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Networks for Sustainability: 
A Conceptual Model of Eco-industrial Park (EIP) – 
SME Relationship Management of Eco-adaptation (EA)

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The management of eco-adaptation (EA) by small and medium-sized enterprises (SME) has received limited research attention, as too, the international networking role played by eco-industrial parks (EIP). As a main source of pollution—especially in emerging markets—but resource-constrained, SME are widely viewed as subordinating, at best, considerations about their environmental and social impact, to those relating to economic gain. The purpose of this paper was to address the theoretical gap regarding SME and EIP relationship management, and thereby the notion of SME as integral to international EIP networking, and to regional development. Clearly, more informed SME can lead to reduced levels of pollution, with concomitant health benefits—an internationally recognised priority and goal. In this conceptual study, research on EIP and SME focused on managerial aspects facing each, and on analyses of eco-adaptation pathways. Invoking various international studies on the former, and research into SME decision-making and models of eco-adaptation, various areas of shared interest were identified, and articulated finally in A Managerial Framework of Eco-adaptation in EIP-SME Relations. Data from interviews with sustainability management experts enabled valuable insights, both theoretical and practical, to be included in the study. A stakeholder-driven approach, organizational continuity needs, eco-metrics’ based collaboration and an experimentalist collaborative culture, emerged in this pioneering research as areas of shared interest. Managerial considerations and a list of recommendations for further research conclude the study.

**Keynotes:** Networks; Management of operations; Local embeddedness; Eco-adaptation stakeholders
Recent attempts to rid global supply chains of conflict minerals such as tin, tungsten and gold-leading drivers of humanitarian crises and armed conflicts in parts of Africa-have involved a web of NGO advocacy, government regulations, multi-stakeholder initiatives and cross-industry coalitions. These require considerable investments in time and effort, and the payoff isn’t always clear or the results certain. But if we are to make meaningful progress in building socially responsible societies, we shall need a great deal more of such spirited and creative collaborations.’ (Jose Carols Marquez and Henry Mintzberg in MIT Sloan Management Review Summer 2015 Vol 56, No 4, 8-11)

Business competitiveness has become inextricably linked in the 21st century with an organization’s abilities to collaborate with one another globally. Advances in information technology communication (ICT) in enabling collaboration, make such co-operation essential to organizational competitiveness and survival. At the same time, these enable individuals, groups, and local communities to be informed by, and to inform, national and supranational bodies across the globe. The interconnectedness of businesses of all sizes, and of these with communities in which they operate is more and more evident. This enables expertise, ‘best practice’ and standards to cross borders so improving business practices. Where such interconnectedness is managed, it gives rise to networks –virtual and physical membership of which, following the precept of social equity (see later), includes representatives of all groups directly affected by the decision(s) within the network’s remit. Each network is, in turn, connected to others within the worldwide web, so ensuring potential linkage between local and global concerns- and between organizations and communities. As shown in this paper, networks are drawn together by cross-border standardisation and harmonisation of quality and safety measures where there are supra-national, as well as national levels of shared concern.
Arguably the area of most need in terms of bridging the gap between global business and local interests and between businesses and consumers is found in matters relating to a community’s quality of life. Air quality, water quality and—in short— the economic, environmental and social sustainability of a community, including its handling of waste are matters increasingly informed by international networks as well as by local stakeholder networks (see Fig 1).

This research explores, with particular reference to China, as an exemplar of a fast-industrialising nation, managerial issues arising in eco-industrial parks (EIP) acting as network hubs for small and medium-sized enterprises (SME), and as co-managers and co-creators of eco-adaptation (EA) by the latter. Using research from a number of nations, it focuses on the management of EIP-SME collaboration within industrial parks. It considers how EIP can attract, maintain and develop eco-friendly behaviours in SME. The environmental impact of SME by way of various forms of pollution is evident, and has been noted (Tang 2010, Strategic Sustainability Consulting) in China for example where SME activities lead to increased public costs from damage to community health. This research examines how EIP’s can use their network hub position and management of (EIP) tenant enterprises to assist SME in their eco-adaptation (EA). While this research will focus on EIP: SME relationships and their management, the wider network of which they are part is shown in Fig 1.
Fig 1: EIP-centred networks supporting SME’s

Source: This study. The circle denotes the focus of the research-EIP: SME relations. Arrows denote IP exchanges between any two or more constituencies, each local one being represented on the EIP committee.

Beyond matters of managing limited resources, economic-not social or environmental goals-dominate SME decision-making. In developing nations, bosses, not boards or stakeholders drive such decisions. For example, SME’s are identified in ‘Embedding sustainability in SME’s (ACCA Report Network for Business Sustainability Report 2012) as being managed in part, or whole, by their owners. They are also independent, rather than a subsidiary or a franchise, informal in their working, short-termist, characterised by multi-tasking and flexibility, and ‘by the importance of personal relationships’. (4) To address the relationship of SME’s to EIP, a useful framework is found in A Review of the Circular Economy (CE) in China: Moving from rhetoric to implementation (following Zhu and Huang 2005, Yuan et al, 2006 and Geng and Doberstein 2010) This identifies micro-, meso- and macro- levels (Yuan, Bi and Moriguchi 2006: and Su, Heshmati and Geng 2012, See Table 1). SME’s- at the micro level and EIP, at the meso-level, either individually, or as local networks, are both informed by macro-level actors. These include regional, national governments and supranational bodies (from Regional Economic Groups (REG) of countries, to non-governmental organizations-NGO), and international networks of experts, of businesses, and of professional trade
bodies/associations. Linking macro- and micro-level, EIP are potentially an important conduit for both top-down (macro-level) communication, and bottom up communication from the very many local SME’s, as also from the communities within which these operate. Critically, in order to fulfil the latter role, EIP’s need to understand what facilitates EA in SME’s.

The research question to be addressed is therefore: How can EIP support SME eco-adaptation (EA)? Identifying various areas of collaboration to be managed with SME’s requires understanding the nature both an EIP, as that of SME’s and their possible routes toward EA.

Limitations, apart from those relating to the conceptual nature of the research, stem from the fact there is a paucity of evidence of research on the topic which, as yet, has received little attention in business texts, or in business journals. Some researchers may also require that attention be paid to discussion of the role played by local and/or national cultural on how EIP-SME relationships are managed. Certainly local cultural ways and collaborations will differ, such cultural-embeddedness requiring a more detailed study than space permits here. Such limitations make the contributions of expert interviewees, support received from professors of various UK universities (at Plymouth and Hull, for example), and discussion with on-line commentators, all the more valuable. In addition, the research owes a debt to major research studies undertaken in recent years sponsored by public bodies in Holland, Norway and in Japan, as also in China (as referred to by interviewee XL). Finally, a focus on the management of EIP-SME relations for EA precludes discussion of a multitude of network relationships (see Fig 1 for a summary of key stakeholders) which might potentially influence SME’s EA.
The practical value of supporting SME EA, and of developing and maintaining a EIP-centred network in which community needs, government eco-regulation and SME interests are discussed, is clear. It can contribute to a reduction in pollution-related-health costs to a community. As a network exchanging EA information and experience on a global basis, it also enables exporting firms to meet foreign buyers’ eco-standards and prepare for related changes. In theoretical terms, the research contributes toward an existing body of studies on networking built around EIP. It suggests a potentially more important, more communitarian, and more international role for EIP-centred networks. It also throws light on SME and change management, as on managerial considerations relating to various EA pathways. Lastly, it can also be viewed as filling a research gap between CE macro-level policy and C2C management by SME’s.

The approach to addressing the research question already stated, through this conceptually-based research, is therefore by discussion of the (a) macro-level context of the enquiry (b) meso-level EIP: their functions and relationships with SME tenant firms in particular. (c) micro-level SME characteristics and SME management of potential EA pathways. Finally (d) a proposed Managerial Framework for SME Eco-adaptation (EA) within a EIP network is posited as a pioneering contribution, and as a tentative basis for further enquiry. A conclusion and listing of recommendations for further research are provided.

A. Context: Progress toward a ‘Zero-waste’ economy: The Circular Economy (CE) and Cradle-to-Cradle Management

The context of the present enquiry is to be found in steps made over more than two decades involving many governments—including those in North America, Europe, Japan, China and elsewhere—toward a ‘zero-waste’ economy. Although dating back several decades, the notion
of a Circular Economy (CE) and cradle-to-cradle (C2C) management practices with their aim of ‘zero waste production’ has been extensively documented (see: The Ellen MacArthur Foundation, for example). The principles underlying CE and C2C management have been articulated, in such sources, as being those of economic wisdom, environmental wisdom and of social equity (widely referred to the ‘3 E’s- see earlier). Research in China (Table 1) helps to identify not only the scope of sustainability-related activities of CE in China, but ,for this study, provides a useful framework within which to consider the management of EIP: SME relations for SME eco-adaptation (EA)- including C2C management (see later) While the former-CE- is concerned with macro-level sustainability-related practices, at the micro-level, SME’s are increasingly seen by governments and communities alike as needing to pursue economic goals congruent with, rather than contrary to, such CE-directives. C2C management exemplifies such an approach. Growth at any costs is out; a more balanced growth (i.e. balancing economic, environmental and social needs) is required. Whether supply-side led (Table 1, row 1) and/or demand-side (Table 1, row 2)- led and/or technology-driven (Table 1, row 3), SME’s need to manage EA as industries and markets adapt to changing climatic conditions and related local community concerns.

Table 1  Structure of Practices of CE in China

<table>
<thead>
<tr>
<th>Production area (primary, secondary and tertiary industry)</th>
<th>Micro (single object)</th>
<th>Meso (symbiosis association)</th>
<th>Macro (city, province, state)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaner production, Eco-design</td>
<td>Eco-industrial park</td>
<td>Network of eco-industrial parks</td>
<td></td>
</tr>
<tr>
<td>Consumption area, Green purchase and consumption</td>
<td>Eco-living park</td>
<td>Renting service</td>
<td></td>
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<tr>
<td>Waste management area, Product recycle system</td>
<td>Waste trade market</td>
<td>Regional circular industry</td>
<td></td>
</tr>
<tr>
<td>Other support</td>
<td>(unspecified)</td>
<td>(unspecified)</td>
<td></td>
</tr>
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Source: Su, Heshmati and Geng (2012:6)
The macro-level (see Table 1) extends, evidently, across national borders, and involves networks of supranational bodies (such as the EU), international trade organizations-trade associations and other professional networks. In monitoring members’ behaviours, and in contributing to discussion leading to regulations and standards (e.g. for waste disposal) the latter serve not only to facilitate international trade, but can help raise production standards to meet export market requirements. At the meso-level EIP committees can act as a conduit, and discussion forum, for new and proposed regulation and knowledge relating to CE and to C2C practices-so linking macro with micro-levels, international standards bodies and governments with commercial enterprises including very many SME. In terms of linkage with local communities, Table 1 also shows EIP’s in China a having a residential element to them –eco-living parks- suggesting that EIP can operate less freely as ‘islands of polluters’ if some of the local community live on site. In such cases, residency on-site can add as an additional spur to EIP-SME EA collaboration. The next section discusses the development of EIP, their relationship with SME’s from a managerial perspective.

B. Meso-level: EIP and SME tenants

This section provides an introduction to the rationale underpinning EIP, their workings and relationship with SME in particular. By assembling evidence from many nations in a chronologically –framed introduction, it identifies the roles and tasks of an EIP and, thereby its relationship with SME. While Industrial Parks, may well house eco-friendly organizations without the park being identified as an EIP, recent years have seen an increase in designated EIP. For convenience, EIP is used here, therefore, as a generic term for various types of eco-park, the number of which has been increasing latterly (See Massard G 2013 for research involving a large - 444 parks and 167 case studies- international survey of eco-innovation in industrial parks). Their origins have been traced back some 30 years:
‘The first generation of EIC’s can be traced back to the 1990’s, when the backyard facilities moved to specialized SME’s in a previously un-zoned area known as the satellite system that resulted in increased productivity. A good example is the Japanese just-in-time model clusters. The next generation of clustering of SME’s and multinational companies (MNC’s) were known as industrial estates or industrial clusters, science parks, corporate synergy systems, and as Environmental Management Systems (EMS) (Anbumozhi et al 2013:97).

Leading researchers in the field (Deutz and Gibbs 2003 et seq.) refer to the formalisation of the EIP concept by Indigo Development at Dalhousie University in 1992, with 17 self-labelled EIP in the USA by 1996. The authors reported that China had enthusiastically embraced the concept –evidence of which can be found in a report entitled Eco-Industrial Parks in China (2000-2010) (Shi and Wang). They cite the Indigo United States EPA Research Project definition of EIP as:

‘An eco-industrial park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues, including energy, water and materials.’ (Martin et al 1996)

In a detailed study (Sarkar 2013) EIP’s are linked to eco-innovation. The author cited various definitions from the 1990’s, but chooses the definition the PSCD in the United States: “A community of businesses that cooperate with each other and with the local community to efficiently share resources with each other and with the local community to efficiently share resources (information, materials, water, energy, infrastructure and natural habitat) leading to economic gains, gains in environmental quality and equitable enhancement of human resources for the business and local community.’ (196)
The author identifies one task of EIP management as the undertaking of environmental audits—eco-audits—‘format and content to be in line with GRI guidelines’ (212) which ‘should provide a list of recommended actions, in terms of cost-effectiveness in addressing the critical environmental issues’ (214) (GRI denotes Global Research Index). While stating that in China, the state EPA-environmental protection agency—has identified the EIP as one of the important tools for realizing the Circular Economy (196), he concludes ‘Special efforts should be used to replicate the successful models of eco-industrial parks under diverse ecological conditions to help reverse the ecological degradation caused by global climate change (218).

In further research, EIP are viewed as a synergistic community of businesses (Lowe, Ernest 2001), a means of cost-saving (Peck, Steven and Laura 2003), and as a means of maximizing efficiency (Gibbs and Deutz 2004). The latter authors see EIP’s as designed in such a way that ‘the way a company operates its production is taken into consideration when ensuring the park’s general maintenance activity, so that it gets to be, through the synergy of different companies, an ecosystem—from the point of view of resource use, and optimizes the energy consumption. (84) This ecosystem needs to be sensitively managed as EIP are not to constrain, by regulation, the often entrepreneurial behaviour of SME, it is even(see later) to create an experimentalist culture in the EIP, and one involving the local community in the design of the park’ (Roberts 2004). The EIP’s support role for SME’s as educator and trainer is clearly stated in the same research, as also its role as a conduit for communicating proposed regulation, and for promoting discussion of possible EA pathways (see later Tables).

In further research (Lowe 2001) refers specifically the main managerial tasks of an EIP as:

- findings new groups of cooperation between partner firms and other interest groups
- enhancing the dialogue between partners
- maintaining and managing services
- supporting material and energy flows
- recruiting new companies
- improving the environmental performance of the park and companies
- maintaining an information system
- linking companies and public organizations
- strengthening public private partnerships (PPP)

The last managerial tasks has been referred to more recently (Dervojeda et al. 2013) as a core priority in SME- EA research and innovation. Public sector bodies may be used by regional governments to show EA leadership. EIP collaborating with local public government can offer tenant enterprises the opportunity for large and long-term public sector contracts (e.g. waste disposal, energy-efficient lighting etc. Significantly, such long-term contracts can also contribute to continuity of firm membership within the EIP which has been identified as an area of concern for EIP management- and, thereby, for its committed tenant SMEs. Such member-firm ‘churn’ needs, however, is to be managed. For example, reference has been made to a EIP’s potential ‘fragility’ (Tudor et al 2006) as regards its ability to remain relevant to a rapidly-changing marketplace. Some authors counsel EIP management to think beyond survival, to long-term planning and continuity (Donkers 1998, Roberts 2004) where EIP and SME’s interests clearly overlap.

Further insight into the goals and management tasks of EIP management of tenant enterprises is to be found (Tudor, Adam and Bates 2006) in a listing of management measures that ‘enhance the success of the EIP ‘ (203). These include:
- cooperation between firms and between firms and local government, the initiative coming from the firms, as active participants in EIP matters, who should be located near one another

- active participation for a range of stakeholders

- the organization should not be in direct competition to one another, but should represent a diverse range with complementary materials

- a level of trust should exist between participants

- regular ecological monitoring against goals

- strategies should ensure a full integration of 3E goals (economic wisdom, environmental wisdom and social equity)

- a widespread support system should be created

If most of these appear self-evident, the authors’ accompanying view of challenges/limitations of EIP’s would appear to be more insightful. System ‘fragility’ arises from firms moving on, leaves others vulnerable. It can possibly threaten the continuity of the EIP itself. One approach used by EIP’s is to create an anchor for tenant SME’s by having a tenant LSE around which to create an eco-cluster of smaller enterprises within the park. This aligns with the research finding that recyclers tend to follow producers –rather than driving the development of eco-synergies (Sterr and Ott 2004). (interviewee IC described how she had visited various EIP where LSE waste was being recycled within the EIP by a cluster of SME’s) A further study of EIP’s in Asia (Chiu and Yong 2005) reported finding insufficient management systems and practices (2004) in Chinese EIP’s- a fact which could threaten continuity. They concluded that bottom-up initiatives, and multi-stakeholder driven decision-making need to be assisted by economic incentives, such as by tax breaks:
‘It is evident that it is difficult to ‘magically’ manufacture EIP’s to work from scratch, rather, their development should be facilitated. There should be the basic ingredients in place, namely the willingness of firms-largely SME- to actively cooperate, and the correct mix and structure of firms. These basic ingredients can then be enhanced and improved upon, with the correct support structure in place-good connections with local government departments ensuring linkage to higher-level (e.g. central government) decision-making. There is also, perhaps, a need to encourage SME co-location and relocation within EIP through tax breaks…The emphasis for the EIP should be on a systems approach, rather than focusing on specific streams’ (14)

Here the authors articulate clearly the coordinating and networking role of EIP linking government EA-related regulation and SME EA. If EIP continuity management is clearly required in order to maintain the EA network, its managerial approach toward tenants need, according to the same report, to show flexibility. A more recent report goes a step further in advocating that there be ‘an experimentalist culture within the EIP (PWC Report 2012).

It is useful at this point to summarise various of the EIP managerial aspects arising from literature reviewed as EIP-SME relationship tasks, namely those of recruitment, maintenance/support, experimentation and continuity/longer-term planning:

(a) Recruitment: enterprises ‘recruited’ need to constitute parts of a system which, if encouraged by co-location incentives, must be offered a credible medium- or even longer-term vision of their future. EIP can play a role in making SME management aware of EA pathway options (models), related metrics, the costs and risk involved, and their management.

(b) Development: stage-based (see life-cycle models later) financial and informational support can be co-managed by EIP and SME. In addition, the EIP enables ‘social capital’
(Thierot and Sawyer 2015) transfer through EIP special events, training and shared meeting facilities. These serve as important means of promoting SME- EIP learning and knowledge-sharing synergies between member firms.

(c) Maintenance/support: acting through a multi-stakeholder committee , EIP management can ensure (a) a 3 E’s (economic wisdom, environmental wisdom and social equity philosophy underpinning CE) focus , (b) local community awareness and involvement in local environmental impact measurement and metrics, and (c) lines of communication with public procurement organizations and with regulators (it has been suggested that EIP’s enable bottom-up (SME and local community) views be heard in regulation proposal discussions. In addition to giving SME some sense of ownership over regulations, EIP support needs to be contextually- and culturally-relevant:

‘whilst one can learn lessons from the development of other industrial ecosystems, as each is different due to variation in social, economic, cultural and ecological circumstances, it is often difficult to make comparisons (Korhonen 2001, quoted in Tudor et al 2005)

(d) Scope for experimentation: EIP may well seek SME tenants as supplier clusters, and will then need to provide the flexible operational and experimental working environment that these need In: Uncovering excellence in cluster management (Price Waterhouse Coopers Report 2011) under concluding remarks, the authors state:

‘Cluster managers operate in a turbulent, uncertain and highly complex environment. The key uncertainties, among others, are related to the continuity of commitment of key stakeholders, financial instability, changes in technological and regulatory fields, external competition and market developments. To survive in such an unpredictable environment, adaptive management structures are needed….carrying out management actions as experiments. Such experiments help EIP learn how the cluster responds to management,
and thereby increases the level of certainty regarding how cluster objectives can be best achieved’. (27).

(e) Continuity management: This final recommendation consists in combining management of continuity with an experimentalist EIP culture. The latter reflects at once the necessary dynamic for operating within times of rapidly-changing technology, markets and regulations, and need for EIP-SME co-management of risk. Where changes threaten the future of a tenant SME or SME cluster, an EIP will search for resolution which, while addressing its own EIP continuity needs, will strive not to view their EA collaboration with the latter as time wasted. (‘waste management’ needs to take this wider focus of wasted skills/knowledge /contacts – Interviewee IC). The extent to which the financial support and regulatory bodies enable this to occur-and how rapidly- may well influence the SME’s decision to commit to an EIP in the first place. In sum, it can be argued that SME need a viable exit, as well as entry, strategy to an EIP. Regional authorities might best view EIP support for SME as investment on which to build, and not waste, important EA knowledge and experience- gained not least through effective EIP-SME management collaboration.

This section has explored EIP from a managerial perspective with SME as potential and actual tenant enterprises. The EIP network acts as a link between regulators (central and provincial authorities) and tenant organizations-largely SME. The liaison contributes to regional development guided by EIP multi-stakeholder management committees (ref Fig 1). EIP are well-placed to take a holistic view of the EA process, and to marry central directives with local industry potential and cultural ways. EIP act as significant EA regional and local network hubs. This is important, as in terms of regulation and local implementation by SME (interviewee RD) there can appear (Interviewee RD) to exist an apparent disjunction. This
occurs where regulation is mainly focused on end-of life and downstream activities (e.g. waste management) i.e. a C2G focus, with less attention being paid to potential upstream EA activities (such as production issues)-i.e. a C2C management focus. So far as for discussion of such existing and of proposed regulations, EIP can potentially play a significant role in enabling bottom-up input from SME-and from local community representatives on the EIP committee. EIP-SME collaboration can foster discussion of EA possibilities, and adopt a shared perspective on continuity and related risk management. This EIP-centred perspective is one side of a coin which explores EIP-SME relations, which, in the next section, is viewed from a SME perspective.

C. Micro-level: Drivers, barriers to, and approaches to SME eco-adaption (EA)

Discussion in this section refers to research relating to SME EA in terms of (i) forces promoting such change (drivers), (ii) barriers to EA and (C) pathways to EA for SME. An external audit by an SME of market opportunities and regulatory changes may present incentives for EA, while an internal ‘readiness’ audit—if undertaken—may help identify the enterprise’s degree of adaptability and adaptiveness (i.e. the willingness to adapt). These do not necessarily equate. These themes are explored here in the context of SME characteristics—not least the wish of the entrepreneur and/or founding family- to retain control over their business.

(i) Drivers

It is widely agree that SME are driven by economic goals and competitiveness, rather than by some balancing of these with social and environmental goals. That said, the overwhelming influence of bosses on SME can result in personal values-social and/or environmental influencing an offering. Some SME bosses want to ‘do good’, as well as do business. Eco-
innovators fit within this category—though altruistic intentionally cannot be assumed. Governments and SME researchers (Esty and Winston 2009, Oxborrow and Brindley 2013) refer to ‘eco-advantage’, implying economic reward through EA, and also, potentially, a failure to compete in the absence of EA. The authors identify a number of other drivers of SME EA: market opportunity, the influence of stakeholder groups (Esty and Winston 2009), public sector organization requirements, eco-related government subsidies, regulation and taxes, industry codes of conduct and international standards—such as ISO 14001 (Interviewee RD: ‘Business like no shocks, and regulation and metrics usually come out of consultation involving business. Hard though some people might find it, businesses like regulation. It provides a level playing field, it spurs innovation’). Also, increasingly (see Green Supply Chain Management—GSCM, later), private sector buyer requirements drive EA in their suppliers. For example, within a supply chain, this arises when a LSE (as in the well-documented cases of ‘eco-conversion’ at the LSE of Interface, and of Desso) tells suppliers ‘go green or lose the business’ (!) Last but not least, technological advances drive eco-innovation (EI) and EA as is the case with the use of bio-mimicry, and through an increased inter-disciplinarity across research fields.

Demand side drivers of EA arise also, from evolving consumer expectations (see Lifestyle of Health and Sustainability (LOHAS) ‘green consumer segmentation’) of ethically-managed, and ecologically-sound products and services. In adaptive organizations, SME employees too can bring ‘bottom up’ influence regarding EA quickly to SME strategy discussion. Internal EA may be promoted within an enterprise in any area where managers’ performance metrics cover environmental and social impacts. Application of Triple Bottom line auditing of performance (Elkington 1994, Savitz and Weber 2006), for example, and/or eco-metrics (see later) can drive forward EA.
(ii) Barriers

A lack of awareness, limited access to information, knowledge and technology, meeting regulatory requirements, lack of skills and qualified personnel, limited access to finance, market and global supply chain access difficulties—such barriers to EA have been identified (OECD working paper on SME’s and Entrepreneurship 2010). SME’s resource limitations have been identified as linked to (the need for) eco-industrial clusters (EIC) of enterprises. ‘SME’s have limited human, technological, financial and capital, and information resources, therefore the necessity of introducing EIC is critical to support a nation’s long-term development goals (Asian Development Bank Institute 2009). (Here EIC-clusters- is used as an umbrella term which includes EIP). More specific examples of barriers to EA, found in related research, include the view that small firms are reluctant/unable to pass their sustainability requirements upstream (Jorgensen and Knudsen 2006), or—may contain a ‘mismatch between views and objectives of managers and skilled workers within firms implementing environmental design changes’.

Views in older studies (Tilley 1999 and Vernon et al 2003) relate that small firms still have difficulty identifying and acknowledging their environmental impact. A fear of creating supply chain instability in the search for new materials (Oxborrow and Brindley 2013) illustrates the likely impact of EA on the supply chain/net as a whole, amongst whose members may be ones having such a reason for resisting EA.

There are clearly many barriers to, as also drivers of SME eco-adaptation. An external audit is needed in order to educate SME owners and senior managers about possible EA pathways/business models, eco-metrics, and about potential EA-related opportunities within the EIP. It can be the EIP’s task to instigate this, and/or to offer SME’s support in so doing.
The SME will, however, need to carry out its own internal audit of its own EA capabilities- and adaptiveness. SME will require support especially in the ‘valley of death’ stage of capital investment (Beard et al 2009) prior to selling production, therefore EIP support-informational and financial- can be essential for many SME in that early stage of EA. So as not to be constrained from normal entrepreneurial and innovative behaviours, SME’s will need and benefit from EIP management which provide a EIP culture which is not only, as stated earlier, flexible and experimentalist-but which is driven by stakeholder interests’- not least those of local communities, who feel the physical impact of SME activities. Finally, a SME committing itself to relocation within an EIP, or exiting from one, will want to see risk shared in part at least by the EIP, tenant exits impacting on the EIP’s own operation and, potentially, on its continuity.

(iii) Approaches to EA in SME

If an SME’s adaptability appears, if not suited to, essential for EA, then having a short-termist, self-reliant culture, and aversion to time-consuming procedures may appear to clash with EA requirements including the re-education of its senior staff, accepting a business model premised on closer external collaborations, and learning and applying additional metrics. (One view expressed -by Interviewee IC- was that eco-adaptation needs to have the overwhelming push of all its employees to bring about the culture change necessary for EA, and that SME bosses, rather than fostering altruistic motives, might best be driven to EA by a human ‘darker side’ such as by greed.) Nevertheless the adaptability of SME and their risk-taking propensity, harnessed to their ability not only to manage change, but to use it to their advantage, provide, it can be argued, a very suitable platform for seeking rapid EA. How SME might undertake EA is now addressed, through examination of analyses of various EA pathways available. These are identified in life stage and life cycle business models, and
incentive-based models and by eco-metrics. The former, if taken sequentially, illustrate ‘creeping eco-commitment’-with concomitant cost, risk and time-requirement elements. The incentive model is closely linked to supply-side drivers. These may be regulations and certification requirements. They may also come from a shift from capital provision (sale of goods) to service provision, a response to demand-side ownership-seeking to access-seeking – i.e. renting (see airbnb.com streetcar.com etc.) and leasing by consumers. (Interviewee RD: This may find cultural fit in China as a collectivist culture, and therefore might be an avenue well-worth exploring in that country). Evidently both supply- and demand-side factors can combine as a powerful motivator for SME eco-adaption and eco-innovation, not least by redefining markets and, thereby, competitiveness criteria. Reference is made here to potential EA pathways as exemplars, followed by discussion of its implications for SME management.

**Life-stage/value-chain model of EA**

A life-cycle stage model (Barsouomian, Severin and der Spek 2011) for the European Cluster Observatory provides a linear value-chain perspective with environmental considerations and the business case for each stage. In so doing, it illustrates managerial aspects relating to each.

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<th>Life stage</th>
<th>Business Case</th>
</tr>
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<tbody>
<tr>
<td>Resource extraction</td>
<td>consider renewal and secondary resources (CE) comply with and anticipate new eco-regulations improve reputation and CSR</td>
</tr>
<tr>
<td>Manufacture</td>
<td>build resilience to changes in commodity prices and resource supplies manage by-products as well as products comply with anticipated new eco-regulations</td>
</tr>
<tr>
<td>Distribution</td>
<td>seek cost reductions comply with anticipated new regulations</td>
</tr>
<tr>
<td>Use</td>
<td>manage selling shift from products to services Improve reputation with buyers</td>
</tr>
<tr>
<td>End-of-life</td>
<td>develop and sell novel products from waste manage re-use, recovery, up-, re-, down-cycling comply with anticipated new eco-regulations</td>
</tr>
</tbody>
</table>

Source: adapted from Barsouomian et al 2011
The model appears of more value to LSE than to SME. EA is enacted, for example, by a vertically-integrated LSE with bargaining power over supply chain partners. FS (under ‘Use’ in Table 2) illustrates the demand-side shift from ownership-seeking to access, as mentioned earlier. Its emphasis on compliance (see ‘manufacture’ in Table 2) with changing regulations prompts thinking as to how, while LSE’s lobby, SME might influence such regulation and, with local community involvement, ensure its local relevance. The need to ‘build resilience’ to changes in commodity prices (under ‘manufacture’, also), and references at two stages to reputation management, all illustrate, amongst under things, aspects of risk management.

Again LSE’s can ride market turbulence more easily than SME’s. SME’s, with little hope of influencing market prices, would benefit from finding a means – through EIP possibly – to influence proposed regulation, and a means of mitigating the potential turbulence of disruptive changes/fluctuations in by-product market prices (see later ‘incinerators’ example).

**Life-cycle models of EA**

**Table 3 Life cycle models**

<table>
<thead>
<tr>
<th>Green Supply Chain Management (GSCM)</th>
<th>an integrated concept of SC greening activities focusing on upstream flow, cost reductions of and innovation in raw materials, components, products and services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take-back management (TBM)</td>
<td>extends the producer’s responsibility of waste management through take back mechanisms of the down-stream use of the product. This includes manufacturers, retailers, consumers and recyclers</td>
</tr>
<tr>
<td>Cradle-to-cradle(C2C)</td>
<td>innovative and essentially waste-free products can be integrated into fully recyclable loops or biodegradable products all along the supply/value chain</td>
</tr>
<tr>
<td>Industrial Symbiosis</td>
<td>a shared utilisation of resources and by-products among industrial actors on a commercial basis through inter-firm recycling schemes. The aim is to reduce costs and the environmental impact of participating companies and municipalities</td>
</tr>
</tbody>
</table>

Source: Bisgaard, Henriksen and Bjerre 2013
The same authors refer to managerial aspects to each EA pathway:

GSCM: a long payback time, difficulty linking costs to internal savings and effects small customers’ low purchasing power unable to influence suppliers’ products or production

TBM: additional logistics, systems’ and facilities redesign for recycling, partners’ IP secrecy, constraints of existing accounting practices

C2C: value-chain complication, partners’ IP secrecy, senior management’s lack of knowledge, supplier switching (costs), few case references

IS: identifying synergies, senior management’s lack of knowledge (private and public sectors), unwillingness to share production process information, lack of available recovery technology (transforming products into resources)

Aside from challenges which are generic to collaborations, there is a pervading ‘watch–and-wait’ quality to managing such EA. Recycling, for example, must have economic attractiveness for a SME. Yet by-product market prices for recycled production may fluctuate, and even undermine the economic rationale for EA. In this connection there is a ‘need for economically viable end-of-life markets’, or SME EA might result in having ‘piles of unsold down-,re-, or up-cycled items’ –themselves a source of pollution/wastage-and a possible target of taxation. The instability also, of such markets was illustrated, in one case where incinerators dropped their prices, in order to regain business from landfill, again, in economic terms, undermining regulators’ efforts to redo landfill (points made by interviewee Interviewee RD). A lack of knowledge among senior management of EA models/possibilities is another salient theme which may be linked also to the findings (see above) of SME’s lack of awareness, and lack of knowledge of, their own environmental impact. EIP waste-processing firms may also fear their clients will set up a similar operation in-house such belief leading to SME reluctance to collaborate (RD).
The life-cycle model appears to describe EA gradation from that of a 3/4R’s repair/ reuse/ reprocess/ recycle etc.)-i.e. C2G character to the SME’s management, to deeper commitment to EA in the form of C2C management, i.e. engaging upstream eco-design (for easily-recyclable products. (In terms of additional management workload. The view was expressed that that it would be felt less in logistics, than on account of the ‘conservative influence’ of existing accounting procedures, and in FS (see Table 2) EA where selling was no longer of a (physical) product but, of a (more complex) menu of utilities relating to the product (RD). Such additional areas for management infer, with additional resource requirements, the need for different types of support-financial, informational, skills, a means of resolving IP-related ‘blocks and metrics which enable eco-adaptation, rather than impede new business model adoption.

A more developed example of a life cycle model of EA-one with an accompanying management framework- is to be found in A Green Business Model Innovation Framework (Danish Business Agency 2012). EA life stages (Machiba 2010) from pollution control and waste management, cleaner production, thence to eco-efficiency and toward industrial ecology are ‘mapped’ in terms of five types of building block required-in varying proportion for each stage. These blocks represent modification, product and process design, life cycle thinking, closed loop production and industrial ecology elements. The stages and building blocks are then inter-related within a Business Model Canvas (Osterwalder and Peigneur 2010, OECD).management planning chart. In this, areas are labelled as key activities, key resources, customer relationships, cost structure etc-12 areas in all. Significantly, the authors (from the Danish Business Agency) see value in the model being able to illustrate how a change in one management area’s blocks’ profile affects that in another area. This framework is distinctive within the current review in its detailed managerial focus. Research into its use
and evaluation by SME managers, for instance, might contribute significantly toward understanding SME EA (see Recommendations for further research).

The above discussion has thrown light on different EA business models, and highlighted differing emphases from management attention. C2C management engages EA more profoundly than GSCM, for example, and so the suitability of a model may depend on the industry, and an SME’s role in it. If such models imply that an SME moves through stages of creeping commitment to EA, there is little evidence to support such sequentiality. However networking requirements will increase in a shift from GSCM and C2G, to C2C management and toward (more extensive supplier collaboration and) Industrial symbiosis (IS). This introductory review illustrates how different EA pathways introduce different emphases for managerial consideration—both SME and by any partners, such as EIP.

Incentive models of EA

The term incentive models is used to refer to EA pathways which provide an incentive—either to consumers (see FS in Table 4) and/or suppliers. Regulators use a ‘carrot- and-stick’ approach (e.g. through eco-subsidies increased landfill charges etc.) and certification (see later). Incentive models are described by the same researchers as follows:
Table 4  Incentive Models

<table>
<thead>
<tr>
<th>Functional sales (FS)</th>
<th>Also called Product Service Systems enable the customer to pay for the functionality or result of the product as a service, instead of buying the product itself, e.g. leasing or product sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Saving Company (ESCO)</td>
<td>Optimises customers’ operations in e.g. buildings and in return gets paid according to the savings achieved. The customer does not have to pay up front and pays less, the less the service is used</td>
</tr>
<tr>
<td>Chemical management Service (CMS)</td>
<td>Based on a long-term contract where the supplier of CMS accepts the responsibility for managing chemicals of its customers, and strives to reduce the associated costs and risks</td>
</tr>
<tr>
<td>Design, Build, Finance, Operate (DBFO)</td>
<td>Suppliers undertake long-term construction projects where private finance, construction, service and/or maintenance are bundled into a long-term contract, typically 20-30 years</td>
</tr>
</tbody>
</table>

Source: Bisgaard, Henriksen and Bjerre 2013

Aside from resource requirements, the following managerial issues were identified from the respondent data:

FS: gaining partner support, internal reorganisation, traditional mind sets, current accounting practices

ESCO: clear metrics and savings’ calculations, long payback time

CMS: clear metrics to calculate savings and determine fees according to chemical usages, lack of customer knowledge of the model

DBFO: uncertainties regarding risk and environmental impacts. Complex public procurement processes.
The role of certification (as a top-down measure in China in 2015, for example) can be referenced to the development of international agreement about, and increasing confidence in, eco-metrics such as: ISO 14001 (international Standards Organization), to Life-cycle analysis (LCA) environmental impact analysis (EIA), and energy-use and waste-management measurement.

To what extent are such requirements seen as EA drivers or barriers by SME? The most important aspect (according to Interviewee RD) is that these do not chop and change, and that there is sufficient notice for enterprises to adjust to meet new standards. In addition there is the problem in extended supply chains of differing eco-regulations across nations. (RD). To have a voice, SME clearly need to network on such matters in their clusters, and are likely to require a forum, such as an EIP, for both influencing, and managing, certification and eco-metric knowledge and skills’ management.

This section was reviewed literature relating to drivers, barriers and models of eco-adaptation applicable to SME’s. It has extracted from these salient managerial aspects, and has provided examples to illustrate various points made. For many SME managers, as business researchers, it will provide a useful point of reference for understanding potential EA strategies which SME can adopt as also managerial aspects linked to each. Eco-industrial metrics are shown to provide a complex area for managers to understand as standards and regulations vary across-borders. A life-stage perspective is provided by Machiba (2010) who reports that earlier stages of EA involve technological changes of modification and redesign which are largely internal to the organization and which are, in many cases, supply-side driven. Once sales are generated, life-cycling thinking is engaged, requiring SME to pay attention also to demand-side influences and, in maturity, products and production are increasingly led by societal needs and 3E goals, in place of economic goals and eco-measures-and regulations-alone.
D. A proposed framework, conclusion and recommendations for further research

EIP-SME relations therefore need to be seen as part of a desired local industrial symbiosis – i.e. the eco-system of enterprises which collaborate and evolve to meet the changing circumstances of their environment. Networking is what enables such multi-party collaboration to function, and networking enables international input-via an EIP’s foreign contacts – as well as national macro-level (governmental) input, to be discussed (and potentially influenced in a bottom-up fashion by SME and local community groups). Where SME’s and local community groups are both represented on EIP committees, there is the opportunity for local needs to be related to certification and regulatory requirements-existing and/or proposed. How effectively the overlapping needs and shared values of these three: EIP, SME and local communities is at the core of managerial success in EIP-SME relationships. Previous discussion has explore both EIP- and SME management tasks, drivers and barriers to SME EA and EA pathways in terms of life stage/life cycle and incentive approaches and the management issues relating to EA pathway options identified. On the basis of such research, an EA framework is now posited (Fig 2).
**Fig 2  A Managerial Framework of Eco-adaptation (EA) in EIP-SME Relations**

5. Lease renewal or facilitation into another EIP
   Review of medium-term shared opportunities or suitable relocation

1. External audit:
   Potential cluster partners

2. Internal audit:
   Eco-metrics capability, revised mission statement. CEO/Board education

4. Implementation:
   Iterative EA learning of the cluster. Monitoring based on certification and 3E’s metrics for exports

3. Finalisation of EIP-based collaboration arrangements:
   Agreement on eco-metrics. Certification

**Source:** This study

**Explanation of Framework**

The principal aim of EIP-SME collaboration is to meet regional needs (regional development). These are, via networking and pollution-spread, inextricably linked to similar efforts nationally and beyond. Effective EIP management of relationship with tenant SME’s is
premised on shared ground (continuity needs), a flexible EIP culture—enabling entrepreneurial behaviour (by tenants), empathy toward the latter’s management, and on support-financial, informational and political premised on a deep understanding of the managerial demands of each any EA pathway (as previously described).

The framework posits a sequence starting with an external audit (Stage 1) of EA options, followed by an internal audit of the SME’s adaptability and adaptiveness, in terms of managing a chosen EA pathway—possibly after discussion with both members of their SME cluster, LSE clients and EIP management (Stage 2) Compliance with eco-regulations, certifications and the use of eco-metrics provides, it is proposed, a clear opportunity for EIP-SME collaboration (Stage 3)—to be carried through to the implementation stage (4) Finally evaluation of performance both by SME and EIP will occur to develop the relationship and/or terminate it with the EIP assisting tenants along the lines of exit provisions written into contracts.

EIP can and do play an important networking role at the regional level—and via international partners—much more widely. Their ability to attract and maintain tenant firms—largely SME is here viewed in the light of a synergistic collaboration—economically attractive to SME, reducing the likelihood of conflict between SME and local communities, and using EIP as a forum for enabling enterprises meet both national regulations and international customer’s evolving eco-requirements. Finally, it can be said that the potential for EIP to develop such capabilities is, as yet, sparsely researched while meriting the attention, the research suggests, of SME—whether as individuals or as clusters. In this connection, a listing of managerial considerations and recommendations for further research follows:
Managerial Implications:

1. EIP managers need to empathise with SME, and must be seen by the latter to provide relevant and non-constraining support

2. EIP’s, as information networks for EA, need to communicate clearly their value as such to all stakeholders through their multi-stakeholder EIP committees, and through ongoing effective communication with foreign, as well as with governmental, about EA-related regulations and expert bodies.

3. SME’s, to influence EA regulation and/or certification, can use EIP’s as forums for single SME or SME clusters, to play an active role in EIP networks

4. Managers in EIP and in SME need to understand the managerial issues of EA pathway options such as identified in this research, and develop, via collaboration, other alternatives.

Recommendations for Further Research

1. To explore the influence of variables identified in the (pioneering) framework of this research, in terms of their impact on EIP-SME relations, and on trust management in particular.

2. To identify the roles played by cultural factors-national/regional/local and organizational in EIP-SME collaboration

3. To examine, at a macro-level, the contribution of EIP toward ‘balanced growth’ within particular national contexts.

4. To research EIP networking as a global phenomenon, and a means of relating local community needs to regionally and globally-shared environmental and social challenges.
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Xiangfu Lu (XL), Member of the United Nations Framework Convention on Climate Change (UNCFFF) Secretariat, with special responsibility for negotiation with governments on climate change issues

Dr. Isabel Canto de Loura (IC), researcher and consultant to the EU on environmental and sustainability issues.