

**INFORMATION TECHNOLOGY, INTEGRATION,
AND
ORGANIZATIONAL CHANGE**

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INTRODUCTION

The driving force behind the economics of the information technology industry has been the ability to integrate ever more tightly electronic circuitry. This integration has taken place since the first transistorized computer in the late 1950s. VLSI circuits with as much as 1,000,000 active elements are now being produced with further breakthroughs promised for the next decade. This has resulted in a unique economic circumstance --- an industry that improves its fundamental technological cost performance at 30% to 40% compounded annually and has been doing so for three decades with more to come.

Similarly just as integration has fueled the economics of the information technology revolution, information technology is also driving new and powerful forms of integration in companies that are enabling them to radically reduce the cost of the primary business transactions and to secure important strategic advantages.

Integration as we have defined it -- integration of multiple classes of transaction data, integration of multiple forms of data representation, integration of knowledge, and integration of group communications-- is enabled by two dominant properties of information technology: improved interconnection, and improved shared data accessibility. The ability to create new forms of integration at any of the four levels described lets the designer build the infrastructure of organizational design and business process appropriate to the strategy.

In this paper we argue:

That information technology and its driving cost performance imperative has changed traditional labor-to-capital-goods price ratios opening up opportunities

for radical change in organizations and process, and that these opportunities are being used to generate strategic advantage applications.

That different forms of integration realized through two key aspects of information technology----improved interconnection, and larger, more complete data bases---- are often the basis for deriving strategic advantage.

That a search strategy for finding strategic advantage applications can be developed by an understanding of the possibilities afforded by integration.

The business press and journals have widely disseminated the idea that information technology is a driving force for enabling competitive strategy. An abundance of examples have been described [6]. What is not well understood is that the driving force of the information technology revolution is a changed economic relationship between capital and labor prices caused by several generations of prodigious performance improvements in the building block information technologies (memories and computational components). This changed economic relationship is reflected in the enormous drop in the relative price of Information Technology capital goods compared to other capital goods produced and provides an undeniable economic imperative.*

Historically labor and capital goods prices tend to move similarly over time. We have found a very modest improvement in the capital goods to labor price relationship for six different product groups (processed foods, appliances, furniture,

*Our appreciation to Gary Loveman at MIT for providing the insights of an economist to this argument.

machinery and equipment, cars, and photographic equipment) over the three decades starting in 1950. To provide an understanding of this change, we define a ratio, the capital equivalency ratio, to be the cost of a technology divided by the cost of labor. The capital equivalency ratio for these six product groups, averaged over all the groups, improved 1.4 times. The best improvement of any of the product groups for a ten year period was 1.7 times.

Apparently unique is the history of the Information Technology Industry which, due to its cost performance improvement for basic technologies of over 30% per annum [5] since the 1950s, shows a dramatic change in the ratio between labor and the price of information technology capital goods (see Figure 1 following).

Taking a typical ten year period, this 30% per annum information technology cost improvement coupled with a 5% per annum increase in labor cost gives a capital equivalency ratio for information technology, which by the end of the ten year period has improved 25 times. The dramatic difference between these two curves suggests the existence of enormous potential for those organizations willing to seize the opportunity.

An example of this impact of information technology on the established order is seen in David Landes's description of the devastation that the Japanese digital watch industry had on the traditional Swiss watch industry, [13] *"What the Swiss makers did not take into account, though, were the prospects of the new technology. Japanese manufacture of electronic watches bounded upwards, increasing more than 10 times in the 4 years 1974-78 (1.8 million to 19.7 million units). This surge was funded, and promoted in turn, by an extraordinary technical rate of improvement, much higher in electronic watches than in mechanical--yielding a steeply falling curve of*

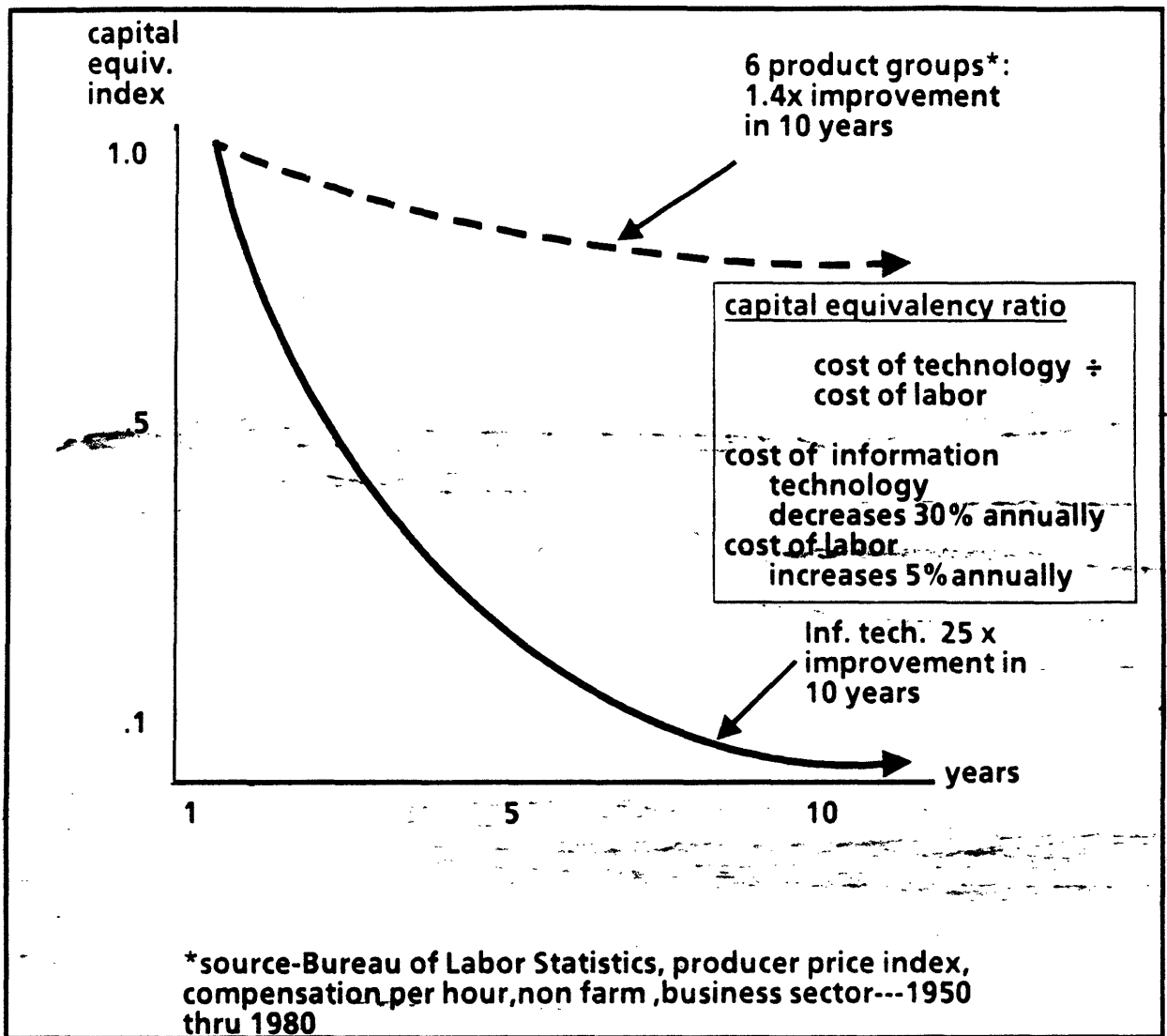


Fig.1 Capital Equivalency Ratio--Information Technology versus 6 product groups 1950-1980

costs (and prices) over time. The Swiss had never seen such a learning curve; things had all been linear with a gentle negative slope; this was exponential cascading downward. Over the same decade retail prices fell to 2% to 3% of what they had been at the start---and this for substantially better time pieces and in the face of inflation."

The benefits of the improved capital equivalency ratio are delivered to the end user in a combination of two ways; reduced cost of the product, and increased

functionality of the product. For information technology, these reduced costs are typified by the reduced costs per MIP (millions of instructions per second) of large mainframe computers [2]. Increased functionality is typified by comparing the functionality of the leading workstations of the mid 1970s, for instance, the IBM 3270 terminals. and leading edge workstations today, for example, the APPLE* Macintosh, XEROX* Professional Workstation, and SUN* Workstation. There are equivalent examples in telecommunications and robotics.

The dramatic rapid rate of change of the information technology capital equivalency ratio over several decades has had several far reaching effects:

1. It has consistently brought to market product and functionality of sufficiently higher cost performance to enable new cost effective applications to be justified and developed. Improvements as shown by the capital equivalency ratio make feasible new types of applications every three to four years. These changed economics are the driving force behind what Rockart [20] describes as the three eras of data processing to which, in 1986, we would suggest a fourth:

The accounting era, typified by stand alone applications that implemented traditional functional processes; applications such as payroll, accounts payable, and general ledger.

The operations era, typified by applications that were direct elements of key operational processes such as order entry, and manufacturing control.

*Apple, Sun, and Xerox trademarks.

The information era, typified by a whole new range of applications, such as decision support systems, end user computing, and electronic mail.

The knowledge era where expert systems are allowing us to capture qualitative knowledge and exploit it with new forms of systems architecture.

2. It has enabled relatively consistent progress to be made in a number of related technology areas each of which reinforces the functionality of the other and extend the range of implementable applications. These are areas such as: computer processing, personal computers and workstations, telecommunications, software, file storage, robotics, special purpose chips and so forth.

3. These improvements have resulted in new application areas such as: CAD/CAM/factory automation, electronic linkage between multiple organizations, and expert systems. These improvements have permitted new and different forms of integration to be achieved, enabling applications that generate strategic advantage.

A CASE STUDY--BATTERYMARCH

Batterymarch [10] is a financial investment management firm, and is one of the leaders in its industry with over 12 billion dollars in assets managed. It was founded in 1969 and by the mid '70s had evolved its basic business strategy, that of a contrarian investment philosophy, "finding those stocks that are out of favor or neglected by other portfolio managers." This strategy, which was supported by a highly integrated information system, allowed Batterymarch to outperform the

market 8 out of 10 years from 1974 to 1984 and to grow its asset base from under \$1 billion to over \$12 billion with corresponding growth to a leadership position in market share in that time period.

The view of the founder of Batterymarch, Dean LeBaron, is that the "investment firm of the future will be a few senior people and one big machine." These senior people are to be used in managing a value added chain "that disaggregates the firm into the technological and economically distinct activities it performs in competing in a particular industry." [17]. For Batterymarch the value added chain was more streamlined than that of the traditional large financial management company. Figure 2 shows a comparison of Batterymarch's and the traditional value added chains including the personnel requirement for each, normalized for the size of the Batterymarch investment portfolio. This comparison indicates that Batterymarch is able to utilize its people more efficiently; 36 professionals for the traditional model versus 18 professionals for Batterymarch, and 108 support people versus 17 support people. This is reflected in Batterymarch's ability to charge lower investment fees than the industry average----.25 percent versus .4 percent and still be profitable.

Batterymarch uses information technology in support of the value added chain as follows:

The Investment Process: Here information technology is used to assist the 12 portfolio strategists to develop research themes, by using the firms's data bases and models to screen for stocks with required characteristics and to determine correlations and to build proposed models of security behavior. When an investment strategy is agreed upon, the entire data base is searched for a universe of stocks that are then screened by the portfolio strategists before

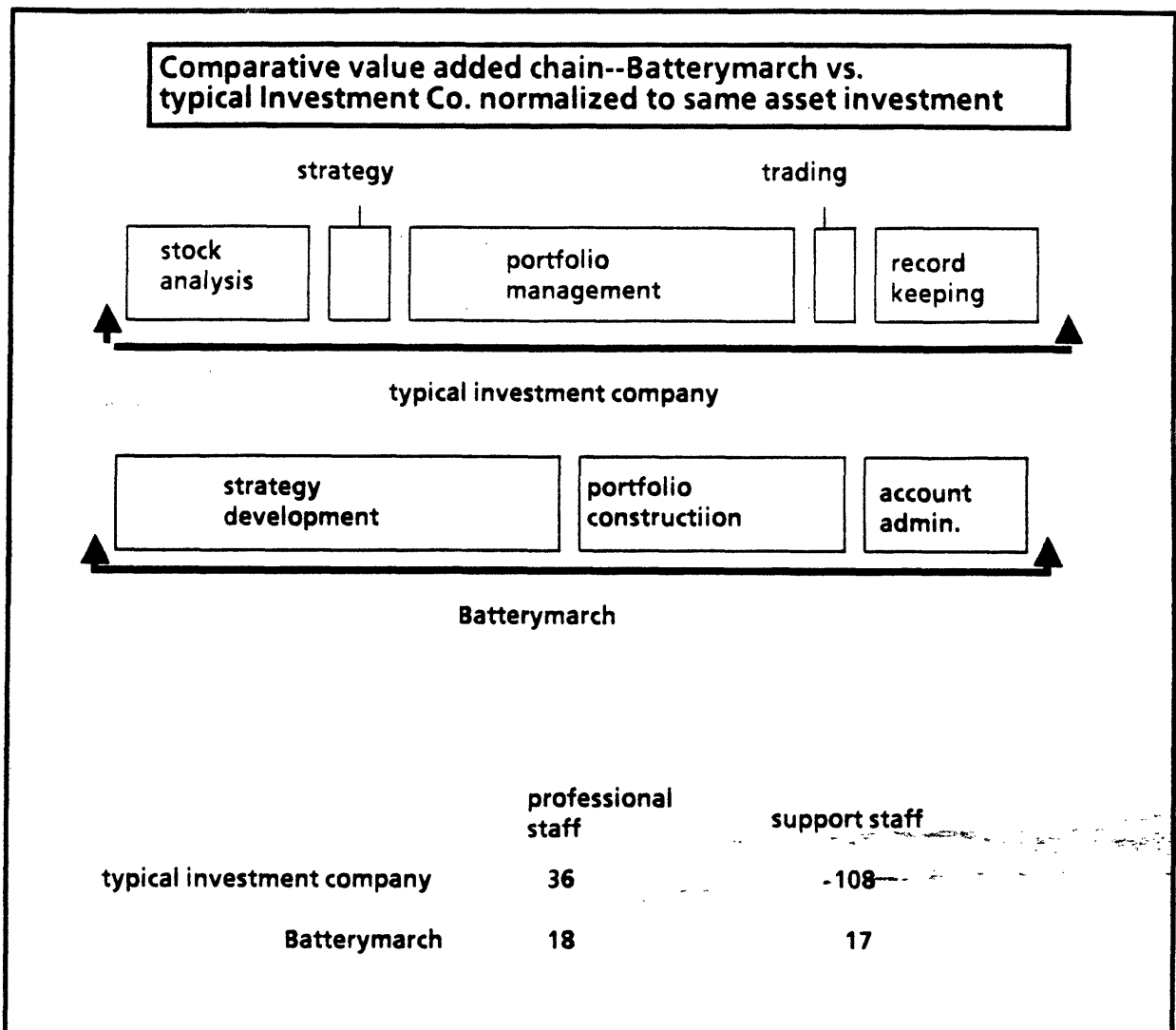


Fig. 2.

finally being put on an approved buy list. Because of the computer use, coverage is not limited by the amount of people to do research, but rather can be expanded as better data becomes available. For example, in 1984, 2200 smaller U.S. stocks were added to the data base. Thus, in this phase of the value-added chain, the computer is a powerful support tool, leveraging, through its extraordinary search capabilities, the time of the senior professional.

Portfolio Construction: In this stage of the value added chain the computer becomes dominant. It takes over all phases of the process of assigning individual stocks to portfolios, and of executing the transactions with the securities firms and markets.

Record Keeping and Client Support: This stage is also extensively automated. It has enabled the small Batterymarch senior professional staff to support personally an average of 15 clients.

The systems that Batterymarch utilizes have all been developed internally, by a small group of systems professionals who are very much part of the senior management staff, to support a highly integrated business process .

To summarize this example, Batterymarch had an idea; 1) a contrarian approach to investment management -- their implementation was feasible because they were able to utilize information technology to analyze and manage the large amounts of data required to construct and execute a strategy and 2) that information technology could be used to integrate the value-added chain components into a much tighter configuration than was traditional in the investment management business.

RESEARCH AND PRACTICE TO DATE

A number of papers have been written on the application of information technology to secure strategic advantage. These papers all provide frameworks, or more appropriately, search strategies, to help the business practitioner determine possibilities for strategic advantage application in his own company. These papers have typically been based on two complementary models; market positioning and the value added chain.

The market positioning model [17] indicates that competitive advantage can be found by understanding where a firm stands in its industry structure and in relationship to its suppliers, customers, competition, threat of new entrants or substitution of new products and services. From this understanding three primary competitive strategies emerge: low cost producer, product differentiation, niche positioning. Information Technology is then used to implement the appropriate strategy.

The value added chain [16,p.151] breaks the activities of the firm into analyzable components that reflect operational and support activities. Each is said to contribute a value added to the final product (or service) in the chain. If the total value added is exceeded by the market price of the product, a profit results. The value added chain can be analyzed to determine which activities can most influence the firm's cost of production or its ability to differentiate product. These then become the critical elements in the value added chain and can be used to fashion competitive strategy through focusing on differentiation or low cost of production.

Scott Morton and Rockart [18] developed a model for information technology and organizational change (see Figure 3) based on Chandler's conclusion [9] that "strategy drives structure," and Leavitt's [14] parallel notion that organizations can be thought of as maintaining balance of several components (tasks, people, technology, and structure). Their model suggests that information technology is a key enabler of strategic direction and that an important problem is to find the linkage between strategic ideas and the application of information technology.

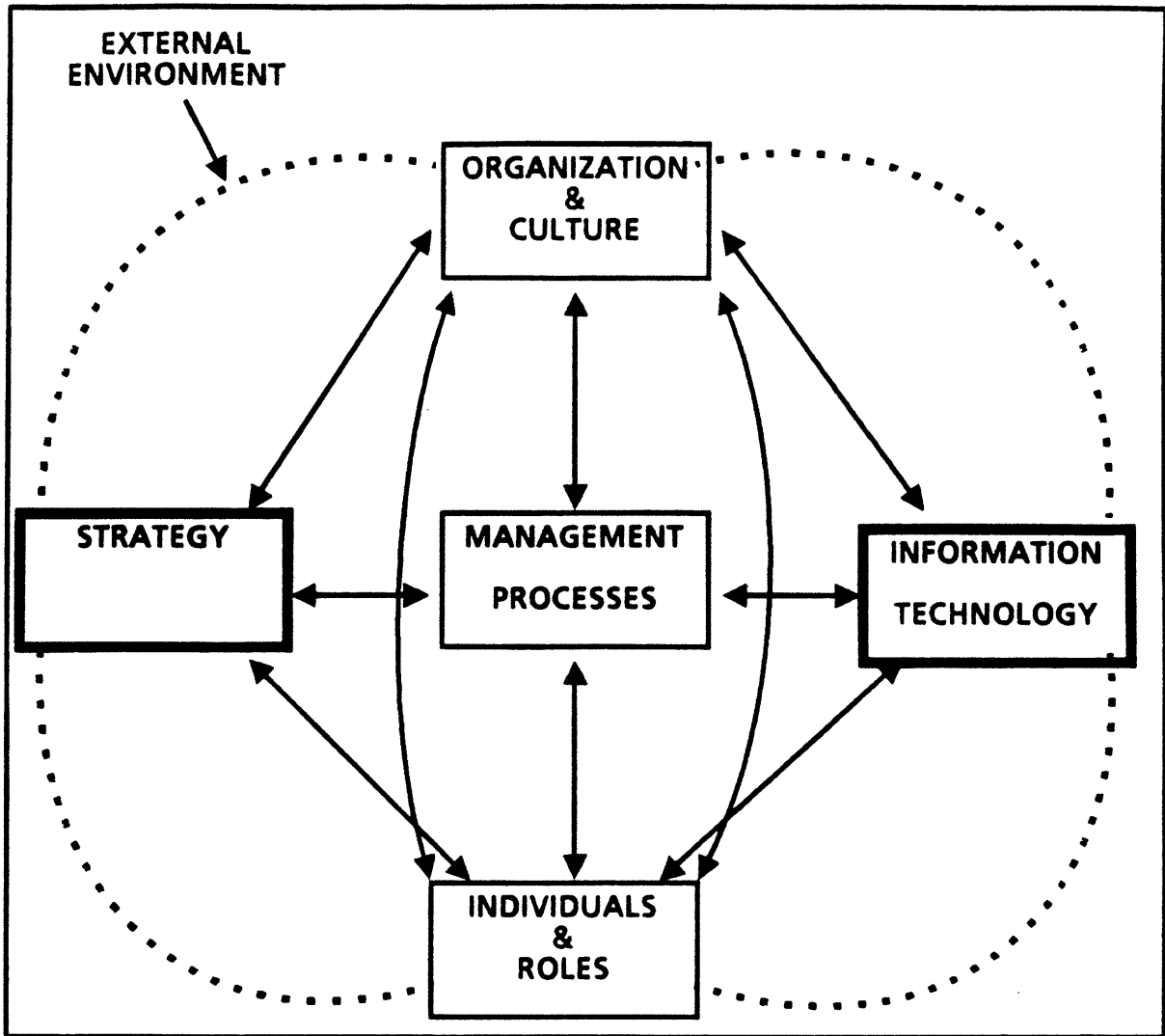


Figure 3
Strategy and Information Technology: Key Variables

A number of search strategies to assist the analyst in determining where strategic advantage applications can be found have been described. The industry structure model has been used [15], [16] to describe examples of use of information technology to secure competitive advantage. Ives and Learchmouth [11] have described strategic use of information technology in terms of the customer service value added chain. Another search strategy [3] is based on looking for opportunities by internal versus market focus in one dimension, and current process

versus structural change in the other dimension. The search strategies that have been described above have all been used retrospectively to identify ways of finding strategic advantage applications, and should be useful in helping organizations to search for such opportunities.

SEARCH STRATEGY: ASSESSING THE INTEGRATION CHAIN

In this paper we propose a complementary search strategy based on finding new forms of integration, enabled by information technology, for significant business problems. We do this because our examination of the traditionally cited strategic advantage applications shows that the underlying forces derive from new forms of integration driven by information technology.

We suggest that opportunities for strategic advantage can be found by a two tiered iterative process as shown in Figure 4. Tier 1 is the the linkage of a strategic idea with the possibilities opened by information technology as, for example, Batterymarch's contrarian approach to managing money where the technology enabled portfolio strategists to effectively scan vast amounts of security data. In the hands of an "excellent" executive, it is the linkage of the strategic idea with the enabling technology that sets the strategic application and leader into motion. What was not feasible yesterday is technically and economically feasible today. Two properties of the ever improving technology are important to consider:

1. The ability to improve the interconnection between people, organizations, and processes, and the ability to provide complete and timely data base access to all the above.

2. The rapidly improving capital intensity ratio of the information technology enables new application opportunities to be exploited every three to four years. As the technology cost performance changes, an application moves from an unfeasible economic state to one where it is affordable in terms of productivity or market advantage. Thus the organization must ever be alert to new possibilities and ready to reject outmoded "it can't be done" attitudes.

INTEGRATION CHAIN

The second tier can be described as the integration chain. It shows the linkage chain between information technology, integration, strategic advantage, and changed organizational forms. It indicates that the improved cost and performance of the information technology makes possible new forms of integration. The new forms of integration then enable changed organizational forms and processes. These changed organizational forms and processes then enable strategic advantage applications which can be realized in terms of a firm's repositioning itself, or changing the structure of an industry, or through more effective or more efficient operations. Both tiers are iterative, as the strategic idea changes with the reality of the implementation possibilities.

Integration has been enabled by changes in two underlying factors: interconnectivity and data accessibility. The cost performance dynamic of information technology has insured the availability of the necessary technologies to improve interconnectivity and data accessibility between and among people and systems components. Not only is there more interconnection, but the quality of the interconnection has also improved in several ways: 1)with respect to cost of transmission, 2)purity of the data, 3)speed of access, 4)type of data (for example

numeric, text, and graphics) and 5) availability of data (for example, on-line access to a large public data base such as Dow Jones, or an electronic message system with several thousand people interconnected).

Additionally, the technology makes it possible to access very large and rich data bases such as the Dow Jones, New York Times, Dun and Bradstreet, Compustat, and Data Resources, Inc. These types of data are enormously large and remarkably low cost.

Integration: Improved interconnectivity leads to new forms of integration. This integration can, in turn, lead to changed behavior by the organization. Xerox, for example, (ref NYT) was able to reduce their new product development time by over one third, and did so with significantly fewer people. However, that is merely the effect of one form of integration. It is important to realize integration comes in several flavors. Some can be identified:

- Integration of multiple transaction classes to present a common useful interface to the user. Examples are found in financial services, airline and other travel reservation services, and electronic data bases such as Lexis and Nexis.
- Integration of multiple forms of representation into a single form of representation. As an example the geometry design data base substitutes for the traditional engineering drawing and change control procedure as well as the traditional bill of materials, and becomes the driver of numerical control machine tools. A variant is the unification of multiple representations into a workable user interface. Text, graphics, data base, and communications capabilities have all been integrated into consistent user interfaces in a number of implementations, among them LOTUS 1,2,3*, JAZZ* and similar integrated

package offerings, as well as the integrated user interfaces supplied by the XEROX** Professional Workstation, and the APPLE** Macintosh.

- Integration of expert knowledge to provide a standardized process for accomplishing or supporting tasks. A plethora of examples have been described recently from medical diagnosis, to on line diagnostics, to geological evaluation, to configuration management.

- Integration of groups into new forms of problem solving networks, through electronic messaging and conferencing, voice messaging, and video conferencing implementations [12].

Restructure: When integration is strong it leads to significant structural change of processes, functions, and organizations. Information Technology fosters restructuring at several levels:

- Process integration is concerned with combining, rearranging and eliminating tasks associated with a process between several people or groups of people. An example of this is a project team utilizing electronic message services to coordinate tasks such as error resolution and schedule activities [12, p.52], thus changing the way people work.

- Functional integration is concerned with combining, rearranging, and eliminating the processes performed. These new collections of processes change the traditional functional responsibility boundaries. An example is the rearrangement of processes driven by the collection of information technologies available in manufacturing and product development, CAD/CAM, factory

*trademark of Lotus Corporation ** trademarks of Xerox and Apple Corporations

automation, robotics, artificial intelligence and the like. One result in a company we are familiar with is the elimination of much of the hand off between engineering and manufacturing in the design process. Processes such as manufacturing engineering (the design of the manufacturing process for production of the new product) and the pilot plant operations are combined into the engineering process.

- Organizational integration is concerned with the electronic linkage of processes between separately owned and/or managed organizations. The growth of electronic integration between organizations has been described in papers by Cash [8] and Barrett [1]. Electronic integration facilitates virtual forms of vertical and horizontal integration, providing an alternative to the high capital cost and management integration requirements of physical vertical and horizontal integration [7]. Electronic integration is a viable strategy across separately owned corporations, as in the implementation of the Cash Management Account [3,p.6] by Merrill Lynch, and within a conglomerate, as in the equivalent implementation by Shearson/American Express [4]. In both cases the consumer saw the product (unified financial services) as coming from one vendor and the vendor's implementation was based on integration through carefully designed interface transactions from each organization into a common data base.

Reposition: An equally important effect of structural change based on new forms of integration is that it is often the key to enabling the organization to gain strategic advantage. The resultant strategic advantage systems fall into two classes; those that result in a more productive (cost efficient and effective) organization--related to the value added chain-- and/or an organization structurally better positioned with respect to its market. Both the productivity and competitive

positioning effects are to be found in many strategic advantage implementations. Shelternet [16,p.155] is a package offered by First Boston informing local real estate brokers what mortgage packages are available and providing them with financing qualifications. It differentiates First Boston from its competitors, and improves the productivity of the real estate broker and the home buyer in their search for mortgage financing.

EXAMPLES: INTEGRATION REPOSITION & RESTRUCTURE FRAMEWORK

Batterymarch and four other examples are presented to illustrate the relationship between integration, restructure, and reposition. They are all taken from commonly cited examples of strategic advantage; airline reservation [6,p.109], engineering/manufacturing financial services [3,p.6], and product configuration [3,p.5]. Figure 5 summarizes these examples. They are explained in more detail below:

Batterymarch: The driving idea behind Batterymarch's success was to implement a contrarian philosophy of security management. This necessitated using information technology to develop a data base of information about very large numbers of securities and then providing information analysis and search tools to help the senior portfolio strategists. The data base also served as the integration vehicle for a redefined value added process for Batterymarch that was more streamlined than their competitors and thus had the added benefit of letting them take a cost leadership stance.

The Travel Industry: Over the past few years the major airlines (American, United, and TWA) have positioned their reservation systems to become powerful competitive weapons against other airlines and to create competitive barriers in concert with

other branches of the travel industry. The strategic idea behind the reservation systems was that information technology would allow for real time access and management of an inventory of perishable commodities for large numbers of people and for many companies and classes of service. At the heart of the reservation process is an on-line data base that enables the travel agent to reserve flights, hotels, cars, and keep track of multiple travel advantage plans for the traveler. The on-line data base is the integrating mechanism making accessible information about multiple classes of reservation data. The advent of these systems has caused significant repositioning in the travel related industries (as an example, United Airlines's recent purchase of Hertz coupled with their ownership of numerous hotels now gives them market position in all major elements of the travel related industry that they can exploit through their reservation system), and has provided competitive advantage to the major reservation systems operators, and productivity benefits to the travel agent and the traveler, and the travel industry component through better space utilization.

Engineering/Manufacturing: The integration of both the design drawing and the manufacturing bill of materials with the integrated geometry (design and build) data base is causing rapid change in engineering and manufacturing organizations with respect to both process change and organizational design. The strategic idea enabled by the cost performance of the computer assisted design workstations, was that one inventory of design data could be used to provide access for operational tasks and managerial control to all the parties involved in the design process, thus providing an opportunity for reduced costs, shorter design cycles, and higher quality designs. The integrated geometry data base is at the heart of the technology and process change taking place in these functions, notably computer assisted design, engineering and manufacturing, as well as robotics and factory automation. The

resultant change is shortening the product development cycle, reducing costs, and improving quality of finished product, providing benefits to both the manufacturer and the customer.

Financial Services: The most commonly cited example of integration of financial services for competitive advantage is the Merrill Lynch Cash Management Account (CMA). Its widespread adoption has served as one of the drivers to restructure the financial services industry, and it has provided productivity benefits to the financial customer in better management of his money. The idea behind the Cash Management Account was that information technology could form a bridge between several financial services companies enabling a package to be retailed by one of them in a consistent manner to the end financial customer. The heart of CMA is an on line gathering of transactions from multiple companies: brokerage, credit card, and banking into one unified customer data base.

Another financial services example is the PRONTO Home Banking Division of Chemical Bank [19], which provides a set of unified bank customer services to the customer at his PC workstation. The integrating mechanism is the on-line data base of up-to-date transaction data on many classes of Chemical's banking services. Chemical is looking to gain a competitive advantage by getting there first and creating a technology barrier. The customer gains productivity in his use of bank data to perform his personal banking transactions more economically.

Product Configuration Management: The Digital Equipment Corporation's XCON system is often cited as an example of the use of expert systems to provide competitive advantage. In this case the idea was to produce consistent and accurate configurations for the special order nature of DEC's product line through manufacture and field installation by the application of a specific information

technology--expert systems. The enabler of this application is an integrated knowledge base of rules for configuring products, that takes into account the best practices of DEC's engineer and converts them into rule based systems for providing configuration instructions to field engineering. The customer benefits by faster more reliable installations. DEC benefits by better use of assets, and by improved customer satisfaction.

CONCLUSIONS

By analyzing these leading edge examples it is clear that much of the strategic advantage is provided by the ability to integrate. This integration comes in several forms, integration of formerly distinct transaction processes, integration of multiple forms of data representation and knowledge, and integration of groups through communication. Such integration is enabled by two dominant properties, improved interconnection and improved, shared data accessibility. Given these facts, some key conclusions can be drawn:

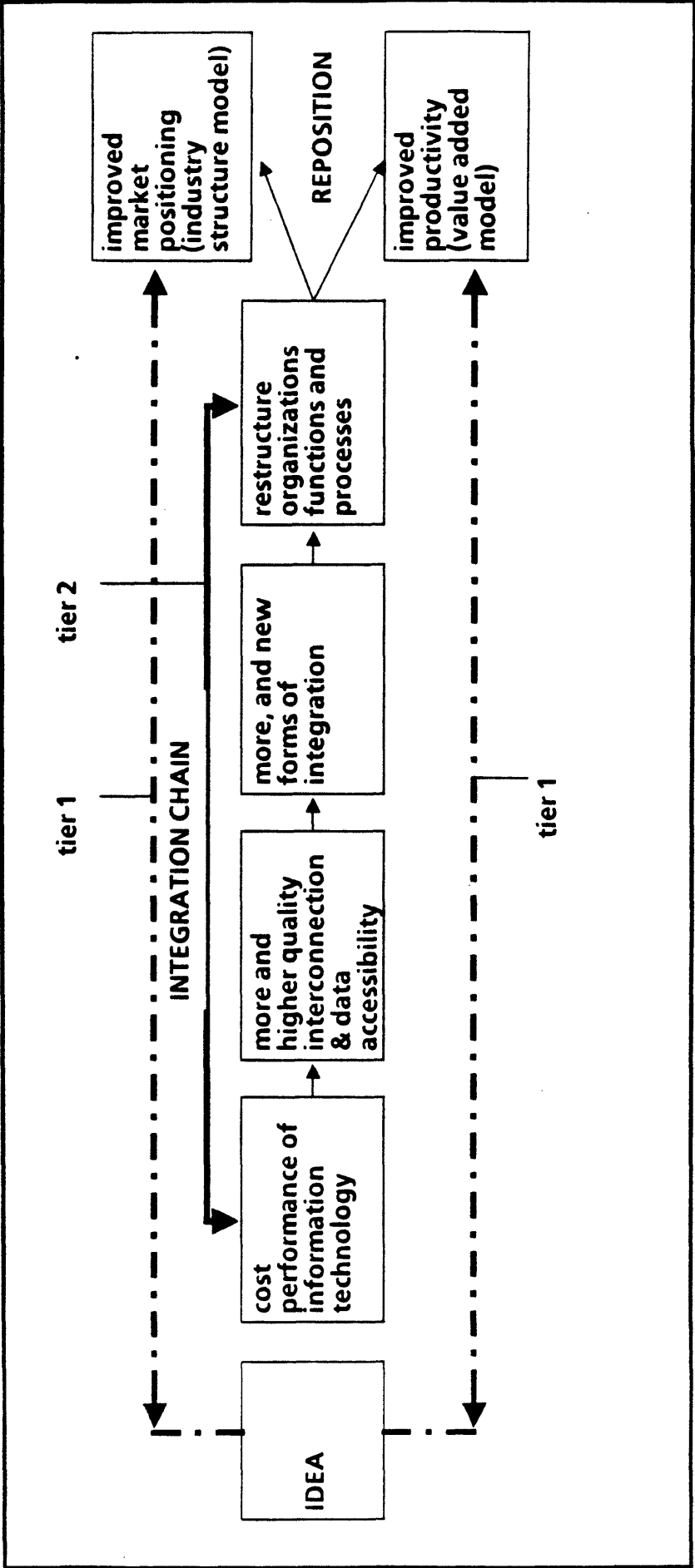
1. Companies must understand that improved capital equivalency ratio is not a short term aberration. It has been happening for several decades now and will continue for several more. For those companies that do not truly understand the consequences of this economic driver it may only be a matter of time before the Swiss watch industry phenomenon overtakes them.
2. Technology creates new integration possibilities. These occur for two reasons: interconnection and shared data. Examples of integration of these two forms have been given in this paper. These, when coupled with strategic ideas, can bring competitive advantage to the organization and should be aggressively pursued. It must be stressed, however, that successful firms have not pursued

new technology-driven integration possibilities for their own sake. Rather, management has had a vision which technology has enabled. Since this vision must be business needs driven, it places a premium on line management and information technologists learning to communicate and share knowledge effectively.

3. The search strategy presented in this paper can serve two managerial purposes. First it can be used as a filter to evaluate and sharpen strategic advantage applications that are currently in the discussion stage. Second, we believe it can be used to develop a process for strategic application scans within the organization. Our future research plans to test this hypothesis. However, it is already clear that what is called for is nothing less than the development of new mindsets. Line management must conceive of information as an exploitable asset and information technology as a form of capital to be aggressively invested in. For the information technologist, the mindset shift is to conceive the full panoply of information technologies as being important only insofar as they support important business needs. One major research task is to understand the nature of the process that will facilitate the linkage between the technological idea and the business goal.

At the very least, one can clearly assert that integration enabled by technology will be a major business force in the years ahead.

4. As the examples illustrate, integration is built on a technical infrastructure of sophisticated communications networks and easily accessible on-line databases. The implementation of this infrastructure is one of the key tasks that the I/S function must perform in the near future.



INTEGRATION, RESTRUCTURE, AND STRATEGIC ADVANTAGE
fig. 4

EXAMPLE	IDEA	INTEGRATION	RESTRUCTURE	REPOSITION/ PRODUCTIVITY
BATTERYMARCH	1. contrarian--search very large data bases to find opportunities where market isn't. 2. few very sr. people	integration of all aspects of value added chain information into one data base	redesign the value added chain into a simplified set of processes designed for few sr people doing more	become low cost producer and market position by differentiation from other investment firms.
AIRLINE RESERVATION SYSTEMS	accessand management of perishable commodity large numbers of people wide geographic area--- real time	integrating multiple classes of reservation data from multiple locations and time periods	airline reservation system into a general reservation system (airline car rental etc.)	travel agent productivity and market repositioning for travel industry.
INTEGRATED ENGINEERING & MANUFACTURING	one inventory of design data to support all parties in the design and build process---lower cost and more flexible design	integration of geometric design drawings with bills of material	refunctionalized engineering manufacturing organization	lower cost higher quality products, shortened product development cycles and market flexible output
FINANCIAL SERVICES	bridge several financial services companies and products into one face to the customer	integrating financial transaction data from several companies	the development of the Cash Management Account concept, and the creation of an "electronic" virtual"	better use of financial clients money, and repositioning of the financial services industry
CONFIGURATION MANAGEMENT	accurate and standard configurations could be built using expert technology.	integrating expert knowledge of product configuration	building and expert system, and restructuring the configuration process for engr. mfg. service and sales	productivity through reduced rework and non billable installations. market positioning by better customer image

Figure 5 EXAMPLES OF SEARCH STRATEGY

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