Measuring the value of information: The information-intensive organization

by R. Glazer

This paper suggests that firms that successfully integrate an information technology (I/T) strategy with their business strategies do so by focusing on the information itself, rather than on technology, as the real carrier of value and source of competitive advantage. A primary mechanism by which a firm becomes an information-intensive firm is the implementation of a procedure for measuring the value of its information assets V(I). This paper presents a methodology for measuring the value of information in the firm. This paper describes the application of that methodology in an actual case study and discusses some consequences of being able to compare organizations with respect to their relative levels of information intensity.

It is now widely believed that information technology (I/T) is transforming the nature of business practice. Firms such as American Airlines, Inc., USAA Life Ins. Co., Federal Express Corp., Inland Steel Co., and McKesson Drug Co., each of which has introduced I/T to alter the dynamics within its industry and change the requirements for its competitive success, have undergone among the most notable and well-publicized business experiences in recent years. At the same time, equally noteworthy is the emerging body of literature, based on a growing number of studies, that suggests little, if any, positive relationship between investment in I/T and overall financial performance. This includes a variety of firms in a wide range of industrial contexts.[1-3] Reconciling the evidence accumulating from these studies with the reports on firms such as those previously mentioned is becoming a major preoccupation of those managers charged with the responsibility of making I/T decisions. If we are to believe those studies, the firms that are usually cited as models for the innovative application of information technology are either unusually skillful, unusually lucky, or just plain unusual.

The theme of this paper is that, if the organizations that successfully use information technology for competitive advantage are unusual, it is because they approach the application of I/T from a different perspective than that of the typical firm. The successful organizations, while first installing an I/T infrastructure, have then gone beyond the technology to view the management of *information itself* as the key variable toward which to direct their attention. This capacity to recognize information as the firm's primary strategic asset becomes the mechanism through which these firms are able to link I/T strategy to business strategy and implement a strategic alignment concept. In this sense, information is the integrating agent between business strategy and I/T strategy.

For example, the Federal Express COSMOS customer service system tracks every movement of every package in the network through hand-held computers carried by all employees who handle packages. This system has become the basis for that firm's ability to differentiate itself in an increasingly competitive market. Federal Express can provide customers both with on-time service and a status report on any package. The report may sometimes be as valuable as the reliable delivery itself. The firm now also provides customers with terminals and/or software so that they can tie into the system directly. The effect is to allow Federal Express to manage the customer's shipping departments. Similarly, McKesson has pioneered its ECONOMOST system by which it places terminals in drugstores and ties them in to McKesson's central computer. This system was originally designed to expedite order-processing and control inventory, but the daily information collected and processed is perhaps more valuable than the pharmaceutical products McKesson distributes. The ECONOMOST system is now aiding the management of retail drugstores for many of its clients by selling back to them the information collected and now processed into a form in which it can be used.

In these instances, information itself is the carrier of value. Most firms focus on what might be called the problem of *bandwidth*. Used in this sense, bandwidth is the expansion in channel capacity resulting in increases in both the speed with which information is transmitted and in the amount of information that can be processed in a given unit of time. By contrast, truly information-intensive organizations see I/T as merely the enabler of growth in the production and distribution of information. These firms focus instead on the output of the technology, the information itself, as the carrier of value and the variable to be analyzed in any discussion of the benefits in performance resulting from I/T investments.

Firms that focus on technology or bandwidth typically take a cost-driven approach to information and information management. Cost-driven firms are typically oriented toward the recovery of costs associated with investments in the information technology infrastructure. Perhaps this is why studies on the payoffs associated with investments in information technology conclude that the costs are rarely justified.

By contrast, information-intensive firms focus on the *information value chain*. The first link in the chain is data that are collected and structured. This process transforms data into *information*. The information is then analyzed, interpreted, modeled, and thus transformed into *knowledge*. That knowledge becomes the basis for decision making.[4] For organizations that manage from this perspective, the goal is to capture the value of the information at each point along the chain. Concerns with the amount and speed of data processing and transmission are less important than the creation of new types or patterns of information organization or information packaging that become the basis of competitive advantage.

The ability to create patterns and package information into new and useful applications, however, is a direct consequence of the ability to appreciate information's value. As is true of any other asset, valuation is a result of measurement. Some say we are experiencing an information age, that is, a period in history when information replaces matter and energy as the primary resource of society.[5] If so, it is becoming apparent that organizations that wish to survive and prosper will be those that solve the problem of measuring and valuing their information resources. The remainder of this paper describes some preliminary attempts at developing a framework for the valuation of information in a business context. It then suggests the implications of being able to categorize an organization as more or less information-intensive.

The evaluation of information

A completely satisfactory definition of what constitutes information is problematic. The idea of information is context-dependent and multidimensional. Analogous to the level at which modern physics describes the entire universe in terms of the equivalence between matter and energy is the level at which communications theory provides a procedure for specifying anything (including matter and energy) in terms of its formal information content. The formal or quantitative definition and measure of information is that which reduces uncertainty or changes an individual's degree of belief about the world.[6] However, except for the utility of this construct in purely engineering contexts, it has not provided the foundation for a practical information-measurement system in most general applications. This

has been the effect, despite the fact that it appears to reflect our intuitive understanding of the proper role of information. As a number of observers have noted, the mathematical definition of information ignores any consideration of content. Two signals that reduce uncertainty by the same amount (and are therefore formally equivalent) may still have vastly different meanings to the receiver.[7,8] Here, *meaning* denotes the grouping or organization of a set of otherwise independent or isolated symbols into a *pattern* that maps into an external referent system. The external system or language is one from which the symbols comprising the signal are drawn.

Thus, although measurement of any given stock of information in purely mathematical communication-theoretic terms is straightforward, its use has been limited because measures of the meaning of the information to the relative agents are ignored. Yet, the meaning of a piece of information is clearly related to the measure of its value.[9] It is the value of information, rather than more abstract and content-free definitions of the construct, that is the principal concern of most economic users of information and is thus the focus of this paper.

Any discussion of an information or knowledge theory of value[5,10] must begin with an analysis of the peculiar attributes of information as a commodity. The typical economic good displays such properties as divisibility, appropriability, scarcity, and decreasing returns to use. By contrast, information as a commodity differs from the typical good in that (1) it is not easily divisible or appropriable (i.e., either I have it or you have it); (2) it is not inherently scarce (although it is often perishable); and (3) it may not exhibit decreasing returns to use, but often in fact increases in value the more it is used;[11–13] (4) unlike other commodities, which are nonrenewable and with few exceptions depletable, information is self-regenerative or feeds on itself[14] so that the identification of a new piece of knowledge immediately creates both the demand and conditions for production of subsequent pieces.

Because of the unique features of information as a commodity, attempts to value information using traditional approaches have proven to be problematic. Typically, the notion of value has two components. (1) Value-in-use means the benefits of a commodity to the user which, in the case of information, is its meaning. (2) Exchange value means the market price. Consider value paradoxes in economics—for example, the fact that water is cheap whereas diamonds are expensive, even though water is vital to life, whereas diamonds are unnecessary. The paradox comes about when the two values do not converge. The solution to the paradox is the concept of supply and demand. Water is cheap where it is not scarce; where it is scarce, the market value of water increases. The divergence between the two types of value is often extreme in the case of information. Although information may be of obvious value-in-use, it may be difficult to establish its exchange value, because information is not appropriable or scarce in the typical way.[15]

The challenge has been to create high exchange value for information, when it has high value-in-use. From the traditional perspective, this has been done by trying to neutralize the ways in which information differs from other commodities. This may be achieved by making information scarce in some sense, either by restricting supply, or increasing demand while holding supply constant. Another alternative is to impose some notion of appropriability through the enactment of intellectual property statutes. Despite the inherent difficulties in these approaches and the inevitable consequence that the markets for information of this type tend to be inefficient and underdeveloped,[11] we should expect these valuation methods to continue in the future.

However, although scarce information may have value, one of the unique and salient characteristics of information as a commodity is that it is inherently not scarce and that its value-in-use often increases with use. The realization of the need to incorporate these features of information into the valuation process is at the basis of any attempt at formal study of the implications of information as an asset.

The value of information

There are many components to a completely thorough valuation of a firm's information assets, that is, the sum total of what it knows. The approach described here follows the one first proposed by Glazer.[16,17] The focus is on one particular aspect of information that is of crucial interest to economic organizations. Information plays a role in facilitating the process of exchange within the val-

ue-added chain. In the downstream chain, the process of exchange is between the firm and its customers, including marketing channels. In the upstream chain, exchange is between the firm and its suppliers. The process of exchange within the firm itself is to facilitate operations.

The unit of analysis is the *transaction*, which we define to be the exchange between a firm and the consumer of goods or services for money. However, a key component of any transaction is that, beyond the exchange of goods for money, information is also exchanged. From the perspective of the firm, this information is assumed to be deposited in a memory store. For example, this storage may be in the form of a record of the transaction itself or of additional data about the consumer involved in the transaction or about the conditions under which the exchange took place. Consider the value of this stored information in facilitating future transactions. Focusing, for example, on the downstream transactions between a firm and customer, three general components of value (COV) can be identified:

- Given the information, revenues from subsequent transactions are greater than they otherwise would be. For example, the number of future transactions is increased through the ability to sell additional units or complementary products. Greater revenues may also be a result of the ability to command higher prices from future transactions, e.g., as a result of the ability to provide customized service.
- Given the information, costs of subsequent transactions are lower than they otherwise would be. This might be the result of more efficient communications programs or more economical distribution arrangements, inventory, or delivery.
- The information itself is marketed and sold to other firms.

Thus, the value of information associated with a given transaction is the sum of (1) profits that result from increased revenues and reduced costs from future transactions that are in turn a function of information collected along with the transaction; and (2) profits from the sale of the information itself. The total value of the cumulative information associated with the transactions between the firm and its customers, V^c, is the sum of the information associated with individual transactions.

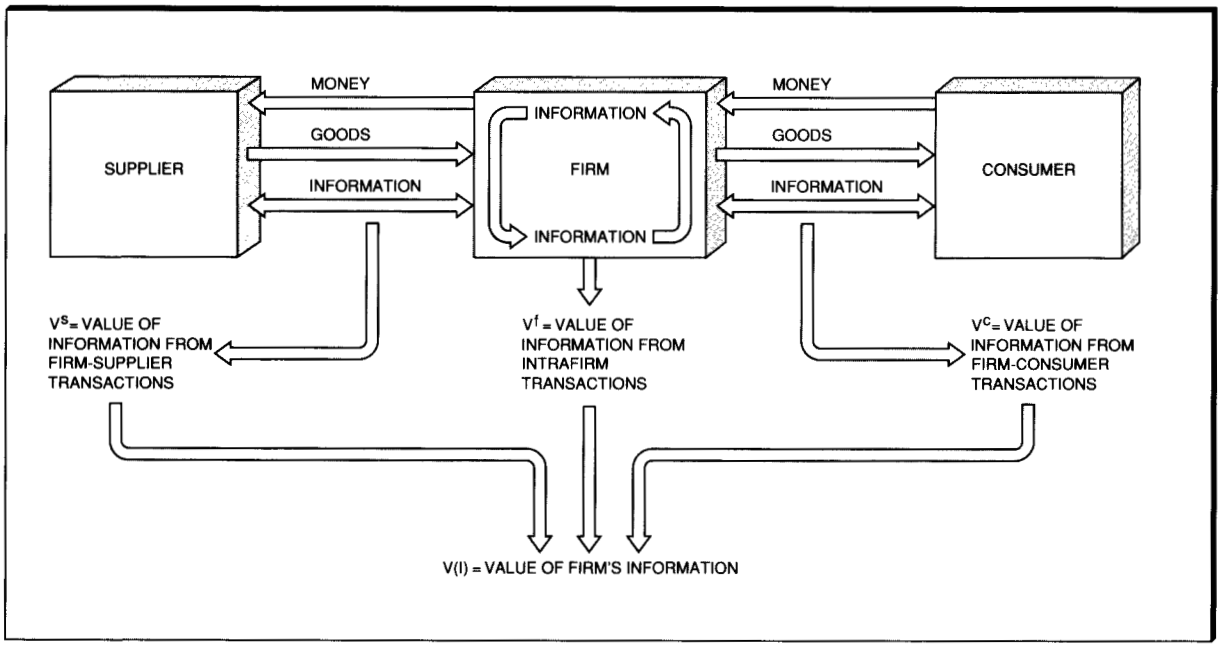
In similar fashion, V^s represents the value of the information associated with upstream transactions between the firm and its suppliers. Here the role of the information is to reduce the costs of the inputs that go into the firm's products and services. The quantity V^f represents the value of information associated with exchanges within the firm. Here the goal is generally the reduction in production/operations costs.

The three measures of the value of information associated with different types of transactions (V^c, V^s, and V^f) can be aggregated to give V(I), which represents the total value of the firm's information. Figure 1 depicts the valuation procedure just described. The information exchanged as a result of the transactions between the firm and its suppliers is measured as V^s. The information exchanged as part of transactions within the firm is measured as V^f. The information exchanged as a result of the transactions between the firm and its consumers is measured as V^c. V(I), the value of the firm's information is the sum of these three measures.

The components of value (COV) encompass those applications of information systems that have begun to be put in practice by firms in a variety of industries. Examples are point-of-sale (POS), electronic data interchange (EDI) as implemented by Procter & Gamble Co. and Wal-Mart Stores, Inc.; and direct store delivery (DSD), such as that employed by Frito-Lay, Inc., and Hanes Hosiery, Inc. More specifically, a number of particular COV functional capabilities can be identified:

- To generate additional revenues by attracting new customers
- To generate additional revenues by extracting more business from current customers
- To generate additional revenues by customizing products and/or services better to meet individual needs
- To generate additional revenues by extracting higher prices from customers
- To reduce advertising and sales force costs
- To reduce costs by designing targeted customer promotions
- To reduce inventory carrying costs and order-processing and/or transportation costs
- To reduce financing costs
- To generate additional revenues and/or reduce

Figure 1 The valuation procedure



costs by developing improved forecasts of customer demand

Note that the focus in the valuation methodology is on the information and not on the information technology. From this perspective, information technology is assumed to be a fixed cost. Thus the fixed cost per unit or transaction decreases as the number of items of information processed increases. This is the assumption underlying all investment in information technology. The role of the technology in the valuation process becomes negligible, as long as opportunities exist for it to be used in the processing of a sufficiently high volume of information. The function of a valuation framework that is oriented toward the information itself is to ensure that the firm has the incentive to identify such opportunities by demonstrating the intrinsic sources of economic value that reside in its information.

The methodology described so far is purely conceptual in nature. The implementation of the proposed measures may appear to be problematic, particularly the estimation of the changes in revenues and costs that result from having collected and processed transaction information. However, the exercise is, in principle, no different from many others involving forecasts of the response functions (i.e., changes in the states of outputs as a function of inputs) associated with other managerially relevant variables.

For organizations wishing to base their strategic initiatives around their information assets, perhaps the most challenging task facing management is the need to implement the conceptual valuation framework previously outlined so that the firm can actually arrive at an estimate of V(I). In this section, the general structure that such a methodology might take is outlined. This methodology is based on a specific interactive computer software program developed to help managers estimate the value of transaction-based information associated with their business.[18] The program relies on a modified decision calculus approach, which has been used successfully in a variety of other applications to estimate marketplace response to managerial decisions.[19] The philosophy behind the decision-calculus approach is that managers themselves are the best judges of the value of the variables with which they work, in this case, transaction-based infor-

mation. The goal of the program is to help uncover and make explicit the tacit or intuitive knowledge possessed by managers. Accordingly, the overall and admittedly complex information valuation problem is to find the total value of the information contained in a firm's customer transaction records. This overall problem is then decomposed into a series of simpler valuation problems, such as to compute the additional revenue that can be generated as a result of being able to raise prices for a given product, based on the knowledge of consumer behavior contained in the firm's customer records. Based on estimates elicited from respondents, these estimates are subsequently recombined to provide a final measure.

An important feature of an information-valuation procedure is that it should allow the analysis to be conducted at two levels. One level is based on the value of information as it is *currently* being used. The other level is based on *potential* ways that the information, such as customer transaction records, might be used but is not. This includes the estimation of components of value based on increasing the number of records in a database and/or changing the contents of records. Consequently, the program should permit the estimation of two measures: (1) the current actual value of information in the firm (V_a); and (2) the potential value of information (V_p).

A case study

Consider the case of Electronics Inc. The specific strategy used by a program for decomposing the general information valuation problem is best illustrated by this real-world case study. The name of the company and its products are disguised to protect confidentiality. The firm involved is a relatively large manufacturer and marketer of consumer electronics. The company several years ago decided to pursue a strategy of being a low-cost provider of certain products in its line. One implication of the strategy was that the firm left its dealers with the responsibility for post-purchase service, with a consequence that the dealers, and not the manufacturer, collected and processed the information, such as warranty cards and service records, from end-use consumers. With emerging technologies leading to rapidly changing product life cycles, Electronics Inc. found that it was increasingly losing market share. Its products were late to market, because the company had lost touch with the ability to understand consumer tastes and predict demand for new offerings. The firm was interested in trying to estimate the economic consequences of this problem. The broader context is that of measuring V^c, which is the total value of the cumulative information associated with the transactions between the firm and its customers.

The product managers of the products affected were brought together to participate in the valuation exercise. The respondents were first asked to indicate two things.

They were asked to state the particular product or product line for which the analysis was to be conducted, because the analysis is to be performed at the specific product/product line level. Later, the separate analyses of individual products or product lines could be aggregated across the entire product portfolio to arrive at an overall measure.

They were also asked to indicate the number of customer transaction records in the database and, for this analysis, whether the typical customer was a dealer, distributor, or end-use consumer. In this particular case, Electronics Inc. was interested in end-use consumer records, although in a subsequent session the analysis was conducted at the dealer level. The firm had only 5000 records in its database, which was a small percentage of its actual end-use customers. These records were not being used in any meaningful sense, i.e., V_a was zero. As a result, the firm was interested in estimating the potential value of its information (V_p) and, for this purpose, it was assumed that 550 000 records were in the database.

The respondents were then asked to consider the record of a typical transaction, say j, between the firm and a typical customer. Such a record might have included specific information about the transaction itself (e.g., name, address, quantity, dollar amount of purchase), or additional information, such as demographic data. As described in the conceptual framework presented earlier in this paper, this information provides three components of value: (1) Given the information, revenues from subsequent transactions are greater than they otherwise would be. (2) Given the information, costs of subsequent transactions are lower than they otherwise would be. (3) The information itself can be marketed.

Focusing first on a single transaction j, by storing, accessing, and using the information from an in-

dividual record, the firm in general can increase revenues from subsequent transactions in several ways. For example, the firm may be able to identify the needs of that customer and offer a customized service at a premium price. The firm might also be able to sell that customer additional units or give complementary products. It may also be possible to lower future costs through more efficient communication programs or lower distribution, inventory, or delivery costs.

When records from different transactions are combined and packaged together, either longitudinal data (j, j + 1) on the same customer or records of transactions from different customers (j, k, l), this can result in increased future revenues. This is made possible by enhanced target marketing, segmentation, price discrimination, and new product development. Costs can be lowered by better estimating customer demand and patterns of buying. It was these applications in which Electronics Inc. was most interested. Furthermore, the aggregated transaction information could also be sold to other firms, such as dealers.

The respondents were then told that the particular ways in which information enhances revenues or reduces costs, or has marketable value in its own right—designated as components of value (COV)—may depend on a given industrial context or be common across industries. To help them get started, the respondents were given a list indicating generic COV for transaction records and were then asked to expand and customize the list for their particular industry. For example, among the generic COV associated with increased revenues are: the ability to sell more of the product to current customers as a result of customer records; the ability to sell the product to new customers; the ability to develop and sell customized versions of the product to current customers; the ability to charge higher prices for the product; and the ability to target special promotions for the product to customers. Among the generic COV associated with reduced costs are: the ability to make more efficient use of the sales force; the ability to lower inventory carrying, cost, order processing, and transportation/shipping costs; the ability to lower advertising costs; the ability to lower customer service costs.

To measure the value of information from a typical transaction j or the aggregated transactions, the respondents were asked, first, to provide an estimate of how much each COV identified as being associated with increased revenues or reduced costs is worth. Respondents were given a one-year time frame for considering the impact of the COV on increased future revenues and reduced future costs. For example, one particular COV in which Electronics Inc. was interested was the increased revenues resulting from the ability to sell more of their current products to their current customers. The decision calculus methodology embedded in the program assists the managers in arriving at this estimate by homing in on their best judgment as to its value, through an iterative series of questions and responses. Thus, when first queried as to what they thought are the additional revenues resulting from the ability to sell more current products to current customers, the respondents were not able to answer. However, through systematic probing, the process arrived at a consensus estimate of $2 million.

In similar fashion, estimates were arrived at for the 13 different primary COV shown in Table 1. Some COV involve using transaction records at the individual customer level. One such COV is the ability to sell additional products to current customers, estimated in this case at $1.5 million. In other cases, COV involve aggregating across all transaction records, such as the reduced inventory carrying costs. Still in other cases, COV involve using transaction records at the individual level and aggregating across records. For example, sales promotions can be targeted to a specific customer, based on that customer's record, or to the entire market, based on analyzing the buying behavior of all customers. In this case, the customer and market were estimated at $.5 million and $5 million, respectively.

These individual estimates, or the sum of the COV, were then combined to give a total value for customer-based transaction information, V^c, of $25 million for the particular product line of interest. To arrive at a measure of the value of customer-based transaction information for the entire firm, the analysis can be repeated across all products and product lines in the organization. Analogously, the process is similar, although based on a different set of COV, for estimating V^s. Other quantities of interest are the value of the information associated with the upstream transactions between the firm and its suppliers and V^f, the value of information associated with exchanges

Table 1 Estimate of V_p for Electronics Inc. (based on 550 000 customer records)

Component of Value	Individual/ Aggregate	Value of Information in Millions of Dollars
Additional revenues from new customers	Individual	1.5
Additional revenues from more business from current products from current customers	Individual	2
Additional revenues from customized products to current customers	Individual	1.5
Additional revenues from higher prices on current products to current customers	Individual	1.5
Additional revenues from sales promotions	Aggregate	5
Additional revenues from sales promotions	Individual	.5
Decreased advertising costs (media advertising)	Aggregate	2.5
Decreased advertising costs (direct mail)	Individual	1
Decreased sales force costs	Aggregate	2
Decreased customer financing costs	Individual	1
Decreased customer service costs	Individual	2.5
Decreased order processing costs	Aggregate	2
Decreased inventory carrying costs	Aggregate	2
	Total	25

V_p = potential value of information

within the firm. The sum of V^c, V^s, and V^f gives V(I), the overall value of transaction-based information associated with the firm.

In the case of Electronics Inc., although the $25 million for the particular product line of interest was only an estimate, its magnitude was rather dramatic and somewhat surprising to the managers involved. Needless to say, the exercise and the economic value arrived at are at the basis of a major initiative into developing both information technology systems and business procedures for capturing transaction-based information and ensuring that it is used.

The information-intensive organization

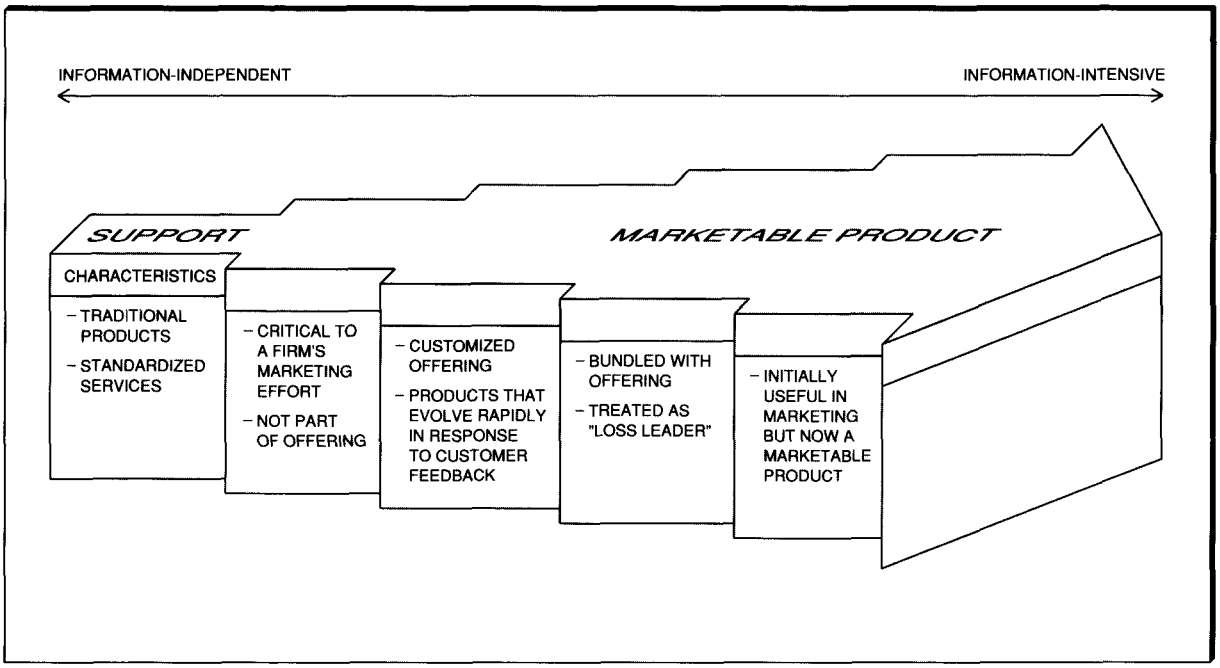
Consider the practical use of an information-valuation methodology. More generally, consider whether there is more than academic interest in a firm's ability to identify and develop a measure such as V(I). The experiences in this area to date suggest several important benefits.

The valuation process. As has been the case with other strategic planning tools, the process of going through an information-valuation exercise is sometimes as important as the output itself. As was true in the case of Electronics Inc., the valuation process is particularly important when groups or teams of managers collectively participate in the valuation exercise, or when different managers working individually provide COV estimates, based on the same set of data. There is often a fair amount of disagreement as to the resulting measures.

The degree to which individual managers' estimates of V(I) significantly diverge and/or there are difficulties involved in arriving at a consensus measure are important indicators of whether the firm is actually using its information assets. More accurately, these measures indicate whether the firm has in place an information value chain whereby data are transformed into information and knowledge. Indeed, the exercise is often the starting point for the development of such a value chain by helping managers to identify applications of information that have previously been ignored. As previously noted, one of the key features of an information-valuation program such as the one described is its ability to help respondents estimate these sources of potential value of information that have not yet been realized in practice. The discrepancy between V_a, which is the current actual value of information, and V_p, which is the potential value of information, represents the firm's information gap. Closing this gap can become the rallying point for the implementation of an information-based strategy and the formal goal of a firm's attempt at becoming more information-intensive.

Because V_a and V_p are both explicit quantifiable measures, the extent to which the firm is successful in closing the gap between the actual and po-

Figure 2 Continuum of information assets



tential uses of its information can be objectively evaluated. This is the recent experience of a financial services firm, where the process of going through the information-valuation exercise for one of its product lines led to estimates for V_a and V_p of $12 million and $27 million, respectively. Thus there is an information gap of $15 million. Recovering this $15 million is now the metric around which a range of activities for aligning the firm's business and I/T strategies are being organized.

The information-intensiveness continuum. The ability to quantify V(I) is the first stage in the firm's becoming explicitly information-intensive. As indicated earlier in this paper, many firms in the vanguard of information-based strategy are also information-intensive. A firm is information-intensive to the degree that its products, services, and operations are based on the information collected and processed as part of exchanges with customers, suppliers, and within the firm itself. Whereas traditional products and operations are relatively static, information-intensive products and operations change as new data from the environment are incorporated into them.

One of the clearest features of the emerging business environment is the extent to which an informational or knowledge component is becoming an increasingly larger part of the product or offering itself. In this respect, a useful strategic tool that can be developed as a consequence of the ability to arrive at quantitative measures of the value of information is the *information-intensiveness continuum*. The levels of the continuum represent the various types of information associated with products.[10,20,21] Figure 2 displays one particular model of the information-intensiveness continuum.

At one extreme of the continuum are offerings that are information-independent, i.e., products whose features are the same regardless of the information exchanged as part of the firm's transactions with its customers and other economic agents. Most traditional products as well as standardized services would fall into this category, but these products are clearly in the decline. Moving along the continuum, there is first information that is not part of the offering *per se*, but is critical to a firm's marketing effort. This is the well-known concept of a product as fundamen-

tally providing a solution to a customer's problem. These products are an established part of the sales process, particularly in industrial purchasing situations.

At an intermediate level of the continuum is information collected and processed that allows for the provision of customized offerings. In general, products that evolve rapidly in response to customer feedback fall into this category. Thus, many products in high-technology industries, which often rely on value-added resellers, are information-intensive. These products also change rapidly as a result of technological advances. A notable illustration of the intermediate level in a traditionally low-technology industry is the bicycle division of Japan's Matsushita Corporation. This manufacturer collects detailed computerized data from a customer at the bicycle store point-of-purchase and uses that information to custom-build any one of several hundred thousand models.

At a higher level of the continuum is information or knowledge that is bundled with the offering. This information is secondary to the main product and is sometimes treated as a loss leader. For example, providing an electronic inventory system to sell hospital supplies, as is the case with American Hospital Supply, falls into this category. In this case, the inventory system that collects and processes information enhances the offering but is not deemed to have independent market value in its own right.

At the other end of the continuum is information that may have been initially useful in marketing the offering, but later becomes a marketable product itself. One day the auxiliary product may eclipse the original product in revenues and/or profits. At any one time, a typical firm is likely to have stocks of information assets (and product offerings based on these assets) that fall at various positions along the continuum. However, the products and services of information-intensive organizations are increasingly clustered farther along the continuum.

As we move along the continuum, the underlying dynamic is that of a shift from information as a support for physically based products or services toward information as a wealth-generating asset in its own right. A product offering is farther along the continuum the more its value added is a function of information collected and processed from transactions. As we move along the continuum, product offerings are based initially on information's role in reducing costs and increasing revenues from future transactions and move toward the sale of the information itself.

One of the most significant characteristics of those firms whose products and services do fall farther along the continuum is that they put a premium on using their information. This is perhaps the hallmark of information-intensive organizations. For this reason, it is important that these organizations first place a value on their information. The information-intensive organization takes seriously the notion that information has replaced matter and energy as the primary social and economic resource. Consequently, it feels comfortable with letting the inherent attributes of information as a commodity reshape the logical structure by which it operates. Physical-based commodities, which are appropriable, scarce, and display decreasing returns to use, lead to concerns with boundaries, ownership, and allocation. Information-intensive firms, on the other hand, recognize that information, which is neither appropriable, nor scarce, and which displays increasing returns to use, results in the breaking down of boundaries and leads to accessing, sharing, and creating opportunities for use. Many of the organizational structure and strategic changes that have been identified as crucial to success in the changing business environment follow directly from an appreciation of this fundamental shift in perspective.[17]

Comparing V(I) across firms and industries. A third important consequence of the measure V(I) is the ability to compare the relative levels of information intensity, both among different divisions and/or product lines within the same firm and across different firms and industries. For these applications, it is sometimes useful to adjust the raw measure V(I) by a measure such as firm/industry profits, revenues, or assets so as to account for differences in size among those entities being compared.

The availability of comparative measures of information intensity and their use in conjunction with hypotheses about the effects of information intensity on a firm's behavior and performance allow us to study more formally whether the pro-

posed measure of V(I) as described in this paper is valid. This is above and beyond organizations' direct experience with the measure, such as we observed in the Electronics Inc. case.

As part of an ongoing project,[18] the V(I) measures collected across different firms (and/or divisions within firms) as well as industries are being organized into a single database. Through time, a set of norms or benchmarks are being established so that the level of information-intensity of an individual firm or entire industry can be compared with the mean level of its peers. We term this the process of competitive information benchmarking (CIB). It is likely to emerge as an important strategic tool for managing in the information age, helping decision makers to gauge the extent to which they are at competitive parity (or greater) with respect to extracting returns from information assets. The ability to implement CIB procedures will depend on the availability of single-source comparative databases, but these are likely to become more common as information valuation methodologies become an accepted part of managerial practice.

More important, perhaps, than the use of relative value-of-information measures for CIB purposes by individual managers, is the ability to use comparative measures of information intensity as the basis for a series of research hypotheses. These hypotheses concern the consequences of increasing information intensity on organizational behavior and performance. (For a representative set of research hypotheses, see Reference 17.) Although the knowledge gained may initially be of interest primarily to academics, ultimately it is practitioners who are most likely to benefit. As the business community collectively comes to understand and can thus anticipate the information-based changes that are taking place in their respective industries, the resulting behaviors are necessary for successful competition based on the relative levels of information intensity they encounter.

Conclusion

This paper has suggested that firms that successfully use information technology for competitive advantage are those that are information-intensive. That is, they focus less on technology than on the information itself as the key asset to be managed. It has been pointed out that a primary mechanism through which a firm consciously and explicitly becomes information-intensive is the implementation of a procedure for measuring V(I), the value of its information assets. A conceptual framework for at least a major component of the information-valuation problem has been outlined along with the presentation of a prototypical program for its practical implementation. Finally, we have suggested several benefits resulting from the ability to develop a measure of V(I) and of being able to specify the level of an organization's information intensity.

Are there any real information-intensive firms today, in the sense discussed in this paper? To the author's knowledge, if there are, they have not yet identified themselves. As suggested in several places above, those firms that are acclaimed as leading the way in information-based strategies appear to be doing so more through an implicit understanding of the information-valuation processes outlined, rather than through its concrete full-fledged realization. At the same time, there are an increasing number of organizations that are well aware of the challenge and are taking steps to make the implicit explicit. In this respect, the paper tries to walk the thin line between the normative and the descriptive. On one hand, we present a normative blueprint or road map of where firms who wish to compete through information should go. On the other hand, the paper suggests what would appear to be the logical or inevitable next step for those that are already well along the way.

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