

Artificial Intelligence in Accounting and Auditing: Creating Value with AI, Volume 5

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SECTION 1 – INTRODUCTION

VALUE CREATION FROM EXPERT SYSTEMS: AN ECONOMIC APPROACH WITH APPLICATIONS IN ACCOUNTING, AUDITING AND FINANCE

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ABSTRACT

The purpose of this paper is to explore some of the value creation processes associated with expert systems. The paper employs a number of different applications of economics to explore the issues. Cost-benefit analysis, based in microeconomics and the economics of defense and government, is used to provide a basic measure of value. Contributions of value for expert systems are explored: economics of strategy/industrial organization, economics of production and innovation, industrial economics, economics of information and economic theory of teams. The paper has a number of conclusions including the following. First, if expert systems can be used to reduce the risk of doing business or develop barriers to entry then those reductions and barriers may be the source of additional value. Second, diffusion of innovations can also lead to additional value through the use of the system by others in the organization for additional purposes or the use of the system by others from different organizations. Third, industrial economics learning processes suggest that building one expert system makes building other expert systems easier and more inexpensive, thus adding value. Fourth, information economics indicates that information has "fleeting" value so the use of expert systems for some applications has limited applicability. Fifth, the economics of teams suggests that expert systems be used to coordinate the efforts of multiple actors. Sixth, the summary suggests that this paper provides a basis for the study of the economics of knowledge and expert systems.

1. INTRODUCTION

The purpose of this paper is to discuss value creation that can occur with expert systems. The issue of value is critical to the selection and evaluation of the contribution of such systems to the firm. In the first case, the choice of expert systems involves an a priori investigation of costs and benefits. While in the second case, the evaluation of the contribution involves an a posteriori assessment. In either case the basic interest in value of the system indicates the need for an economic approach. As a result, the paper employs an economic theory-based approach to elicit and investigate the issues related to such value concerns.

Using that economics structure, it is argued that value can be created in a number of ways in the processes of development, implementation, use and diffusion of an expert system, from one department to another and from one organization to another. For example, expert systems can provide the organization with a means of reducing risk of doing business and with a basis of barriers to entry to other firms.

By examining value creation using an economic basis, a theoretical foundation is established for eliciting research issues and corresponding associated research methodologies. Although a detailed investigation of the later is beyond the scope of this paper, couching expert systems in an economic setting provides the basis for the use of a variety of methods or metrics, based in economics could be used (e.g., experimental economics).

Throughout, although the term "expert system" is used and so-called expert systems are found in business and academic endeavors, the terms "knowledge-based systems" or "artificially intelligent systems" could be used. The paper assumes that these expert systems and artificially intelligent systems are different than other such computer systems. These existence of these differences has been discussed by a wide range of authors (e.g., Hayes-Roth et al. [1983]) and is further exemplified by the rapidly growing set of journals and conferences in expert systems and artificial intelligence.

A number of accounting, auditing and financial systems are used as a basis of demonstrating various concepts with particular expert systems. The basic economic concepts are not limited to the those domains, instead applications from production or other functional areas could be used.

The purpose of this paper is not to summarize the growing literatures of expert systems in accounting, auditing, finance or taxation. For survey papers on these topics see for example, Brown [1988] or O'Leary and Watkins [1989].

1.1 Measuring Value

Microeconomics (e.g., Mansfield [1979]) and the economics of defense and government (e.g., Hitch and McKean [1960]) is the source of one of the most important ways of measuring the existence and extent of value creation in economic systems. Cost/benefit analysis often can be used to decide which expert system project should be pursued -- a particularly important issue in the development of any computer-based system. As noted in Mansfield [1979], in general, projects are chosen so as to maximize (value) the difference between the benefit received and the cost incurred.

Measurement of cost/benefit in expert systems and other artificial intelligence-based systems sometimes is viewed as difficult or impossible because of the difficulty of measuring all the costs and benefits of the system. Depending on the particular system, costs and benefits can include a wide range of activities, some of which are more identifiable than others, some of which are more immediate than others, while still others are more certain to occur. As a result, the full range of the costs and benefits is difficult to anticipate -- some secondary or tertiary benefits may be derived. Further, in some cases, it might be argued that the benefits cannot be measured until a system is developed and implemented -- thus, making it difficult to use cost/benefit before development of the system.

In the area of expert systems, the measurement of the value of an expert system has taken different approaches. Perhaps the most commercially successful, in terms of developing systems that are actually used, is the approach promulgated by large scale developers of such systems, e.g., Walters [1989]. Those developers suggest that when choosing which expert system should be developed, only the immediate benefit of the system be considered in the computation of cost/benefit. Most secondary or tertiary benefits would be ignored. Typically, the immediate benefit is much easier to measure and much more likely than benefit measures that include other less definite returns to the firm. For example, with a production scheduling system, the immediate value of the system would be the value of the difference in production that occurs by use of the system, say, a 10% increase in production.

Further, the approach promulgated is to spend enough up-front time in the analysis, design and testing of a prototype that a reasonable estimate of those costs and benefits could be attained. Again, with a production system, a prototype system would be developed sufficiently so that the actual costs and benefits of the system could be estimated. This indicates that enough up-front requirements analysis is performed so that such an assessment can be made.

Clearly, the implementation of such a cost-benefit approach could have an impact on the systems that are chosen to be implemented. In addition, such an approach has definite life cycle implications. In particular, it indicates that substantial emphasis be placed on the initial prototype and the resulting requirements analysis. Using this approach, it is not always clear when to stop the requirements analysis, i.e., the building of the prototype. Further, this approach implies less of an evolving process than normally would be suggested for such systems (e.g., Keen and Scott-Morton [1978]), although it does not ignore system evolution typically attributed to expert systems.

1.2 The Need for Locating Other Sources of Value

Although the purpose of this paper is not to argue with the choice of when or to what extent to measure cost/benefit relationships, it is concerned with exploring where

and how value is created and the cost and benefit numbers that would be derived. As a result, it is from that perspective that there are a number of reasons to search for other sources of benefit and for sources of reduction in costs that may not be quite so immediate, yet may contribute substantially to the ultimate value of the system.

In the measurement of the value creation of expert systems there is a need to go beyond the immediate cost and accessible benefit numbers. By assessing only immediate benefit, the additional benefits of transferring the same system to other locations or selling the same application to different firms are ignored. Although the possibility of these applications is much more tenuous, the value created by the system can only be recognized by accounting for those benefits.

Also, by choosing only the immediate sources of costs and benefits, it is likely that a suboptimal choice of projects may be made. For example, by stopping short of some of the sources of value discussed later in this paper, the amount of value associated with a given project may be underestimated. Assessing immediate benefit also assumes that the immediate use of the application has sufficient return to cover the costs. In some cases that may not be the case and thus applications with substantial secondary and tertiary benefits could be ignored.

1.3 The Plan of this Paper

Using cost/benefit analysis section 1 has provided an introduction and a statement of the search for value sources from expert systems. The remainder of the discussion draws on theories from a number of different economic disciplines. To find those sources, section 2 takes an economics of strategy and industrial organization approach to value creation in expert systems. Developing intelligent systems that provide barriers to entry and reduce risk are viewed as sources of value. Section 3 examines value creation of expert systems from the economics of production and innovation, in particular, the diffusion of innovations. Using industrial economics, section 4 investigates the implications of developing an expert system on additional, future expert system development efforts, suggesting that with each system, value is gained because costs of additional systems decrease. Section 5 examines the creation or lack of creation of value from the perspective offered by information economics. Section 6 assesses the use of a team theory approach, rather than a single user philosophy, to derive additional value from expert systems. Finally, the summary of the paper in section 7 indicates that possibly efforts outlined in this paper ultimately be referred to as the economics of knowledge or expert systems.

2. ECONOMICS OF STRATEGY AND VALUE

Value creation in the firm is an issue that has received attention by researchers in the economics of the firm, as discussed in the economics of internal organization (Williamson [1975]), finance (e.g., Fruhan [1979]), industrial organization (e.g., Bain [1968]) and strategy (e.g., Chandler [1962] and Porter [1980]). These contributions are summarized here as the economics of strategy.

While summarizing some of the arguments in this literature, Fruhan [1979] suggested that value can be created if the firm can create barriers to entry or reduce the risk of doing business. Expert systems and other artificial intelligence systems can be

used to accomplish both activities. Chandler [1962] argued that the strategy of the firm led to the structure of the firm. If expert systems are regarded as a strategy variable, then the previous research indicates resulting changes in structure. Williamson [1975] and Caves [1984] have suggested that substantial benefits can accrue to the so-called first mover. In the development of expert systems, firms are searching for these types of benefits.

2.1 Creation of Barriers to Entry

In the economics of value creation (e.g., Fruhan [1979]) one of the approaches toward developing value is to foster the creation of barriers to entry of other firms. As noted by Fruhan [1979, p. 2] "Entry barriers make it possible for a firm to increase operating revenues above (or reduce operating cost below) levels that would otherwise exist in a fully competitive situation."

Bain [1968, p.255] lists some sources that function as barriers to entry. These barriers include, "Product differentiation advantages established over potential entrant firms" and "Absolute cost advantage of established over potential entrant firms." Similarly, Porter [1980] elicits what are referred to as three generic strategies: overall cost leadership (requires efficient facilities, vigorous pursuit of cost reductions and cost minimization), differentiation (something that is perceived in the industry as being unique) and focus (concentrating on a particular buyer, product line or geographic market). The first two are similar to those of Bain [1968]. Other such barriers might include quality or reliability.

Expert systems can assist the firm in developing such barriers to entry. Cost leadership might be attained by automating jobs done by human workers with intelligent systems. Discussions with one executive indicated that the development of an expert system had led to the elimination of a "room full of clerks" (O'Leary and Watkins [1990]). Now instead of those clerks, there is an expert system manager who remains to maintain the system. Systems designed to perform accounting or auditing functions might also reduce costs to the point where a barrier to entry could be developed.

Cost leadership is not limited simply to reducing wages. Commercial loan decision systems (e.g., Duchessi et al. [1988]) can assist in the automation of certain loan officer activity. As part of the analysis of loans, such systems typically are designed to minimize costs incurred, such as loans not repaid, and maximize interest received.

Expert systems also can function as a basis of product differentiation. For example, Peat Marwick's system "Loan Probe" (Willingham and Ribar [1988] and Ribar [1988]) was designed to assist in the analysis of the evaluation of the quality of loans of a financial institution. Peat Marwick already holds a large portion of the market for financial institutions. This system gave them some additional product differentiation from other audit firms since no other audit firm has such a product to assist their personnel in their audits.

Product differentiation also can be attained with the use of systems designed to ensure security of a service. TRW's system "DISCOVERY" (Tenor [1988]) is the only intelligent system designed to monitor and secure a commercial credit history file. As a result, services rendered by the system (determining unusual client agent accesses -- say at 3:00 AM on a remote printer) provide their clients with a unique service.

Further, expert systems can assist firms in focus. Typically, expert systems and other intelligent systems are aimed at specific problems. These systems are narrowly

defined in terms of purpose and function, in part, due to the technology and in part, due to the understanding brought to the capture of a problem not previously put in a computer environment. The system Loan Probe clearly assists in focusing efforts of Peat Marwick. Similarly, the capital budgeting system discussed in Meyers [1988], provides the user with a number of tools including cash flow analysis, net present value, forecasting, etc. All these tools are brought together in one system in order to develop a focus on a problem solving issue: capital budgeting.

Quality, reliability and speed also can create barriers to entry. The "Authorizer's Assistant" developed by American Express (Davis [1987]) provides the ability of that firm to respond to card member purchases in a timely manner, while, providing a high quality of service.

2.2 Reducing Risk of Doing Business

Another approach suggested by the economics of value creation is the reduction of risk. As noted by Fruhan [1979, p. 2], "A firm can sometimes ... reduce its business risk below that experienced by less imaginative competitors ..."

Expert systems allow a reduction of risk for a number of different reasons. First, expert systems allow the firm to increase consistency of problem solving approaches (Willingham and Ribar [1988]). Such consistency can lead to a decrease in the variance of behaviors and a corresponding increase in quality. Consistency is particularly critical in financial expert systems, such as American Express's "Authorizer's Assistant," (Davis [1987]) where lower level personnel are using the system to perform higher level activities.

Second, expert systems and artificial intelligence technology in some cases allows the developer to archive expertise. Such archival activities allow for survival of expertise. The importance of such efforts is emphasized in Rosegger's [1980] discussion of "forgetting by not doing." Take for example, the knowledge of how to construct and repair windmills: fifty years ago, these devices served as an important source of energy in rural America. They fell into disuse, as rural electrification and home generators provided alternative power. Under the impact of the recent 'energy crisis', there has been a great revival of interest in windmills, but there are virtually no engineers and technicians left who know anything about the technology -- and only a few firms skilled in building windmills. (p. 163)

Third, by documenting the decision process, these systems provide a record of the process thus, reducing the risk that there will be no such record of why decisions were made. In addition, the existence of documentation provides a basis on which to evaluate the actual risk. As noted by Willingham and Ribar [1988, p. 172] in the discussion of an audit-based system, "Through the proper design of expert systems, the required documentation for a given audit judgment can be automatically provided as part of the output of the judgment exercise" Similar statements can be made for credit granting systems, security systems, etc.

2.3 Strategy Leads to Structure

The use of expert systems and other artificial intelligence systems to reduce risk or to produce a barrier to entry is a strategy developed by the firm. It has been argued and documented by Chandler [1962] and others, that changes in strategy lead to changes in organizational structure.

Although the extent of such changes in organizational structures has not yet been examined in substantial detail, there have been some initial investigations (e.g., O'Leary and Turbin [1987] and O'Leary and Watkins [1990]). The empirical findings include the following organization structure changes: an expert systems manager or team (similar to a database manager) has evolved as the basis of the maintenance of many systems; clerical workers have been replaced with workers involved in the development and maintenance of knowledge-based systems; and expert systems teams have moved into the specific application development departments, fostering a decentralization of the computing environment. Since such changes directly impact payroll and the quality of systems developed, such changes in structure can have an impact on value.

2.4 First Mover Effects

First mover effects as a phenomenon have been described as follows by Williamson [1975, p. 34]:

Winners of initial contracts acquire, in a learning by doing fashion, nontrivial information advantages over nonwinners. Consequently, even though large-numbers competition may have been feasible at the time the initial award was made, parity no longer holds at the contract renewal interval. The information acquired through experience is impacted in the sense that (1) original winners may refuse to disclose it (which is a manifestation of opportunism) or (2) they may be unable, despite best efforts to disclose it (because of bounded rationality of the language impeded variety). Small numbers bargaining situations thus evolve in this way."

Recently, the author was involved in discussions with a large international financial organization that was pursuing the use of artificial intelligence because it did not want its direct competitors to gain any additional advantage. They felt that if they were to wait until their competitors developed and deployed such technology that their competitors might have an insurmountable, first mover advantage. Other firms, such as TRW and American Express have received additional advantages of being first movers. Substantial publicity has been given to those firms in the technical and general press, regarding their systems. As a result of these and other first mover benefits that could result, it is clear that value can accrue to a first mover.

3. ECONOMICS OF PRODUCTION AND INNOVATION

Additional value can accrue to the firm with diffusion of the expert system, as with other innovations (e.g., Rosegger [1980]). In the area of expert systems, typically this either means additional uses or users for the same system within the firm, or additional uses or users for the same system in other firms. In either case, if the costs are covered by the first users or uses, any additional users and uses are leveraged at a small cost, while there may be substantial gain. These gains are made in spite of the narrowness that is typical of expert systems.

Expert systems are not limited to independent, stand alone systems or processes. Instead, they can be integrated into other existing intelligent or non-intelligent computerized or noncomputerized systems. Accordingly, a new technology, such as expert systems, can serve as a vehicle to complement and up-date existing technology.

Expert systems also provide a unique forum for the diffusion of knowledge and provide an educational function. Although difficult to measure, some count these benefits as some of the greatest values of the system (e.g., Willingham et al. [1988]).

3.1 Additional Uses and Users of the Same System

O'Leary and Watkins [1990] describe an internal auditing application for a large bank, that was designed to process large quantities of foreign currency transactions, in a timely manner for auditing purposes, to investigate the possibility of fraud. When the manager of the foreign currency department heard of the system, he asked if he could also use the system. The manager was not interested in the audit purposes. Instead, the intention of the manager was to use the system to assist in the management of the operations of the foreign currency department.

Tenor [1988] describes an intelligent system designed to monitor, control and secure the use of a credit file. One of the processes used by that system was to create "user profiles." These profiles were designed to capture those characteristics of users that differentiated one user from another so that the system could differentiate among them. It later was found that the same system could be used for marketing purposes, since the user profiles identified those aspects of the system that were used or not used. Thus, marketing could identify to the firm's clients those aspects of the credit file that were being used and those that were not, offering the opportunity of improving the client's operations.

These same systems also have been transferred to other organizations. In addition, auditing, financial and tax-based expert systems have been offered for sale by developers, whose intention was to offer the systems for sale, rather than limit use for internal purposes.

3.2 Integration of Systems and Processes

In a discussion of the characteristics of innovations, Rosegger [1980, p. 248-249] includes the following: location in the production system and complementarities among innovations. The location refers to a number of different issues, including are they replacing or displacing present techniques?; and, are the effects isolated or system-wide? When discussing complementarities, Rosegger [1980, p. 248] notes "Frequently, the full benefits of adopting an innovation can be reaped only if ancillary or complementary changes also are adopted. Thus, what may appear as a single innovation is in fact perceived as a technical package." Location. Expert systems technology often replaces present technology. In auditing and loan evaluations, expert systems frequently replace checklists (e.g., Sphilberg and Graham [1986]). Because of the specific nature of most expert systems, the effects frequently are isolated. However, in a recent survey of applications of expert systems in internal auditing, roughly 20% of existing applications were judged to have an impact outside the isolated area for which they were developed (O'Leary and Watkins [1990]).

3.3 Complementarities

Complementarities occur with integration into other systems. Integration of expert systems can take at least two basic forms: integration into a work process (auditing, accounting, loan evaluation, etc.) and integration into existing computer-based systems (possibly more traditional information systems). Thus, complementarities also can take a number of different forms.

In the case of auditing work processes, Kelly et al. [1987, p. 168] note that "There are any number of applications for the AI technology that, when harnessed, can be used as tools in the support of auditing field work, thereby freeing the auditor from many of the more mundane tasks, and making the work of the auditor significantly more interesting." Thus, it appears that partial adoption can occur, without a need for an entire package.

Similarly, in O'Leary and Watkins [1990], an example of an expert system that is integrated into an existing management information system to perform a security analysis of transactions is discussed. That overall system, in turn, is embedded within a work process. One of the initial findings of management is that human workers have various specified activities so that much of the security work is delegated to the system. However, security checks on the process that are supposed to be done by the people are often neglected, since there is a perceived notion that "the system does that."

Thus, there can be both increases and decreases in value that can occur with integration of expert systems into processes and existing computer-based systems.

3.4 Diffusion of Knowledge: Education and Human Capital Development

Rosegger [1980, p. 248-249] also includes the expected effect on other inputs as another characteristic of innovation. This effect can take multiple forms, including education of the users of the system. This is consistent with the economics of interaction discussed in Fama and Jensen (p. 25), who argue that competitive interaction among agents in organizations leads to human capital development.

Expert systems can add value based on the diffusion of the knowledge from a few experts to a broader base of information consumers in the firm. As noted by Kelly et al. [1987, p. 168]

The complexity of modern auditing as dictated by the complexity of modern business, leads to areas of audit specialization. ... By capturing the expertise in specialized areas, however, we can provide knowledge where the expert is not available.

In addition, such systems can function as surrogates for interaction with human agents.

4. LEARNING THEORY MODELING IN INDUSTRIAL ECONOMICS

Learning theory modeling in industrial economics is dominated by two sets of issues: modeling the improvement (improvements in quality and efficiency of the process) that occurs with additional trials and the extent to which such processes initially

are impacted by fixed costs. Since costs are affected in both issues, learning theory has insight for value of expert systems.

4.1 Improvement to the Process

It is well-documented (e.g., Baloff [1966] and Horngren and Foster [1988]) that efficiency of production improves as the number of times that the task is done increases over time. Typically, the cost per unit decreases as the total production to-date increases and quality increases. These improvements occur because of learning that occurs.

The same also seems to hold true in the development of expert systems. As systems are developed, the decision making domains become understood, and thus, are more readily modeled. Further, the tools necessary to build the systems become understood better. This is exemplified by the increase in the number of expert systems shells in 1982 from two (AL/X and MYCIN) to probably over one hundred in 1990.

This suggests that value is added with each system that is developed, since increased efficiencies lead to decreases in costs or improvements in the quality, and since decision domains and system tools become understood. Thus, limiting the analysis of the value of an expert system or other intelligent system to a single development effort is unlikely to capture the actual value or costs of the system. It is likely that the huge costs and cost estimates of expert systems development expressed in the early literature on expert systems were so large, partially because of their position on the learning curve.

Not only does learning occur with the building of systems, but as time increases so does the set of tools designed to assist in the tasks of system development. These developments are necessarily linked to the production process and implementation of such systems. For example, in the discussion of a case study of twenty major projects (not expert systems), Rosegger [1980] noted that "... of over 800 identifiable technical `events' that had to be completed in order for full success, approximately one third occurred after the projects had been initiated on a commercial basis."

4.2 Fixed Cost Nature

The development process of an expert system initially has a large amount of fixed, one-time costs. These costs include easily measured costs, such as the purchase of new hardware, software and other tools. They also include the more difficult to measure costs and benefits of education in the use of the hardware and software, research and development in the understanding of problem solving in general and problem solving in the particular domain. In addition, it often is documented that before a system is built it is necessary for the developers to become "near experts" (e.g., Lethan and Jacobsen [1987]). More and more this becomes a common finding in papers that discuss the development of expert systems. Becoming such a "near expert" in the domain application area in order to build the system can require a substantial fixed cost. If only one system is developed then each of these costs is likely to be attributed to that system. On the other hand, as other systems are developed, these fixed costs are likely to be amortized or averaged to the other projects. Taking into account these additional systems in the allocation of fixed costs, will have an impact on value, as measured.

4.3 Maintenance Costs

However, fixed costs are not the only costs to be incurred in expert systems projects. A large continuing cost is in the area of maintenance of the systems. Since

additions and changes to a knowledge base often increase size and complexity of the system, maintenance costs can increase, rather than decrease over time. A system discussed in O'Leary and Watkins [1990] initially required only a part-time effort to update and test the system. However, as the system was developed to include more and more rules, the effort required a full-time position. In addition, the stability of the domain also can impact maintenance costs. Systems designed to archive expertise may reflect an environment that is slow to change.

Other domains may require substantial change over time. Structuring the problem as an expert system may facilitate up-dating of the knowledge across the organization or inhibit knowledge up-dating, depending on the system, the problem area and the manner in which up-dating was done previous to the system. For example, a system designed to assist auditors with income tax issues, *ExperTax* (Shpilberg and Graham [1986]) requires a full-time staff to keep the system up-to-date, because of frequent changes in income tax law and its interpretation. Conversations with a former executive involved in the development and maintenance of that system, however, indicated that in spite of that need for staff, the cost of the efforts to keep the system up-to-date still are less than if a paper-based approach were used. Now instead of headquarters sending tax up-dates in a paper format to each of the firm's offices, a revised version of the system is sent. Thus, the firm has experienced an addition to value that likely was not anticipated.

5. INFORMATION ECONOMICS

Although information economics treats information as a resource or economic good, there are some fundamental differences between information and other economic goods, that are critical to value creation (or lack of creation) in expert systems. These differences impact the markets for information. In addition, they include the impact of information asymmetry that occurs in most organizational settings and the ill-defined nature of what information is to the expert.

5.1 *Efficient Markets*

Many theoretical and empirical results have led to the assumption that stock markets are very information "efficient." Jensen [1979, p. 96] defines an efficient market as follows: "A market is efficient with respect to information set T, if it is impossible to make economic profits by trading on the basis of information set T." Basically, efficiency indicates that information rapidly is compounded into stock prices. Clearly the notion of efficiency has implications for any expert system efforts aimed at trading in any of a variety of markets.

Probably because of the potential payoff, expert systems designed to manage stock portfolios or expert systems for decision analysis in securities trading (e.g., Breese [1987]) are an area of development that has received increasing attention. Unfortunately, because stock markets are so efficient, any advantages that would result from an expert system for trading would theoretically be built into the price of stocks. In addition, and perhaps most importantly, even if an absolutely superb trading expert system could be built, if that system was sold to multiple traders theoretically all advantages resulting from that system would be lost. Given the realities of an efficient market, value would

not be created, for the users of such a system. Users would find that use of the system would provide little, if any competitive edge, if distribution of the system were too broad.

As a result, most such trading system efforts are proprietary, possibly based on hardware and software environments, to which intelligence can be added (PC Week [1990]). Proprietary efforts could result in risk reduction or the development of barriers to entry, as discussed above.

The impact of market efficiency is not limited portfolio management or trading programs. Clearly, other applications, such as bidding systems face similar problems.

5.3 Information Asymmetry

Organizations function with large quantities of information asymmetry. In some cases, employees maintain their jobs because they have knowledge not in the hands of their employers. In other cases, managers do not have the time or resources to closely monitor employee activity so information asymmetries develop.

Ideally, expert systems move to limit the extent of information asymmetry by capturing knowledge in a computer-based medium. In fact, it is easy to envision the initiation of an expert system simply to try to understand what processes are being used by employees.

Unfortunately, for the reasons noted above, employees have incentives to continue information asymmetry. This can impact the quality of the system developed because participants in such projects may not provide a complete set of knowledge for the system. Further, in the evaluation of the system, employees may be unwilling to point out limitations of the system because of fear of being replaced by the system.

5.4 Agency Costs

Jensen and Meckling [1976, p. 308], "... define an agency relationship as a contract under which one or more persons (the principal(s)) engage another person (the agent) to perform some service on their behalf which involves delegating some decision making authority to the agent." Agency costs include the monitoring expenses incurred by the principal. "The principal can limit divergences from his interest by establishing appropriate incentives for the agent and by incurring monitoring costs designed to limit the aberrant activities of the agent" (Jensen and Meckling [1976, p. 308]).

Monitoring of activities using artificial intelligence spans a broad range of activities. Vasarhelyi et al. [1988] discuss an auditing system that is used to continuously monitor transactions processed through the accounting system. Tenor [1988] discusses a system designed to monitor the activity of agents' use of a database, where unusual use may be reported to the principal. Lecot [1988] reviews some systems designed to accomplish some monitoring activities in banking. Banking systems include monitoring credit card use (Lecot [1988]) and monitoring bank clearing accounts for fraudulent activity (O'Leary and Watkins [1990]).

5.5 Knowledge and Information to the User, Expert or Developer

Another issue is what is information to the user, expert or developer. There are at least two issues. First, if the expert on which a system is based regards a set of information or variables as fixed then it is unlikely that knowledge regarding those variables will appear in the system that ultimately is developed. Unless the expert can manipulated the variables, those variables may be ignored. Unfortunately, this has some

potential negative implications for the value of the system to the firm. Simply because an expert cannot manipulate a set of variables does not mean that either manipulation of those variables cannot be done by someone else in the firm or that the unchanging nature of those variables is permanent. Unlike many commodities, the nature of information changes over time.

Second, as has been argued elsewhere, humans have limited information processing capabilities (e.g., Hogarth [1985]). As a result, general effects of a total population are often seen as being specific to particular members of the population. This perspective can lead to systems such as that encountered at a large European financial institution, by the author. The hardware included multiple screens over which the system would suggest stocks of potential interest to the trader, based on an "expert analysis of the market and those stocks. The system incorporated intelligent software based on experts' evaluation of the key factors in trading. The system was designed to isolate investment opportunities and then point those opportunities out to the trader.

Unfortunately, the institution found that virtually all the advice built into the system was based on factors that did not impact a single stock, but instead influenced a large number of stocks. Thus, instead of developing a system that would signal a single stock of interest to the trader, large number of stocks were indicated. Instead of providing detailed insight, the system only traced general market activity. As a result, the system was scrapped. Looking back on why the system did not work, representatives from the firm felt that prior to the development of the system, experts apparently were unable to differentiate between firm and market effects because prior to the system experts only monitored a few stocks at a time. Accordingly, the system captured market, not firm effects.

6. *ECONOMIC THEORY OF TEAMS*

There are a number of situations in which employees must work as a team. For example, auditors must work together on an audit and bank loans are part of a portfolio of loans and thus, must be considered in concert with other loans. Thus, value derives from vehicles designed to ensure the coordination of such efforts.

In a discussion of one characterization of team, Marschak and Radner [1978, pp. 123-124] note the following difference between a single actor and multiple actor model that they develop:

The proper multi-person team differs from the one-person team mainly in the extended meaning that must be given to the term 'rules.' Each individual member of a team decides about a different action variable, and each member's decision is based, in general, on different information. Accordingly, the concepts of decision rule and information structure developed ... for the single person case must be reinterpreted. If there are n members, the team's information structure and decision rule will consist of n information structures and n decision rules. The problem is to choose the pair of n -tuples that serves the well-defined interests of the team. ... The information and decision rule of the team taken together can be called its organizational form.

There have been few expert systems in financial applications that explicitly coordinate multiple users, since most systems treat each user as the only user. However, many more traditional decision aiding or supporting systems are designed to coordinate individual efforts. For example, one audit system, AY/ASQ summarizes the totality of audit efforts to-date. The system integrates the efforts of an individual over time or multiple users with a smart questionnaire approach: given some activities other activities are determined to be either essential or nonessential.

Further, although no published reports of loan decision expert systems consider the portfolio of loans in its decision rules, such coordination would be an intelligent addition to such a system. The concern of the institution is not with each credit decision individually, instead the marginal impact of each credit decision, given the portfolio of previous investments should be established.

Unfortunately, the integration of a team approach into expert systems that accounts for "portfolio" efforts, even major commercial efforts, apparently is not an easy task. For example, as noted in Willingham and Ribar [1988, p. 183], in a discussion of "Loan Probe" noted above.

"The greatest concern raised during the field test was about the scope of the system. Analysis of multiple loans to a single borrower was difficult to do with the system."

7. SUMMARY AND EXTENSION

This paper has used economics as a basis to elicit issues in the value creation associated with expert systems. That approach presents a basis for searching out expert systems applications that perform specific strategy tasks for the firm, for example, using expert systems to create barriers to entry and reduce risk. That approach also suggests sources of additional derived value from a given expert system, integration with other systems and diffusion of knowledge contained in the system. The economic basis also led to the notion that development costs largely are fixed and likely to decrease as the number of applications increase. Treating information as an economic good leads us back to the markets of information as a basis of evaluating whether an application is a good one or not, based on its use in an efficient market. Further, the economic notion of information asymmetry provides us with expectations regarding system development. Finally, focusing on the team structure of many decisions leads us to some desirable characteristics of some expert systems.

The specific nature of the elements in the discussion in this paper suggests that the economic study of these phenomenon be grouped in the study of the economics of expertise and expert systems or the economics of knowledge and knowledge-based systems. Such study would be concerned with many of the issues delineated in this paper.

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