Working Paper for Discussion

'SOLUTION STRATEGIES' for ENTERPRISE LEARNING

in the GLOBAL ECONOMY

Report on a Pilot Project

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‘SOLUTION STRATEGIES’ for
KNOWLEDGE-BASED ENTERPRISE LEARNING
in the GLOBAL ECONOMY

Abstract

The convergence of three trends -- shaping current realities in the world market -- is creating both challenges and opportunities for global enterprises. These trends are (a) continued economic globalization buttressed by worldwide electronic connectivity, (b) significant shifts in the global economy toward knowledge-based performance, and (c) ‘environment’ and ‘sustainability’ as new factors in corporate strategy (see, for example, the Dow Jones Sustainability Index). This paper develops core conceptual features of ‘solution strategies’ for enterprise learning – drawing on literature reviews of (i) knowledge networking, (ii) e-commerce, and (iii) design for sustainability -- and highlights some key research questions and relevant methodologies. Proposed solution strategies are derived from implementation of the Global System for Sustainable Development, an interactive distributed knowledge based electronic networking system operating on a world-wide basis.

Results of literature survey of design for sustainability illustrated the evolution of approaches and the knowledge gaps across the supply chain in extended enterprises. Results of the exploratory Pilot E-Survey Analysis administered to GSSD users in both private and public sectors -- nationally and internationally -- explored through conjoint analysis, show some central tendencies. Those surveyed: (a) Visit GSSD between 5-30 minutes, on average, (b) Prefer organized data, expert opinions and case studies in the GSSD knowledge base; (c) Tend to rely on human-expert opinion rather than electronic products. (d) Differ in their preferences for e-products, (e) Consider the quality of knowledge content as the most important factor in e-knowledge, and (f) Rank digital library, online publishing, and training courses as the most needed new functions of

GSSD. These results helped formulate the research methods for the next phase of the Project , focusing on developing new knowledge-based solution strategies.

‘SOLUTION STRATEGIES’ for ENTERPRISE LEARNING Based on KNOWLEDGE NETWORKING & KNOWLEDGE E-COMMERCE

Report on a Pilot Project[i]

Nazli Choucri

1. Enterprise Learning in the New Global Economy

The convergence of three trends is shaping the new global economy, creating both challenges and opportunities for extended enterprises. First, among the challenges is, the continued economic globalization buttressed by worldwide electronic connectivity. Second is the notable shift toward knowledge-based competitiveness. Third is the emergence of ‘environment’ and ‘sustainability’ as new factors in corporate strategy.

Global markets are also beginning to recognize these trends. The emergence of the Dow Jones Sustainability Index as a relevant decision variable in asset management and investment strategies shows this new sensitivity, reinforced by evidence that companies ranking high on DISI also outperform the S&P Index.[ii]

Among the opportunities are gains due to knowledge networking, power of co-development and co-laboratory frontiers, innovations in e-commerce modalities, forging markets for new modes of knowledge, and facilitating learning for extended enterprises. [iii] All of this may be sufficiently salient as to call for new ‘solution strategies’ to emergent challenges and new modes of enterprise learning.

1.1 Goals & Methods

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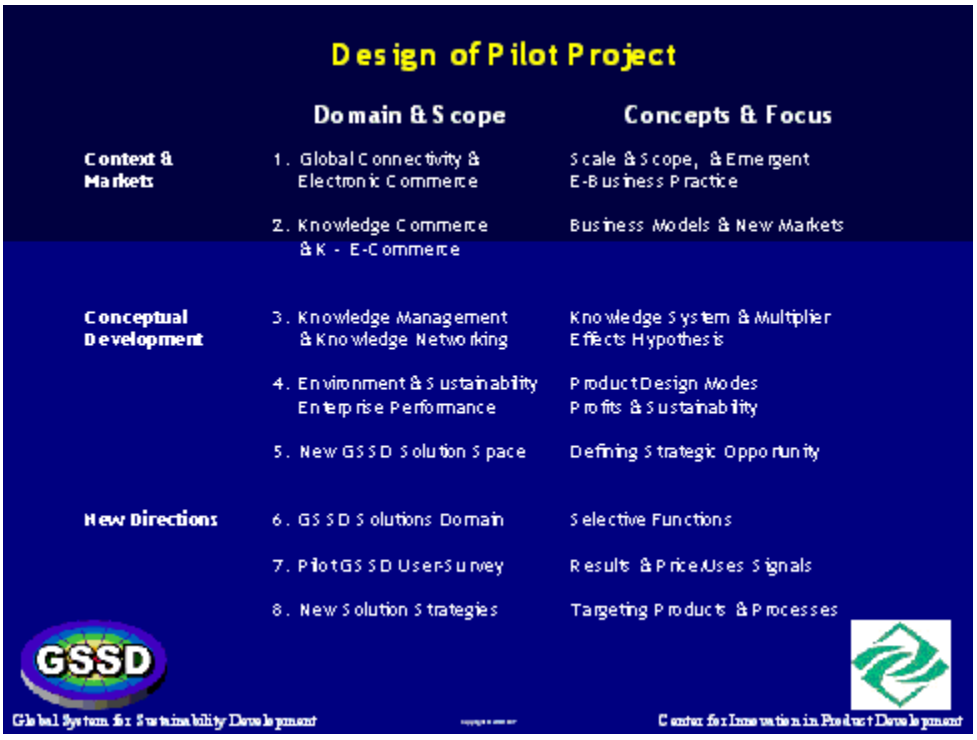
This paper reports on a Pilot Project seeking to develop conceptual foundations for ‘solution strategies’ in this new global economy -- drawing on patterns of practice in (i) global connectivity & emergent markets; (ii) knowledge markets and e-commerce; and (iii) the frontiers of knowledge networking – focusing specifically on (iv) design for sustainability.

The knowledge-system that we employ for this project is the Global System for Sustainable Development (GSSD). GSSD is an adaptive knowledge networking system for use in conjunction with its ‘CyberLibrary’ on sustainability -- derived from cross-indexed and quality controlled Internet resources -- to explore innovative responses to

sustainability challenges for different types of decision-units. Adopting a meta-networking strategy, GSSD provides networking facilities for use by decision-units in stakeholder communities to help identify innovative approaches, enabling technologies, as well as new institutional, financial and regulatory mechanisms for meeting sustainability challenges. [iv]

The research design consists of methodological pluralism, modularity, and falsifiability. Methods include reviews of cross-disciplinary literatures, web-based survey research, distributed knowledge networking, and cross-national applications. Modularity refers to the near-decomposability of theory and substance while retaining conceptual and empirical interface among the components. Falsifiability is built-in as a form of 'insurance policy' to provide signals for corrective in the event creeping analytical ambiguity. Reinforced by initial probes of participatory action research (PAR), this strategy provides broad-based coverage of key issues.

Outlined below is the research domain of the pilot project-- as a 'road map' of the research terrain, and as a checklist of key issues. [v] At issue is clarifying the conceptual, empirical, and strategic challenges for enterprise learning, taking account of *external* as well as the *internal drivers* of change shaping priorities for enterprise learning.



The results of the Pilot are intended to provide directions for new "solutions" in knowledge based products and processes. Because GSSD enables evolving, dynamic, interactive, contextual, and distributed meta-networking, new developments maybe designed to support e-commerce extensions and e-commerce in knowledge products

and processes.

1.2 The New Global Economy[vi]

The remainder of this Introduction highlights key converging features of the new global economy, defining specific problems for industry, and emergent opportunities for extended-enterprise learning.

1.2.1 Globalization & Connectivity

Almost everyone agrees that the global economy is continuing along a globalization trajectory, the implications of which are not fully understood. Contentions and uncertainties are due as much to market conditions as they are to clashes of norms and values in both the private and the public sectors, nationally and internationally. Less ambiguous is the realization that no one, anywhere, can fully be insulated from this process. For extended enterprises whose performance is contingent on efficiencies of the supply chain, the exposure to globalization pressures is unprecedented in scale and scope.

Closely coupled to globalization worldwide is the increasingly dense network of electronic connectivity made possible by the Internet. The growth of the Internet is reaching near-legendary proportions, and usage statistics are outdated almost as soon as they available. Much of this connectivity is lateral (across borders), but it is increasingly accompanied by vertical linkages (within borders). That, too, is a factor of relevance to new market conditions. For the most part, enterprises are beginning to make good use of the connectivity and attendant technologies to facilitate internal communication. But implications for external performance are only barely appreciated.

1.2.2 The "Knowledge Race"

The second salient trend is that global economy is increasingly becoming knowledge-driven. Knowledge is no longer a residual – companion to the proverbial technology factor in the production function – but central to economic performance and, in some sectors, it is clearly the driving factor. With advances in information technology, growing density of the Internet, and enhanced efficiencies in the information management, "handling" knowledge is rapidly assuming the status of 'core competence' for global firms.

If there is a cliché that most aptly characterizes the competitive features of the world economy today it is the "global race for knowledge." [vii] While scholars and observers alike may differ on the determinant role of knowledge, everyone agrees that we have already embarked on a transformation of such pervasive importance that it may be compared to the agricultural revolution (independently in different parts of the world around 8000 BC) or of the industrial revolution (in 18 Century Europe). And, if 'knowledge is power', as is commonly believed, then the global economy at the end of

the 20th century is increasingly reliant on the use of cyberspace facilities for “fueling” the world economy and accelerating transformation of knowledge into power.

Of importance here is less engaging in a debate about the salience of knowledge relative to agriculture and/or industry in shaping if not creating social value than it is highlighting a seemingly obvious in world politics today. Knowledge matters. And it matters a lot. The power of knowledge is, fundamentally, the power of access, uses, diffusion and expansion. This composite power is shaped by the interaction between the *content* of knowledge and the *value* of knowledge—and both are significantly enhanced by networking-networking practices made possible through innovative uses of the Internet. In this context, the Internet becomes both a ‘cause’ and a ‘consequence’ in the global race for knowledge.

In economic terms, knowledge is a public good, privately produced. In practice, knowledge is increasingly generated through group activity rather than through more traditional the individual scholar-researcher practices. This sociological shift in itself necessitates adjustments in research modalilities which, when combined with new communication technologies, enable knowledge networking (and meta-networking) empowering mechanisms for creating new knowledge make knowledge networking (and meta-network) mechanisms for generating new knowledge of new knowledge.

Enterprise learning may now require learning *about* knowledge and how to *generate* knowledge of relevance. The potential for strategic uses of knowledge has, in turn, shaped new modes of knowledge management, giving rise to what is now known as ‘knowledge-networking’ – a verb, a noun, an adjective and a new mechanism for generated added value.

1.2.3 Environment (E) & Sustainability (S) Factors

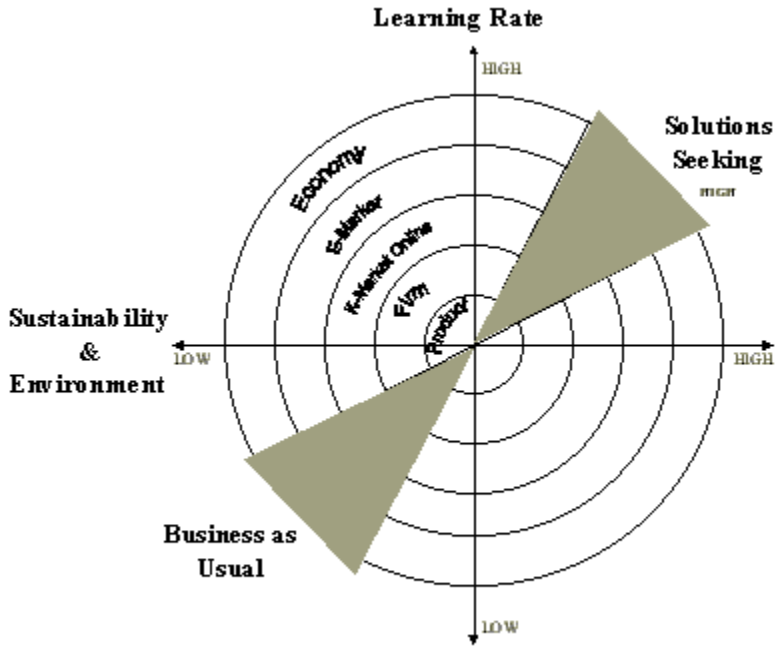
The third, and perhaps most thorny, global trend is the consolidation of interests around matters related to environment and to sustainability.[viii] It might be foolhardy indeed for any self-respecting CEO to feign indifference to environmental conditions or even to proclaim irrelevance to corporate goals. At a minimum it would be rather poor public relations; at most it could serve as a magnet for litigation. For some segments of the global market, adjusting to environment is old news. It is a challenge that has already been addressed, and responses aside, it is not longer material for corporate concern. While this might be the case for the E-Factor, it is hardly the case for the S-Factor.

Now that the DJSI is issued by firms and by sector, the S-Factor has become visible as well as an indicator to be reckoned with. Of relevance here is less the reliability and validity of that indicator than the fact that is exists. If the past serves as precedent, then we can expect a plethora of competing indices amounting to something of a new cottage industry. Recent evidence that high S-Factor firms are also out-performers is rather compelling.

1.3 Challenges for Global Enterprises

Any agenda for enterprise learning – conceptual, empirical practical or strategic -- cannot but take account of these new market factors. While analysts disagree as to the relative importance of the individual trends, consensus prevails as to the nature of this 'short list'. For enterprise learning this means, at a very minimum, that (a) developments along any one of these trends be carefully monitored and that (b) the challenges may well point to new opportunities. If 'staying ahead of the competition' is a driving motivation, then ignoring the 'radar function' in enterprise learning may not be wise. If 'moving ahead of the curve' is the preferred modus, then harnessing the power of knowledge in a globalizing economy amounts to an imperative. Below we provide a conceptual map of the enterprise choices in locating its responsive strategies (if any) and the relevant level and unit of market exchange.

Enterprise Learning Space
Nested System



Conceptually, foundations for tracking the role of 'knowledge' in the enterprise response -- given the new global economy —are shaky at best. Section 2 covers recent trends and theoretical implications. *Empirically*, the contours of a viable research design require careful bounding. Section 3 provides a first cut with respect to sustainable products and processes. *Strategically*, precisely how knowledge of environment and sustainability can best be captured is akin to the proverbial 64 million dollar question. Section 4 presents some research questions (and paths) for this purpose. Section 5

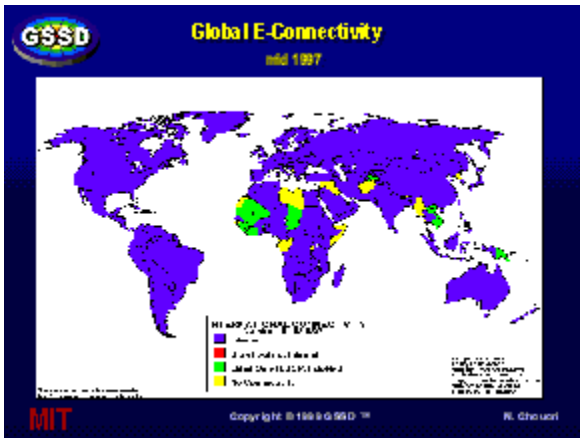
outlines new directions of research –extending beyond the Pilot and conceptual foundations.

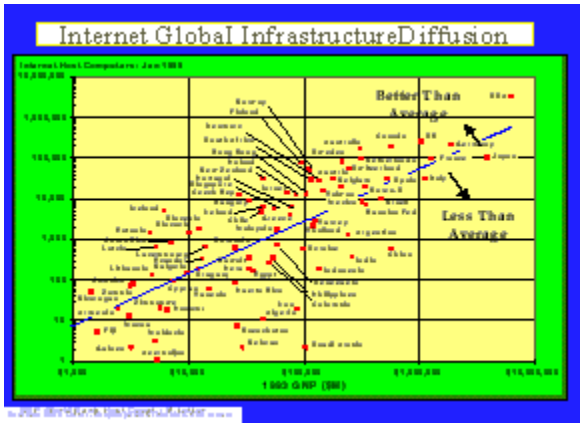
2. State of the Art & Conceptual Foundations

In the absence of an established research tradition, the first step is to articulate what appear to be the most salient 'unknowns' in current theory and practice on (a) global connectivity and related infrastructure (b) e-commerce and knowledge e-commerce; and (c) knowledge-networking, as these bear on (d) design for environment and sustainability – both at economy-wide level at the enterprise level.

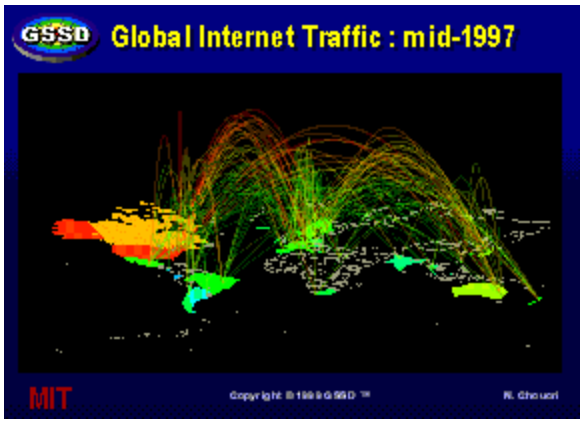
2.1 Global Connectivity & Emergent Markets [ix]

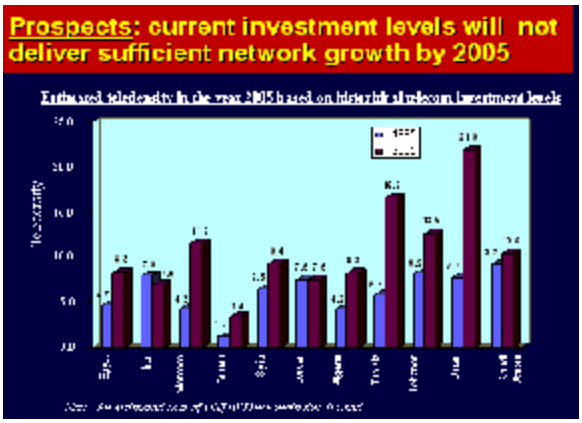
Recent growth in worldwide connectivity and infrastructure developments, shown in the figures below, carries a clear message. Noteworthy also is the emergent reality that greater use of the Internet





requires added investments. In that context, we also see a relationship between economic performance and investments in Internet related infrastructure. But there is great variability across the world in intensity of uses.



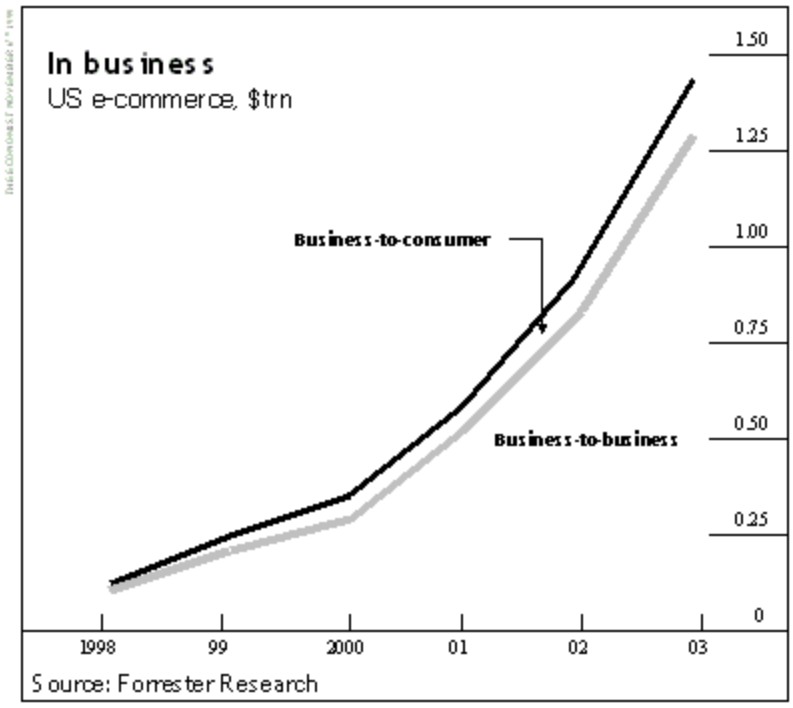


For rapidly developing regions -- particularly those that are 'rich' infrastructure investments are not expected to keep up with the rate of network growth. Moreover, the level of investments required to attain a 15% level of use for these countries is high. Such realities aside, what can be said about attendant conceptual developments? So far, not too much other than noting the explosive growth to date. Given emerging structures and signals are emergent, patterns of practice show no general economic model, no business model, and no common valuation framework. At the same time, there are significant barriers to the development and assessment of needed information as well as compelling institutional problems, bearing on assignment of ownership, protection of privacy, impacts of size and market share, and realistic assessment of infrastructure requirements.

2.2 Global Markets & E-Commerce[x]

The practice of electronic-based commerce is a remarkably recent development, but it has exploded in scale and scope. It goes without saying that e-commerce is 'exploding' in the US; however trends worldwide are less clear – and in some regions barely discernable. What appears critical in this regard is less the *fact* of communication and connectivity than the *form* in which that communication takes place and the value to the participants.

So far e-commerce is mainly for conventional goods and services, in the sense of supporting and servicing the traditional industrial and manufacturing economy. And almost all e-commerce is business to business.

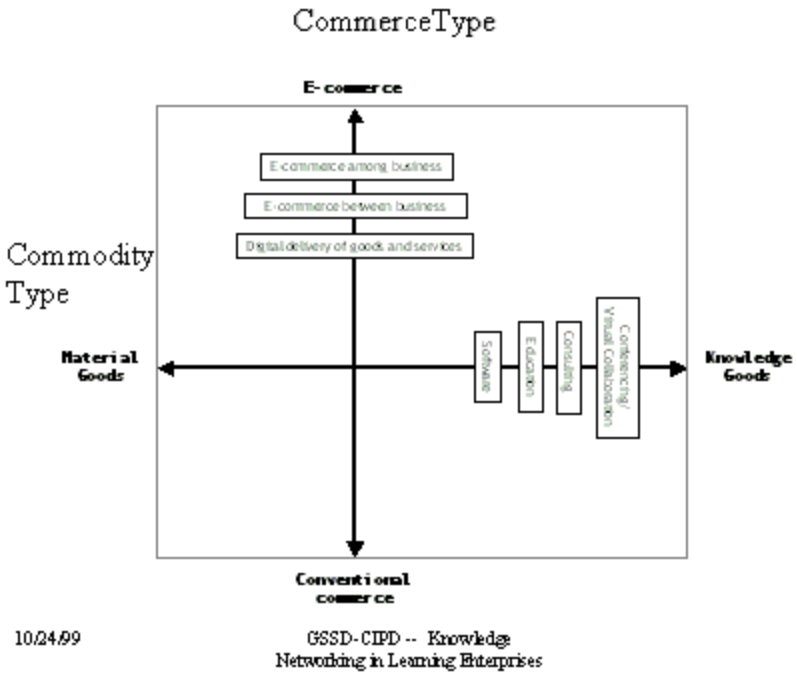


Reproduced from The Economist

The academic literature is still nascent, but all signs are that the 'market' for e-commerce is emerging and getting stronger. To the extent that e-commerce in knowledge is developing, remains concentrated in traditional forms of knowledge exchange, namely training, consulting to some extent, publishing etc.

Based on these considerations, we formulate a conceptual 'map' of emergent global commerce– in terms of major forms and manifestations – defined by two intersecting core axes: (a) commerce type and (b) goods type: [xi]

Global Commerce System



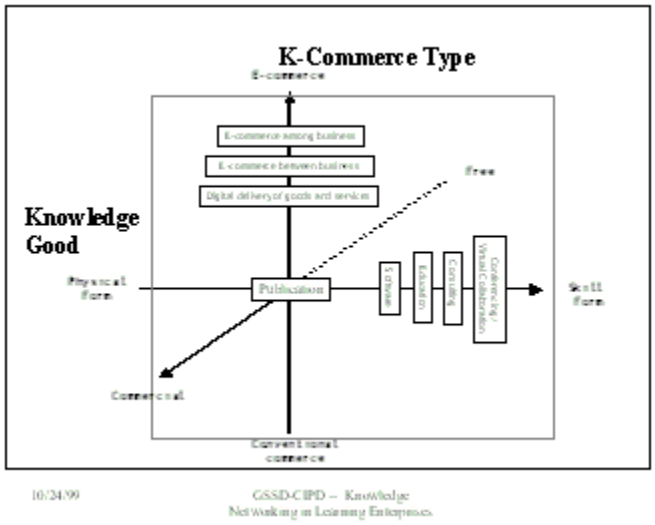
Creating knowledge through e-commerce in knowledge is not yet a fully recognizable "commodity". However, implications for players in conventional markets are apparent. At least three appear incontrovertible (a) ignoring the e-market domain appears hazardous; (b) adjusting is a necessity precisely how is debated (d) as a result the growth in support services is "exploding" as well.

2.3 Knowledge Markets & Market System

A representation of knowledge markets derived from the overall global market configuration along by two specific domains -- (a) the role of price mechanisms, and (b) the market-driven expansion of knowledge – follows reasonably from the foregoing. This extension locates the pricing issue in the overall market enabling us to differentiate pricing among different product types. Equally important, it provides a conceptual basis for content and quality-based value differentiations driven by potential impacts of knowledge networking for generating (i) higher quality of knowledge, (ii) at lower costs, and (iii) with greater diffusion (i.e. market share).

In the figure below we present, first, a schematic view of characteristics features defining the context (or market) for knowledge networking – locally and globally; and then we try to specify the potential role of networking in global knowledge markets, including uses of networking as an institutional enabler for developing new knowledge.

Framing Knowledge Markets

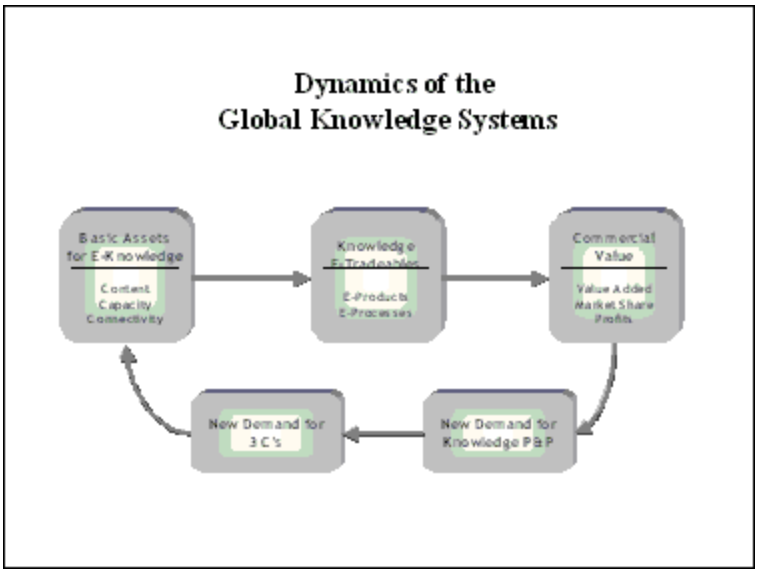


The next step is to specify – based on what we now know -- the constituent elements of a knowledge market in modular terms:

- **Basic assets** required for e-commerce, which include at a minimum the 3-C's, namely physical connectivity (as in Section 2), content provision, and management capacity.

- **Knowledge e-tradeables** representing the products and the processes (in terms of goods and services) that are traded
- **Forms of commercial value** in terms of value added, market share, profits, etc.
- **New demand for K-e-tradeables generated** by growth in commercial value
- **New Demand for 3'Cs** shaped by emergent constraints in basic assets for E-knowledge.

These discrete elements can be viewed as a dynamics system, as follows, to localize relevant variables:



The simple causal logic above serves largely as a guiding proposition. If we use this schema as an organizational tool, we can now locate the potential impacts of knowledge networking.

2.4 Knowledge Networking System

Put simply: What is the value added due to knowledge networking? And how do we know? A review of the literature on knowledge networking shows two trajectories—one rooted in social theory and sociological literature, and the other in computer science and network analysis, focusing on. The former is primarily behavioral and empirical; the latter is computational and analytical. Neither has addressed matters pertaining to enterprise learning, to the new global economy, or to the increased salience of knowledge in economic performance.

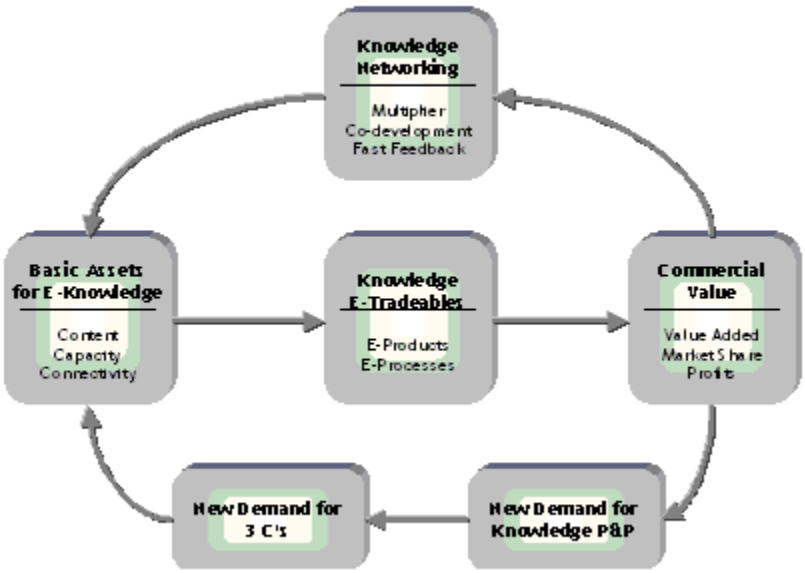
Much of the inferences about e-knowledge networking derive from our own research program, related experiments and ongoing global networking initiatives (see Section 5 below). Through actual practice, empirically and on a global scale, we define properties of knowledge networking as:

> "A computer assisted organized system of discrete actors knowledge, with (a) knowledge producing capacity, (b) combined via common organizing principles, (c) retaining their individual autonomy, such that (e) networking enhances the value of knowledge to the actors and (d) knowledge is further expanded" (Choucri and Millman, 1999).

Jointly these seemingly contradictory properties generate patterns of interaction that, themselves create multiplier effects throughout the entire knowledge system. In the figure below, we extend the dynamics of the global knowledge system by introducing

the multiplier effects which operate through two distinct transmission routes and influence market size, as well as managerial and infrastructure requirements. We refer to these effects as the Knowledge Networking Multipliers, illustrated in the following figure:

Knowledge Networking System



GSSD-CIPD

The proposition embedded in the figure above is that, in the absence of impediments, the interactions or 'flows' will sustain and support a growing market in e-commerce in knowledge. We propose that, to the extent that impediments emerge, these could be reduced through effective operate as barrier highlight interventions at key points in this process. In this figure, the "top" loop representing the basic *system assets* and relations; and the "bottom" loop representing the *demand for new* properties in assets or relations

Since barriers to knowledge e-commerce and to system-wide dynamics can (and do) emerge at various points throughout these processes, the strategic challenge is to minimize impediments, remove barriers, and facilitate overall efficiency. None of this is contingent on specific content. Its conceptual structure is generic in form. The trends outlined in Section 1 above – bearing on fundamental features of the new global economy – drive the content-specifics of knowledge, knowledge networking, and knowledge-e-commerce.

In practice, knowledge networking enables two mutually reinforcing dual outcomes:

globalization of knowledge via greater diffusion, and *localization* of knowledge via representation of distinct local technical and linguistic features. The diffusion of knowledge networking functionality now makes it possible to engage in multidirectional and multiparty interaction (i.e., top down as well as bottom-up) and enables the flow of knowledge generated bottom-up into domains at the top, both within and across societies that greatly enhance inputs into decision.

Access to interactive knowledge networking enables stakeholder communities to express their preferences and make explicit inputs into decision while giving decision-makers access to multiple stakeholder communities. Given the new global economy, the domain of the Pilot -- in terms of substance and content -- relates to environment and sustainability.

3. Environment & Sustainability in Enterprise Performance[xii]

3.1 Knowledge as Enterprise Asset

If knowledge is an asset, then investments in learning about and responding to, new challenges, remains a fundamental for all enterprises. In practice, this translates into the quest for 'solution strategies' targeted to management of factors as environment and sustainability. This duality, in itself, may be a thing of the past as both enterprises and national government increasingly couple both into one notion, namely sustainability.

Assuming that neither 'environment' nor 'sustainability' will evaporate as salient factors in the global economy, that world-wide connectivity is here to stay, and that competition remains at the core of economic activity, then enterprises have little option but to explore the opportunities afforded by current conditions. As noted in Section 1 above, enterprises have as yet barely explored potential gains due to knowledge networking, co-development and co-laboratory initiatives, innovative e-commerce modalities, -- as well as the expansion of markets for knowledge.

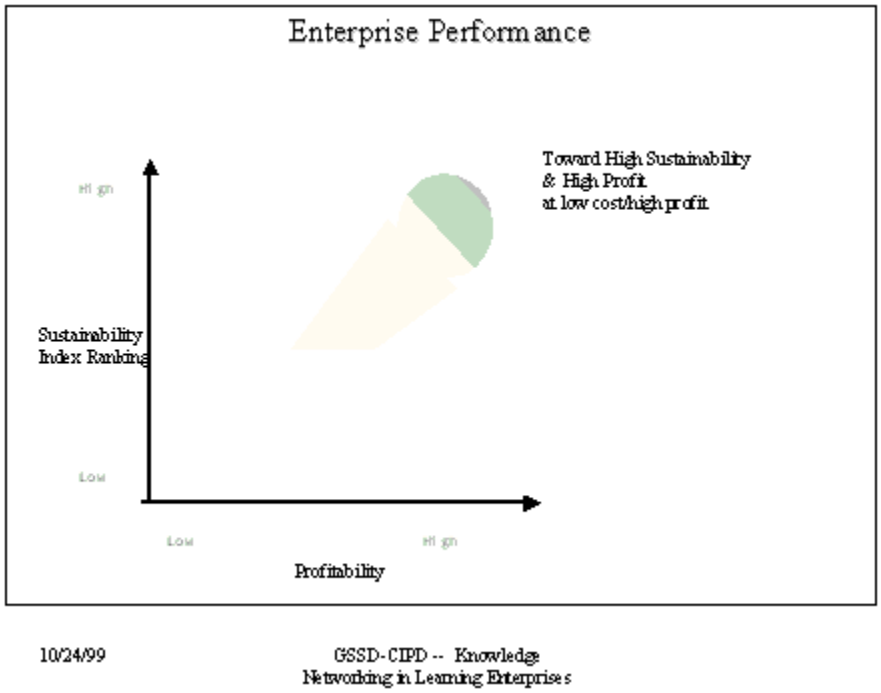
Emergent efforts to develop new metrics for internalizing environmental and sustainability factors economic activity and enterprise performance have lead to new concept coupled with a new vocabulary to track progress along these lines. Most notable among these are 'eco-efficiency', 'full-cost-accounting', 'green accounts', 'green GNP', and the like. In some parts of the world these concepts have seeped into the legal framework – nationally and internationally – providing added support for the growing legitimacy of these trends. Even 'hard' measures as efficiency are being modulated by new concerns for 'equity', 'cleaner production', and protection of environmental amenities.

At issue is less the pervasiveness of these trends – and their dominance worldwide – than their staying power. No enterprise today, anywhere, can proceed much longer without some attention to environment, and some response to sustainability concerns.

At a minimum, to do so would be poor public relations indeed, potentially leading to loss of goodwill. More seriously are the opportunity costs associated with ‘missed learning’ in a global economy where knowledge provides a competitive edge.

3.2 Performance Dimensions

For enterprises – especially extended enterprises – the decision space is captured by performance along two dimensions: sustainability and profits. The trajectory depicted, in the figure below, posits that enterprises seek to optimize on both profits and sustainability assessments. This presumption defines the broad contours of the learning space and the content thereof, namely responding to, and designing for, sustainability.



For extended enterprises this means design for sustainable products and processes – along the value chain. And this means expanding the learning space throughout the value chain as well.

3.3 Reviewing Knowledge & Practice

The earliest forms of industry response -- focused on ‘cleanup’, end-of pipe, and remediation efforts – provide the foundations the practices reviewed here. From an enterprise perspective, in contrast to economy-wide or global views, practices to date converge along three broad modalities. Each can be viewed on a stand-alone basis, but

together they reflect evolution in strategies of design for sustainability. By necessity, the syntheses below capture only the most salient features at hand.

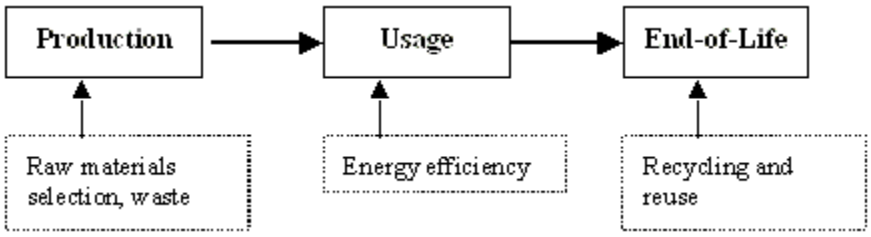
These modalities reflect practice to date as well as and the legitimization practice. In general terms, the literature (and the record) can be represented along a developmental trajectory starting from (a) life cycle and related modalities on the one hand, through experiences with (b) enjoinment management system, transcended by (c) focused design for sustainable products and processes. The synthesis below -- intended to capture salient features, rather than variations thereof or operational details – provides the bases for identifying specific domains or potential market niches for “solution strategies”.

3.3.1 Life Cycle, Product Chain, & E-O-L Management

Among the life cycle modes of responses to environmental hazards, Life Cycle Analysis (LFA) is probably the most commonly applied or envisaged approach to environmentally friendly production. A life cycle approach seeks to minimize the overall environmental impact of a product or process. Environmental concerns are factored in at each stage in the product life cycle, from material acquisition to disposal, or from 'cradle to grave', (Coulter et al, 1995).

Broadly defined, life cycle analysis takes into account the safety, health and social factors across the life-span of a product, process, material, technology, or service. But in applied terms, it refers to methodologies and tools for quantitative analysis and assessment of material and energy inputs and environmental effects - i.e. Life Cycle Assessment or LCA. (Richards et al., 1994; Vezzoli, 1999). For instance, pump-maker Flygt (part of ITT Industries group) considers three general phases: production, usage, and end-of-life, and measures the impact of each phase in Environmental Load Units, based on international guidelines, see below:

Basic LCA System

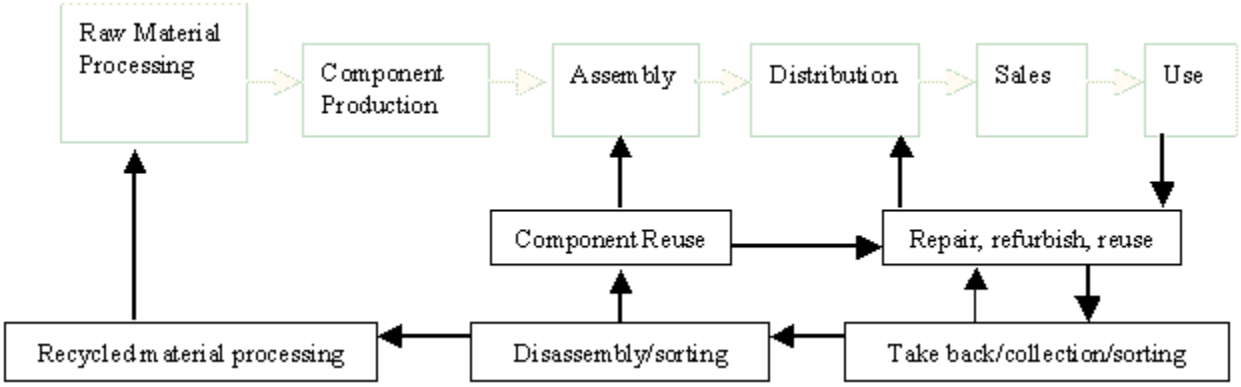


(Graph based on text in 1998 Environment, Safety and Health Report, ITT Industries).

A related, and more differentiated effort is illustrated in the workplan of a Europe based project of leading firms in the electronic industry, on Strategic Comprehensive Approach

for Electronics Recycling and Re-use (1999). Known as SCARE, this strategy starts with the traditional product life cycle consisting of production, distribution and use but then it subsumes more extended functionalities. The object is then to reduce the consumption of materials and energy and control or eliminate use of hazardous materials, a goal referred to as 'thinning' the cycle. As depicted below, what happens at the end of product life chain will influence decisions, design, and operations upstream.

The SCARE Strategy



Adapted from SCARE (1999).

The SCARE design explicitly closes the product life cycle by taking into account component design for reuse, materials for recycling, collection and sorting logistics, and so forth. It does not however treat the final stage, which is waste disposal, although it is implicit in environmental design for material control. The logic product life cycle requires us to think about – and design for -- end-of-life management.

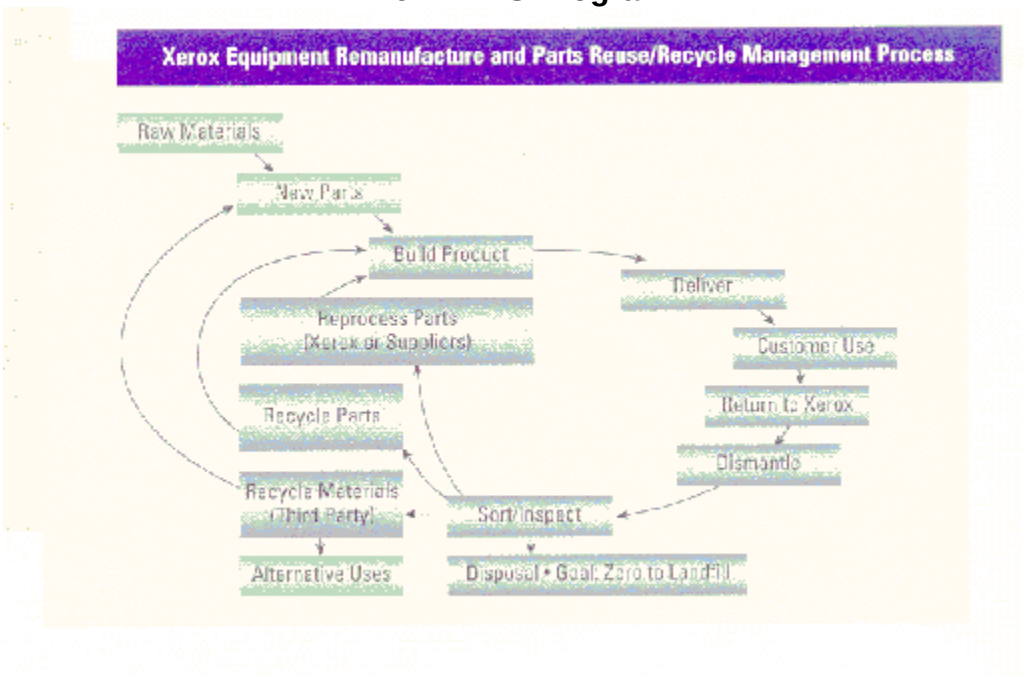
3.3.2 “Best Case”[xiii]

The related design in the figure below attempts to close the product life cycle and needs to factor in component design for reuse, materials for recycling, collection and sorting logistics, and so forth. The ‘best case’ in this practice is by Xerox, notable for having had a successful remanufacture and recycling process for its LAKES product line. Xerox has developed a successful remanufacture and recycling process for its LAKES product line, sometimes referred to as 'zero-to-landfill', which aspires to complete elimination of waste.

The project had to address materials use, assembly processes, component and modularity design, servicing and take-back logistics, and product ownership (customer

leasing). As such, LAKES provides a rich and concrete case of sustainable product embedded in sustainable process.

The LAKES Program



(1999 Environment, Health and Safety Progress Report. Xerox)

The LAKES product line is distinctive in that it is conceived, designed, developed, produced and marketed with no direct reference to market-wide considerations or broader policy directives. Driven by a ‘zero-to-landfill’ goal, the design parameters defined the product output. In fact, the LAKES case can be viewed a market-leading enterprise strategy rather than a market-reacting response – as posited in the Introduction (Section 1).

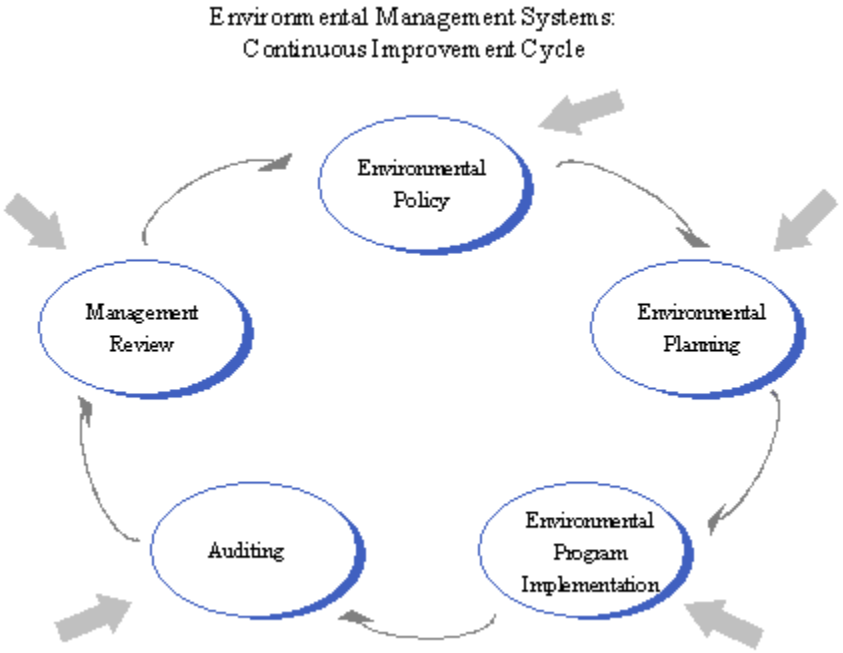
3.3.3 Environmental Management Systems

As a subset of management systems in general, Environmental Management Systems are defined as "formal structures of rules and resources that managers adopt in order to routinize behavior that helps satisfy corporate environmental goals," (Ehrenfeld and Nash, 1999, p.1). Firms can develop their own EMS structures, follow trade association models and practices, or adopt standardized systems, such as ISO 14001. In all instances, management must set goals, develop an implementation plan, gather information, track progress, institute training programs, and undertake corrective action when needed (Ehrenfeld and Nash, 1999). Environmental goals will vary depending on firms' industry, strategy, and culture, but in theory, properly executed EMSs can lead to improvements in environmental performance above basic compliance and policy requirements.

The ISO 14001 standard provides a common framework for a verifiable environmental

management system. The framework does not prescribe detailed operating practices, but instead requires "organizations to establish a coherent, justifiable and consistently applied procedure for setting environmental policy goals, and to implement plans for achieving them,"(Nash et al, 1999, p.9). The ISO 14001 is based on a continuous improvement model, or a "Plan-Do-Check-Act" cycle. Below we represent the fundamental relations assumed in this cycle. The solid arrows provide a reminder that each of these elements is also (perhaps principally) subject to exogenous factors. [xiv]

The EMS Logic



The distinctive feature of EMS is an expanded system-boundary in response to emergent global policy directives. This means that the extension of organizational tasks becomes a necessary requisite for implementing EMS. And in the context of the above figure, the empirical question is: What factors drives each of these modules, and how?

3.3.4 Design for SP&P

At this writing, the convergence of the S-Factor and the E-Factor points to an emergent practice of design for sustainable products and processes (SP&P) – recognizing the sustainability imperatives on both the production and the consumption sides of a market but still within the basic framework of LCA. This practice is early in its making, and the record remains to be consolidated.

Its foundations are both problematical and solid at the same time. For example,

although it is an important improvement over pollution control, this approach has been criticized for its limited view of what is environmentally 'preferable'. According to critics (Richards et al., 1994; Vezzoli, 1999), LCA techniques do not give definitive answers to environmental effects because of assumptions about types and modes of pollution and energy. Because LCA models do not describe the whole range of environmental impacts, developmental work pioneered by Allenby (1999) to concluded that current Life Cycle Assessment methods are better suited to simple products, such as personal care products or plastic packaging.

The contribution of such methods to the evolution of design for sustainability lies mainly in its analytical features, however LCA-based system does not directly address design issues. It is a methodology that requires data, which in turn requires a record of practice. During the first phase, the strategic design of a product development, data is scarcer. But that is also the time when innovation for reducing environmental impact can be most effective as it is integrated into the whole design process (Vezzoli, 1999). These trends have provide essential foundations (perhaps even modular) in the overall S and E strategy and design, both part of, and transcending traditional enterprise practice (if any) toward S and E factors.

The core issue here pertains to expansion of system boundaries – literally and figuratively – for enterprise learning. We conceive of such choices as boundary conditions for acceptable 'solution spaces'—subject to market and profit considerations—and knowledge about key choices as essential to the decision process. By definition, then, these become key factors in enterprise learning bearing on design for SP&P.[xv]

4. GSSD Framework & "Solution Strategies"

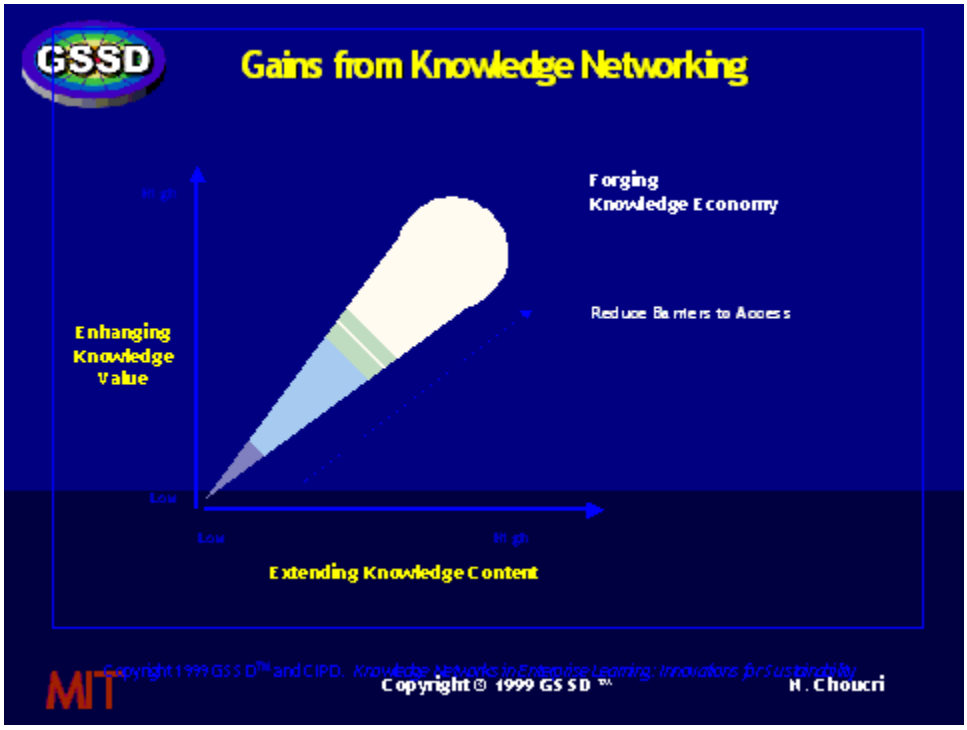
Given the sustainability-focus of the Global System for Sustainable Development, its framework and functionalities are used as the platform to facilitate the solutions-segment of the Pilot Project. Overall, GSSD consists of knowledge-based infrastructure to facilitate new ways of exchanging knowledge, developing new knowledge, and devising mechanisms for generating feedback on the robustness of knowledge – as basic support for decision and strategy.

Of the many outstanding important research questions, several are especially pressing, as they bear on the nature of the demand for 'solutions,' potentials for 'supply', models of exchange, and implications for knowledge assets and enterprise learning. Central among these are: First, defining relevant enterprise solution domains (which we address in conceptual terms only). Second, specifying key functions and services, in relation so substance and content, (examined here in terms of current applications). And, third, defining important applications to, and uses for, learning in extended enterprises (inferred from the foregoing).

4.1 Enterprise "Solutions" Domain [xvi]

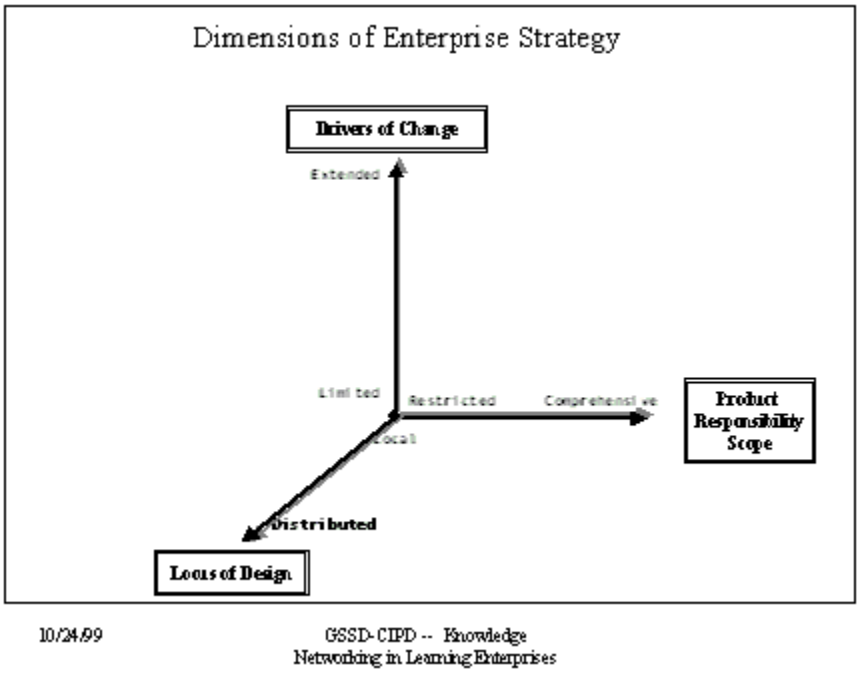
Defining the solutions domain is itself an important subject of research. Conceptually, we would expect a relationship between the *content* of knowledge needed, and the *value* of the knowledge. This is a domain where application of participatory action research, combined with survey and interview analysis may provide insights into the underlying parameters. Posited in the figure below is a trajectory joint maximization along both dimensions. The operational relationship is, in any case, an empirical question.[xvii]

Knowledge Parameters [xviii]



Assuming that firms seek to develop knowledge-based responses – buttressed by new learning—then framing the knowledge-strategy is an essential next step. At issue is capturing knowledge along three dimensions: the proximity driving factors, the location of response, and the scope of product responsibility. These are depicted in the figure below:

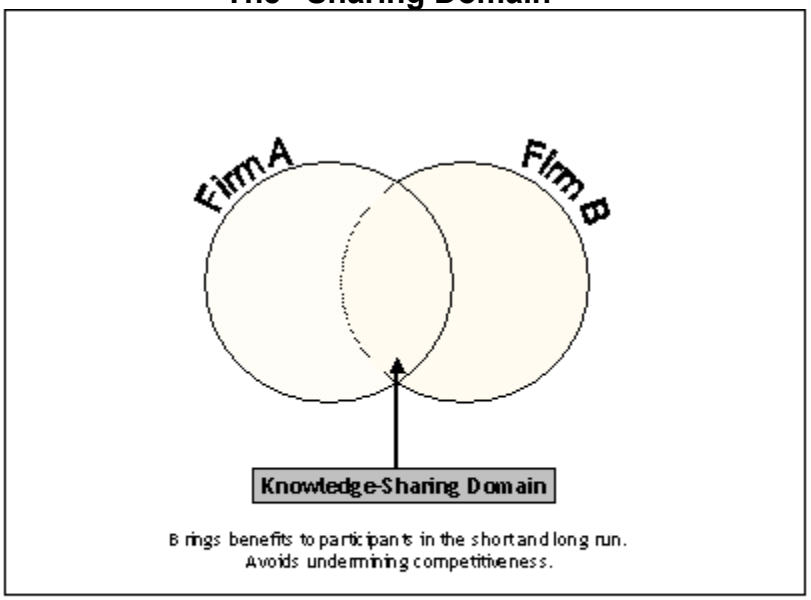
Applications to Enterprise Strategy [xix]



Each of these dimensions anticipate organizational adjustments, knowledge management capacities, and advances in communication technologies. With few exceptions, if any, organizational complexity is increased, requiring added means of tracking and streamlining. The larger the size and extendedness of the enterprise, the more challenging are the organizational requisites.

At this point decisions about knowledge sharing become relevant**.** Beyond matters of economy of scale, 'sharing' may be particularly attractive in new market conditions as those potentially sensitive to matters of environment and sustainability. In practice, what the sharing domain might be in any one case appears to be an empirical question. Conceptually, it can be represented as follows, recognizing that Firm A and Firm B may in reality consist of complex and extended enterprises:

The "Sharing Domain"



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4.2 GSSD in Knowledge Markets[xx]

Applied to sustainability issues, broadly defined, GSSD can be characterized as a computer implementation method for facilitation identification and storage of data, retrieval, combination and the communication of information among a plurality of geographically separated entities working to solve problems related to global sustainability. The basic architecture of GSSD is applicable to a wide range of issues and problems characterized by *uncertainty*, *complexity*, and *contextual diversity*. The critical mechanisms pertain to uses of knowledge networking for knowledge generation, sharing, and implementation. The GSSD strategy consists of

- Organizing knowledge and data related to global sustainability problems into several hierarchies of interrelated sub-concepts stored on several computer systems interconnected by a number of communication links;

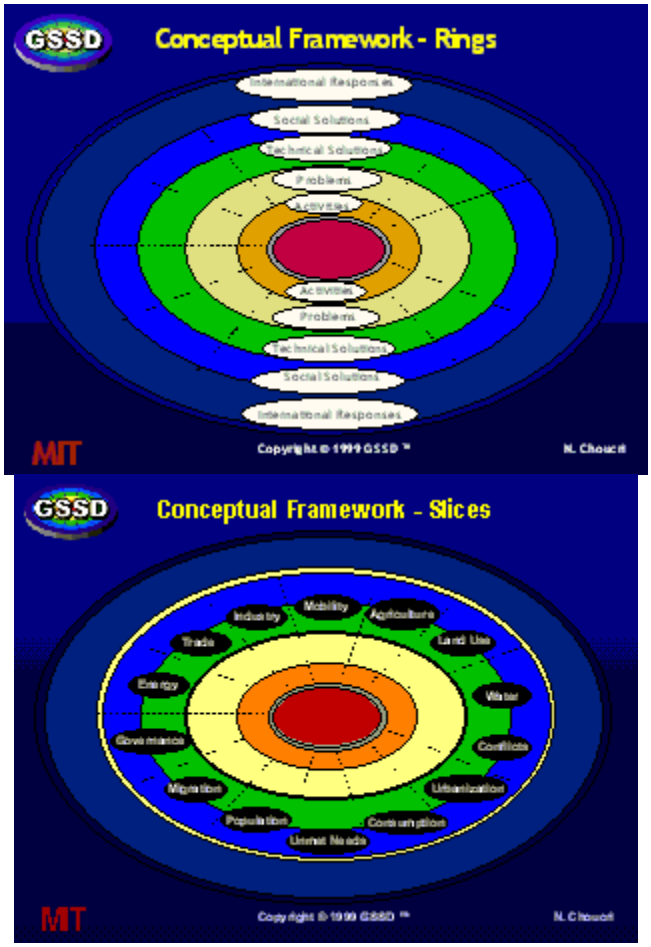
- Providing access of plurality of entities, to data within any of sub-concepts stored in pluralities of remote locations in response to mapping specifications;

- Providing access to data and information of hierarchies of interrelated sub-concepts on any computer systems from any sub-concepts according to defined connectivities and in to mapping provided by system functions; and

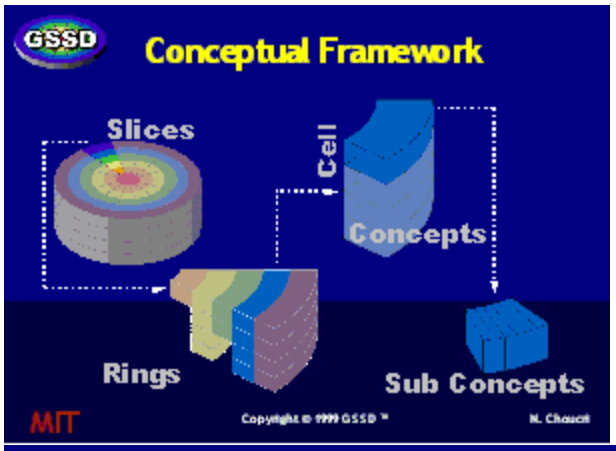
- Supporting a set of knowledge-based functionalities, including: (a) Evolving interactive CyberLibrary on Sustainability (b) Specialized Search Engines, and (c) Multilingual Electronic Capacities, including Western and non-Western languages.

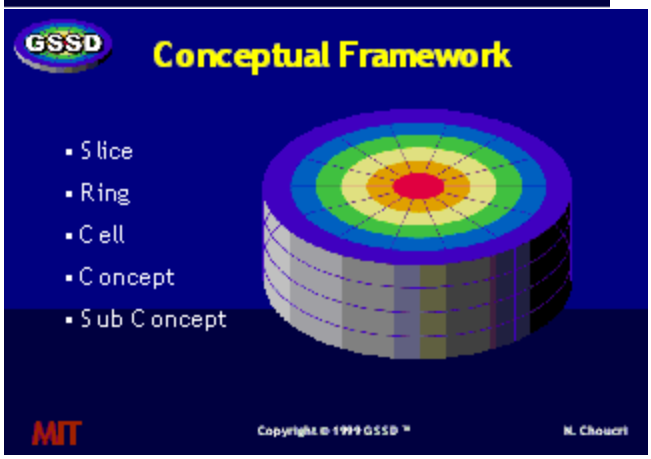
The figures below show the conceptual structure, some basic indication of content, and clues into the logic of content connectivity. [xxi]

Nested Hierarchical Structure Domains of Human Activity



Decomposing Single Slice Reviewing System Structure





Generic Knowledge Problems Knowledge Type

Search & Navigation GSSD Emergent Functions

In theory, GSSD services are generic, in the sense that they are fundamental to the diffusion of knowledge, they are relevant to all societies at all levels of development, and they will almost certainly remain central to all future uses of the Internet. In practice, how important is such knowledge infrastructure and functionalities to enterprise learning depends on the nature of the enterprise and the scale and scope of operations. The

task is to determine how these might support enterprise learning. What do enterprises want? Where are the critical 'needs'?

4.3 GSSD Pilot Survey Analysis[xxii]

Given the paucity of empirical evidence, the first task was to conduct an on-line GSSD survey – undertaken as a Pilot for subsequent iterations. This exercise yielded preliminary insights as prevailing views on (a) the knowledge base, (b) the research strategies and (c) initial price/use relationship.[xxiii] However, responses came from large companies, private and public, nationally and internationally, thus variance yields compensates somewhat for excessive commonalties. Application of conjoint analysis – to normalize distributions and balance statistical inferences – is an important exploratory step in the Pilot. B.[xxiv]

Results of the exploratory Pilot E-Survey Analysis administered to GSSD users in both private and public sectors -- nationally and internationally -- explored through conjoint analysis, show some central tendencies. Those surveyed: (a) Visit GSSD between 5-30 minutes, on average, (b) Prefer organized data, expert opinions and case studies in the GSSD knowledge base; (c) Tend to rely on human-expert opinion rather than electronic products. (d) Differ in their preferences for e-products, (e) Consider the quality of knowledge content as the most important factor in e-knowledge, and (f) Rank digital library, online publishing, and training courses as the most needed new functions of GSSD.

Particularly revealing is the finding on the relevance of content – ranking highest among the factors considered – thereby reinforcing our initial propositions about the content of knowledge in relation to the value of knowledge. Other 'findings' relating to the respondents' priorities with respect to new GSSD functionalities helped design the next phase of the Project, targeted to developing new knowledge-based solution strategies

4.4 GSSD Solution Space

Taking these results into account, we can now partition the GSSD 'solution space' -- given contours of the global knowledge market and attendant products and processes – and identify potential new 'solutions'. Conceptually, we can locate this 'space' in an extended version of the knowledge market presented earlier (Section 2), as seen in the shaded space of the figure below: This figure is developed by B. Huang, with contributions by V. Haraldsson. It is central to the MS thesis of the former, and only indirectly related to the MS thesis of the latter.

GSSD Solution Space

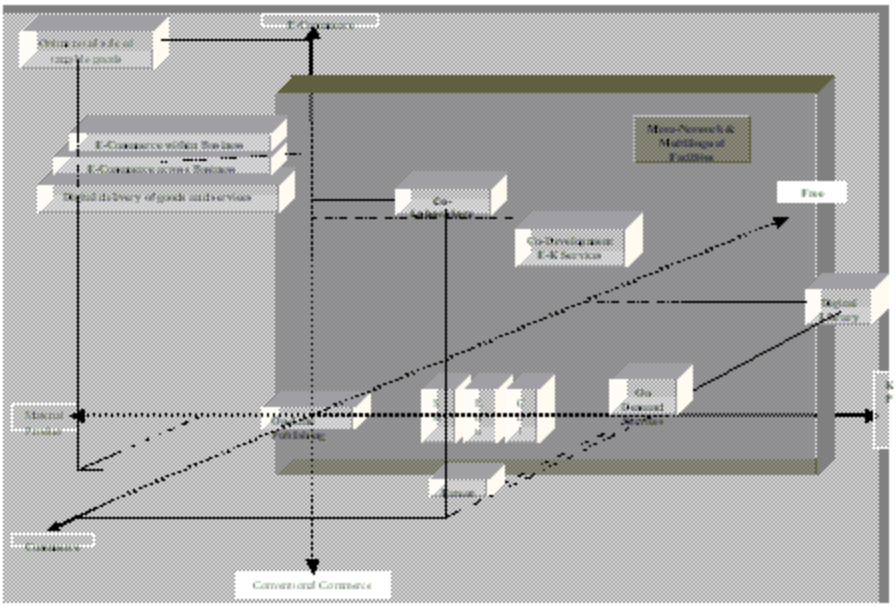


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Figure 10. Global Commerce System (GSSD is commercialized)

Three current functionalities in this figure – digital library, search & browser options, and co-laboratory via multilingual capacity – are described below. Their operation, in conjunction with emergent needs, helps point to new directions for product development.

4.4.1 Knowledge Base as Evolving CyberLibrary

In cyber-*parlance*, the core principle of a library is one of ‘posting’, meaning that items are deposited in cyberspace, with the expectation of sequential and one way interaction. This means that items are placed on the Internet and users can “withdraw” them as needed. The GSSD CyberLibrary, by contrast, is interactive, iterative, participatory, and based on conferencing conceptions. Almost by definition, the materials placed on in a CyberLibrary are subject to revision as needed, with as many ‘cooks in the kitchen’ as relevant (subject of course to the library’s operating principles). It is these factors that provides transforms a cyberlibrary into an evolving knowledge system. And it is these properties that enable acceleration as well as the rapid diffusion of new understandings.

The current holdings of the GSSD CyberLibrary consists of well over 250 institutional Internet holdings represented in close to 3000 indexed and cross-referenced internet sites. Unlike a conventional library where the indexing system generally covers title, author and select related items, the power of this CyberLibrary lies in the cross-indexed and referencing of the *contents* that is available within each site. Technically, this is closely related to the term ‘spidering’ in Internet idiom.
As an evolving knowledge base, it covers a comprehensive range of sustainability-

related resources. Since it is a distributed system, the holdings are generated throughout the user community worldwide and maintained at the source.

A key feature of the CyberLibrary derives from its distributed properties. Given that the holdings remain under the control of author or authoring institution, the holdings of the CyberLibrary strictly speaking consist of the cross-references, cross-indexed system embedded in an abstract whose contents are 'keyed' to the conventions of the indexing system. Since the latter itself is based on a coherent multidimensional conceptual framework, the coherent of the knowledge base for the CyberLibrary as a whole is thereby ensured.

The challenge is to maintain, update, and retain quality and reliability. Also important is the ease of use, given the GSSD system-wide search and browser functions.

4.2.2 Specialized Search Engines

Every user knows that in the absence of search engines as Yahoo, Excite, etc., the Internet would be even more of a jungle or a spaghetti plate is presently the case. But every user also knows that these search engines caste their net in broad terms, with as much discrimination as is allowed by the user. Nonetheless, the need for specialized search engines is now widely recognized in scholarly, industry, and policy-making circles. While specialized search engines are considerably more difficult to design and operate, they are invariably more valuable to the discerning user. The design difficulties are generally not technical in nature, but rather related to content representation and configuration of representation.

The GSSD search engines operate over the CyberLibrary's quality control and evolving holdings, and they directly responsive to the user's conception of his or her specific needs. Of course, the retrieval record is only as good as the holdings of the entire CyberLibrary and the skill and interests of the user(s). In the context of the GSSD Figures above, we can illustrate the search engines options in terms of retrieval by subject or by modality or by location (geographic, etc.), level (global, regional, local), etc. – with as many options as specified by the user (assuming relevance to the subject at hand).

Is there a demand for user-designed search facilities? Can adaptation and learning be effectively embedded in agent-based search systems without undue costs to content and coherence? And what about impact of context and culture – and language?

4.4.3 Multi-lingual Capacities This development was undertaken in collaboration with Lotus Development Corp. and the participation of K. Cavanaugh, VP for Product Development. We are grateful to the joint GSSD-Lotus team for developments to date.

It stands to reason that in a non-English world, English-Internet is somewhat limiting.

Multilingual functionality provides three distinctive advantages, which, in the context of sharing domain, in Figure, multilingualism could facilitate, effective use of common space. For GSSD users, the implementation of its multilingual facilities enables:

(a) Improved access to information, reducing difficulties facing non-English speakers by allowing them to find specific information on the Internet through our use of abstracts. Each site included in the GSSD knowledge base is abstracted, and that abstract is, in turn, translated into each of GSSD's supported languages. These are then available for e-searches through the system's five search modes.

(b) Strategic use of resources, given that GSSD's abstracts allow the user to know in advance of translation where the most fruitful information is housed thus improving access significantly.

(c) Expansion of knowledge base, since the absence of a platform for non-English content has limited the access to distributed knowledge.

To date, multilingual facilities, however limited, have enabled multiple communication directionality – i.e. top-down and bottom-up – thereby linking the seemingly contradictory trends of globalization and localization. Nonetheless, a major research question is: To what extent multilingual functions can be effectively built into technical communication for extended enterprises – throughout the supply chain, across countries, spanning jurisdictions, and transcending common modes of communication? Do communication barriers translate into profits foregone? Are their modalities for tracking this question down?

4.5 At Issue

At issue here are, once more, is the matter of system boundary – and its expansion literally and figuratively – for enterprise learning. The knowledge-based functions reviewed above must be innovative and acceptable 'solution spaces'—subject to market and profit considerations. At issue here is also development of knowledge about key choices as inputs into the decision process. By definition, then, these become relevant factors in formulating emergent research directions – in Section 5 below -- resulting from the Pilot Project.

5. New Research Directions

5.1 The Pilot Project

The goal of the Pilot Project was to develop robust conceptual foundations for research on new venues of global knowledge networking in support of enterprise learning. The check list in the Introduction provided the road map for navigation through complex terrain – with uncertainty and complexity dominating both the theoretical and the

empirical routes. The terrain in question is shaped by convergent trends in the global economy and the intersection of new pressures on enterprise performance.

Throughout the Pilot, two interacting and mutually reinforcing lines of inquiry help shape the entire investigation: (a) developments in e-commerce and (b) design for sustainable product and processes. The coherence of the Pilot was maintained by a focus on (c) knowledge networking, and formulation of the Knowledge Networking System; and (d) the overall initiative converged around knowledge infrastructure facilities embedded in GSSD.

5.2 Prioritizing New Directions

In the context of GSSD Solution Space above, we can point to types of products and processes of relevance to evolving knowledge markets and to the potential contributions of GSSD to enterprise learning. A set of specific capacities can be envisaged to strengthen the 'learning' functions, and a set of new organizational modes canals be envisaged.

Among candidates for new solutions are improved products related to streamlined on-line publication facilities, E-Journal platforms, interactive conferencing, augmented knowledge-base coupled with customized and customizing search and navigation tools, visualization capacity across data types and forms of representation, and knowledge-mining intelligent agents, platforms for tracking and representing knowledge generated and transferred across the value chain and throughout extended enterprises.

Among candidates enabling new organizational flexibility for knowledge generation – over and above management and sharing – are facilities supporting distributed co-laboratory capacities where innovation is the goal, and not merely conferencing. The challenge is less in analytical and computational than in organizational terms and ease of operation. All of this would be rendered more complex once we consider matters of multilingualism and cross-culture and cross-connect communication.

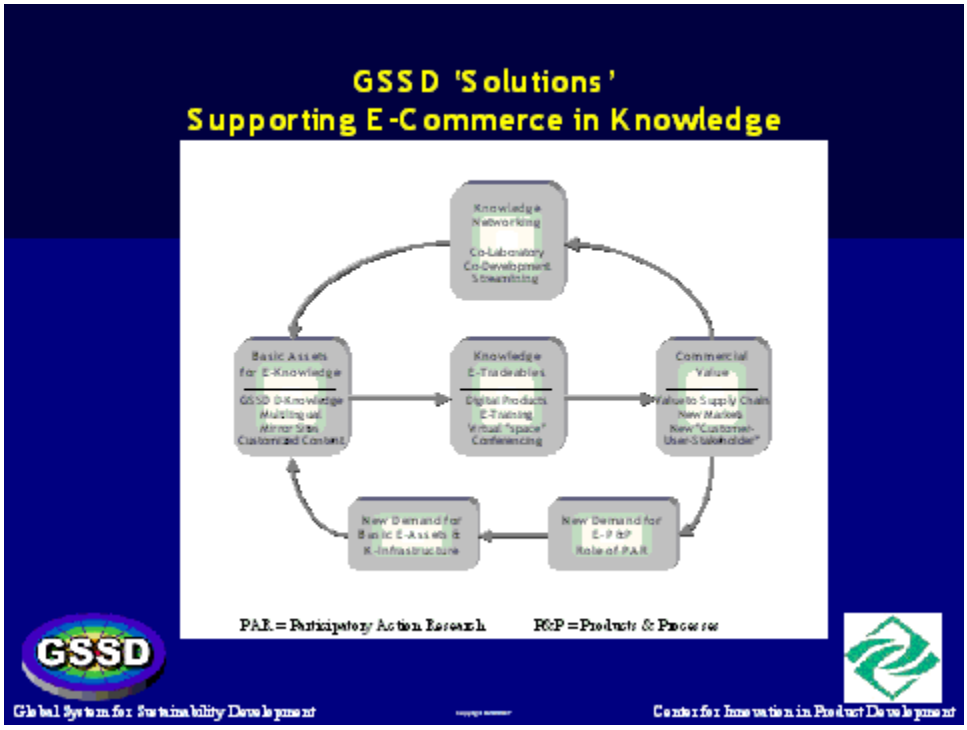
All of this bears directly on the Knowledge Networking System put forth in Section 2. At that point participatory action research become especially critical to the research enterprise, enabling access to basic insight on the composition of enterprise knowledge "demand" and venues for generating "supply". This appears an essential venue for reviewing the results of the Pilot, prioritizing the sequence of next steps, and clarifying conceptual and strategic choices.

5.3 Post-Pilot Research Strategy

Returning once again to the networking hypothesis, we conclude the Pilot by proposing

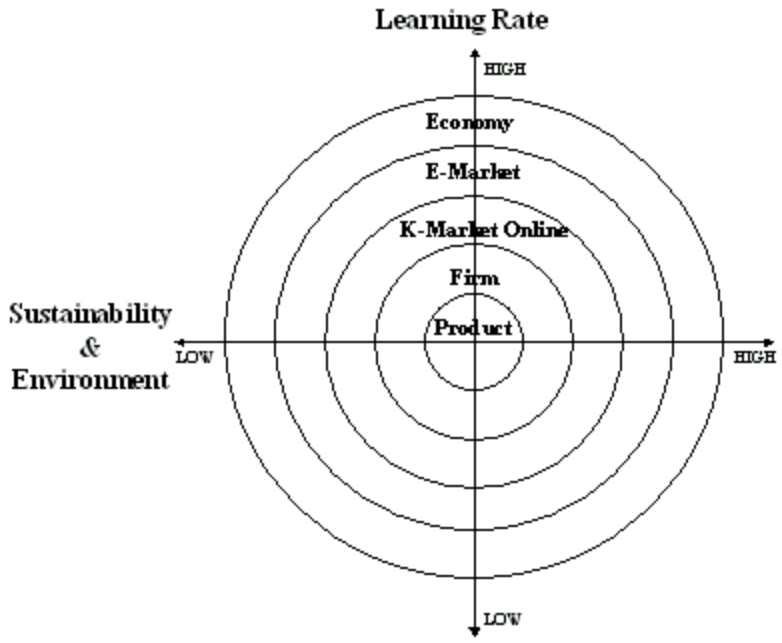
that the framework put forth to represent the elements of an overall knowledge system (or market) be used as a guide for next steps. Combining elements of the GSSD solution space (noted above) with a logic of coherence, the transition from hypothesis to research strategy can be visualized below. This figure retains the modular design introduced earlier – representing features and functions – as a reminder of the organizational and institutional underpinnings of a knowledge market. It also enables effective unbundling of these complex processes for research and policy purposes.

The logic driving our formulation of the gains from Knowledge Networking is shown graphically below, and should be viewed as a 'model' informing further specification of the research design.



. As a final step in this Report of the Pilot Project, we draw attention to the enterprise learning domain -- introduced in Section 1 above – as a reminder of the decision context and strategic choices in facing extended enterprises, and differences in response strategies. Below we partition four domains (I,II, III, IV) to formulate research questions of relevance to enterprise knowledge-strategy.

Types of Enterprise Knowledge-Strategies



Among the challenging research questions are the following:

Are their differences in knowledge strategies among enterprises positioned in different quadrants? Are some forms of knowledge-based response more dominant across quadrants? Can we characterize differences between II and IIII as distinct from I and IV? Are the knowledge needs and solution product requirements variable across quadrants? Are their distinctive knowledge-based solutions that cut across all quadrants? Operationally, does the utility of different GSSD products and processes vary across quadrants – given the imperatives of the new global economy?

Selective Bibliography

Allee, Verna. 1997. *The Knowledge Evolution: Expanding Organizational Intelligence*. Boston: Butterworth-Heinemann.

Allenby, Braden. 1994. "Integrating Environment and Technology: Design for the Environment," in Braden Allenby and Deanna Richards eds., *The Greening of Industrial Ecosystems*. Washington D.C.: National Academy Press.

Amor, Daniel. 1999. *The E-business (R)evolution.* New Jersey: Prentice Hall, Inc.

Aronson, Brad. 1999. *Advertising on the Internet*. London: John Wiley & Sons.

Benedikt, Michael. 1994. (ed.) *Cyberspace: First Steps* Cambridge: The MIT Press.

Betancourt, Marian. 1999. *The Best Internet Businesses You Can Start*. Adams Media

Corporation.

Buchholz, Rogene A. 1998. *Principles of Environmental Management: the Greening of Business*. New Jersey: Prentice-Hall, Inc.

Cashin, Jerry. 1999. *E-Commerce Success : Building a Global Business Architecture*. Computer Technology Research Corporation.

Choucri, Nazli. 2000. “Governance and International Management,” in Ted Munn, ed., *Encyclopedia of Global Environmental Change*. London: John Wiley and Sons.

Choucri, Nazli. 2000. “Knowledge Meta-Networking for Decision and Strategy,” MIT Working Papers Series.

Choucri, Nazli. 1999. “Strategic Partnerships with Multilingual Functionality for Globalisation and Localisation,” Prepared for European Commission Directorate-General Information Society Workshop on “Sustainability and E-nvironment,” IST99 Conference in Helsinki, November 1999, Finland.

Choucri, Nazli. 1999. “Links Between Population Dynamics/Migration and Security,” Proceedings, Symposium on Migration, Environmental Change and Security, October 1999, University of Michigan.

Choucri, Nazli. 1999. “The Political Logic of Sustainability,” in Egon Becker and Thomas Jahn, eds., *Sustainability and the Social Sciences*. New York: Zed Books.

Choucri, Nazli. 1999. “Report on Consortium Partners Special Initiatives,” MIT Working Papers Series.

Choucri, Nazli. 1999. “New Strategic Partnerships: Knowledge Frontiers and Enabling Technologies, Discussion Paper for the Global Environment Facility,” MIT Working Papers Series.

Choucri, Nazli. 1998. “Knowledge Networking for Technology ‘Leapfrogging’,” *UNDP Cooperation South,* Number Two, 1998, pp. 40-52.

Choucri, Nazli. 1998. Paper prepared for UNFCCC-COP/4, GSSD Special Event, MIT Working Papers Series.

Choucri, Nazli, Gerard McHugh and Steven R. L. Millman. 1998. “Innovations in Cyberpartnering for Sustainability,” *Care Innovation ’98: Proceedings,* Second International Symposium, Brokerage Event and Environmental Exhibition, November 1998, Vienna, Austria.

Choucri, Nazli. 1995. “Globalization of Eco-Efficiency: GSSD on the WWW.” *UNEP Industry and Environment,* October-December 1995, pp. 45-49.

Choucri, Nazli. 1994. "Corporate Strategies toward Sustainability," in Winfried Lang, ed., *Sustainable Development and International Law,* Boston: Graham & Trotman/Martinus Nijhoff, pp. 189-201.

Choucri, Nazli. 1994. "Moving Forward: Priorities and Practicalities." *Business & the Contemporary World,* Special Issue: Global Environmental Accords: Implications for Technology, Industry and International Relations VI (2): 134-5.

Choucri, Nazli. 1993. “Environmentalism,” in J. Krieger, ed., *Oxford Companion to Politics of the World,* New York: Oxford University Press.

Choucri, Nazli. 1991. "The Global Environment and Multinational Corporations." *Technology*
Review 94 (3): 52-9.

Coulter, Stewart, Bert Bras & Carol Foley. 1995. "A Lexicon of Green Engineering Terms." International Conference on Engineering Design, ICED 95, August 22-24, 1995, Praha.

Dertouzos, Michael L. 1997. *What Will Be. How the New World of Information Will Change Our Lives.* New York: HarperCollins Publishers, Inc.

Funk, Karina. 1997. *Information Networking as an Instrument of Sustainable Development: The Photovoltaic Example.* Masters Thesis: MIT.

Gielgun, Ron E. 1998. *1 Business, 2 Approaches : How to Succeed in Internet Business by Employing Real-World Strategies.* New York: Actium Publishing.

Hance, Olivier, et al. 1997. *Business & Law on the Internet*. New York: McGraw-Hill.

Imparato, Nicholas, ed. 1998. *Capital for Our Time: The Economic, Legal and Management Challenges of Intellectual Capital.* Palo Alto, Calif.: Hoover Institution Press Publication, 448.

Korper, Steffano, Juanita Ellis and Jerry D. Gibson. 1999. *The E-Commerce Book: Building the E-Empire.* Burlington, Mass: Academic Press.

Kwasnicki, Witold. 1996. *Knowledge, Innovation and Economy: An Evolutionary Exploration.* Northampton, Mass: Edward Elgar Publishing Co.

Merkow, Mark S. and Jim Breithaupt. 1998. *Building SET Applications for Secure Transactions*. London: John Wiley & Sons.

Moldan, Bedrich, Suzanne Billharz and Robyn Matravers, eds. 1997. SCOPE 58: *Sustainability Indicators: A Report on the Project on Indicators of Sustainable*

Development. London: John Wiley & Sons Ltd.

Nash, Jennifer & John Ehrenfeld. 1999. "Environmental Management Systems and Their Roles in Environmental Policy." Multi-State Working Group Summit Conference on Environmental Management Systems, November 2-3, 1999, Washington D.C.

Nash, Jennifer & John Ehrenfeld. 1999. "Environmental Management Systems and their Roles in Environmental Policy." Multi-State Working Group Summit Conference on Environmental Management Systems, November 2-3, 1999, Washington D.C.

Nash, Jennifer, John Ehrenfeld, Jeffrey MacDonagh-Dumler & Pascal Thorens. 1999. "ISO 14001 and EPA Region I's StarTrack Program: Assessing their Potential as Tools in Environmental Protection." Prepared for the National Academy of Public Administration, October 15, 1999, Washington D.C.

Neef, Dale, G. Anthony Siesfeld and Jacquelyn Cefola, eds. 1998. *The Economic Impact of Knowledge.* Boston: Butterworth-Heinemann.

Neef, Dale, ed. 1997. *The Knowledge Economy (Resources for the Knowledge-Based Economy)*. Boston: Butterworth-Heinemann.

Nemzow, Martin. 1997. *Building Cyberstores : Installation, Transaction Processing, and Management.* New York: McGraw-Hill.

OECD. 1996. *Employment and Growth in the Knowledge-Based Economy.* Paris, France: Organisation for Economic Co-operation and Development.

Pallot, Marc and Victor Sandoval. 1998. *Concurrent Enterprising - Toward the Concurrent Enterprise in the Era of the Internet.* Norwell, Mass: Kluwer Academic Publishers.

Radding, Alan. 1998. *Knowledge Management: Succeeding in the Information-Based Global Economy.* USA: Computer Technology Research Corporation.

Richards, Deanna J, ed. 1997. *The Industrial Green Game: Implications for Environmental Design and Management*. Washington, DC: National Academy Press.

Richards, Deanna, Braden Allenby, and Robert Frosch. "The Greening of Industrial Ecosystems: Overview and Perspective," in Braden Allenby and Deanna Richards eds., *The Greening of Industrial Ecosystems*. Washington D.C.: National Academy Press.

Rosenoer, Jonathan. 1999. *The Clickable Corporation : Successful Strategies for Capturing the Internet Advantage*. New York: Simon & Schuster.

Ross, L. Manning. 1998. *businessplan.com : how to write a web-woven strategic business plan.* Oregon: Psi Research - Oasis Press.

Rudy, Dale and Diane Rudy. 1999. *Antiqs4u, Inc. Buyers/Sellers Guide for eBay Auctions and More.* Colorado: Antiqs4u, Inc.

SCARE. *Strategic Comprehensive Approach for Electronics Recycling and Re-use*. 1999. SCARE, Programme Information, Version 2.2., March 3.

Schiller, Dan. 1999. *Digital Capitalism : Networking the Global Market System*. Cambridge, Mass: MIT Press.

Schmidheiny, Stephan, Federico Zorraquin with the World Business Council for Sustainable Development. 1996. *Financial Change: The Financial Community, Eco-Efficiency, and Sustainable Development*. Cambridge, Mass: MIT Press.

Silverstein, Barry. 1998. *Business-To-Business Internet Marketing : Five Proven Strategies for Increasing Profits Through Internet Direct Marketing.* Florida: Maximum Press.

Stewart, Thomas A. and Tom Stewart. 1997. *Intellectual Capital: The New Wealth of Organizations*. New York: Doubleday.

Tapscott, David, Alex Lowy and David Ticoll, eds. 1998. *Blueprint to the Digital Economy: Wealth Creation in the Era of E-Business.* New York: McGraw-Hill.

Tapscott, Don, ed. 1999. *Creating Value in the Network Economy*. Boston: Harvard Business School Press.

Thomas P. Vartanian, Robert H. Ledig, Lynn Bruneau. 1998. *21st Century Money, Banking & Commerce.* New York: Fried, Frank, Harris, Shriver & Jacobson.

Endnotes

[i] Team Members: Vignir Haraldsson, Biao Huang, John F. Elter, David Bell, Richard Giordano and Nazli Choucri (team leader).

[ii] Dow Jones SustainabilityGroup Index. *Guide to the Dow Jones Sustainability Group Indexes*. Version 1.0, September 1999.

[iv] The patent obtained for GSSD (1998) was the first, ever, in the history of MIT from the School of Humanities and Social Sciences.

[v] This listing is adapted from a related listing by B. Huang representing elements of overall market structure for knowledge products.

[vi]This section represents a set of inferences based on the literature survey and on interpretation of empirical trends. As such it is a distillation of dominant influences, based on our reading of the literature, it is not a set of conclusions based on our own

empirical research..

[vii] For related issues see, United Nations Development Report, *Human Development Report*, UNDP, 1999, p. 57

[viii] The definition of sustainability is, itself, subject to debate. The origins of the concept are traced to 1972 World Enviornment Conference, and formally defined by the World Commission Environment and Development, as "…development that meets the needs of the present without compromising the ability of future generations to meet their own needs," (World Commission on Environment and Development 1987, p. 8). Among contributors to the evolving definitions and related conceptual foundations are Munaisngh and Mcneely (1995), Constanza ed. (1991), Turner (1993), and Choucri (2000), "We define sustainable development as the process of meeting the needs of current and future generations without undermining the resilience of the life-supporting properties or the integrity and cohesion of social systems." This and further differentiations are also found on the GSSD site:http://gssd.mit.edu/ . Definiutions that take into account business opportunities are proposed by for Sustainable Development and Deloitte&Touche as follows: "For the business enterprise, sustainable development means adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustainaing, and enhancing the human and natural resources that will be needed in the future,"http://www.betterworld.com/BWZ/9610/explore.htm. For applications to design see *The Journal of Sustainable Product Design, see* http://www.cfsd.org.uk/

[ix] These trends are illustrative only of emergent markets. Individually they provide only descriptive signals of change.

[x] The literature reflects considerable confusion (or ambiguity) about the relation among these factors. Nonetheless, efforts toward analytical clarification are needed. Also relevant is the need to design appropriate methods for pursuing clarity.

[xi]This representation is a simplification to be sure, but it covers matters of dimensions and modalities.

[xii] This section is written with the assistance of V. Haraldsson. Our purpose is to distill major braod trends, not to provide a ‘precise’ rendition of the literature. Of relevance here is the enhanced salience of S and E factors for extended enterprises. The literature is more complex than representedhere; nonetheless the developmental trajectory implied in this section appears robust.

[xiii] Much of the pilot project coverage of LAKES derives from materials provided by, and discussions with, J.F. Elter, as well as materials he presented in N Choucri’s graduate course on Dimensions of Sustainability (MIT 17:182). Discussions of the ‘models’ potentials for LAKES remain incomplete, given the absence of systematic efforts to extract ‘lessons’ from the case. Nonetheless, we have not encountered other, more self-

contained, and compelling cases.

[xiv] This representation may provide the basis for hypotheses about extent or connectivity or disconnect within organizations pertaining to EMS and, for our purposes, to knowledge about EMS.

[xv] Ongoing research by J.Nash and J. Ehrenfeld track firm voluntary responsiveness to international guidelines on environment and sustainability, formulation of guidelines by trade associations, and extent of behavior adjustment to perceived external directives.

[xvi] OF relevance here is delineating 'solutions to what?', why? by whom? At this point these become pragmatic questions not intellectual constructs. However, in the absence of conceptual guidance in the literature, come conceptual organization is called for – at least to serve as core propositions. Much of the materials in this section is of this type and for this purpose.

[xvii] Developing the research design to generate empirical referents for these dimensions – and enable cross time and cross enterprise comparisons – is a valuable next step. Not it is not a simple task.

[xviii] Developed with V. Haraldsson.

[xix] Developed with V Haraldsson and in discussion with B. Huang.

[xx] See the GSSD Internet site at //gssd.mit.edu/ for detailed description of system features and operation.

[xxi] These figures show only the structure of the knowledge base and the relationships in the organization of content. They do not address other functionalities of GSSD. See site.

[xxii] The GSSD survey was designed and undertaken by B. Huang, with direction from R. Giardiano and reviews by other team members. An early pre-pilot was done in conjunction with the Workshop on Knowledge Networking and Technology Collaboration of the GSSD Strategic Partnership, MIT, January 2000.

[xxiii] Given the survey size (N=20 returns), only some broad contours can be inferred, at best

[xxiv] B. Huang's application of conjoint analysis is innovative both in the context of GSSD domain as well as web based survey research.

[xxv] This figure is developed by B. Huang, with contributions by V. Haraldsson. It is central to the MS thesis of the former, and only indirectly related to the MS thesis of the latter.

[xxvi] Technically, this is closely related to the term ‘spidering’ in Internet idiom.

[xxvii] This development was undertaken in collaboration with Lotus Development Corp. and the participation of K. Cavanaugh, VP for Product Development. We are grateful to the joint GSSD-Lotus team for developments to date.
