ASSESSING THE IMPACT OF INFORMATION TECHNOLOGY ON ENTERPRISE LEVEL PERFORMANCE

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ABSTRACT

Implicit in most of what we do in MIS is the belief that information technology (IT) has an impact on the bottom line of the business. Surprisingly, we rarely know if this is true. It is very difficult to trace and measure the effects of information technology through a web of intermediate impacts upon enterprise level performance. In this paper, we review research that has been performed on enterprise level impacts of information systems, with a particular emphasis on research that has attempted to measure those impacts. We begin with a survey of articles published within the last ten years. This is followed by a discussion of the reference disciplines that underlie most of this work. From this we are able to draw conclusions about future directions for research in this area.

INTRODUCTION

Implicit in most of what we do in MIS is the belief that information technology (IT) has an impact on the bottom line of the business. Surprisingly, we rarely know if this is true. It is very difficult to trace and measure the effects of information technology through a web of intermediate impacts upon enterprise level performance.

When computer systems were used largely for cost displacement, the evaluation of their impact on enterprise performance could be conducted using an accounting framework cost/-benefit analysis. The costs were the costs of putting the system in place. The benefits were some offsetting reduction in headcount or other organizational costs. Currently, systems are often used to enhance performance without any necessary reduction in organizational costs. With some systems, the benefits are better decision making, improved communications, or other semi-tangible instrumental changes. With systems that try to affect the competitive position of the firm in its marketplace, the benefits are usually even less tangible.

The lack of measures of enterprise performance impacts is a serious practical and theoretical problem. In practice, we assume that our systems will deliver bottom line value, but we can neither predict that value for the investment decision, nor measure it once the system is in place. In testing our theories about effective information systems, we are left with surrogate dependent variables that may only weakly relate to the ultimate measure of impact on the firm. Thus, we develop theories about what makes systems valuable, but we can often only test whether the systems engender individual level satisfaction or usage.

In this paper, we review research that has been performed on enterprise level impacts of information systems, with a particular emphasis on research that has attempted to measure those impacts. We begin with a survey of articles published within the last ten years. This is followed by a discussion of the reference disciplines that underlie most of this work. From this we are able to draw conclusions about future directions for research in this area.

DATABASE OF ARTICLES STUDIED

A total of 11 articles relating to enterprise level performance were found by searching 10 journals from 1975 to 1985. These were felt to be representative in terms of methodologies, variable definitions and operationalizations, and findings and were used for analysis. Tables 1 and 2 contain a listing of these articles classified according to the type of methodology used. Empirical studies include cost/benefit analyses and field surveys; the remaining articles are framework or theory development pieces.

SURVEY OF STUDIES OF ENTERPRISE LEVEL PERFORMANCE

There are a number of articles that attempt to develop techniques for identifying strategic systems opportunities. As is characteristic in a new field of study, many of these articles propose frameworks. They try to establish a clear vision of possible alternative systems by employing a categorization scheme built using important dimensions of the problem. Different ones have been proposed by Bakopoulos and Treacy (1985), Barrett and Konsynski (1982), Beath and Ives (1986), Benjamin., *et al.*(1983), Cash and Konsynski (1985), Gerstein and Reisman (1982), Ives and Learmouth (1984), Keen (1981b), McFarlan (1984), Parsons (1983), and Rockart and Scott Morton (1984). Through descriptive work we have developed a fair degree of understanding of what the range of systems possibilities and impacts are. It is now time for academic research to contribute explanations of how these systems impact competition and corporate performance. If we are to correctly influence managerial practice, we need to understand how internal support systems contribute to enterprise level performance, and how that performance should be defined and measured.

Cost/Benefit Analysis

Some authors have begun to address these issues. One group of articles generally suggests doing some form of cost/benefit analysis to justify an organization's investment in information technology. These articles, based as they are on a simple accounting view of productivity, are perhaps the most common and the least informative. (It should be noted that in some of these articles, a cost/benefit analysis is presented as a small part of a larger paper.)

Crawford (1982) describes the pilot test and actual implementation of an electronic mail system at DEC, and presents some figures on the costs and benefits obtained. These figures show that the system cannot be justified solely on the grounds of cost displacement, but that improved managerial performance must be considered as well.

Others, recognizing the increasing difficulty of assigning a precise value to the intangible benefits of information systems, suggest new ways to estimate or defend estimates of benefits. Matlin (1979) advocates assigning values to IT projects based on how they achieve "business goals" and describes such an evaluation done at Land O'Lakes. Keen (1981a) suggests using a technique he calls "value analysis" to justify decision support systems rather than trying to rigorously calculate their costs and benefits. He suggests first developing a prototype system which can be considered R&D and thus not need rigorous justification. After the potential benefits of the system are clearer, an assessment of the final implementation can be made, and a rigorous cost/benefit analysis done only if the estimated benefit is not obviously greater than the cost. Gremillion and Pyburn (1985) suggest evaluating a portfolio of applications as a whole rather than trying to defend the estimated benefits of each individual system. Strassman (1982) suggest calculating a system's effectiveness by dividing the value it adds (the market value of the final product less the input costs) by the overhead labor cost.

Most of these articles are think-pieces, presenting a methodology for cost/benefit analysis, but little or no real data. Of those that do give empirical results, two (Crawford and Matlin) are case studies of the organization for which the author worked. While these studies are interesting, they have limited external validity; knowing that DEC or Land O'Lakes believe that they are gaining benefit from their systems tells us very little about any other company. The results are generalizable only if they are based on characteristics shared by many other firms. We have no idea what features of these firms allow their systems to be successful while many other

Table I. Cost/Benefit Analyses

		Variables		
Article	Method	Independent	Dependent	Comments
Crawford, 1982	Case study of pilot and implementation of an electronic mail system at DEC	Cost	Perceived benefit	Cannot justify system on cost displacement alone
Matlin, 1979	New methodology for cost benefit analysis and example of use at Land O'Lakes	Cost	Perceived value of success in achieving "business goals"	
Keen, 1981a	Suggests using value analysis instead of rigorous cost/benefit	Estimated cost	Estimated benefit	Suggests creating a prototype to make estimates
Gremillion and Pyburn, 1985	Suggest evaluating a portfolio of applications as a whole	Estimated cost	Estimated benefit	technique to defend estimates rather than to make them
Strassman, 1982	Suggests evaluating systems based on value added, measured by market place	Cost of overhead labour	Value added as measured by market	

Table II. Economic Analyses

		Variables		
Article	Method	Independent	Dependent	Comments
Cron and Sobol, 1983	Survey of 138 wholesale companies	Ownership of computers, number of applications used	Return on assets and net worth, profits, net growth	Inconclusive results
Stabell, 1983	Survey of 82 Norwegian companies	Number of non-production workers, expenditures on IT, number of applications used	Efficiency in transforming production capital and labour to labour costs + profits	Used frontier analysis to calculate efficiency
Chismar and Kriebel, 1985	Description of DEA with numeric example	Capital, labour and IT investment	Return on investment and total sales	Used DEA to calculate efficiency and rates of substitution
Elam, Henderson and Thomas, 1984	Survey of 10 DP departments	IT investment, employee satisfaction, performance, task complexity and technology level	User information satisfaction	Used DEA to calculate efficiency of each department
Kleijnen, 1979	Suggests using system dynamic simulations and gaming	Delays	None given	No examples given
Jonscher, 1983	Use microeconomics to estimate impact of information technology on efficiency and a macro-economic model to estimate impact on economy	Investment in IT	Level of economic growth	

systems fail. This is a problem of internal and external validity, and it is compounded by weak operationalizations of IT. These studies generally measure the presence or absence of IT, but do not assess the level and type of use to which it is put. Therefore, it is difficult to assess the mechanism by which the system affects enterprise performance.

Yet another problem with cost/benefit based studies is their weak concept of performance. These studies try to identify benefit, but unfortunately it is unclear what the benefits due to the system are, and there are no accepted methods for assessing them. The actual benefit obtained may be different from that expected, may change over time, or even differ for different users (Ginzberg, 1979). The best these articles can suggest is that this is a difficult problem that must be faced (Matlin), avoided (Keen), or left to the market (Strassman). Given this combination of idiosyncratic and poorly operationalized measures and case analyses, it is not surprising that there have been few solid results to date. There will be little progress in this area without a better choice of options.

One attempt in this direction was made by Ginzberg (1979), who developed a list of nine types of benefits based on a study of project proposals and justifications. Unfortunately, many of his categories are rather vague (e.g., promote organizational learning) and difficult to operationalize without a better theoretical base, a point to which we will return later.

Economic Analyses

A second group of authors try to measure performance by applying methodologies and definitions of performance drawn from economics. Cron and Sobol (1983) attempt to relate the performance of wholesale companies, measured by return on assets, return on net worth, profits as a percentage of sales, and average growth, to their use of IT, measured by ownership of computers and number of software capabilities used. Their results are inconclusive, showing that heavy users of IT tend to be either higher or lower performers than average.

Many authors have suggested measures of technical efficiency drawn from microeconomics. These authors compute how well each firm does with its resources by using some form of efficient frontier analysis. Stabell and Forsund (1983) relate a firm's use of computers to its efficiency. They first use frontier analysis to calculate the efficiency of 82 large Norwegian companies who used computers, taking as input the number of production workers and capital, and as output the sum of total labor costs and net profits. They then relate the estimated efficiency to measures of information systems use, such as the number of non-production employees (both total and as a ratio of total employees, a ratio Stabell calls "administrative intensity"), expenditures on EDP (total and as a percentage of sales), number of different applications, and number of terminals (total and per 100 non-production employees). Their results seem to show that efficiency is unrelated to firm size or any absolute measure of use of IT, but is correlated with the "administrative intensity" and to the relative DP expenditures.

Chismar and Kriebel (1985) suggest using a type of frontier analysis called data envelopment analysis (DEA) and time-series data to measure efficiency. They model the firm's inputs as investment in information technology, non-production labor and capital, and production labor and capital and provide a numerical example of the technique, using return on investment and total sales as output. They demonstrate how the technique can be used to estimate technical rates of substitution between input factors, such as IS investment and non-production labor. They also mention some unresolved problems with DEA, such as the difficulty in choosing what to measure as inputs and outputs, and the scarcity of usable data. The first concern is especially troubling since the inputs and outputs are used as a characterization of the activity and performance of the firm.

Elam, Henderson and Thomas (1984) view the information systems group itself as a production unit, taking inputs and producing some output. They use DEA to assess how successful 10 data centers are in providing user information satisfaction, given inputs of money, technology level, IS employee satisfaction, and performance and task complexity.

Another approach to the problem of productivity is the creation of an explicit model of the system. This methodology has the advantage that any assumptions about the system must be made explicitly and the effect of changing them can be quickly determined. Kleijnen (1979) advocates using system dynamics models, and suggests using simulations and laboratory games to investigate effects on productivity. At a much higher level of analysis, Jonscher (1983) uses a macroeconomic model of the U.S. economy to predict that the effect of the estimated level of investment in information technology will reverse the slowdown of economic growth by the 1980's. (We will have to wait to see if this prediction has been fulfilled.) Jonscher's conclusions rest on an estimate of the effect of information inputs on economic output through improvements in the efficiency of production and trading functions. This estimate is based on microeconomic arguments, which were calibrated for use at the national economy level.

Many of these studies done at the firm level using economic methodologies seem to suffer from much the same data problems as the cost/benefit analyses. To calculate efficiency, these studies need to measure the firm's inputs and outputs, but there is little agreement about what these should be or how to measure them. Most of these studies use very blunt and aggregate measures, taking as inputs such variables as the total investment in information systems or the amount of non-production labor. As an output, Elam, Henderson and Thomas use user information satisfaction, but it is unclear that this relates to firm productivity. Studies at the individual level obtain correlations between job satisfaction and performance of less than .2 (Vroom, 1964). Other studies use financial performance indicators such as return on assets or total sales. These variables are very aggregate products of the firms' accounting system and are not closely related to information technology impacts. To show a measurable change in these variables, an information system would have to have a huge impact at some lower level. Once again, progress in this area will be slow until we have a better idea about which performance variables to choose and how to measure them.

REFERENCE DISCIPLINES

The following admittedly simplistic model of the firm (see Figure 1) is a useful way to organize our discussion of the underlying reference disciplines. The model illustrates simply that firms take some inputs, perform some processes, and produce some outputs. The articles we have discussed in the first half of this paper investigate link 1 in this figure. The difference between the reference disciplines used by these authors affects how the research is approached and what is put in the process box.

Accounting

The first set of articles are based on some notion of productivity drawn from accounting. These studies basically ignore the process box altogether. Instead, they attempt to sum up the additional inputs (the cost) and the outputs (the benefits) and check that the output (the benefit) is greater than the input (the cost), or that the system added some value. This approach is only satisfactory when the benefits are large and obvious to compute, as was the case with systems applied to routine problems to reduce costs (e.g., by reducing clerical labor). For the less routine applications being studied today, an accounting view can give no advice about which variables to consider as inputs or outputs, explaining the prevalence of idiosyncratic measures in this area.

Furthermore, since the process is ignored, there is no way to logically link the chosen inputs to the outputs. Even a perfect cost/benefit analysis could only tell you the benefit derived from the system. It could not suggest if the benefits of one system were more worthwhile than those of other systems, if you are doing better or worse than others, or, most importantly, what you

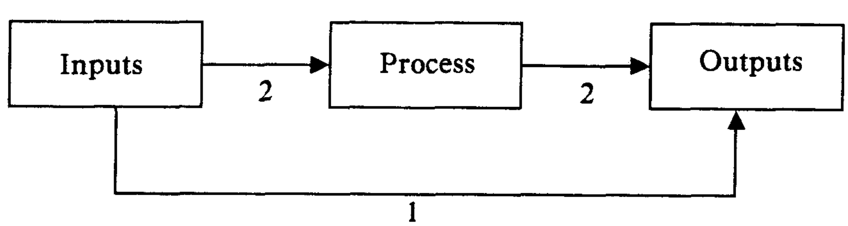

Figure 1: Input-Output Model.

could or should be doing instead. This final problem was recognized by Matlin, who wrote:

> Many companies follow the similar pattern in their search... companies apply controls to the largest, obvious expense activity--the computer. Cost and efficiency measures are reflected in the request for and production of data relating to equipment utilization, productivity, and responsiveness.... these control measures are satisfied quickly. Even though these controls are established and reporting satisfactory performance, management is not satisfied.... After spending a considerable amount of time and energy in these control activities, senior managers find that they are still frustrated in their attempts to feel good about their management of the information systems activity....(p. 33).

Microeconomics

The second set of articles we discussed draws on methodologies from microeconomics. Here the process that links inputs to outputs is modeled, but very simply using computed ratios of input to output transformation. Since we know nothing specific about the process, we find ourselves in the same position as before when we come to choose variables. Literally anything could be an input or an output of the process, and we have no theory to guide our choice. Furthermore, treating the process as a "black box" implies a static view of the firm. It is difficult for such an economic approach to model changes in the processes in the organization, possibly confounding any such study (Cohen, 1984). Kleijnen and Jonscher both suggest using some type of simulation model to fill the process box, but even so their work is not tied to any particular theory of the firm, leaving their choice of variables still somewhat *ad hoc*.

Filling the process box with a theory that links inputs to outputs (i.e., that investigates the links labeled with a 2 in Figure 1) has some obvious advantages that recommend it as an approach for future research. First, the process theory should clarify which inputs and outputs of the firm are important and may even contribute methodologies to measure them. Second, by explicitly including the processes within the firm, we can look at the impacts of IT in much more detail. Instead of standing outside and attempting to pick out small variations in, for example, return on investment, we can look at where IT directly impacts the firm and make a much more precise estimate of this impact. Finally, and most importantly, we can discover the contingencies that allow systems to affect firm performance, and prescribe the features of systems that will be useful to particular firms. As Ginzberg said:

> It is only once we understand *how* the new information will be used that its value can be estimated. Thus, efforts to quantify benefits should focus on the changes in organizational process which will result from changes to information systems (p. 535).

Many different theories about organizations could be used to fill the process box. One obvious source for such theories is the field of strategy. In a rough sense, strategic performance is concerned with long-term profits, which can be achieved either through superior revenues or superior cost performance. The utility of partitioning strategic performance into these two components is that a body of literature within industrial economics and corporate strategy relates to each, namely monopolization theory and Williamson's theory of transaction cost economics (1975, 1983). These two fields are obvious places to look for foundational theory for studying the impact of information systems on enterprise performance and they provide methodologies which could serve us well in these studies.

Market Power

The industrial economic theory of market power, or monopolization theory, provides a basis for understanding the effects of information technology on prices, market share, and revenues. Monopoly power is enhanced through attractive product differentiation and by reducing the amount of searching for suppliers performed by customers. Information technology can affect both these variables. For example, product differentiation can be achieved by bundling IT with existing products to differentiate them from competition. The size of a customer's search for suppliers can be affected with direct order entry systems and other forms of vertical information integration. This strategy has been employed most notably by American Hospital Supply (Harvard, 1985; Petre, 1985).

A supplier's monopoly power can be reduced by avoiding unique, differentiated products and by searching widely for competing suppliers. The economics of searching, which directly affect the size of the search set, are often radically altered with information technology. In fact, electronic marketplaces, much like a stock exchange, can reduce the cost of searching for the most economical supplier nearly to zero. This facilitates finding the best product at the best price and reduces any price premium that the supplier might otherwise have extracted from the firm. For example, electronic reservation systems, such as the American Airlines SABER system, have reduced the differentiation between airlines and made it possible for customers to quickly select the best flight, regardless of airline. As a result, sales by travel agencies have jumped from 35% to 70% of the total, and American now makes more money running SABER than they do running an airline (Petre, 1985).

Transaction Cost Economics

Williamson's studies of markets and hierarchies can help to explain the enterprise and industry-level impact of information technology by explaining changes in production and transaction costs. He points out that the boundaries between industries arise at those points where a market's advantage of production efficiencies outweigh the transaction cost superiority of the internal organization. Simply put, separate and specialized industries exist because at some point it is cheaper to buy a product or service than to make it. Williamson's model has been used to study the degree of vertical integration in the automobile manufacturing industry (Monteverde and Teece, 1982; Walker and Weber, 1984) and the decision to forward integrate with a direct sales force versus using manufacturers' representatives (Anderson, 1982).

Information technology has the potential to radically alter cost structures and transform the structure of industry boundaries. In some cases, functions that were once integrated into the firm may be eliminated and alternatives may be purchased in a market. In other cases, products and services that were once purchased now may be functions within the firm. IT can have this impact on industry structure by altering the relative production efficiencies and transaction costs of market and organization mechanisms, and the specificity of assets that create products.

Information Processing

Another useful source of theories for future investigations of enterprise level performance impacts is the information processing view of organizations (Galbraith, 1974; Cohen, 1984). This view includes many ideas drawn from Williamson's analysis, but goes beyond it by attempting to uncover the content of transactions and the requirements of their processing. A few articles have been published using this view to link productivity to internal features of the firm. These authors view the firm as an information processor, with a resulting focus on organizational units as processors that communicate information between themselves within the firm. Huber (1982) summarizes existing research related to information handling, identifies four key processes operating in organizational information systems--message routing, summarizing, delay and modification--and presents a number of propositions about each. Malone and Smith (1984) show how the structure of a firm affects the ways in which information can be exchanged between its subunits. Using queueing theory, they calculate the relative efficiency, flexibility and vulnerability of several simple organizational forms. Malone (1985) extends this analysis to incorporate elements of other organizational theories and shows how an information processing view can be used, for example, to explain historical changes in organizational structure. Benjamin, Malone, and Yates (1986) discuss how IT may increase the use of markets for coordination, rather than decisions within a firm.

The information processing view has a number of features that make it useful as a process theory for studying enterprise level performance impacts. First, information processing is ideally suited for interpreting the effects of IT on organizations because it explicitly addresses the ability of computers and humans to process information. This ability is in many ways orthogonal to features central to other organizational theories. For example, it is unclear what effect an electronic mail system will have on the power structure of groups in an organization, but it is more clear what it will do to their ability to communicate. The effect of IT is better reflected through certain reference theories than through others.

Second, although more encompassing, the information processing view still has ties to traditional microeconomics and to transaction economics, suggesting the possibility of borrowing some definitions and methodologies from these more developed fields. The definition of technical efficiency used in some of the studies reviewed above could be employed, for example, to examine input and output variables suggested by the information processing view. Block modeling may be a useful method for determining communications patterns within a group.

Finally, information processing suggests and permits the use of organizational simulations, as is also suggested by Kleijnen. Simulations have a number of advantages for research that are desirable in this area. First, simulations require that assumptions be made explicit, making them easier to see and the results of changing them easier to test. Second, simulations make it possible to analyze systems that are too complex for analytic solution.

CONCLUSION

The three theories we have discussed, market power theory, transaction cost economics and the information processing view of organizations, identify variables through which we can study the impact of information technology on enterprise performance. Market power theory suggests output variables related to consumers' search for products, such as the number of similar products available, the number actually considered, or the method used to search for new products. Transaction cost economics highlights the cost of transactions between entities such as customers, firms or divisions. Williamson identifies features of the environment that affect these transactions and shows how they interact with differences in production costs to change the relative advantages of market and internal production. The information processing view includes many of these transaction variables, but looks more closely at the content and processing of transactions within as well as between firms. This suggests examining more closely the pattern of communication (or who talks to whom), and the specific processing that needs to be done and the messages required.

Once we have chosen a specific process theory, we can identify interesting input and output variables and begin to investigate more precisely the possible impacts of IT. For this investigation, we can use methodologies proven in other fields, such as technical efficiency and DEA from microeconomics, or different ones suggested by the new reference discipline, such as simulations or games.

SUGGESTED RESEARCH DIRECTIONS

So far we seem to have learned little about the impacts of IT on enterprise level productivity. There have been a number of studies based on accounting data, either performing a cost/-benefit analysis or using methodologies borrowed from microeconomics. These studies, however, are flawed by a lack of theory about the processes within the firm. This absence leaves the selection of measures of performance somewhat arbitrary. Furthermore, although operational systems have been the focus of most of the work done in MIS in the past, IT is now viewed as a strategic tool, dictating a longer term view of the impacts of IT. This change in focus makes it even more important to develop sensitive measures of performance, based on strong reference disciplines and useful theories about the processes within firms. Research must be able to make prescriptions about the features of systems and organizations that contribute to successful uses of IT, as well as recognize them after they have happened. Unfortunately, most of what has been written about the strategic use of IT has lacked this strong theoretical foundation. We have seen, however, a few promising reference disciplines, such as industrial economics and the information processing view, that could guide future research.

The need for a strong reference discipline becomes even clearer when we look at the literature with the framework suggested earlier (see Figure 2). It is clear that there are still a large

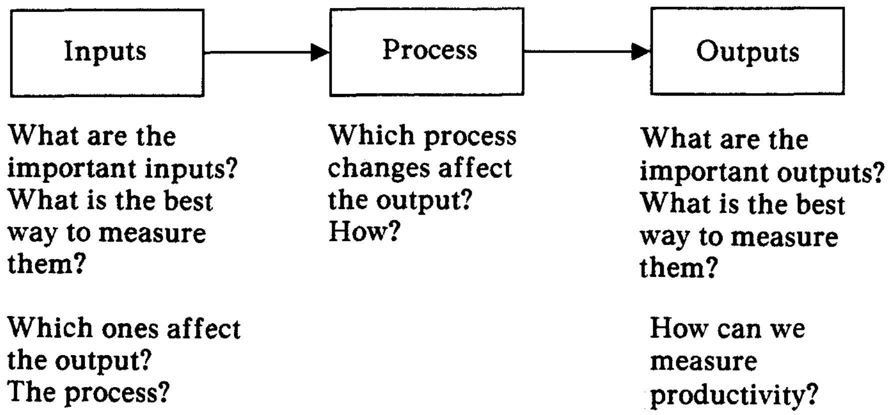

Figure 2: Input-Process-Output.

number of fundamental, yet unanswered questions. Most of these questions remain unanswered because there is no way to address them based solely on empirical studies of the inputs and outputs, the form of the majority of the studies to date. Instead, we must look for a strong theory about the processes in organizations to guide our choice of variables and to generate testable hypothesis about them. Without such a theory, we will be faced with far too many possible input or output variables and no way to control for the many interactions between them. For example in the cases of AHS and SABER mentioned above, it is clear how the use of IT is affecting the *process* of searching for suppliers and the effect this change has on the *performance* of the company.

Once we have chosen a reference discipline and thus our variables of interest, we can borrow accepted definitions and well tested methodologies to do more systematic and valid studies. These studies should cover more firms but at a more specific level. Rather than trying to use blunt measures like existence of a computer system or return on investment, we can look at precise measures of the inputs and outputs. This suggests starting with a better typology of organizational processes and the possible impacts of IT and working from there towards productivity.

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