SME ADOPTION OF ELECTRONIC COMMERCE TECHNOLOGIES: IMPLICATIONS FOR THE EMERGING NATIONAL INFORMATION INFRASTRUCTURE

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Abstract

This paper compares models of technology adoption for small manufacturing enterprises (SMEs) and notes that a learning model captures much of the research findings across a wide range of settings. The paper reviews the implication of such a model for SME adoption of electronic commerce technology (ECT). Adopting this technology is necessary if SMEs are to participate in the emerging National Information Infrastructure (NII) and its defense counterpart (DII). These systems are expected to provide US SMEs with competitive advantages, but only if SMEs implement technology that enable them to use this network. Evidence suggests that small firms currently are ill-equipped to realize benefits from the NII. Because SMEs contribute significantly to the creation of jobs and payrolls for the US economy, their contribution could be at risk unless they are able to participate in the emerging electronic network. The paper concludes with a suggested strategy for accelerating the adoption process.

Introduction and Overview

The vision for the future is that an emerging National Information Infrastructure (NII) and its defense counterpart (DII) will equip US industry to be second to none in the global economy. The NII will enable the US industrial base to become more agile and to operate as a highly competitive, flexible, just-in-time, manufacture-on-demand system that facilitates free competition and specialization among manufacturers and suppliers. All firms, regardless of size, will have ready access to product requirements and specifications and will be able to compete fairly with other firms. Moreover, the NII with the DII will encourage commercial suppliers to respond to defense needs, enabling dual use designs and strengthening the flexibility of the nation's defense infrastructure.

The reality is that many existing small firms are ill-equipped to participate in this vision. Moreover, there is concern that the learning cycle for small manufacturing enterprises (referred to in this paper as SMEs) to implement information technology is too long and too costly for them to effectively make the transition to the NII environment. The solution to the problem is not simply one of assuring that every SME can purchase and install a new information system. Instead, the solution requires an understanding of how a complex combination of structural, technical, managerial, and economic factors affect the diffusion of information technology in the manufacturing sector, especially among SMEs. From the viewpoint of our national economy, the problem is that this complex set of factors impedes the effective implementation of information technology in SMEs and puts at risk a significant component of the nation's manufacturing base, a component that is responsible for up to nearly 40% of the nation's manufacturing employment. Developing nations may "leapfrog" over the US and other advanced nations if our established enterprises are unable to change quickly enough. The purpose of this paper is to help understand this set of factors and to explore how best to manage the risk associated with a slow rate of diffusion of information technology in SMEs.
The following section provides a synopsis of the different views on the role of SMEs to the nation's economy and manufacturing infrastructure. This section also summarizes the different frameworks within which we can understand the economic, behavioral, structural, and technical issues associated with how SMEs may participate in the benefits of the NII.

The Analysis section of the paper provides more detail on the frameworks outlined in the Background section and examines the prospects for SMEs to become full participants in the NII. This section synthesizes adoption and diffusion studies and research on the implementation of new information technologies. The emerging framework is that of organizational learning at the level of the firm and the concept of the supply chain (or value chain). The learning framework enables us to make sense of the range of factors associated with technology adoption, and the value chain framework illustrates why action by an individual firm is inadequate for that firm to realize the benefits of an NII.

The final section of the paper discusses opportunities for national policy to alleviate the problem of SMEs' participation in the NII. The paper concludes that a coordinated collaboration among private, university, and government resources offers the best way to assist US SMEs in making the transition to electronic commerce and the benefits of the NII.

**SMEs and the Economy**

Small manufacturing enterprises (SMEs) are responsible for an estimated 28-40% of the employment in the manufacturing sector [1]. Moreover, there is evidence that SMEs are more effective at job creation [2] and job replacement [3], more innovative in the development of products and process improvements [4] and more flexible and thus more competitive in terms of the ability to produce small quantities. All these factors may explain an observed tendency toward smaller average plant size [5]. The claims to new job creation are open to question—SMEs also exhibit high failure rates and thus new jobs may not be long-lived [6]. However, others point out that small firms will continue to add jobs because much growth will take place in industries in which small businesses have relative advantages [7].

There is no question that SMEs are a crucial element in the nation's manufacturing base. Many believe that manufacturing must continue to be a foundation for US economic competitiveness [8, 9] and that SMEs will continue to be a crucial part of this competitiveness [10]. The role for small firms appears to be increasing; there is evidence of a trend toward more of the total production coming from smaller manufacturers [5]. However, the US is lagging behind Europe and Japan, where small firms account for 45-60% of manufacturing employment [1, 4].

**SMEs and the NII**

Neither the global competitiveness of US industry nor the future role of SMEs is assured. The NII vision of preserving the tradition of free market competition both among manufacturing suppliers and among international companies is consistent with what Porter [11] suggests are the conditions for global competitiveness: demanding customers who can choose from an intensely competitive local network of suppliers.

The NII and DII are expected to enable this competition and development of dual use processes and designs. Large manufacturers (including Department of Defense purchasers and contractors) can make their specifications available online, eliminating distribution delays and increasing the scope of distribution. In one vision currently being articulated by the US Department of Defense (DoD), the NII and DII enable the creation of an Integrated Data Environment (IDE) in which information itself (e.g., designs, production methods) becomes a commodity and is traded. With information available on both specifications and designs, firms can work only on those opportunities for which they are most capable, reducing the risk and costs of bidding on marginal opportunities.

For SMEs to participate, they must have access to the NII and they must be able to use computer technology to integrate their business and technical functions. They must understand and use electronic commerce technologies (ECTs). Currently, small businesses are not utilizing computers to the degree necessary to fully participate. A recent survey commissioned by IBM indicated that while 82% of small businesses (not just manufacturers) had desktop computers, only 37% had local or wide area networks [12]. In a stage model of information technology maturity [13, 14], almost two-thirds of these respondents would fall into the first, most elementary, stage of maturity.

SMEs are becoming aware of the need to adopt some form of electronic communications. With increasing frequency, prime contractors and large firms have demanded that their suppliers have electronic capabilities. As one would expect, this
has heightened interest in electronic commerce capabilities among small- and medium-sized businesses. The interest is likely to escalate. One software vendor executive, explaining that his company was trying to respond to customers' needs for advice and consultation about electronic commerce, put it this way, "Our executives have been around long enough to tell the difference between a ripple and a wave. This one is a wave" [15].

Engineers from the Cleveland Electronic Resource Center (Cleveland ECRC) report similar interest but observe that some small firms are satisfied with a "rip and read" solution: they link into a bulletin board or value-added network with a PC but use the computer as an expensive fax machine. They "rip off the printed specifications," then read them and insert them into their manual system [16]. This approach works for written specs and to some degree for drawings, but it clearly is limiting. More advanced firms install a CAD system to enable them to accept design data in digital formats. Often, they too have a manual internal system and do not attempt to use the digitally stored format.

Compounding the technical problem is the lack of a single standard that is widely accepted; Chrysler, Ford, and GM use different, incompatible CAD systems. For most SMEs, the cost of implementing multiple standards is too high, and they either choose a single customer's standard or opt for another market. In either case, the situation does not lead to increased competition and to the increased competitiveness of SMEs. A single standard would help. Standards such as PDES/STEP are being developed, but agreements and adoption take time, and such standards address primarily the technical issues of data sharing.

Organizational (i.e., managerial and cultural) issues are equal to, if not greater than, technical capabilities in importance. In their discussion of agile manufacturing, Goldman and Nagel [17] share the vision of integration of virtual enterprises through the use of information technology, including standards and "broad-band communications channels." They acknowledge the need for flexible production machinery but point out the need for organizational innovations as well. The agile system they envision requires flexible production workers and managers, not just technology. Getting the integration of technology and people into a new, responsive system is a challenge. They conclude, "an understanding of the nature of managerial decision-making is more important than ever before" [17, p. 36].

Other researchers agree with Goldman and Nagel that the managerial, organizational, and cultural issues are at least equal in importance to the technical challenges of tapping into the benefits of the NII. In a field study of five large firms that were judged to be implementing integrated information systems successfully, a study team found six shared characteristics among the firms, and only one (the goal of capturing all data in electronic form at its origin) was technical [18, 19]. The other five characteristics (vision and clear strategy, vocabulary/language incorporating metrics shared by technical and business staff members, customer focus, and a sense of urgency) were organizational factors.

Factors Affecting SMEs' Adoption of Technology

One approach to understanding SMEs' use of information technology would be to view ECT as a technology that will diffuse throughout manufacturing. This diffusion approach uses the familiar S-curve to identify the percent of SMEs that have adopted ECTs over time. Factors associated with an individual firm's propensity to adopt technology might suggest strategies for working with innovators, early adopters, etc. [20].

Implications of this type of model for policy are discussed further in the final section.

Another useful approach, the one taken for the remainder of this paper, is to seek an understanding of the decision-making process within the SME. From this viewpoint, we may gain some insight into the economic, technical, structural, and other barriers to adoption as seen by the SME.

The stage model suggested by Venkatraman [14] of firms' use of information technology is used as a basis for identifying the gap between the "as is" state and the "desired" (or "to be") state of SME capabilities.

The data from the IBM survey of small businesses [12] indicates that almost two-thirds of the survey respondents are in the first stage of maturity in applying information technology. Virtually none of them have progressed beyond the second stage, and there is no assurance that they will go beyond this stage. For SMEs to benefit from the NII, they must be at level 3 or above, developing capabilities for network/supply chain integration. Although the IBM survey was not limited to manufacturing firms, our experience with SMEs leads us to speculate that small service firms and those in the retailing and trade sectors may use computers even more than manufacturers,
lowering even further the estimate of how many SMEs have moved beyond the first stage of computer use.

This stage model is descriptive, and it only indirectly suggests how an organization moves from one stage to another. Our concern is to understand how the organization, particularly an SME, progresses from the applications of isolated systems to network and supply chain integration and, more importantly, how this process can be accelerated. The relevant fields of research are those of technology policy, innovation adoption, the decision-making process within the firm, and the emerging field of inquiry on organizational learning.

The concept of organizational learning [22], particularly the use of the human experiential learning model proposed by David Kolb [23] and recently applied to organizations [24] provides a useful framework to interpret the findings from the other fields. This model, shown in Figure 1, illustrates the different modes by which an individual (organization) learns. Learning takes place in two dimensions: in the concrete-abstract dimension (shown vertically as a continuum) and in the active-reflective dimension (shown horizontally). Individuals (and organizations) have different preferences for learning and processing information in these dimensions [23]. Some prefer more concrete and active learning (e.g., entrepreneurs); others prefer more abstract and reflective learning (e.g., professors).

The learning cycle model suggests that only when the organization goes through all four modes is learning complete. For example, a firm may introduce a new process for a customer or product line (active experimentation), collect sales and quality data over time (concrete experience), interpret these data and compare with prior experience (reflective observation), and develop a projection of sales and costs of quality if the new process were applied to all their product lines or to all their customers (abstract conceptualization). Based on the model, the firm may choose to switch their other products to the new process, again moving to active experimentation and restarting the cycle. By passing through each of the learning modes, the firm generates new knowledge. The firm learns and the learning is not limited to the simple aggregation of additional data or to thinking about a new idea--the cycle is complete.

Using the concept of the learning cycle, we can frame our concern as that of understanding the predominant learning modes of SMEs and of understanding how SMEs can incorporate all learning modes in their progress toward the higher stages of information technology maturity. For this understanding, we can draw on several areas of research about how organizations adopt technology. In each of the relevant areas, it is evident that one must use caution in applying concepts derived from the large organizational context to the SME [25]. However, some studies have focused specifically on the decision-making and policy-formulation in the small firm, and these studies are particularly helpful in our efforts to understand how to accelerate learning and ECT adoption in SMEs.

Three Perspectives

Three areas of inquiry--diffusion of innovation, SME decision making, and SME learning--offer differing, but overlapping, insight into how firms, and SMEs in particular, may implement and use information technologies. The following three sections outline these areas. The fourth section outlines the structural issues that may initially inhibit SMEs' effective participation in the NII. The final section includes a synthesis of ideas about how SMEs may approach the adoption of electronic commerce technologies and realize the benefits from the NII.

Diffusion of Technology

Figure 1. Experiential Learning Cycle (Kolb)

The diffusion literature [20] characterizes the industry adoption of new products by an S-shaped curve. The curve reflects exponential growth with a rate that depends on the size of the remaining market. The diffusion model has been used with
some success in technology forecasting. With good data on when a low level of adoption has been achieved (e.g., 5%), the model is effective in identifying the dates by which a specific level of industry penetration (e.g., 50%) will occur.

The S-curve model is often used to identify firms according to when (early or late) they make the decision to adopt the technology. The classifications may indicate different organizational characteristics. A modification of this conceptual model [26] classifies the "buyer profiles" as being one of five types: innovators, early adopters, early majority, late majority, and laggards.

Recent research [27] tested the idea that psychological characteristics (e.g., attraction to technology, risk-taking) rather than economic variables might be used to discern buyer profiles. The study found that the benefit-cost variables were better predictors. Although one could argue with how the variables were operationalized and with the limits of the study (focus groups on a single product), the researchers' conclusion has face validity: companies that pioneer new products must focus on the benefits desired by purchasers. Even the early adopters, who are less price sensitive, seek benefits that meet their needs better than current technologies. What is not discussed in the study is the changing nature of the benefits and costs with changes in the organizational characteristics and with changes in risk as the technology matures.

Kelley and Brooks [28] also showed the predictive power of economic incentives in the diffusion of process innovations. Not surprisingly, firms with high wage rates were more likely to adopt labor-saving technologies than were firms with low wage rates. The key is to note that the benefits and costs are established by the firm's perceptions; these perceptions are affected by the organizational values and the firm's particular situation.

As noted by Schroeder [29], the survival of an SME is linked to the adoption of technology as a regular part of doing business. If it is in the nation's interest for SMEs to thrive, then the diffusion issue is how to accelerate the adoption of information technologies among SMEs. The diffusion model may be a useful metric by which we can track and predict adoption rates as early data become available. However, the diffusion model does not help explain how firm-level decisions are made. Concepts that examine how the individual firm makes a technology adoption decision may be more informative in the early development of the NII.

SME Decision Making

The literatures relevant to an SME's decisions on technology adoption are those on corporate strategy, technology strategy, technology policy, information systems implementation and planning, strategic information systems, and investment decision-making at the level of the firm. These areas of study are rich in topics that are relevant to technology adoption, but the focus on SMEs and their adoption of technical innovations reduces the scope considerably.

SMEs differ from large companies in how they develop their corporate strategies and their technology policies. Large companies typically have well-defined processes for developing and implementing strategies through a corporate planning process. Small firms often use less structured approaches; strategies and policies may not be formulated but may "emerge" from a set of actions and experiments [30].

In an SME, the chief executive officer (CEO) often is one—or perhaps the—owner of the firm. In these firms, the CEO's viewpoint is a critical contributor to strategy and policy. A recent study of SMEs [31] showed that implemented technology policies (not just written policies) in SMEs are strongly influenced by how the CEO perceives the world. Even though all the firms in the study were immersed in the same industrial setting in the same Canadian province, the CEOs differed in their view of how hostile and how dynamic their environment was. The firms' propensity to invest in new technology was strongly related to these views. The basis for decisions is not an objective reality but rather a socially constructed reality [32] as reflected in the viewpoint of the CEO.

The social construction of the adoption decision by a firm has other participants as well. For the SME, a strong influence is the supplier, who may be a major source of information [33].

The innovativeness of an SME is related to the firm's outward orientation (e.g., customer focus) and the participation of the firm's functional groups in the decision [33]. There is the same study provides evidence that the SME learns with increasing technological capabilities so that, over time, its decision-making places more weight on factors that are more closely related to the true potential of the technology.

SME Learning

Arrow [33] noted that firms learn through experience. This learning normally is considered
to be related to process improvements and is the foundation for the concept of reduced costs over time because of "the learning curve." More advanced technologies may have greater productive potential, but the firm has less expertise in implementing such technologies. Knowing its has less expertise, the firm expects greater costs. The firm thus faces a tradeoff in its choices of technologies to adopt [34].

The capacity for learning affects the rate of adoption of new technology. Firms that have existing technological capabilities have higher "absorptive capacity" [35] for new technology; they are able to learn more quickly [36].

A firm's installed technology also affects the extent and magnitude of benefits the firm experiences from installing new systems. Firms that have more existing technological capabilities--for example, firms that have implemented information technologies in both the administrative and engineering/production operations--enjoy benefits that are greater than the sum of the benefits from individual systems. There is synergy and, because of the added benefits and increased capacity for learning, the "rich get richer" and vice versa. This appears to be the case both for large firms [37] and for SMEs [38].

When a technology is new to an industry--before its technical and economic superiority have been widely accepted--the learning capacity of a small firm is related to the firm's linkages with other firms and other industrial organizations. These external linkages, many of which provide informal but trusted conduits for sharing of technical know-how, appear to lower the cost of learning for the firm. Kelley and Brooks put it this way: "Small firms' propensity to adopt a process innovation is particularly enhanced by the nature of linkages to external resources for learning about technological development...Where linkages to such external learning opportunities are particularly well-developed we would expect to find a more rapid rate of diffusion of productivity-enhancing process innovations to small firms" [36].

Organizational learning may be "single-loop" or "double-loop" [39]. In single-loop learning, the organization improves its efficiency, becoming ever better at dealing with a prescribed problem or environmental situation. The lowering of costs because of the "learning curve" is an example of single-loop learning. Double-loop learning, by contrast, is characterized by a shift in viewpoint and a modification of basic premises. Double-loop learning requires unlearning prior assumptions and standard operating procedures; it involves developing new paradigms, new frames of reference, and new interpretive schemes. Single-loop learning reduces variability; double-loop learning increases variability in search of more relevant objectives or more effective strategies.

Because prior procedures and paradigms have a history of success, organizations have difficulty engaging in double-loop learning; they actively resist double-loop learning [40]. However, dynamic and turbulent environments demand that firms exhibit more variability in order to meet changing needs. One approach to stimulating variability--and possibly double-loop learning--is organizational restructuring. Restructuring (changing the top management team and/or the CEO) is especially effective when combined with a change in strategy (e.g., new products or markets) [37].

SMEs, especially the smaller ones, are less likely to adopt a restructuring approach. A turbulent environment sometimes stimulates an SME owner to sell or merge with a larger firm. Often, however, the SME that can not adapt quickly enough to environmental changes simply ceases to exist. The latter outcome contributes to the statistics used by those who argue that SMEs provide unstable employment, even if they do create a significant portion of new jobs.

The learning model in Figure 1 provides a framework that helps synthesize these issues. Since complete learning means that the organization engages in each of the modes, an enterprise may engage in formal or informal collaboration with external organizations to learn. For example, the motivation for close alliances between suppliers and manufacturers [41, 42] is partially explained by the benefits of learning, and the higher rate of innovation adoption because of external contacts [36] may be due to the expanded learning modes made possible by these contacts.

An alternative to restructuring or going out of business is to establish and maintain external relationships that enable learning. Such organizations, which "bridge" [43] sources of knowledge about new technologies (e.g., universities) and the SMEs (as potential users) have been stimulated by Federal- and state-level programs that have set up technology transfer centers and assistance networks. Ohio's Thomas Edison Technology Centers, the Federally-funded Manufacturing Technology Centers (MTCs), and, most appropriately, the Federally-funded Electronic Commerce Resource Centers (ECRCs) are examples of such bridging organizations.
The value of such organizations was set forth over a decade ago by Trist [44], who noted that complex societies and rapidly changing environments give rise to "meta problems" that a single organization is unable to solve. The solution is the development of "referent organizations" that mediate the inter-organizational collaboration required in the organizational domain of interest. Although detailed studies of the effectiveness of MTCs and ECRCs are premature given their recent formation, the political judgment seems to be that they are effective. Studies of the Ohio's Thomas Edison Technology Centers generally have praised their value and effectiveness [45]. One of the challenges noted is that of "relationship-building. There is the explicit acknowledgment that the relationships and the process of technology solving is equal to, if not greater than, the importance of developing the technology itself. These evaluations appear to support the concept that the bridging, or referent, organizations contribute to learning, and that at least part of the new knowledge created is not migratory knowledge but is embedded in the relationships that are established and maintained [46]. Implicit in the Mt. Auburn report is the notion that the relationship-building role of these organizations is underdeveloped.

The Structural Issue: Of what benefit are a few telephones?

The current status of electronic commerce technology may be similar to that of the early telephone. Imagine being given the opportunity of purchasing the third or fourth (or even the fiftieth) telephone: unless you are assured that the other people (organizations) with whom you want to talk (trade/communicate) are equipped with compatible technology, the benefits are nil. Unless the advanced technology has its own appeal, a prudent business decision is to "wait and see," wait until there is a critical mass of manufacturers and suppliers with whom you can beneficially communicate. Except the innovators and early adopters, most of the potential SME users of ECTs—if they are aware at all of the NII and its electronic commerce benefits—are likely to think of these as something that may be possible in the future.

One approach to dealing with this structural barrier to the diffusion of ECTs is to think of the SMEs in clusters [11, 47] that share a characteristic or interest. Geographic clusters exhibit their own rate of technology diffusion that can be enhanced by bridging and referent organizations in those regions [59]. Other clusters that share other interests (e.g., those firms in a supply chain) may be distributed geographically.

For industries in which the technology is relatively stable (e.g., automobile manufacturing) compared with the dynamism of emerging technologies (e.g., biotechnology), the shared interests of the supply chain may motivate groups of firms to adopt ECT more quickly. Although the relationships of suppliers to the manufacturers has become closer over the past several years, there still are no widely-accepted technical standards nor are there any established social mechanisms for engaging in collaborative efforts.

Summary: The Key Concepts

The literatures related to SME adoption of information technologies may be summarized in six key points:

1. Business success and implementation of new technology appear to be related.
2. SMEs decide to adopt new technologies based on perceived benefits and costs.
3. SMEs perceive, but may not articulate, costs of learning to use and integrate new information technologies. This makes evolutionary changes seem less costly and less risky than revolutionary ones.
4. SMEs appear to follow a stage model in implementing information technologies from simple, stand-alone applications to more complex and integrated applications. At the highest level, information technology becomes a component in the strategic definition of the business. There is no evidence (except for greenfield operations) that a firm skips levels, but the movement from level to level may be accelerated.
5. SMEs' benefits from applications of information technologies are cumulative and synergistic, with disproportional greater benefits as the number of applications (and enterprise integration) increases.
6. SMEs' learning and adoption of new technologies are related to the number and quality of inter-organizational relationships in which they are active.

Implications for SMEs and the NII

The potential benefits of the NII to SMEs go much beyond simple manufacturing process improvements. If SMEs are to realize the full benefits of the NII, they must advance their level
of information technology applications to levels 3 and 4 in the stage model of Venkatraman [14].

Once at these levels, manufacturing costs may become lower—for example, firms can more readily specialize and develop core competencies in particular processes. Other benefits, however, contribute to the overall lower costs: shorter administrative lead times, improved risk management through better information about future demands, more flexible (agile) production, etc. These benefits do not arise because a single firm or even a few firms adopt ECT; they will be realized only if a critical mass of firms in a value chain become interconnected.

The NII is the key element in this interconnection; it is the communications backbone. Even with the backbone, interconnections are not assured. The problem is not merely one of enabling individual firms to adopt ECT, it is one of enabling groups of firms to adopt ECT. This framing of the problem is more than just a change in scale (from one to many), it is a major change in scope and may add significantly to the complexity of the solution. As a minimum, it changes how we approach accelerated learning and adoption of ECT in SMEs.

The SME technology adoption process, as studied by most researchers and as understood today in the US, premises independence among the adopters. However, interdependence, not independence, is necessary if the full economic benefits of the NII are to be realized.

This requires cultural changes in SMEs, and the rate at which SMEs change their cultures can be expected to dominate the rate of diffusion of the technology itself (including ECTs) among SMEs. Firms that traditionally have viewed the world through lenses of competition as a zero-sum game now must view competition as a positive sum game: competition as a means of benchmarking and improving one's own performance (e.g., as in organized sports, such as the Olympics). In such a view, technological advances by other firms provide a learning opportunity for their own firm.

**Conclusions and Recommendations**

**A Strategy for Setting Priorities for NII Services to SMEs**

SMEs, perhaps more than larger firms, have fewer options for second-order learning. For most SMEs, moving to the higher levels of information technology maturity—those levels required for electronic commerce and for realizing the greatest benefits from the NII—will be possible only by evolutionary change. The services available over the NII are expected to be offered by a mix of private, not-for-profit, and government providers. To enable SMEs to benefit from the NII, these providers, to the extent possible, should:

1. Give early priority to encouraging and establishing high value, low cost services that SMEs can use as individual firms.

The rationale for this recommendation is that most SMEs are at the lowest level of information technology maturity. They will perceive the highest costs (including learning) to services that require additional technology and integration. If individual firms can learn to use networks to obtain valuable information from read-only services or for simple firm-firm communication (e.g., e-mail), the cultural change is evolutionary and the perceived subsequent costs of moving to more integrated levels will be lower.

2. Match the services offered to the information technology maturity level of the early adopters (e.g., the most advanced 10%) of SMEs.

The perceived costs of moving more than one level make the benefits of adopting a new technology seem "out of reach," setting the most advanced services just above the capabilities of the early majority balances the need for SMEs to see the possibilities of greater additional benefits with affordable costs of organizational change.

**A Strategy for Public-Private-University Partnerships**

Much of the technology will be developed and made available from the private sector. Moreover, the Federal government is expected to continue to participate in the establishment of, and encourage the widespread acceptance of, international standards for ECT. As established by the summary of research in this paper, the rate at which SMEs adopt ECTs (and benefit from the NII and DII) is dominated by organizational issues rather than purely technical factors. Consequently, the following paragraphs outline high leverage opportunities for the Federal government to improve the capabilities of existing public and partnership programs to address these issues.

In particular, DoD and Department of Commerce programs such as the Manufacturing Technology Centers (MTCs), Electronic Commerce Resource Centers (ECRCs), and Manufacturing Learning Centers (MLCs)
provide an appropriate infrastructure for accelerating the changes required in SMEs. These programs comprise geographically distributed networks of centers through which SMEs can receive assistance. From all appearances, these programs are performing their perceived missions successfully and satisfying their constituents. However, there are opportunities to expand these perceived missions and to accelerate the learning and development of SMEs as participants in the NII.

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