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Really Changing the Course: the Limitations of Environmental Management Systems for Innovation

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ABSTRACT
The paper broadens the scope of environmental management system (EMS) research by describing how EMSs can contribute to inertia in present production systems. In conjunction with other factors this inertia can inhibit dramatic shifts toward more sustainable technologies and systems. Our approach builds upon *technological lock-in theory*, which focuses on market coordination and technological interdependencies as generators of inertia in technological systems. Building on this framework, we call attention to previously under appreciated non-market social forces and institutional structures that can further reinforce lock-in. We argue that the co-evolutionary mechanisms that generate increasing returns for physical technologies may also be applied to social technologies, such as management systems. The paper describes the emergence of 'EMS lock-in' as a path dependent evolution occurring within the context of the larger quality management paradigm. While EMS may initially produce improvements in environmental performance, EMS may also constrain organizational focus to the exploitation of present production systems, rather than exploring for superior innovations that are discontinuous. The paper questions the enthusiastic private and public sector support for EMS implementation and instead recommends an ambidextrous management approach that integrates foresight and broader stakeholder collaboration. Copyright © 2006 John Wiley & Sons, Ltd and ERP Environment.

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Introduction

SINCE THE PUBLICATION OF *CHANGING THE COURSE*, THE INTRODUCTORY BOOK ON ECO-EFFICIENCY by the World Business Council for Sustainable Development's Steven Schmidheiny (1992), companies have increasingly sought win–win solutions that combine simultaneous improvement in corporate competitiveness and environmental performance. Theoretical work supports this approach (e.g. Porter and van der Linde, 1995; Von Weizsäcker *et al*., 1997) and argues that pollution is a sign of both environmental and economic inefficiency, and that many cost-effective environmental measures are inadequately exploited by managers. This divergence from neoclassical profit maximization arises because managers are constrained by imperfect information, cognitive limitations and the existence of inappropriate organizational/incentive structures within companies (Decanio, 1993). The general corporate response to these challenges has been to improve management controls through the implementation of formalistic and procedural environmental management systems (EMSs) (Welford, 1997; Ulhøi and Welford, 2000). A variety of European and international environmental management standards have been introduced throughout the1990s and now over 70 000 companies hold some type of EMS certification world wide (ISO, 2003). Beyond these official registrations, many more companies – and other organizations including universities and public agencies – have implemented uncertified systems. Thus EMS has seemingly become the pre-eminent approach to environmental management globally.

The impact of EMS on technological innovation, however, has often gone unevaluated. Technological change theories (Schumpeter, 1934; Nelson and Winter, 1982; Dosi *et al*., 1988) distinguish between two types of innovation: *continuity* (incremental) and *discontinuity* (radical) type changes. In general, continuity change improves the performance of existing technologies while discontinuity leads to the replacement of existing technologies by superior alternatives. Distinguishing between the two can be complicated, however, by the fact that what is discontinuous at one level of analysis may appear continuous at a higher level of analysis (Unruh, 2002). The shift from hard disk drives to flash memory, for example, can be discontinuous for disk drive manufactures, but continuous for the larger personal computer value network in which memory is an embedded component. For this paper, we define *continuity* type changes as incremental competence enhancing modifications that preserve existing production systems and sustain the existing value networks in which technologies are rooted. From an environmental perspective, continuity solutions address pollution through adjustments to the input mix, incremental process changes or through end-of-pipe treatment methods. Estimates are that continuity approaches account for 70–90% of environmental technology expenditures (OIG, 2000), and have focused principally on waste management, energy use and water consumption (Kuisma *et al*., 2001; Hertin *et al*., 2003). *Discontinuity* type changes, in contrast, are competence destroying, radical changes that seek the replacement of existing components – or entire systems – and the creation of new value networks. In the environmental case, these approaches generally require returning to the initial design phase to eliminate environmental flaws from the business model at the earliest stages possible (Hawken *et al*., 1999; McDonough and Braungart, 2002). Such alterations may also require corporate transformation and restructuring of production systems, services, products and markets (Christensen, 1997; Tushman and O'Reilly, 1997).

It is becoming apparent that some environmental problems such as global climate change, resource depletion, biodiversity loss, accumulation of persistent pollutants or impacts on the nitrogen cycle cannot be effectively solved through continuity approaches. Dealing with global climate change, for example, will require nearly 90% reductions in carbon dioxide emissions by industrialized countries, something that currently seems beyond the scope of continuity approaches (Unruh, 2002). Fostering discontinu-

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ous innovations therefore appears to be an attractive strategy that could generate large sustainability gains. However, examples of discontinuity innovations are far less abundant than ones of the continuity type and understanding the barriers to discontinuity changes is an important area of research.

A useful starting point for understanding such barriers is *technological lock-in theory* (Arthur, 1989), which has identified numerous causal factors that can help explain inertia to technological change. The theory, however, has focused dominantly on market coordination and technological interdependencies as the primary sources of inertia in technological systems (e.g. David 1989, 1997; Arthur, 1994). In this paper, we focus on EMSs as an additional factor that may increase inertia to environmentally superior discontinuity innovations. Up to now, the research on EMSs has largely disregarded discontinuous technological innovation, focusing instead on incremental improvements in environmental management (e.g. Freimann and Schwaderlapp, 1996), combined economic and environmental performance (e.g. Hamschmidt, 2000; Kuisma *et al.*, 2001; Hertin *et al.*, 2003) and policy optimization within the existing production systems (Jordan *et al.*, 2003). Given the scope of environmental challenges and the potential for discontinuous change to create improvements in environmental performance, this lack of attention appears important. In this article, we seek to broaden the scope of EMS research by considering the impact of EMSs on technological stability and change. The following section introduces the concept of technological evolution, focusing specifically on technological lock-in theory. In the next section, we explore the potential role of EMSs as an additional factor in fostering ongoing technological stability within companies and industries. Here we note, however, that two different aspects of lock-in theory can be applied to EMSs. The first is that the EMS can itself be conceptualized as an organizational innovation, subject to increasing returns to adoption and thus potential lock-in. The second is the collateral impact that the adoption of EMS can have on innovation within a company, especially the potential locking out discontinuity innovations. Finally, the fourth section explores corresponding management and policy responses to address the apparent limitations of EMS-based environmental management.

Technological Lock-In

Many environmental problems are linked to the technologies involved in the production, distribution and use of commercial and industrial products. Understanding the process of innovation and technological diffusion is therefore important in any effort to pursue sustainable development. Technological change theorists, such as David (1989, 1997) and Arthur (1994) have developed the concept of *technological lock-in*, which argues that technological change is not the frictionless adoption of superior innovations by rational agents, but is instead subject to barriers and irreversibility that can limit the diffusion of superior technologies. Technological lock-in arises through path dependent co-evolution, driven by increasing returns to scale. In the presence of increasing returns, apparently inferior designs can become locked in to the production system through a historic process in which circumstantial events in the techno-institutional context can determine the winning alternative (David, 1997). Because technology adoption decisions are made with incomplete information about their impacts, apparent early superiority of a design is no guarantee of long-term suitability (David, 1989; Cowan, 1990; Nelson, 1994). In the realm of sustainability, authors have argued that many environmentally damaging systems have become locked in, hindering environmental improvement efforts by businesses and governments (Unruh, 2000; Kline, 2001; Grubb *et al.*, 2002).

Technological lock-in theory has focused dominantly on market coordination and technological interdependencies as the primary sources of inertia in technological systems. Arthur (1994), for example, emphasizes four principal increasing return mechanisms: *scale economies, learning economies, adaptive*

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economies and *network economies*. This view, however, tends to under-appreciate non-market social forces and structures that can create or reinforce lock-in. The connection between physical technologies and the related social systems that build and manage them is an ongoing theme in the technological innovation literature. From this perspective, technological systems are best understood as being composed of both *physical technologies* – in the form of components and infrastructure – and *social technologies* – in the form of organizational hierarchies and managing institutions. Nelson and Sampat (2001) as well as North (1990) have posited that the co-evolutionary features identified as creating increasing returns for physical technologies may also be applied to social technologies, such as management systems. In an effort to understand the failed diffusion of technologies that can limit global climate change, Unruh (2000, 2002) elaborates an interdisciplinary framework termed a *techno-institutional complex* (TIC) that emphasizes the impact of interdependent co-evolution between social and physical technologies. A TIC is conceived of as a large technological infrastructure, such as transportation or energy generation, along with the social organizations and government agencies that build and perpetuate the systems. The combination of costly, durable technologies and legally codified social management systems – with rules and practices designed to guarantee their perpetuation – creates an intense condition of lock-in. It is the combined interactions among the technologies and the governing institutions in a TIC that ultimately explain the system's long term stability.

While a techno-institutional lock-in occurs on a national scale, similar processes are at work on smaller scales, within industries and even within individual companies themselves. In particular, incumbent companies establish their own micro-scale TIC around technological production processes and management hierarchies, which creates stability at the company and industry levels. Industry-wide coordination mechanisms, including standards, supply chain integration, contractual commitments and regulatory structures, can also create meso-level stability. As a result, empirical research shows that incumbent industries are prone to inertia and tend to maximize returns through the exploitation of existing dominant designs. While companies are generally good at innovation that improves and perpetuates existing systems (Christensen, 1997), they are frequently incapable of commercializing superior innovations that can make their existing products obsolete. Van de Ven (1986) discusses three universal limitations that lead to this type of organizational inertia, including focus on short-term demonstrable progress, inadequate problem definitions and the tendency of human behaviour to protect existing practices. Tushman and O'Reilly (1997) extend these ideas by distinguishing between structural and cultural inertia: the former rooted in the size, complexity and interdependence in the organization's physical structures, systems and processes while the latter is embedded in the organization's social structure including shared expectations, norms, values and social networks. As companies grow, structural and cultural inertia intensify, hindering proposed changes and innovations, especially if they demand radical or discontinuous modifications to currently successful activities.

As hopes for environmental sustainability focus increasingly on technological innovation, it is important to analyse both the physical and social aspects of technological systems. In the following sections we extend the techno-institutional complex approach by conceptualizing companies as composed of technological production systems and social management systems. History demonstrates that the limits of technological change tend to lie not with science and technology, which evolves much faster than governing institutions, but with the organizational, social and institutional changes that facilitate or inhibit the diffusion of new technological solutions (Unruh, 2000). The following sections specifically explore the impact of EMS on environmental innovation from the technological lock-in perspective. Two sets of insights emerge from applying lock-in theory to the case of EMS. The first is that EMSs themselves can be conceptualized as an innovation that can diffuse across industries. We further argue that this diffusion process is subject to increasing returns to adoption, holding out the possibility that an EMS can become locked in as a standard, dominant approach to environmental management. The second insight

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is the impact that 'EMS lock-in' may have on second order sustainability innovation and the emergence of environmental superior designs.

The Lock-In of EMS

Lock-in theory emphasizes the path dependent nature of technological evolution, noting that most innovations build off past discoveries and need to adapt to pre-existing conditions for successful diffusion. From this perspective, EMS can be seen as a path dependent extension of the pre-existing *total quality management* standards that were adopted on a large scale in the 1980s. The *quality management* paradigm and its associated managerial practices (TQM, Six Sigma, ISO 9000 series, Kaizen, among others) emerged as a major managerial innovation in the last 20 years and promised reduced product variation, increased process control and improved product quality. The origin of the quality management movement itself lies in the early inspection practices of production lines and the division of labour. Under the auspices of Taylorism, the use of statistical quality control methods lead to increasing attention to minimizing errors and optimizing efficiency. Starting from statistical control methods in manufacturing processes, its use has spread to other functional areas. In the last two decades, the concept has been extended to all areas of business practices, including customer, supplier and stakeholder relations management (e.g. Social Accountability SA8000), even to strategic management and R&D (e.g. Six Sigma, IS0 9000 and 14000 Series). Many companies have established cross-functional total quality management activities and systems, which all together have created an interdependent set of management systems at the company level (Miller, 1996).

In line with this development path, the quality management approach has been applied to environmental issues in the form of EMSs as a logical extension of approaches that were successful in the standardization of quality techniques. This process of standardization and the cross functional transfer of learning represents an increasing return, or positive feedback, process that has fostered the rapid adoption of EMSs by corporations. At the simplest level, increasing returns arise because there are large set-up costs associated with the creation of the first EMS, which are subsequently exploited and spread across an increasing number of adopting companies. Thus, we posit that the emergence of EMSs as a dominant approach to managing environmental issues is the result of path dependent evolution facilitated by increasing returns to scale.

Widespread exploitation of knowledge, which lowers the cost of adoption, is an important driver of EMS diffusion. EMS adoption creates *increasing returns to learning* as skills and knowledge accumulate through learning-by-doing and learning-by-using (Arrow, 1962). Firms with quality management routines in place have already acquired relevant skills and knowledge during implementation and use, which familiarize management and lower the cost of putting a similar system in place (Corbett and Cutler, 2000; Rondinelli and Berry, 2000; Darnall, 2001). Existing management routines are leveraged to cover new areas rather than pursuing the development of totally new practices. As the path dependent extension of quality management systems lowers the cost of adopting an environmental management system, one would expect greater adoption of EMSs by companies already operating quality management systems. Research appears to confirm this, as a statistical correlation between EMS adoption and pre-existing quality management systems has been identified in a variety of industrial settings (Corbett and Kirsch, 2001; King and Lenox, 2001; Florida and Davison, 2001).

Network or co-ordination effects can also accrue as companies adopt standardized social technologies directly through contracts with other organizations or indirectly through induced investment. In the 1980s, for example, the first standardized approaches to coordinate EMS implementation appeared, such as the Responsible Care Programme of the chemical industry. Responsible Care was developed in

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response to the Bhopal India disaster, which demonstrated that poor environmental management by one company could endanger an entire industry (Rheinhardt, 1999). Thus, an industry-wide management standard such as Responsible Care was seen as beneficial, and possibly indispensable, to the whole industry network. These initial experiences were built upon as EMSs underwent further standardization through the introduction of EMAS and the ISO 14000 series in the mid-1990s. Today, network effects are inducing EMS adoption through their integration into corporate value chain management. Much as the chemical industry did with Responsible Care, companies – such as Ford Motor Co. General Motors, Honda, Toyota Motor Manufacturing and Xerox – are seeking to manage their risks and gain legitimacy by requiring their suppliers to obtain EMS registration. This has spurred network effects to the point that in some industries (e.g. in the automotive industry) ISO 14001 registration is not a choice but a business mandate.

In turn, standardization of EMSs (ISO, 2003) and related reporting practices opens new profitable areas for consultants, auditors and rating agencies to offer services. In particular EMS third-party auditing has become a promising new business area for ship inspection firms, such as Det Norske Veritas, Lloyd's Registry, Bureau Veritas and international accounting firms, such as KPMG and Deloitte and Touche Inc (Andrews *et al.*, 2001). Continuous EMS implementation, reporting, audits and third-party verification all drive environmental management towards practices that require frequent standardized consulting and auditing services. This creates a secondary industry, which further extends the standardization and lock-in of EMS practices and at the same time becomes dependent upon the continued adoption of EMSs. Network effects also induce third party investors and insurers to support standardized EMSs as a way to manage their own risks and reputations. Thus the EMS moves from a tool for individual companies to manage environmental issues to a complex set of cross industry standards that create special interests dependent upon ongoing extension of the standards.

The standardized services can further intensify network effects by increasing the demand for trained professionals. This, in turn, has induced universities, business and vocational schools to create EMS curriculum and provide EMS training through their study programmes. This professionalization drives ongoing incremental improvements in EMSs and facilitates the standardization needed for comparability, continuity and credibility (Skillius and Wennberg, 1998) of EMS systems. Over time this process reduces uncertainty as both companies and stakeholders become increasingly confident about the performance, acceptability and longevity of EMSs.

Finally, governments have also become active proponents of EMSs, thereby facilitating *adaptive expectations* that strengthen the value of EMS adoption. EMSs have appeared attractive to government policy makers because they raise the general level of environmental management competence without interfering with other existing regulatory objectives. Given these characteristics, some governments have decided to provide technical assistance and incentives for EMS adoption. For example, the US Environmental Protection Agency is carrying out a number of programs involving EMSs, such as the Compliance Assistance Program, the Design for Environment Program, the Environmental Management System Pilot Program for Local Government Entities, the Public Entity Environmental Management System Resource Center and the National Environmental Performance Track Program (EPA, 2004). The European Union EMAS Regulation calls for member states to promote EMAS on an EU-wide basis at the national, regional and local levels. Some initiatives in the EU have included providing information on the regulation and fostering participation through public procurement policy and other mechanisms. The EU has also sought consideration of how EMAS could be used in the implementation and enforcement of other environmental legislation (COM, 2004). In Japan, government authorities have taken various steps to encourage the implementation of ISO 14001 by small and medium enterprises and some ministries are implementing EMSs in their own organizations (Mizuno, 2002). This institutionalization of EMSs provides a further strengthening of the lock-in condition.

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Dimensions of increasing returns	Definitions of dimensions	Examples in EMS implementation
Learning economies	Skills and knowledge accumulate through learning-by-doing and learning-by-using	EMSs as an extension of quality management
Network and co-ordination effects	Advantages accrue via contracts and by induced investment and through informal constrains	EMS standardization, supplier requirements
Economies of scale	Unit price decreases when quantity increases	Repeatable consulting and auditing services
Adaptive expectations	Expectations arise as increasing adoption reduces uncertainty	Mimetic benchmarking, EMS standardization

Table 1. Dimensions of increasing returns of EMS implementation

	Model	
Variable	Linear	Quadratic
Intercept	−17972	3431
Time (years, 1994 = 0)	8113	−3561
Time Squared	*NA*	1167
R squared	0.90	0.99

Table 2. The evolution of ISO 14001 certifications

We argue that the above factors have facilitated the increasing returns driven diffusion of EMSs and are creating a condition of *EMS lock-in* (see Table 1 for a summary). One way to identify a growth process driven by increasing returns to scale is to look for evidence of exponential expansion rates. To test for this, we evaluate the data series of global ISO 14001 certifications for the years 1994–2003 for exponential growth by performing a time trend analysis of the certification evolution over the period. The data were regressed on a time measure, τ, with the year 1994 set equal to zero in order to assure the same order of magnitude for the series. The data were regressed using both a linear and quadratic functional form. The regression results are detailed in Table 2. As can be seen, the fit for the quadratic function is excellent, indicating that the data evolve in an exponential manner (see also Figure 1).

A second, confirming, empirical expression of increasing returns is the drive towards a single dominant standard within a context of 'winner-takes-most' competition. This is seen in empirical innovation studies, which demonstrate that new inventions first emerge in a variety of forms. These multiple variants then compete in the marketplace for dominance. When the automobile emerged at the turn of the century, for example, there were many variants, including gasoline, steam and electric vehicles. As one variant gains a lead in the marketplace, increasing return benefits favour its continued growth and capture of market share. In the history of automobiles, the gasoline engine vehicle gained a lead and went on to dominate the market. In the case of environmental management systems, multiple EMS standards emerged in the late 1980s and early 1990s at the regional, national and industrial levels. By the mid-1990s there were several leading systems, including the British Standard (BS) 7750, the European Union's EMAS, the Canadian Standards Association and the developing ISO 14000 series. Today the EMS space has consolidated around ISO 14000 (Freimann and Schwaderlapp, 1996), largely through the abandonment of competing standards or through efforts to make alternative standards com-

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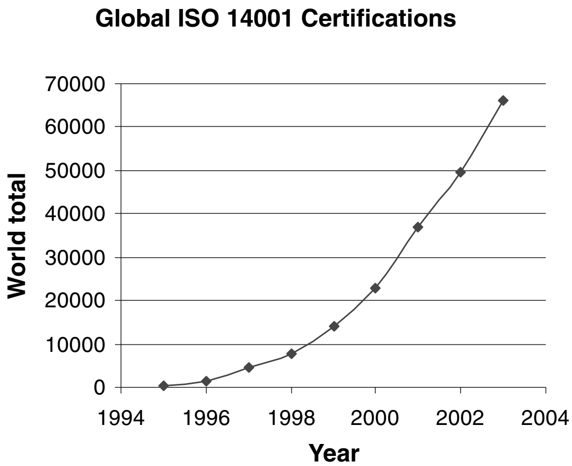

Figure 1. Global ISO 14001 certifications (1995–2003)
Data source: ISO, 2003.

patible with the ISO series. Both the British Standard and the revised EMAS2 have been recently redesigned to be compatible, and therefore equivalent, with the ISO standard. Again, this standardization around a single variant is evidence that increasing returns to adoption are at work.

There is little to indicate that the process has exhausted itself, so it is probable that this expansion of EMS registrations will continue in the future, ultimately resulting in a condition of *EMS lock-in*. While this may provide near term improvements in environmental performance, the possibility exists that EMS lock-in may exacerbate barriers to the development and adoption of alternative innovations that could dramatically improve the environmental performance of technological and organizational systems.

The Lock-Out of Discontinuity Changes?

The above processes are driving the diffusion and adoption of EMSs by a broad cross section of both public and private organizations. The implementation of systemic approaches to monitoring and reporting environmental impacts is likely to improve near term environmental management. EMSs will most likely help companies adapt quickly in the short term and create mimetic environmental gains as firms benchmark one another, and implement incremental improvement routines. However, as alluded to above, many important environmental challenges will require not just the improvement of existing production systems, but their ultimate replacement by superior technologies. It is argued here that this type of innovation is poorly served by EMSs, which tend to foster improvements by identifying inefficiencies and reducing emissions within the context of existing production processes (Hamschmidt, 2000; Kuisma *et al.*, 2001; Hertin *et al.*, 2003). The concern is that EMSs will further constrain the locus of environmental innovation to changes that sustain current systems and contribute to organizational inertia by de-emphasizing the potential of discontinuity changes. There are three foci inherent in EMSs that may increase this organizational inertia: (i) the focus on optimization of present production systems, (ii) the focus on routinization and conformity and (iii) the extrapolation of past experiences into the future planning and investment activities. Each of the points is expanded upon below.

Quality control methods, upon which EMSs build, are fundamentally based on continuous incremental improvements and *optimization of present production systems*. Thus, the management focus is on

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the identification and elimination of inefficiencies in the present production systems through the exploitation of existing capabilities, dominant designs and markets. This has already been seen in the historic case of total quality initiatives. For example, proactive quality and process management efforts in companies such as Alcoa (Kolesar, 1993) and Hewlett Packard (Henderson *et al.*, 1998) lead to initial competitive gains, but have also created concerns about the slow pace of change and lack of radical innovations fostered by the efforts. The EMS focus on incremental improvements has been related to organizational *single-loop learning* – characterized by the 'mechanical' application of rules and routines. This contrasts with *double-loop learning*, which depends upon the questioning of existing rules and the development of new structures for changing environments (Argyris and Schön, 1978; Van de Ven, 1986), something which is more conducive to discontinuity type innovations. However, because an EMS does not support exploration of the trade-offs between continuity versus discontinuous innovation, it can create cultural and structural inertia that inhibits responsiveness to environmental shifts and readiness to create new pathways for discontinuity changes (Garud and Karnoe, 2001).

Second, an EMS institutionalizes the optimization approach through the *routinization* of internal processes such as formal responsibilities, procedural instructions, periodical audits and detailed environmental manuals. The previously mentioned harmonization of standardized EMSs (ISO 14000 Series, EMAS and BS7750) has furthermore reduced variation and increased the *conformity* of industrial responses to environmental challenges (Freimann and Schwaderlapp, 1996). However, from the viewpoint of innovative capabilities of an organization, it is necessary to increase variation – instead of minimizing it – through experimentation in order to create radically new approaches and new competencies (Van de Ven, 1986).

Finally, EMS implementation favours planning through the *extrapolation* of existing production and market activities, instead of foresighting alternative futures. Thus, an EMS may disorient – or even lock out – strategic future-oriented thinking (Starbuck, 1983), as participants go through the procedural phases of completing planning forms that focus attention on routines and optimizing existing organizational practices (Van de Ven, 1986). Such a routinized approach to internal processes slows responses to shifts in the external environment and has prevented incumbents from keeping their leadership in a variety of industries including watches (Glassmeier, 1991), photolithographic equipment (Henderson and Clark, 1990) and disk drives (Christensen and Bower, 1996). Hence, the investment of management effort in EMSs is unlikely to produce dramatic discontinuous improvements in the structure and environmental performance of industries.

The above assertions would lead to the hypothesis that EMS adopters would probably lead in improving the environmental performance of existing systems, but lag in the creation or adoption of discontinuous environmental innovations. There is some initial evidence that this is indeed the case. Recent statistical studies of German manufacturing industries implementing EMSs have found evidence of process improvements but little or no evidence that EMS certification is leading to improved product innovation activities (Frondel *et al.*, 2004; Ziegler and Rennings, 2004). In their study, Ziegler and Rennings (2004) apply econometric binary and multinomial discrete choice models to analyse a data set consisting of 588 interview results from German manufacturing companies. They conclude that single measures such as product design with life cycle analysis and take-back systems for products have a considerable positive effect on environmental product and process innovations. In contrast, the effects of certified EMS adoption are statistically less reliable. ISO 14001 demonstrates a weak positive influence, while EMAS demonstrates no significant effect on environmental innovation. Furthermore, in a second study, Frondel *et al.* (2004) use a recursive bivariate probit model to examine a facility and firm-level data set derived from 899 German manufacturing companies. In accordance with King and Lenox (2000), their results indicate that 'while the adoption of an EMS may insulate environmental innovation from stakeholder pressure, it does not necessarily trigger environmental innovation'.

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In parallel, Raven and Verbong (2004) have examined how routinized environmental management practices favour incumbent technologies over discontinuous innovations in two case studies on power generation from heat pumps and bio-gas production from manure. Both potentially radical innovations failed to diffuse substantially in the Netherlands, while they succeeded in other countries. The cases findings endorsed the authors' hypothesis that the incumbents' managerial rules constrained the development of innovations into specific directions. While these studies are suggestive, it is recognized that EMS adoption is unlikely to be the sole causal factor in these outcomes. However, it is argued that the characteristics of EMS can exacerbate any pre-existing inertial innovation patterns.

Discussion

As argued, incumbent companies tend to focus on *exploitation* activities through the optimization of existing production systems. While this can lead to improvements in environmental performance, it can also bias management efforts away from *exploration* activities, which can lead to new, superior production and business models. EMSs can exacerbate this tendency by focusing environmental innovation toward incremental pollution reduction and away from new environmentally superior approaches (Ulhøi and Welford, 2000). The concern is that EMS lock-in may foster a lock-out of initiatives for exploring discontinuity changes. It could be argued that over time this limitation may be overcome with the saturation of opportunities for incremental EMS improvements. Exhaustion of opportunities can occur because the first environmental improvements are typically the most economically viable, but as the low hanging fruit is harvested it becomes harder and harder to find similar kinds of incremental efficiency improvement. As incremental improvements become exhausted, management attention can turn towards exploration activities. From the viewpoint of environmental protection, however, it makes a clear difference whether the company pursues incremental improvements as long as possible or whether it fosters radical changes by exploring new opportunities for discontinuous improvement early on (Tushman and Anderson, 1997). While obviously not the only important factor, the EMS is part of the overall innovation regime. If, indeed, public and private policy makers wish to foster discontinuous environmental improvements, then both businesses and governments need to consider the implications of broad EMS adoption.

Business organizations need to balance two conflicting needs to survive over the long term. *Exploiting* existing production systems and product lines to maximize shareholder returns is clearly important in the near term. However, limiting managerial attention to this role can threaten the long-term viability of an organization in the face of discontinuous change that alters the basis of competition in an industry (Tushman and Anderson, 1997). For long term survival, companies need to also pursue *exploration*, or the search for discontinuous innovations and market opportunities. To meet this demand, Tushman and O'Reilly (1997) have elaborated the concept of *ambidextrous organizations* as an organizational design that can balance these conflicting needs. This is equally true for environmental management innovations. Companies therefore need to develop alternative management activities and actively explore for discontinuous product and service innovations that eliminate environmental degradation at the design stage (Hawken *et al.*, 1999; McDonough and Braungart, 2002). They need to be ambidextrous in their search for environmental improvements, something that over-reliance on EMSs may hinder.

Second, it can be argued that the search for environmentally superior solutions, and their successful implementation, requires a broader view of innovation that goes beyond internal management systems and the factory gates of any single company. No single company, or government for that matter, can define and implement comprehensive environmental solutions alone (Unruh, 2003). The generation of radically new technological options requires a redefinition of stakeholder roles and institutional struc-

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tures in addition to actual changes to the production systems under management control. This means that managers must engage in an extended view of production systems to include not only suppliers and customers, but also government and civil society stakeholders, as partners in the innovation process. Both policy makers and other stakeholders tend to shape institutional context through their strategic actions of creating and claiming value (Powell and DiMaggio, 1991) and can help create new social networks and agreements, which can open up possibilities for lock-in breaking innovations. Governmental environmental policy makers also need to be ambidextrous. In addition to providing incentives for the implementation of EMS standards, policy must also spur variations and the emergence of competing coalitions through support for the development of their widely different architectures, configurations, features and standards (Tushman and O'Reilly, 1997).

Conclusions

The 1992 publication of *Changing the Course* set the metaphor for business in the face of escalating environmental challenges by arguing that traditional industrial technology and associated management approaches have put us on a course that is unsustainable. Future hopes for a sustainable economy appear to depend upon escaping the current path and changing our development course. It has been argued here that the EMS dominantly seeks to incrementally improve the environmental performance of the current development path, ultimately extending the life of traditional industrial processes that emerged over 100 years ago. If resolving the complex global environmental problems requires new and discontinuous solutions, then it appears that new tools beyond EMSs will be required to really change course.

It has been argued that EMSs are undergoing an increasing return driven expansion and becoming the standard environmental management approach. This brings both environmental management improvements and concerns, especially the potential disorientation of companies away from exploring environmentally superior discontinuity changes. Therefore, companies should be cautious about sole reliance on EMSs. Emphasis is also needed on explorative activities, and the creation of new organizational capabilities that can help foster discontinuity changes. This also questions the exuberant government support for EMS implementation seen to date. Both companies and regulators need to develop ambidextrous approaches to environmental management that foster both incremental and radical improvements in environmental performance. While market conditions and technological dependencies, as the obstacles for discontinuity type of changes, have been extensively studied, the impacts of management systems in general, and EMSs in particular, on discontinuous innovations have received scant attention in the environmental management literature. Given the apparent importance of discontinuous sustainability innovations, we advocate further work in this area.

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