VAR Analysis: A Framework for Justifying Strategic Information Systems Projects

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Abstract

Recently, strategic implications of information technology have attracted much attention. Many successful applications have been analyzed and frameworks have been developed to help firms identify opportunities for applying strategic information systems (SIS). However, little research has studied how these strategic opportunities can be evaluated. Previous applications of SIS have indicated that competitive advantages are not guaranteed and risks always exist. Hence, for a firm pursuing strategic uses of information technology, careful evaluation of potential opportunities before their implementation is crucial. In this article we present a competition-oriented approach to analyzing potential competitive advantages. This approach enhances the traditional cost-benefit analysis to fit the need for evaluating SIS. It consists of three major modules: value analysis, advantage analysis, and risk analysis. An example showing how a project having negative net present values can become feasible in VAR analysis is illustrated.

ACM Categories: H.1.1, H.4.2, J.1, K.6.1

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INTRODUCTION

The rapid proliferation of information technology (IT) has drawn considerable attention to its strategic implications in the past several years. A growing amount of literature has been published concerning how this technology can be used strategically to gain competitive advantages, and several successful applications, such as airline reservation systems, American Hospital Supply's ASAP system, and McKesson Drug Company's system have been widely discussed.

In contrast to these success stories, however, cases where information systems generate little competitive advantage also exist. One example is the automated teller machine (ATM). Most commercial banks spend a substantial amount of money to maintain their ATMs, which provide almost no competitive advantage for an individual bank (Banker and Kauffman, 1988; Zimmer, 1987). Another example is the TWA self-service ticket machine that sells tickets directly to the customer. These machines failed to be accepted by customers, even though they could provide convenient service (Gifford and Spector, 1984). The failure of Bank of America's MasterNet system was reported to have cost the bank 45 million dollars (Rifkin and Betts, 1988). A recent empirical study investigating electronic integration and strategic advantages in the insurance industry reports no increases in premiums, commissions, or operating efficiency by the introduction of computers (Venkatraman and Zaheer, 1990).

In fact, because of the environmental uncertainty and the competitive nature of strategic information systems (SIS), risks associated with SIS projects are much higher and the impact of system failure is much more severe compared to conventional data processing systems. For instance, the failure of MasterNet "totally wrecked the trust accounts business it was supposed to energize" (Edelhart, 1988). Before pursuing opportunities for SIS projects, therefore, it is important for a firm to evaluate their costs and benefits carefully.

This article will present a framework called Value-Advantage-Risk (VAR) analysis to help evaluate these opportunities. The framework improves existing cost-benefit analysis by considering the nature of SIS and suggests that SIS projects be evaluated by three dimensions: (1) the potential value of the system, (2) the extent to which competitive advantages can be attained, and (3) the risks associated with the project. Because competition is very dynamic and strategic planning usually requires predictions of future events, the evaluation of SIS opportunities is complex and difficult. The proposed framework provides a systematic approach to support this task.

CHARACTERISTICS OF STRATEGIC INFORMATION SYSTEMS

Before discussing SIS evaluation, it is necessary to discuss the nature of these systems. The essential concept of SIS is to apply IT to gain competitive advantage, such as by increasing bargaining power and creating higher entry barriers. Broadly speaking, SIS can be defined as information systems that generate internal and comparative efficiency (Bakos and Tracy, 1986). Although they may look like transaction processing systems (TPS) or decision support systems (DSS), most existing SIS examples, such as SABRE and ASAP, suggest certain common characteristics that make them different from traditional TPS and DSS.

A typical TPS, such as a payroll or order entry system, emphasizes processing efficiency and focuses on tangible costs and bene-fits. System development is usually triggered by the need for improving the efficiency of internal operations. The task to be processed is structured and the uncertainty of benefits is low. Evaluation of these systems often can be done by a traditional cost-benefit analysis.

Traditional DSS concentrate on decision support and the intangible benefits which result from improving the effectiveness of decision making. Its development must consider both environmental factors and internal operations (Sprague and Carlson, 1982). Because some of the anticipated benefits are intangible, the uncertainty is higher for developing DSS. Value analysis is considered more appropriate for evaluation (Keen, 1981).

Compared to traditional TPS and DSS, an SIS can be described by at least three characteristics: linking multiple parties, providing direct benefits to the involved parties, and affecting the competition. First, SISs usually involve multiple parties outside the organization. For example, an airline reservation system involves airlines and travel agents. The ASAP inventory system involves American Hospital Supply and the participating hospitals. Traditional TPS and DSS are normally used within a single organization

The second feature of SIS is that they benefit all involved parties directly and have significant impact on the way those organizations do business. For example, an airline reservation system benefits both the airlines and travel agents. It provides airlines with more information about passengers and flight scheduling, and allows travel agents to make reservations more efficiently and conveniently. Traditional systems directly benefit only one organization, such as payroll systems that save costs for the organization directly, but provide no direct benefit to its customers or suppliers (although part of the cost savings may be transferred indirectly to customers through lower prices). A system that links multiple parties does not neces-sarily change the way businesses are run. An E-mail system linking travel agents will have less impact than a reservation system.

The third feature of SIS is that their benefits are often affected by competition. Because one of the primary impacts of SIS is to outperform competitors in dealing with customers or suppliers, development of SIS must take competitors' reactions into consideration. For example, since American Airline's SABRE reservation system was implemented, most airlines have developed similar systems or have taken legal action to retaliate. This has restricted SABRE's advantages. Competitors' reactions may have a significant impact on the anticipated benefits of SIS, but this is not true for TPS or DSS. The cost savings that result from a payroll or accounting system are rarely affected directly by a competitor's implementation of a similar system.

These three features indicate that SIS are more environment-oriented and may face higher uncertainty, as shown in Figure 1. Although some early SIS created in the 70s may have developed serendipitously and become successful through luck, the increased awareness of the importance of SIS makes a careful planning and evaluation crucial to successful implementation.

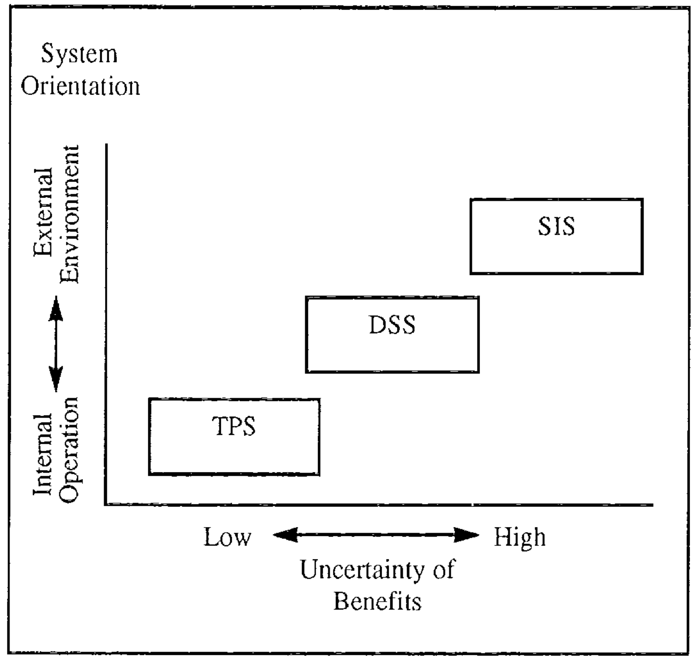


Figure 1. Three Different Types of Systems

VAR ANALYSIS

Previous literature in information systems has reported at least two different approaches to evaluating the financial impact of information systems: cost-benefit analysis and value analysis. A traditional cost-benefit analysis uses quantitative measures to assess the costs and benefits of information systems. This approach usually is recommended for evaluating data processing systems whose primary costs and benefits are tangible. For DSS focused on intangible benefits, value analysis that stresses "value first, cost second" is considered more appropriate (Keen, 1981; Pieptea and Anderson, 1987). In addition, various approaches, such as using surrogate measures, are available for giving monetary value to intangible benefits (Emery, 1987). Since the costs and benefits of SIS are not only intangible but also dependent upon competitors' reactions, evaluation of these systems must consider environmental uncertainty and the competitors' strategies; hence, neither of the above approaches is adequate.

The VAR analysis for evaluating SIS opportunities incorporates competitors' strategies into the evaluation process and suggests that managers assess not only the potential benefits of the system but also to what extent the potential benefits can be converted into competitive advantages. This analysis is useful when a firm is exploring SIS opportunities or analyzing the economic feasibility of implementing a particular SIS project.

VAR analysis includes three components: value analysis, advantage analysis, and risk analysis. Value and competitive advantage are defined differently in this context. The value of a proposed system is the incremental contribution of the new system compared to the current system. Competitive advantage is the difference between the value of the system and that of similar systems used by competitors. The competitors' reactions are incorporated in this step. Risk analysis requires managers to assess the risks associated with different competitive situations.

VALUE ANALYSIS

To illustrate the VAR analysis, we shall use an example of a wholesaler who would like to develop a retailer order system to link with its retailers. The retailer order system is considered to be an SIS because it meets the criteria described earlier. Value analysis is grounded on a cost-benefit analysis. For any system, the first step in a financial evaluation is to determine the costs and benefits of the system. An SIS is no exception. The value of a system is defined as the anticipated net cash flow minus costs. In this stage, competitors' possible reactions are not yet taken into consideration. Benefits that may be affected by competitors' strategies are not included.

The procedures of value analysis are very similar to the traditional cost-benefit analysis. First, the time frame for analysis must be determined. Then tangible and intangible costs and benefits must be estimated for each year within the time frame. Most of the tangible benefits of SIS result from the improvement of operating efficiency and are reflected as cost and time savings. Traditional cost-benefit analysis methods developed for evaluating other types of information systems can be applied to calibrate the tangible benefits. For example, a retailer order system can significantly reduce the time and effort required for processing orders. If the system is estimated to have a life of three years and it can reduce the number of order entry clerks with an average salary of $20,000 each by thirty after the first year, then the total amount of cost savings for the second and third year would be $600,000 each.

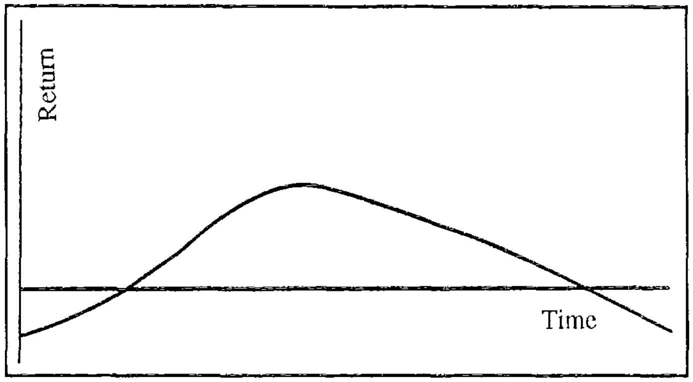
The tangible costs in the first year may include equipment acquisition, software development, user training, etc. Assuming that the total tangible costs are $800,000 for the first year, and $200,000 for each of the second and third years, then the net cash flows are -$800,000, $400,000 and $400,000 respectively.

In addition to the tangible benefits, it is also important to assess the intangible benefits that are affected by competition. Previous literature has identified several approaches to converting intangible benefits to their corresponding monetary value. One of the popular methods is to use surrogate measures. For instance, the retailer order system can improve the accuracy of order processing and customer service. These benefits can be estimated by surrogate measures such as time spent on handling ordering errors and time spent on processing customer complaints. If we estimate that the total time spent on error correction and customer complaints can be reduced from two man-years to one man-year at $24,000 per man year for the second year, and to 1/2 man-year for the third year, then the intangible benefits can be determined to be $24,000 ($24,000 * (2 - 1)) and $26,000 ($24,000 * (2 - 0.5)), respectively. These must be added to the tangible benefits estimated earlier. The net cash flows after adding intangible benefits become -$800,000, $424,000, and $436,000.

The result of the value analysis is a value cycle that shows the net cash flow for each year. The net present value (NPV) of the project can then be calculated and used to decide whether the project is financially justifiable before taking competition into consideration. If the discount rate is determined to be 10% in our example, then the NPV of the retailer order system project is -$54,215. The negative NPV indicates that, based on the traditional cost-benefit analysis without taking into consideration the strategic nature of the system, the project is not worth implementing.

This is a simplified example for illustrating the procedures of traditional analysis. In a real-world situation, the time frame for SIS is usually longer than three years and the value cycle may not be a monotonic increasing function. The net cash flow may be decreasing due to higher maintenance costs after certain years. Figure 2 shows a sample value cycle. Furthermore, the selected discount rate has a significant effect on the resulting NPV. These issues, however, are common in information systems evaluation and hence not discussed here in detail.

Figure 2. Value Cycle of an SIS



ADVANTAGE ANALYSIS

Following the traditional cost-benefit analysis, we must assess the strategic benefits of SIS, such as higher entry barriers and increased bargaining power. By "strategic benefits," we mean those benefits that are affected by competitors' strategies. For example, the investment on the retailer order system may increase the economies of scale and hence raise the entry barriers for new wholesalers. The system may also increase the costs for retailers to switch to other wholesalers and, as a result, increase the wholesaler's bargaining power over its retailers.

Since strategic benefits are determined jointly by the firm's and competitors' strategies, both must be considered when assessing competitive advantage. For each firm there are two generic strategies for developing SIS: proactive and reactive. The proactive strategy requires the firm to be an innovator; whereas, the reactive strategy suggests the firm to be a follower that quickly copies or leapfrogs a valuable application. The innovator has a better opportunity to create competitive advantages by having early profits and an opportunity to define the market. Followers, however, are able to take advantage of new technology and avoid innovation risks.

Miles and Snow (1978) classified organizations into four categories: prospectors, defenders, analyzers, and reactors. A prospector is an organization with an aggressive competitive strategy that attempts to pioneer in product/market development. A defender is an organization with a conservative competitive strategy that engages little new product development. An analyzer is an organization with a mixture of competitive strategies. It may be aggressive in some markets but conservative in other markets. A reactor is an organization that does not have a consistent competitive strategy and cannot effectively respond to their organizational environments. Generally, prospectors and analyzers are more likely to use the proactive strategy while defenders and reactors are more likely to use the reactive strategy.

When the competitors' strategies are taken into consideration, firms face four possible situations (as shown in Figure 3) when they evaluates an SIS project. The advantages and risks associated with each of these situations must be carefully assessed. The discussion is simplified to show how to incorporate competitors' strategies in advantage analysis. In reality, the situation is often more complicated. We have to consider multiple competitors who may choose different strategies as well as different timing for implementation.

In advantage analysis, the competitive advantage resulting from an SIS is defined as the additional benefits due to the difference between the firm's system and competitors' systems. If the firm and its competitors are both taking the proactive strategy, then a business war is underway. In this case, the quality of the system is the key factor that determines competitive advantage. The better system will be able to convert its premium into advantages and the firm with less information and financial resources will lose competitive advantage.

Competitor's Strategy \ Firm's Strategy	Proactive	Reactive
Proactive	War	Defense
Reactive	Offense	Peace

Figure 3. Four Competitive Situations

In offense and defense situations, innovators develop an SIS and followers mimic or leapfrog the system after a certain lead time. Because the firm and its competitors react to each other's strategies, the innovator has certain first-move advantages, such as early profits and control of certain critical resources, whereas followers have second-move advantages such as newer technology and lower innovation risks (Porter, 1980). We can see that advantage created by the innovator's SIS will decay over time and the competitive advantage has a lifecycle called the competitive edge lifecycle (CELC). Based on the changes in competitive advantage, the lifecycle (shown in Figure 4) can be divided into four stages: introduction, growth, maturity, and obsolescence. In the figure, the upper half presents the innovator's and the follower's value cycles (changes of cash flows over time), and the lower half illustrates the CELC of the innovator's system.

In the upper half, the innovator's value cycle indicates how the cash flow (to the innovator) of the innovator's system changes over time. The follower's value cycle indicates the innovator's estimation of the changes in the average cash flow (to the follower) of a similar system developed by a competitor, if competitors decide to follow. Because of technological advances and other strategic moves (such as a major improvement in system functions), the innovator's and follower's value cycles may be different in shape. The lower half shows that the innovator's competitive advantages equal the difference between the two value cycles.

Note that the offense and defense situations described above assume that once a system is proven successful all remaining firms decide to imitate or leapfrog simultaneously (called

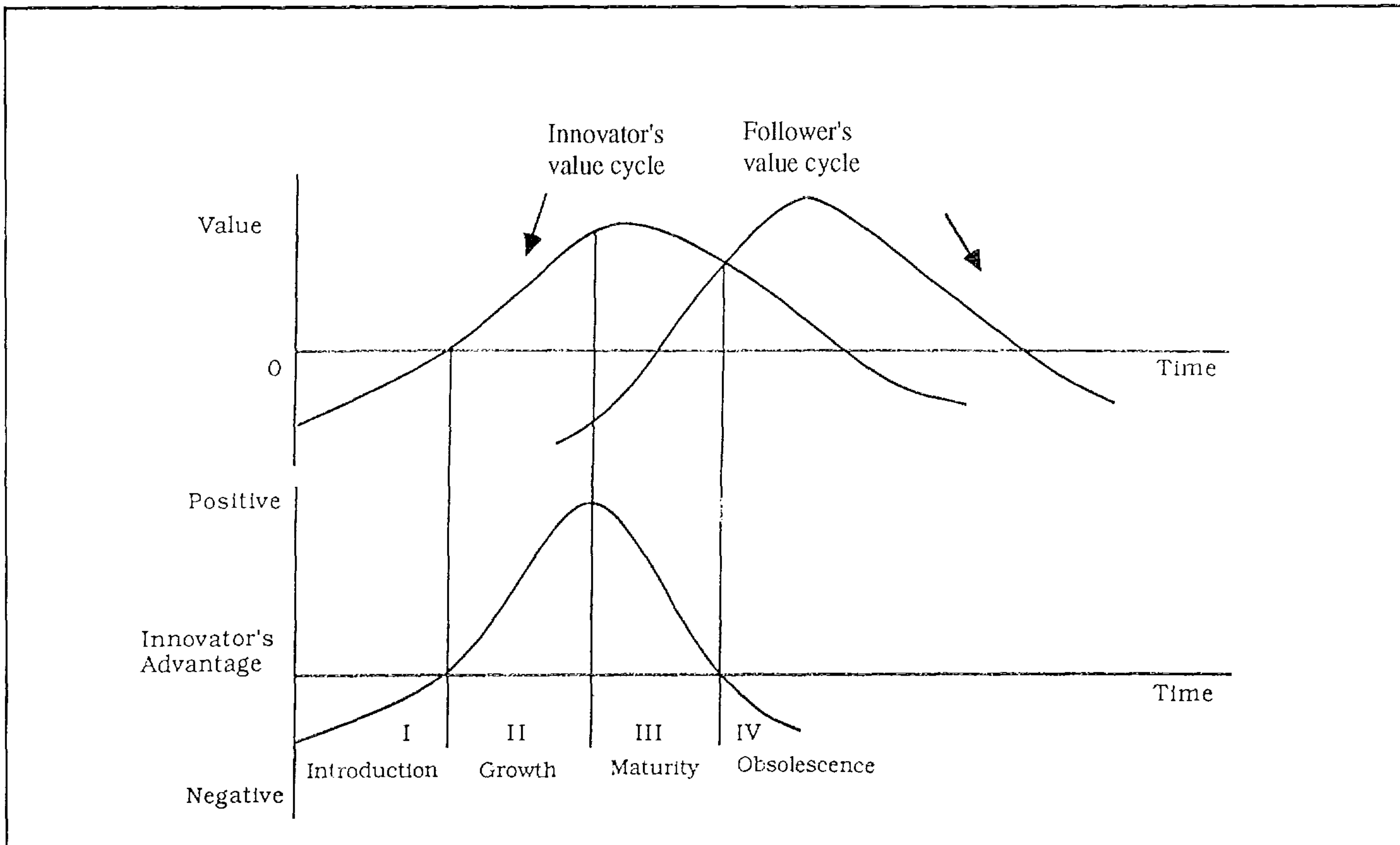


Figure 4. Competitive Edge Lifecycle

simultaneous entry). Although sequential entry, in which the remaining firms develop similar systems at different times, is more likely in reality, simultaneous entry is the worst case of sequential entry for the innovator. In other words, if the innovator's system is successful, the worst case for the innovator is that all competitors develop similar systems at the earliest possible time. The assumption of simultaneous entry makes the resulting advantage analysis conservative. If a firm feels a more aggressive estimation is appropriate, it may divide the followers into three or four groups. The core concept of advantage analysis, however, is not affected by the number of groups into which the followers are divided.

There is a special case in which the competitors decide not to develop competing systems. Then, there will be no follower's value cycle and the CELC will be equivalent to the innovator's value cycle. The value anticipated by the innovator can be fully converted into advantage.

Given these four situations, estimation of strategic benefits must be conducted for each of them. Furthermore, we have to convert strategic benefits into monetary values to combine strategic benefits with traditional benefits. Since most strategic advantages are intangible, surrogate measures are necessary. Generally speaking, strategic benefits can be divided into two categories: benefits across the whole industry and benefits specific to the firm. For example, higher entry barriers can increase the average profitability of an industry, whereas higher customer switching costs can increase the bargaining power of a firm over its customers.

Estimation of Industry-wide Advantages

Benefits across the whole industry are shared assets among all firms. They can be realized only if the majority of the firms in the industry take similar actions. For example, higher entry barriers due to the capital investment in information systems (e.g., ATMs in consumer banking) become crucial only after the majority of banks implement the system and take advantage of the entry barriers. If all firms in an industry take a similar action, however, the likelihood of a price war usually increases unless some sort of collusion takes place. Therefore, in estimating industry-wide benefits, we must determine the potential benefits and the degree to which these benefits can be transferred to a firm separately for both price-war and no-price-war cases. Then the share of the benefits attainable by a particular firm can be estimated.

Since higher entry barriers are intangible, surrogate measures are again necessary. The benefits of higher entry barriers due to capital investment in information systems, for example, can be estimated by multiplying the estimated increase of overall profits due to the system by the market share of the firm. This requires the following data: (1) total profit of the industry, (2) regular average increase in profits without the system, (3) estimated increase in profits after the majority of the firms implement the system (with and without a price war), (4) estimated lead time for imitation, and (5) market share of the firm. The total profit of an industry, regular increase in profits, and market share of a firm usually are available.

Estimating the increase in profits after most firms implement the system is more difficult and subjective. We may have a group of experts using the Delphi method to estimate the impact of the system on the profitability of the industry. We may also investigate systems that have been implemented in industries with similar characteristics to find their impact. Imitation time can be estimated by the number of years we expect to complete the project, with adjustments for the speed of technological progress.

Once these data are obtained, we can estimate the fair share of a firm. We assume that the following data have been collected for our retailer order system.

(1) Total profit of the industry = 50 million dollars
(2) Regular average increase in profits = 1%
(3) Profit increase with the system (no price war) = 2%
(4) Profit decrease with the system (price war) = -0.5%
(5) Lead time for imitation = 1 year
(6) Market share of the firm = 5%

If all incumbents find the opportunity and decide to implement the system, this would increase the entry barrier. If no price war occurs, the profitability would increase from 1% to 2% for the second and third year (there is no effect in the first year when the system is under development). Therefore, the monetary value of higher entry barriers is estimated to be $25,000 (50 million * 5% * (2% - 1%)) for each of the second and the third years. Should a price war take place (e.g., some banks offered incentives to their customers for using their ATMs), then the monetary value of higher entry barriers may not be able to offset the loss. The estimated net value in this example would be -$37,500 for the second and third years. Therefore, the net effect of entry barriers depends upon the likelihood of a price war. If the firm estimates that there is a 30% chance of having a price war, then the expected benefits would be $6,250 ($25,000 * 0.7 - $37,500 * .3) for the second and third year.

In the case of offense, where the firm develops the system and the competitors imitate in the second year (one year lead time), the effect of entry barriers will not be effective until the third year (assuming that all firms have similar systems installed). It becomes more complicated if some firms decide to leapfrog. As a result, the monetary value of the higher entry barriers is $0, $0, and $6,250. The value in the no-price-war situation is $0 for all years.

It is possible that more factors can be included in the estimation of allocating industry-wide advantages to individual firms. For example, a firm may decide that the market share of the firm is different when a price war occurs. In this case, the firm may use different market shares to calculate its share of benefits. The general procedures should be similar to those illustrated above. In addition, there may be some factors that affect the likelihood of a price war. This needs to be analyzed in the risk analysis.

Estimation of Firm-specific Advantages

Strategic benefits specific to a firm can also be estimated by surrogate variables. In our example of the retailer order

[1]Because there may be many followers, we may use the average figure when there are many small competitors and use the major competitor's figure when there exists only one.

system, the most likely strategic benefits specific to the firm is higher customer switching costs. A proper surrogate measure for this benefit would be an increased percentage of orders from existing retailers. Because certain setup costs are involved in dealing with new customers, a low customer switching rate means savings in these setup costs. We assume that the following information about the wholesaler is available:

(1) Total number of retailers = 100
(2) Current turnover rate per year = 5%
(3) Estimated turnover rate after implementing the system = 4%
(4) Setup costs for a new retailer = $2,000

These data allow us to estimate the monetary value of the benefits due to higher customer switching costs. Because the system has one year of development time and one year of lead time for imitation, the estimated value would be $20,000 ($2,000 * 1,000 * (5% - 4%)) for the second and third years in the price war and offense situations, $20,000 for the third year in the defense situation, and $0 in the peace situation.[2]

In addition to maintaining existing customers, the system may also increase the firm's capabilities to bring in new customers. Here, new customers include customers switching from competitors as well as brand new customers. Customers willing to switch may be estimated by the total number of existing customers and the average customer turnover rate of the industry, and brand new customers can be estimated by average customer growth. The capability of a system to attract new customers can be converted into monetary value by multiplying the estimated increase of new customers due to the system and the estimated profit each new customer could bring in.

With the retailer order system, we assume that the industry includes 20,000 retailers with an average growth rate of 0.5%, the average turnover rate of existing retailers is 6%, and the firm can attract: (1) 5% of the new customers if all firms implement the same system or implement no system, (2) 7% of the customers if only the firm implements the system, or (3) 4% of the customers if the firm does not implement it but competitors do. In addition, each new customer brings in an average profit of $2,500. These numbers can either be estimated by experts or be assessed by market research.

In our example, the system is not available in the first year. No benefits exist. In the second year, the anticipated benefit in a price war is $0. The anticipated benefit in the offense situation is 26 new customers or $65,000 ($2,500 * 20,000 * (6% + .5%) * (7% - 5%)). The anticipated loss in a defense situation is 13 customers or $32,500 ($2,500 * 20,000 * (6% - 5%) * (4% - 5%)). There is no benefit or loss in a peace situation. In the third year, followers should have finished their systems (based on the one year lead time), and no extra benefit exists for a particular firm if we assume their systems are equivalent in quality. If we assume that the competitors will leapfrog, then a deficiency may occur.

In summary, the advantage analysis suggests that managers use surrogate variables to estimate the anticipated competitive advantages. These figures can then be added to the results obtained in the value analysis. In our example, the cash flows of the retailer order system, after value and advantage analyses, are as follows:

	Years of Implementation			
Situation	1	2	3	4
War	(800,000)	450,250	462,250	0
Offense	(800,000)	509,000	462,250	0
Defense		(800,000)	391,500	462,250
Peace	0	0	0	0

Table 1. Cash Flows of Retailer Order System

The result of the advantage analysis is a decision tree indicating potential advantages for each of the four competitive situations—peace, offense, defense, and war. The NPVs for the war, offense, defense, and peace situations are -$20,882, $44,752, -$56,423, and $0, respectively. The decision tree for the retailer order system can be shown in Figure 5, in which the probabilities are estimated in risk analysis.

RISK ANALYSIS

Risk analysis assesses the uncertainties of outcomes. A good risk analysis can significantly reduce the chance of surprise. Because the successful implementation of SIS is strongly affected by the environmental uncertainty and the competitor's reactions, risks may be associated with all potential strategic benefit, including basis of competition, entry barriers, switching costs, balance of power, and new products or services (Vitale, 1986). In general, these risks fall into several categories[3]:

Technological Risks

The technological risks are two-fold. On the one hand, the technology obsolescence may be faster than expected, which reduces the anticipated benefits and hence cuts back the potential advantage. On the other hand, as the technology advances, the use of IT may actually reduce the switching costs rather than increase them. For example, new technology may make it easier for the followers to imitate the innovator's system or to develop a better system in a very short time. In this case, the innovator will lose advantage.

Financial Risks

Developing SIS requires a substantial investment of financial resources which may weaken the firm's advantage in other areas. In addition, this is not a one-time project. Given the CELC, existing systems must be modified or new systems must be implemented to alleviate the reduced advantage caused by the obsolescence of the old system. Therefore,

[2]An alternative to assessing the value of switching costs from the changes in turnover rate is to determine the value from changes in prices. In other words, given the same turnover rate, higher switching costs allow the wholesaler to charge a higher price. The firm may estimate the degree to which the price difference between implementing and not implementing the system may be acceptable to its customers.

[3]The list is not intended to be complete. For a comprehensive list of information systems risks and constructs, see Cash, McFarlan and McKenney, 1988, pp. 161-178.

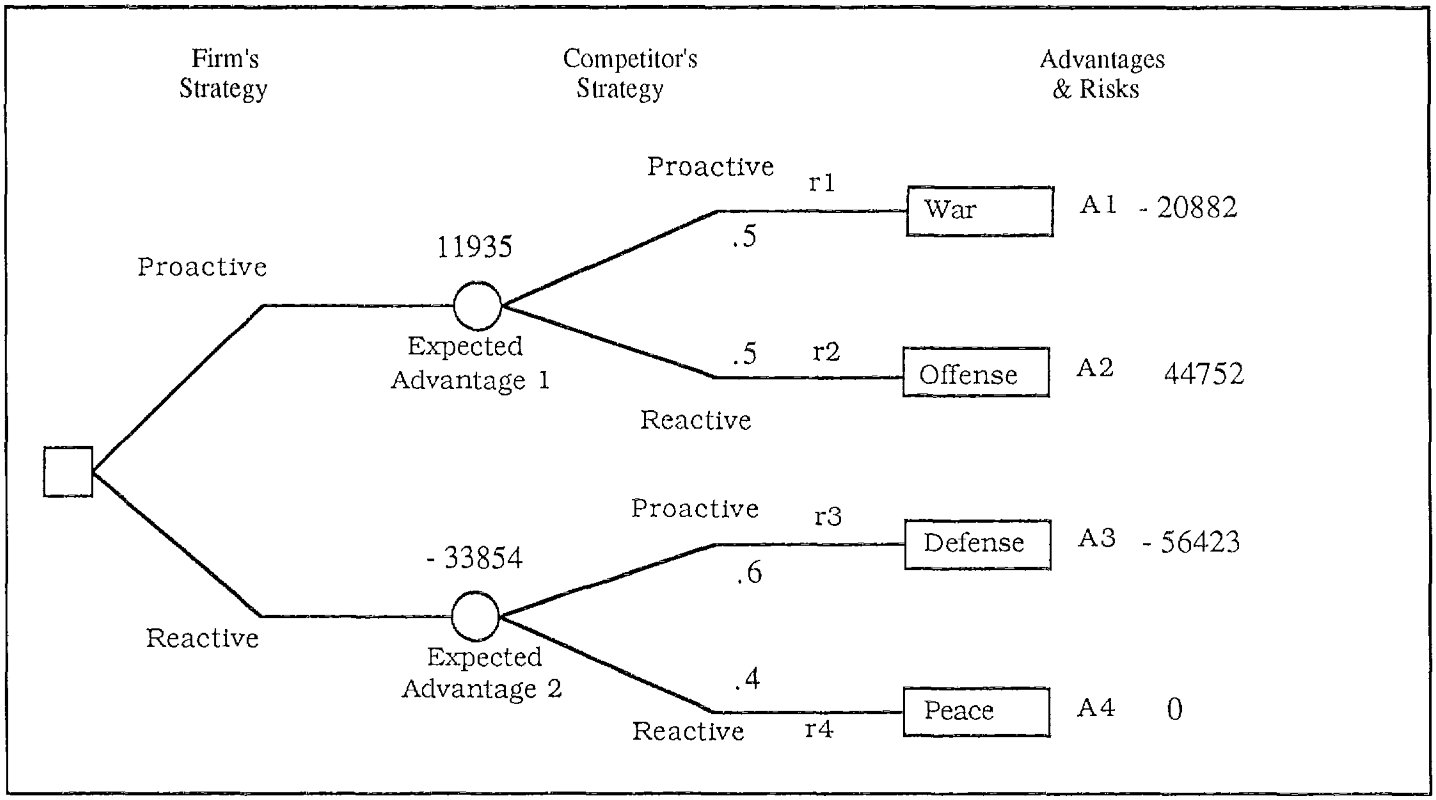


Figure 5. Decision Tree Analysis

unless a firm has a long-term financial commitment to maintaining and updating SIS, the chance of failure would be high.

Implementation Risks

Any IS project is subject to the risk of system development and implementation. For example, employees may resist using the system. This is particularly important for SIS because these systems usually involve several parties with different objectives. The failure of self-service ticket machines is an example. Although the developers considered the machine valuable, customers saw it differently.

Strategic Risks

An innovator may not always gain a better competitive status. An incorrect strategy may initiate an unanticipated price war that causes a substantial loss. In addition, a successful system may result in legal retaliations from competitors (e.g., American Airlines has been sued for unfair competition).

Risk analysis for SIS includes two steps: (1) determining uncertainties associated with the firm, and (2) determining uncertainties associated with competitors' actions. Uncertainties due to the firm itself include the technological, financial, implementation, and strategic risks. The first three are related to the implementation of the project and the fourth is related to the choice of proactive or reactive strategy. Their estimation must be done separately. For risks related to the project, a key point is that they are conjunctive; that is, if any of them comes true, the whole project fails. Therefore, we can have experts estimate separately the likelihood of having technological, financial, and implementation problems and then aggregate these figures. For example, if the expert's estimation of having technical, financial, and implementation problems that may damage the retailer order system is 0.1, 0.1, and 0.2, respectively. Then we can calculate the likelihood that the system will be successful as 0.648 (0.9 * 0.9 * 0.8). Strategic risks are hard to measure and can be taken into consideration by defining a profit range for triggering a strategic move. This range serves as an insurance for strategic risks. For example, we may define a range of ±$10,000 for the retailer order system. No action will be taken unless the calculated results exceed the defined range.

Uncertainties of competitors' actions indicate the likely situation the firm is going to face after the decision. We need to assess the likelihood that each of the four situations happens. These likelihood estimations have significant effects on the choice of a strategy for a firm. For example, the probabilities shown in Figure 5 indicate that if the wholesaler develops the retailer order system, there is a 50% chance that the competitors will follow in the second year and 50% that the competitors will not follow. If the firm decides not to develop the system, then there is a 50% chance that at least one competitor will develop a similar system as an innovator and a 40% chance that nothing will happen.

Unfortunately, there seems to be no single best method for assessing these risks. One possible approach is to list all factors that may affect the likelihood of each competitive situation, assess the possible risk due to individual factors, and then aggregate them (Cash, McFarlan and McKenney, 1988). For example, the factors that affect the likelihood of having a peace situation include the willingness of major competitors developing similar systems and the major competitors' capability to imitate the system. The willingness can be estimated by examining the competitors' past strategies. If the major competitors are prospectors and analyzers, as classified by Miles and Snow, then their willingness to compete head-to-head would be high. The competitors' capabilities to carry out a similar project depends on their technological and financial resources, as well as their ability to implement. Again, what we can do is to estimate competitors' capabilities. In our example, suppose that our major competitors usually are aggressive and their willingness to compete is 80% and the likelihood that they may have some technical, financial, and implementation problems is 0.1, 0.1, and 0.1, respectively. We can calculate the overall likelihood that the competitors will develop a similar system, if we are proactive, as (0.8) * (0.9)3 or 58.3%.

DECISION CRITERIA AND OTHER COMPLICATIONS

Given the results of value, advantage, and risk analyses, a decision about whether to develop the system can be made. In game theory, there are several possible criteria for selecting a strategy. For example, a minimax criterion requires that the strategy whose maximum loss is the lowest be selected. In our example, this criterion suggests developing the system because the maximum loss is lower (-\$20,882). A maximax criterion requires that the strategy whose maximum gain is the highest be selected. In our example, the firm still should develop the system because its maximum gain is higher (\$44,752). A drawback of these strategies is that both are easily affected by extreme situations. Furthermore, neither takes into consideration the risks we estimated.

To incorporate risk factors, we can use the expected value method that chooses the strategy with the highest expected value. In the retailer order system, the decision is the same because the expected value of developing the system is \$11,935, whereas the expected value of not developing the system is -\$33,854. Once the strategy is chosen, we compare its expected return with the strategic risks that may be involved (remember, we specified a range of ±10,000 as an insurance). In this case, the return exceeds the range and hence the wholesaler should go for the SIS project. This example shows how an SIS can be evaluated positively, although the traditional cost-benefit analysis suggests a negative NPV.

In addition to the previous simplified two party description, VAR analysis can be formulated as a formal model to illustrate the economic intuition behind SIS justification. We assume that an SIS, like a new product, is an innovation and follows a new product diffusion process. The likelihood for a firm to adopt an innovation is an increasing function of the number of firms that have already adopted it (Davies, 1979). Let N be the total number of potential adopters, N_t be the number of adopters up to time t, and the number of remaining adopters at time t is $N-N_t$. The diffusion theory usually assumes that, at time t, the percentage of the remaining potential adopters who will adopt the innovation is a linear function of existing adopters, i.e., N_t/N. Therefore, at any given time t, the number of firms adopting an SIS idea, N(t), is:

$$(1) \quad N(t) = \frac{dN_t}{dt} = \frac{\beta N_t}{N}(N-N_t)$$

Where ß is the imitation rate. The higher the imitation rate, the shorter time it takes for the follower to imitate the innovator.

For an SIS project, there is usually a lead time T_1 before the followers imitate the system. Let $\pi 1$ be the unit instantaneous benefit of the innovator before T_1, let π_2 be the unit instantaneous benefit of each firm after T_1, and assume that all remaining firms develop similar systems and have equal competitive advantages (i.e., having the same profit share) after T_1 (this is the worse case for the innovator). Then, at the discount rate of r, the innovator's overall benefit, Π_0, is:

$$(2) \quad \Pi_0 = \Pi_1 + \Pi_2, \text{ where}$$

$$(3) \quad \Pi_1 = \int_0^{T_1} \pi_1 N(t)\exp(-rt)dt$$

$$(4) \quad \Pi_2 = \int_{T_1}^{\infty} \frac{1}{M} \pi_2 N(t)\exp(-rt)dt$$

where M is the total number of firms adopting the system.

Based on this information, if the investment of the SIS project is I (where $I < \Pi_2 < \Pi_0$), then all firms should invest in the project as early as possible because all firms implementing the system will have positive returns. If $\Pi_2 < I < \Pi_0$, then only the innovator's system can be financially justified because followers may not be able to make profits unless they develop a superior system that changes Π_2. If $\Pi_0 < I$, then the project should not be implemented.

APPLICATION ISSUES

The first question most people would ask is how to obtain the numbers for the VAR analysis. We described several ways for estimating different factors, such as the Delphi method. Some of the necessary data can be collected from databases (such as average industry profitability and market share), while others must be estimated by experts. Expert judgments are subjective and can be erroneous. However, this is the only option available until a better method is developed. The problem is common to all economic evaluation methods.

A second issue related to using VAR analysis is the dichotomous classification of innovator/follower and proactive/reactive. They are used here to simplify the discussion. In reality, of course, an industry usually consists of multiple players, each having different levels of willingness and capabilities to use information technology, different competitive strategies, and different timing preferences for entering the competition. How can we analyze this kind of complicated real world case? The best approach to performing VAR analysis for real world cases is simulation. In addition to a point estimation for factors such as implementation risks, we can give it a range and integrate them into a simulation program. This is an approach that has not been proposed by existing literature on information systems evaluation. The major advantage of using simulation is that it allows the competitive nature of SIS to be encoded and sensitivity analysis to be done easily. A simulation software for this purpose is under development.

The third question some people would ask is, "Given the uncertainties involved in SIS, can we trust the numbers resulting from the VAR analysis?" The answer depends on whether you believe in rational decision making. True, there are so many factors that may result in significant differences between the predicted and actual outcomes. If we did the analysis and things do not go our way, we can at least look back to find where we figured wrong and correct it in future analysis. There would be no learning and improvement otherwise.

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