistemology, axiology, and methodology. Failure to think through these concepts and other philosophy of science issues, while not necessarily fatal, can seriously affect the quality of management research because they are central to the notion of research design (Easterby-Smith, Thorpe and Lowe, 2001).

Lee and Lings (2008) discuss practical issues of applied business research in terms of philosophical concepts. According to the authors, ontology is the study of the nature of reality. It refers to how objective or independent reality can be in reference to an observer or participant in an event. The construction of reality is an essential issue for research ontology.

Epistemology follows ontology, since it is the study of what we can know about reality. While ontology is concerned to the nature of reality, epistemology studies the origin, nature and limits of human knowledge (Martinich and Stroll, 2010). An epistemic analysis then would discuss "how valid is the knowledge created?", whether it is generalisable or not, or specific to a particular time and place (Lee and Lings, 2008).

Axiology is another important concept within the theoretical debate in Philosophy of Science. From Greek *axios*, "worthy"; and *logos*, "science", axiology refers to the philosophical study of goodness or value (Encyclopaedia Britannica Online, 2010). Lee and Lings (2008) say axiology is in essence about the aims of research – and in its relation to ontology, it should consider the intentions of a researcher to explain, predict or understand reality.

Last but not least, methodology refers to how the research will be conducted in order to create original and relevant knowledge. It can be defined as a combination of techniques used to enquire into a specific situation (Easterby-Smith, Thorpe and Jackson, 2008). It can be quantitative or qualitative.

As a result of the application of research methods within a certain methodological approach, theory can be built. Theory is an attempt to explain the behaviour of the phenomena (Christensen and Sundahl, 2001, Carlile and Christensen, 2005; Christensen, 2006). It is a representation of reality which states what causes what and why, and under what circumstances (Christensen and Sundahl, 2001).

Theories on Green Operations Management

The theories of sustainable and green operations do not have a judgmental view on the essentiality of businesses, productions processes, and their products. The major focus is on environmental impacts - usually represented by their main environmental aspects such as emissions, energy and water consumption, wastes, etc.

Sustainable and Green Operations are usually understood as economically viable, socially fair, and environmentally friendly operations. The review paper written by Carter and Rogers (2008) corroborates this view. In order to minimise the contradiction of this view, academics tend to use the term 'greener' or 'cleaner' production for some industries that have an intrinsically high environmental impact (e.g. oil production, car manufacturing). Here represents the use of alternatives with lower environmental impact.

The philosophical debate in the field of green operations is almost non-existent and the theories are therefore build without the basic philosophical underpinnings. Greener operations is conceptualised as having environmental considerations in the decision making process by Sarkis (1995) and Gupta and Sharma (1996), while Kleindorfer, Singhal, and Wassenhove (2005) defines sustainable operations around the use of environmental practices, particularly: eco-design, green manufacturing, closed-loop supply chains. Without the considerations concerning the essentiality of goods, the assessment of sustainability for operations is incomplete. High-impacting but essential companies (e.g. in the energy sector) are highlighted as unsustainable; while insufficient attention is paid to less harmful but non-essential goods offered for mass consumption at high quantities for individuals. Life-cycle analyses (LCA) are constantly used, but without acknowledging the fact that reality involves a higher level of complexity. This could make LCA of little value for strategic decision making given the high number of stakeholders involved, the dynamic changes of technology, and the environmental priorities of the locations where operations take place.

Indeed, there are some attempts to measure sustainability level. For example the Dow Jones Sustainability World Index (DJSI World) covers the top 10% of the biggest 2,500 companies in the Dow Jones World Index in terms of economic, environmental and social criteria (Dow Jones, 2007). In fact, a number of sustainability indices that take an ethical-security approach exclude industries such as tobacco, gambling, adult entertainment, firearms, nuclear power and alcohol, given the negative aspects associated with their operations and products (Ali and Yano, 2004, p.151). Nonetheless, these financial indices are not necessarily being translated into the green operations performance management.

Philosophical questions about sustainability should address the nature of economies, businesses, production and consumption patterns. Sarkar (2012) writes on the importance of environmental philosophy and its ability as an applied science to address fundamental questions of sustainability when putting problems into context. For instance, Sarker also states the Western view of sustainability is mostly anthropocentric rather than bio or eco-centric, which may create problems when considering environmental preservation for other species beyond our own *homo sapiens*. By analysing the proposed two components of sustainability (essentiality and environmental impacts) it is possible to provoke reflection on more profound issues of greening operations while combining an anthropocentric (essentiality) and eco-centric (environmental impact)

- Can we have sustainable operations in an 'unsustainable' economic environment?
- How endogenous would production need to be when considering sustainability of supply chains?
- How do we consider specific location advantages or constraints in environmental performance measurement?
- How do we consider uncontrollable factors such as individual rates of consumption when designing product and operations' environmental performance?

Methodology

This paper is based on a conceptual research methodology (Meredith, 1993). Taking a philosophical conceptualisation the authors use conceptual induction and deduction from 12 years of research experience in the field. Three relevant research projects were undertaken between 2000 and 2011. First, scenario analysis and quantitative techniques was used for an environmental impact assessment and to evaluate the substitution of petrol and diesel fuels by natural gas. Second, a survey questionnaire investigated the use among livestock farmers of environmental practices and the introduction of environmental concerns into management decisions. And finally, environmental decision making processes were investigated in manufacturing companies from four industrial sectors (the car industry, textiles, chemicals, and food processing) in four countries (UK, USA, Germany, Thailand). Put together, the critical philosophical underpinnings of operations sustainability are analysed, and their links to theory and practice are explored. Table 1 indicates the basis of analysis on the philosophical aspects of green operations research in the view of essentiality and environmental impact analysis.

Table 1 – Philosophical aspects of the green operations management research, and its essentiality and environmental impact components (developed by the authors)

Philosophical aspects of green operations management	Essentiality	Environmental Impact
Ontology: reality is mostly subjective for the environmental sustainability of companies. There are different worldviews in different parts of the world for the same concepts and facts. Although some of the issues related to emissions, environmental impacts and aspects can be understood in a quantitative and objective world, the environmental decisions are within a subjective dimension which varies according its context.	Largely subjective. Concrete evidence can only be given at the basic physiological needs of humanity but not of aspirations	Largely objective but with components of subjectivism when analysing environmental aspects as the origins of environmental impacts
Epistemology: knowledge is currently being created on both theory and practice of green operations. As a consequence of its early stages, the nature of the knowledge is particularly linked to its time and place, which creates strong limitations to generalisability of environmental decisions; however favouring the investigation on the patterns of environmental decision making processes in an interpretivist approach	The knowledge around Essentiality is a dynamic; therefore needs contemporary and constant assessment after built.	The construction of knowledge around products, materials, organisations and their impact on the environment can be narrow towards an objective paradigm. However, when time dimension is added it may favour a interpretivist approach
Axiology: the value of this research is mostly on its contributions to increase understanding of green operations management. In coherence to its ontological and epistemic views, the explanation and prediction of the field are limited since it is necessary a deeper understandings of the events on this field of knowledge.	The value of the research on essentiality is recognised as critical to inform government and companies about the sustainable value of products in the market	The value of the research on environmental impacts is understood as critical to the preservation of our biosphere and the species living within. It can be used to inform the sustainability performance of operations processes and products.
Methodology: considering that a study on green operations management is a dynamic and contemporary event embedded in a contextual complexity of organisations, the methodology is mostly qualitative; however able of quantification.	A qualitative evaluation of critical needs and aspirations is fundamental before the use of quantitative methods	A qualitative understanding of the operations' environmental surroundings at local, regional, and global scales is key before using quantitative methods.

Findings

This section presents the findings from the three research projects mentioned in the methodology section.

Natural gas as a substitute for petrol and diesel fuels

The main objective of this project was to conduct an environmental impact assessment on the substitution of petrol and diesel by natural gas. The main results were aimed to help in the development of environmental policies that reduce urban air pollution.

The use of natural gas in the urban fleet was analysed in the city of Natal (Brazil). It was found that compressed natural gas was suitable as a substitute given the technological feasibility in the adaptation of petrol engines to burn methane. The low investment levels in the supply (infrastructure) and demand (engine convertors) would allow a rapid growth in the market place. The best environmental and socio-economic benefits happened when in converting taxis fleets from petrol to natural gas. This was given their pattern of mobility and distances travelled by taxis in the city. Furthermore, when private cars were converted to natural gas, because of their lower running costs, the positive impact on emissions could be offset by more journeys and traffic congestions could worsen in the long run.

Given the maturity of the field, no serious issues were reported as part of the conceptual philosophy. Natural gas was mostly understood as a *cleaner* and *alternative* fuel rather than *green* or *sustainable.* This was because of its well-known origin from non-renewable fossil fuels. From an environmental philosophy perspective, the essentiality and environmental impacts issues are easily identified. From an essentiality perspective, a growing economy needs better alternatives of personal mobility. However, the essentiality of the journeys becomes a subjective matter.

Since the emissions are also easily measured, the environmental impact assessment informs an objective reality. Likewise, the urban pollution levels are of tangible measures, able to be predicted, and an important driver for environmental policies. For example, in the case of the use of natural gas it was found that, on average, emissions from natural gas-converted vehicles were 2.3 times less ozone forming than those from the same vehicle fleet when petrol-powered. They could also reduce CO emissions by 88%, hydrocarbons (excluding the methane) by 91% and NOx by 40%; however it increased by 13% for hydrocarbons including methane (Schifter et al, 2000). According to Nunes et al (2002), a one study undertaken by PETROBRÁS DISTRIBUIDORA S.A. the urban buses run by diesel were converted to natural gas in 1989, and they were emitting 4% less CO, 24% less hydrocarbons and they had overall reductions for particulate materials and SOx. However, the rate of NOx increased by 13%.

In the end the environmental policy decision therefore needs to be made according to the composition of local urban air to avoid further environmental impacts. The link between environmental philosophy and environmental policy for urban pollution is particularly strong. However, the implementation of environmental policies may suffer from the influence of various other drivers beyond essentiality and environmental impacts that could differ theory from practice. Nonetheless, variables in the dimensions of space and time can be easily introduced in the analysis of essentiality and environmental impact assessment.

Sustainable livestock

The main objective of this research project was to identify and assess the perception of environmental and competitiveness among farmers in rural areas of developing countries. The work included a survey with approximately 100 livestock farmers in a goat and sheep breeding cluster in the Northeast of Brazil. The main results indicated that location (municipality), educational level, and size of the property were associated with higher perception levels; while, associative condition, family income, and production volume could not be as influencing perception.

The research project faced several challenges from a conceptual philosophy perspective. First, the terminology of sustainable farming was not always clear. Confusion with organic farming could usually happen both in theory and practice. The environmental practices were not always unanimous as enhancing competitiveness or even protecting the environment. This was clear when the environmental impact assessment was done and showed that organic farming required more land than intensive and semi-intense livestock systems. Therefore a higher impact could be created on native vegetation. Terminology was not always clear either since European countries for example would classify 'conventional' systems as intensive while in developing countries 'conventional' systems are mostly semi-intensive. The higher interdependence between agricultural systems and the environment gives the farmers a false impression that agriculture is an activity of low environment impact, when it actually depends on the type of production systems.

On the other hand, there was very little argument on the essentiality of the product and production processes. Given the simplicity of assessment, the main products from the farms (milk, meat, and leather) were seen as essential for society and their production as indispensable for the local economy.

The strength of the link between philosophy and theory is medium for livestock systems given the difficulties in defining the concepts. Aronson (2011) demonstrates concerns with the lack of a common terminology in sustainability sciences, which supports this view. Nevertheless, a number of sustainability approaches (e.g. microcredit schemes, economies of scope, industrial ecology, closed-loop systems, etc) were taken from theory into practice with proven positive results. This strong link between theory and practice is likely to happen given the 'visual' evidence of local environmental impacts in the farm (soil erosion, degradation of native forest, contamination of fresh water, etc) and once essentiality is easily supported.

The dimensions of space and time with regard to production locations are embedded in the production system in a way that permits a fair assessment of sustainable technology alternatives. For example, the use of pesticides or irrigation systems is designed according to the specific environments where they are to be used.

Environmental decision making in manufacturing firms

The third research project reports an investigation of green operations initiatives and environmental decision making. It includes the analysis of the drivers for environmental initiatives, origins of ideas, and decision making processes as well as the development, application, and evaluation of systems thinking for environmental decision making.

The findings of the project show that companies that want to demonstrate environmental leadership will need to take environmental decisions beyond manufacturing processes. Nunes and Bennett (2010) provide a classification of green operations to help companies take strategic environmental decisions. The classification includes five main environmental practices: green buildings, eco-design, green manufacturing, green supply chains, and reverse logistics. Because the benefits (including financial gain) of non-manufacturing activities are not yet clear the decisions related to product design, supply chain and facilities are fully embedded with complexity, subjectivism, and intrinsic risk. Nevertheless, this is the challenge environmental leaders will face - they may enter in a paradoxical state of their decisions – where although the cost of going green may be high, the risk of not doing it is even higher.

A number of issues were found when analysing the philosophical underpinnings of the environmental decision making in manufacturing firms. The literature shows confusion with the concepts of green manufacturing. Lean and efficient production systems are often considered 'green' without discussion on the nature of the products. Lean can indeed improve operations environmental performance (King and Lenox, 2001, Florida, 1996); but the lack of debate around the essentiality and environmental impact assessment is evident, which contributes to the confusion on derivate concepts. The predominant focus on environmental aspects (mainly emissions) diverts the assessment of environmental performance from reality.

In practice, the weak link between philosophy, theory and environmental practices has a serious effect. Automotive companies in the sample struggle to define what a green product is. So do carpet manufacturers. The environmental practices are not easily linked to drivers. Ironically, in some cases they also fail to improve environmental performance when environmental performance measures are not well defined. Within the environmental practices only eco-design and reverse logistics considers in depth the issues of essentiality and environmental impact. Essentiality is debated mostly on product-oriented initiatives; while for process-driven practices the management of environmental aspects and impacts is dominant.

The environmental philosophy starts to emerge in the literature relating particularly to the automotive sector. Here it is discussed whether the role of car companies should be to provide sustainable personal mobility or pursue the production of low-emission vehicles. Despite the emergence of environmental philosophy as part of the scientific rationale, theories are given without strong evidence. Orsato (2006) comments on Porter and Van Der Linde's (1995) green and competitive theory and shows that it is not always easy to find win-win environmental solutions. Hart (1995), in one of the most cited papers on sustainability management, admits the difficulty in finding a real company in the market that represents the final stage (sustainable development) of his classification. The link between theory and practice is strong for issues of pollution control and prevention developed by Klassen and Whybark (1995). But Zhu, Sarkis, and Geng (2005) show how it is still difficult to link environmental pressure to environmental practices adoption, and environmental practice adoption to environmental performance improvement in a study in China.

Given the current complexity of dispersed manufacturing networks, variables belonging to the dimensions of space and time issues are not easily linked to environmental impact assessment and analysis of essentiality of goods. The choice of green technologies for manufacturing can become complicated given the number of uncontrollable factors around their products and processes (e.g. consumers' rate of consumption, geographical concentration of production and its effect on local sustainability, responsibility on global logistic routes, etc).

Discussion and implications for MOT field

The philosophical underpinnings of green operations management are necessary when constructing robust theories and evaluating what companies are actually doing in practice. The two main components proposed here are essentiality and environmental impact assessment. Of course these are very broad concepts that need to be better defined in order to follow a conceptual philosophy approach.

Essentiality of consumption, for instance, needs to be linked to the rate of consumption in accordance with location specifics. For this, Maslow's hierarchy of needs framework (Figure 1) can be used in helping to define the priority of goods and services. Essentiality of production, on the other hand, could be linked to social and economic development level, strategic importance for national interest, and so on. For example, scale of production is a measure that should to be informed by the level of environmental impacts, particularly, the availability of resources (in order to avoid Hardin's (1964) 'tragedy of the commons').

An assessment of essentiality and environmental impact at local/regional/global levels could reveal the critical drivers for environmental policy while being structured by an environmental philosophy approach. Figure 2 shows a model for sustainability assessment of goods and services. Goods and services that are essential with low environmental impacts need to be rapidly developed to achieve a higher number of consumers. On the other hand, good and services that have high environmental impact will need careful assessments of their essentiality, and when produced and consumed they will require the use of environmental policies in order to reduce their burden on the environment.

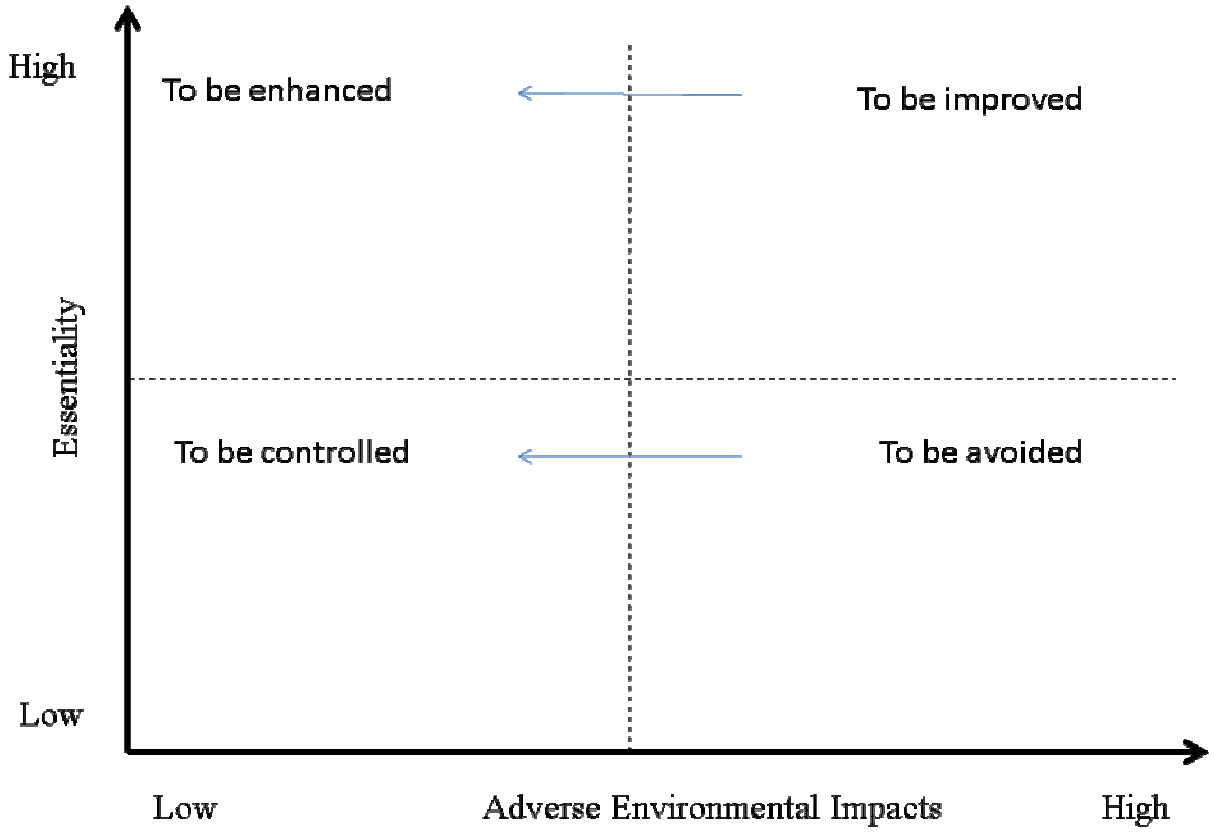

Figure 2 – Model of sustainability assessment

This approach highlights a number of considerations when developing sustainable technologies. First, there are issues around the limitations of technology as an exclusive promoter of sustainability as mentioned in the report 'Our Common Future' (WCED, 1987). Technology alone may not be able to promote the sustainability levels necessary to provide economic prosperity, social equality, and environmental conservation. Figure 3 shows the combination of technology-driven and social-behaviour change approaches.

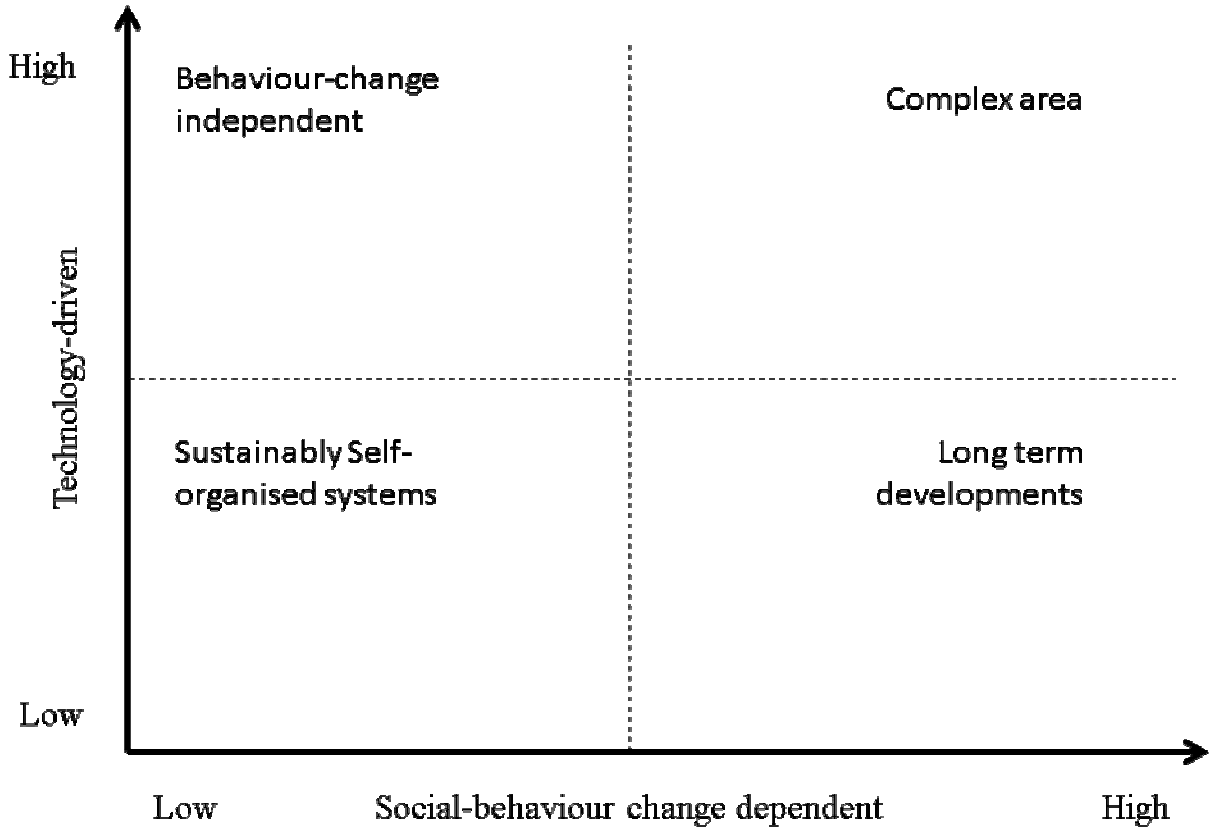

Figure 3 – Technology-driven and social-behaviour change dependency of sustainability policies

Figure 3 proposes an assessment of the areas where technology alone can make a difference. For example, intelligent lighting systems can save energy in buildings with very little behavioural change by users. On the contrary, recycling programmes need behavioural change besides the use of technology to avoid incorrect landfill disposal. Societal problems such as obesity and traffic congestion are predominantly dependent on behavioural changes although technology can play a role in helping to change behaviour. Finally, by reaching a sustainable resilience stage, systems may develop self-organising properties being able to maintain themselves sustainable on little interference from the use of technology and behavioural changes.

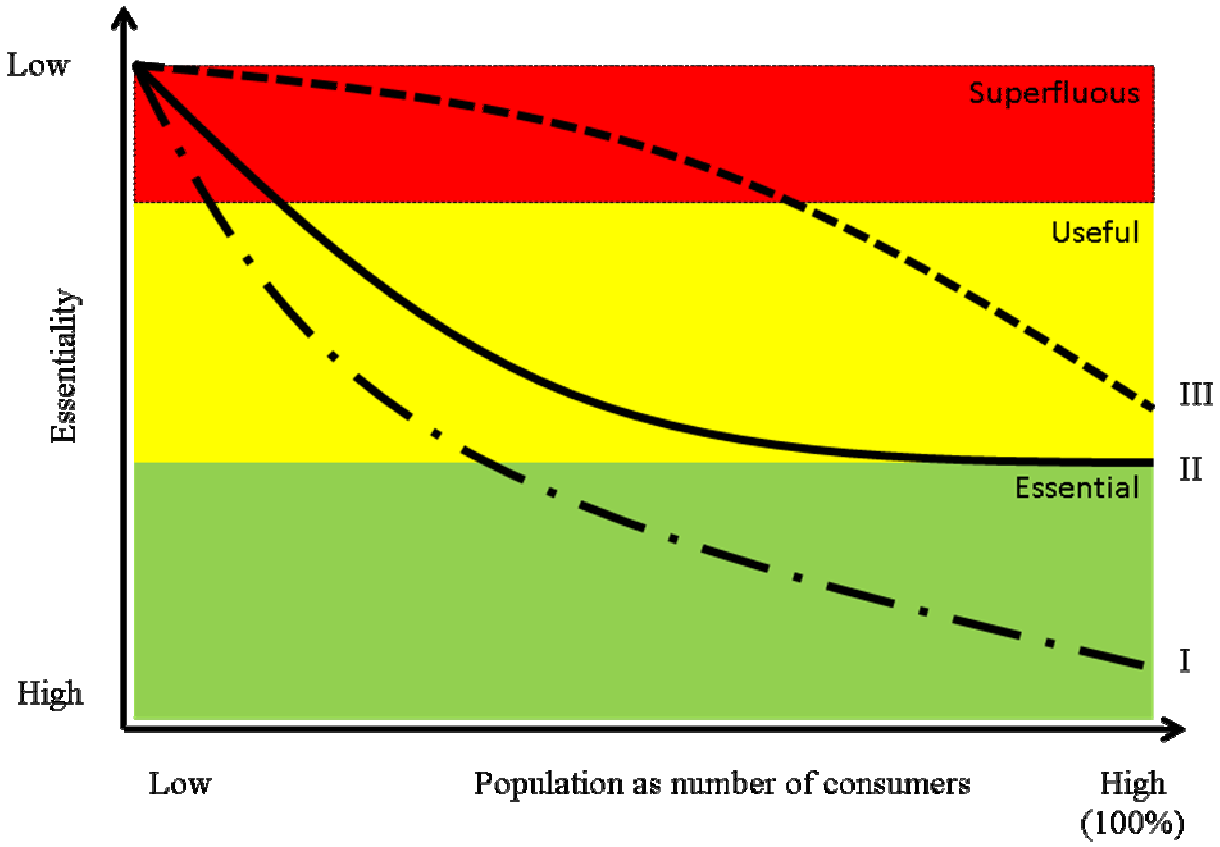

Figure 4 – Sustainability as a function of essentiality and number of consumers.

Because essentiality and environmental impacts are dependent on types and rates of consumption Figure 4 evaluates how the number of consumers can be accommodated in a sustainable way. The three curves in this figure explain the consumption of essential, useful, and superfluous goods and services. Curve I represents the current and unsustainable stage where global population is from a social dimension. Very few people can meet their needs and aspirations; but a high number of people are not able to meet their essential needs yet. Curve II shows a desired condition where most of the population is able to meet their needs as stated by United Nations' millennium goals. Curve III is a prediction that many fear, including sustainability scholars. As economic prosperity reaches more countries a large number of people may develop environmentally-unsustainable consumption patterns which could put in jeopardy the future generations in meeting their essential needs and aspirations.

Ultimately, technology can play a major role developing and making available essential and useful goods and services at low environmental impact levels to guarantee higher levels of local and global sustainability. Where social-behaviour change is necessary to avoid severe environmental impacts, government can act with regulations and environmental legislations.

Conclusions

This paper has proposed and demonstrated a central thesis on the importance of aligning philosophical thinking with theory building and practice assessment. A profound philosophical debate should include conceptual philosophy, aiming at defining clearly what the concept means and how it behaves when the dimensions of space and time vary, before theory establishment and practice assessment.

In a globalised world, the difficulties with creating valid sustainability standards are huge. However, on a smaller scale, such as with local or regional territories, it becomes easier to visualise patterns and define sustainability measures. For this purpose the paper has offered an approach of assessing two of the main components of sustainability: essentiality and environmental impacts.

This approach was developed as a result of insights from three research projects. These projects were analysed under the lens of essentiality and environmental impacts, with the intention of bridging the gaps between environmental philosophy, theory, and practice. Within this context, the design, development and management of sustainable technologies are also discussed. The findings section shows, for instance, the importance of accommodating location specifics and the variables belonging to the time dimension (historical analysis, seasonal aspects, etc).

The discussion section suggests three models for sustainability assessment. The first (Figure 2) proposes an assessment of economic activities, goods and services based on their level of essentiality and environmental impact. The second model (Figure 3) is a way of debating whether sustainability challenges can be addressed through solely technology driven approach or with a combined social behaviour change. Last but not least, the third model (Figure 4) suggests that by analysing the nature of consumption (essential, useful, superfluous) against the number of consumers can be a powerful tool when designing environmental legislations, regulations, and policies. These approaches are not completely alien to policy makers. For a long time they have been taxing indulgent economic activities such as gambling and goods that have adverse social impacts such tobacco and alcohol. In times where environmental challenges such as food safety, energy security, biodiversity loss, water availability, and soil contamination may threaten our way of life, a similar approach can be taken. Although still work in progress, the tools and the rationale behind this paper can help in the daunting task of preserving the environment when respecting the rights of each individual to meet their essential needs and aspirations.

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