The Dynamics of the Escalation Phenomenon

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ABSTRACT

The "escalation phenomenon" (Staw 1976; Staw and Ross 1978) refers to the tendency for decision makers to "throw good money after bad," that is, to invest beyond the point where benefits equal costs. The commonly accepted view is that such "escalation" occurs as a result of decision makers becoming overcommited to a previously chosen course of action through a series of decision errors. This paper presents a generic system dynamics model of resource recommitment behavior that is able to produce "escalation" without the presence of decision error. Implications of this model to the theory and practice of project management are discussed.

INTRODUCTION

The propensity for people to recommit resources to failed or failing projects has been the subject of a rapidly expanding literature in the behavioral sciences over the last several years. This tendency to "throw good money after bad," that is, to reinvest in a project beyond the point where benefits equal costs, is referred to as the "escalation phenomenon" (Staw 1976; Brockner and Rubin 1985; Staw and Ross 1987).

The behavioral dilemmas that "escalation" represents are thought to be common in every-day life. Simple examples of potential escalation situations include deciding when to repair an aging automobile, when to take a possibly ill child to the doctor, or how long to wait when one is placed on hold for a telephone call. Each of these situations involves the receipt of information that something has gone wrong, but also "...where potential actions aimed at curing the problem may actually deepen or compound the difficulty" (Staw and Ross 1987, 40). More complex situations, such as the U.S. government's recommitment of resources to the war in Vietnam, and the provincial government of British Columbia's decisions to proceed with the recent world exposition, EXPO 86, in Vancouver, have been described as prototypical of the phenomenon. In these cases, it is argued that decision makers erroneously reallocated resources to failing strategies.

Theoretical explanations for escalation behavior have been advanced from two distinct perspectives which we have elected to call the: 1) Decision error perspective; and 2) No decision error perspective. Proponents of the first, and most common framework in the literature, argue that escalation occurs as decision makers become overcommited to a course of action. They become locked-in to a strategy hoping to justify their previous decision(s) to invest in a project. This need to justify prior behavior represents a departure from the economic rationality of an issue. In other words, the psychological influence of past commitments can override the maximization of future utility assumed by expected utility models. Because there is thus a violation of normative rules for decision behavior (e.g., Nisbett and Ross 1980), "decision errors" are presumed to have been made. From this perspective, the end purpose of understanding escalation to a failing course of action is to prevent its occurrence. If decision makers avoid or overcome their dysfunctional biases which prevent them from behaving correctly, they can avoid overcommiting to failed courses of action.

A recent article by Bowen (1987), however, presents an alternative perspective on the issue. Focusing on the implications inherent in the notion of "decision error," Bowen argues that such errors cannot occur, due to the non-programmable nature of strategic decisions. Indeed, he argues that the concepts "failure" and "correct" should not even apply to ill-structured decision situations. Thus, in contrast to the decision error perspective, the purpose of understanding escalation is to understand the make-up and development (i.e., enactment: Weick 1979) of subjective decision criteria that provide the basis for expectations in uncertain strategic circumstances. If project managers can make explicit and question their mental models, including their theories, assumptions, values, biases, etc. that lead to their expectations, and more explicitly consider the limits of their ability to know the future, they perhaps can make sounder, more balanced, judgements.

The purpose of this paper is to present a generic system dynamics model of the escalation phenomenon. The structure of the model incorporates insights into the cause of project escalation gleaned from both the decision error and no decision error perspectives. Of importance is that the model is able to produce behavior that would commonly be identified as escalation to a failed course of action without the presence of decision error by the project manager. As a result, the model is able to provide an internally consistent explanation of the phenomenon that lends support to the no decision error perspective, while simultaneously synthesizing many of the important insights into the cause of the phenomenon that have been contributed by other researchers. In addition, as the generic structure was derived from the essence of a system dynamics model of the EXPO 86 world's fair (a project whose management was widely criticized and has been described by Ross and Staw (1986) and Staw and Ross (1987) as prototypical of project escalation), the implications of the structure vis-a-vis the management of the fair will be addressed.

LITERATURE REVIEW

Escalation situations can be defined as "predicaments where costs are suffered in a course of action, where there is opportunity to withdraw or persist, and where the consequences of persistence and withdrawal are uncertain (Staw and Ross 1987, 40). Since 1975, three rather independent research streams on the escalation of commitment have developed. These three consist of: 1) the "escalation" literature, represented in the main by the work of Barry Staw and colleagues; 2) the "entrapment" literature, conducted primarily by Joel Brockner, Jeffrey Rubin and colleagues; and, 3) the "dollar auction" literature, conducted primarily by Allan Teger and associates (see Teger 1980; Staw 1981; Brockner and Rubin 1985; and Staw and Ross 1987 for excellent in-depth reviews). In general, the results of the studies from these streams are interpreted to suggest that, once individuals commit some non-trivial amount of resources to a project, they will tend to continue to reinvest beyond the point where benefits equal costs.

Decision Error Perspective

Several different frameworks have been used to understand escalation behavior. Among these are: 1) Justification; 2) Reactance; 3) Problem solving; 4) Attribution; 5) Cognitive bias; 6) Prospect theory; and, 7) Stages of commitment. Each of these theoretical views lies within the domain of the decision error perspective described above.

Justification. This predominant theoretical framework in the escalation literature is predicated upon self-justification/dissonance reduction mechanisms (e.g., Festinger 1957). From this perspective, once a decision maker has made a choice, he or she experiences dissonance wondering if the correct course of action has been chosen from among the alternatives. When information on poor project results is encountered, the focus turns to ways to correct or reduce the magnitude of what is perceived to be a previous error, within the framework of the prior decision, rather than focusing on alternative ways to either increase decision outcomes or cut losses.

The cumulative body of research within the justification perspective suggests that, under circumstances of uncertainty, decision makers will continue to reinvest resources in what is perceived to be a "failing" course of action in order to justify the appropriateness of past investment(s) in the course of action (e.g., Rubin and Brockner 1975; Staw 1976). This literature, however, has never established exactly how a situation can be both "failed or failing" and "uncertain."

Reactance. In the theory of psychological reactance (e.g., Brehm 1966), "reactance" is a motivational state that impels individuals to restore freedoms that are threatened or have been eliminated. The literature on reactance theory suggests that threatened choice alternatives tend to become more attractive and threats to attitudes produce a "boomerang" attitude change. That is, reactance in the face of a threatened choice alternative adds to the total amount of motivation to have that alternative. In terms of escalating commitment, reactance theory might argue that recommitment decisions will depend upon the relative utility(ies) of an alternative course(s) of action. In addition, this framework implies that decision makers will invest more heavily in situations perceived to be failing than in more equivocal situations, perhaps in a proactive sense, in order to reverse the situation through a heightened effort (Staw and Ross 1978).

Problem solving. Conlon and Wolf (1980) have argued that the escalation behavior exhibited in previous research may be contingent upon intervening cognitive processes that can develop a prospective rationale for the reallocation of resources to, or withdrawal of resources from, a course of action. Personal problem solving style (i.e., whether the decision maker is a calculator vs. non-calculator) and situational variables (such as the level of ego involvement with the results of prior investment, decision makers' visibility, and the stability of the perceived cause of the failure feedback) influence the development of rationales which can preclude the effects of justification. According to this framework, recommitment decisions are "reducible to objective cost-benefit analysis, once all the economic facts are known (Staw and Ross 1987, 63).

Attribution theory. Applied as a framework for escalation by McCain (1986), attribution theory (e.g., Kelley 1973) suggests that investing and reinvesting in a course of action is essentially a learning process, a learning process by which the cause of failure can become known over time through repeated investments. Also, in this way, the implications of the cause of failure can be understood. From this view, as failure recurs, investors can eventually learn that investment in a course of action should be terminated (perhaps in light of the good performance of alternative investment options), and the cause of the failure can thus be identified as both intrinsic to the prior strategy and important to future performance.

Cognitive bias theory. Recently advanced as an important factor in escalation situations by Schwenk (1986), this framework looks at escalating commitment from the perspective of behavioral decision theory. Here, executives are seen, on the one hand, as being caught in the dilemma of having to create commitment to a course of action in order to effectively carry it out while, on the other hand, having to avoid the problem of creating dysfunctional overcommitments to a course of action. According to Schwenk, once a strategy is implemented the executive in charge of the project may continue to place the progress of the project in the best possible light (to promote his or her own heuristics and biases) and/or to attribute any setback(s) to exogenous variables. The result of these behaviors is to make it more difficult to recognize failed strategies so that those strategies can be abandoned.

Prospect theory. Based upon the ideas of Kahneman and Tversky (1979; 1981) and brought to the escalation literature by Bazerman (1983) and Whyte (1986; see also Davis and Bobko 1986), prospect theory describes certain rules that decision makers follow in their evaluation of risky choices and also suggests the methods that decision makers use to interpret the results of prior choices (i.e., actions). Assuming that decision makers will, under certain conditions, violate the dictates of rational choice, Kahneman and Tversky (1981) argue that a decision made after observing the results of prior similar decisions will be "framed" so as to reflect the "success" or "failure" of the previous decision(s). A decision made after receiving "good news" about the project will be framed as a choice between "gains," while a decision made after receiving "bad news" about the project will be construed as a choice between losses. According to the tenets of prospect theory, escalation to a failed course of action (risk-seeking behavior) is encouraged after the receipt of bad news because the distastefulness of a "certain" loss is greater than the distastefulness from a situation where the prospects of loss are uncertain.

Stages of commitment. In a recent attempt to integrate the results of prior research and to provide a theoretical framework for escalation, Staw and Ross (1987; see also Ross and Staw 1986) have suggested that it is possible to isolate four general classes of variables that affect behavior in escalation situations. These sets of variables include: 1) project factors relating to the objective utility of the previously chosen course of action (e.g., size of a project's payoff, efficacy of further information; 2) information processing biases, which can lead to the misinterpretation of data (e.g., self-justification, commitment processes, mechanisms for belief perseverance); 3) social forces that can create persistence in the face of information that the project is doing poorly (e.g., face-saving effects, "hero" effects); and, 4) structural or institutional factors that can bind an organization to an ongoing course (e.g., political and/or competitive forces). Staw and Ross's conclusion is that prototypical escalation might represent an evolution of commitment that can develop with the support of different variables at each of the successive stages of a project.

A "No Decision Error" Perspective

In contrast to the decision error perspective, Bowen (1987) argues that previous views on escalation all contain the implicit assumption that escalation situations can be described and understood objectively. This is a critical assumption because it provides the rationale for explaining the escalation phenomenon as some function of "decision errors." Without the existence of an objective situation, in this case one that contains information that a project is failing/failed, there clearly cannot be "decision error."

To this point, Northcraft and Wolf (1984) have argued that prior research on escalation has left both the concept of and manipulation of "bad news" ill defined. In support of this idea Bowen has pointed out that, for information to indicate that a failed or failing strategy exists, a decision maker must have some credible a priori criterion(ia) against which to compare that information. In the absence of such criteria, information that indicates that a project has failed and the decision errors that are assumed to underlie the manager's behavior cannot occur as "objective" truths. While allowing that there may indeed be cases where persons in or out of organizations may consciously throw good money after bad, Bowen suggests that the literature has not demonstrated this effect.

From the no decision error perspective, a recommitment of resources (excluding instances where information that a project is doing well is perceived) results from a dilemma caused by the interplay between the degree of commitment to a course of action and the amount of equivocality perceived in both feedback on prior investments and expectations about the future. Recommitment decisions can therefore be the focus of political machinations where different points of view, each with their own set of expectations, vie for the power and/or authority to implement their respective strategies. Unless one expectations suggest disaster, there would be no reason to terminate investment in a project.

EXPO 86

As mentioned earlier, EXPO 86, held May 2 - October 13, 1986 in Vancouver, B.C., Canada, has been analyzed and discussed as a prototypical example of the escalation phenomenon (Ross and Staw 1986; Staw and Ross 1987). Staw and Ross (1987) describe the fair, initially proposed by the then Provincial Premier William Bennett, as presenting high expectations to planners in terms of visibility and financial benefits to the province, which was in the midst of an economic recession at the time. As planning for the fair progressed, however, the original estimates of costs and revenues proved to be overly optimistic. For example, the projected cost of the exposition skyrocketed from \$78 million to \$1.5 billion. The estimated loss from operations of the fair eventually totaled over \$300 million. Referring to budget summaries that appeared in the public press before the fair, Ross and Staw wrote: "These budgets graphically show the financial deterioration of EXPO over time and why the fair may constitute a useful prototype of the escalation of commitment" (1986, 288). Indeed Ross and Staw summarize their arguments by stating that "In short, from what started out to be a great idea, EXPO 86 turned into a fiscal and procedural quagmire." (1986, 67).

Because of his role as principle decision maker for EXPO, Premier Bennett's public statements and behavior during the course of the project have been the subject of much discussion. Generally speaking, he has been described as having become increasingly committed to the fair, even as the flow of bad news grew in magnitude. More specifically, Staw and Ross have analyzed Bennett's management of EXPO in terms of their "stages of commitment model." They suggest that Stage 1 -- the original decision to proceed -- is reflected in the fair's initial project economics and that the recommitment to the fair in Stages 2 and 3 was driven by Premier Bennett's psychological and social commitment. "He not only argued strenuously for the fair's continuance, but staked his career on the project to the point where withdrawal might cost his political office" (Staw and Ross 1987, 68). Finally, they argue that Stage 4 of the EXPO escalation prototype occurred when various "structural determinants" such as interest group pressure, the cost of stopping the project, and the more abstract goals for the region, began to dominate the decision to proceed with the fair.

The EXPO story, however, can also be interpreted in terms of the no decision error perspective on escalation. For example, in an interview with the authors of this paper, Premier Bennett stated that the fair was originally conceived to accomplish several goals. These included: 1) providing a vehicle that would attract international attention to Vancouver and the province of British Columbia; 2) promoting tourism within the province over the short and long run; 3) developing and encouraging the possibility of international trade, particularly from the so-called "Pacific rim" countries; and, 4) developing the physical site of EXPO and providing long-range residual benefits from the infrastructure improvements that would be necessary in order to hold the fair. These goals suggest that EXPO planners felt that the fair would be a worthwhile investment, regardless of whether its *revenues* exceeded its *costs*. Conversely, it is clear that EXPO critics focused only on the size of the expected loss from the fair's operations, or on the expected benefits of alternative strategies that they felt might better have contributed to the B.C. economy (see Anderson and Wachtel 1986). Thus, the critics did not consider the possibility that the fair was being held because its *long-term expected benefits* outweighed its *expected total costs*.

Because of these conflicting explanations of the EXPO 86 world's fair and, more generally, of the escalation phenomenon, a new approach for examining the forces that affect the decision to recommit resources to a course of action may be of value. As a result, the next section of this paper presents a generic system dynamics computer model of the dynamics of project escalation. Its structure represents the essence of a much larger model of EXPO 86 that is currently under development. It is felt that this generic structure and accompanying computer modeling environment can help to shed light on the debate over the forces that underlie the dynamic process of escalating commitment.

A SYSTEM DYNAMICS APPROACH TO THE ESCALATION PHENOMENON

The system dynamics method lends itself quite nicely to the task of understanding and explaining the phenomenon of escalation. In the first place, the very definition of escalation: the *recommitment* of resources to a failed or failing course of action, suggests a feedback structure dominated by at least one self-reinforcing, positive loop. Second, the phenomenon fits neatly into the category of project management -- an area of research that has traditionally been investigated by system dynamicists (e.g., Richardson and Pugh 1981; Roberts 1974; Roberts 1964). Third, the system dynamics method is based, to a large degree, on the utilization of the information contained in the "mental model" of a decision maker. Such information figures prominantly in the analysis of both EXPO 86 (e.g., Premier Bennett's expectations) and the escalation phenomenon in general (e.g., the no decision error perspective). Last, a system dynamics model that is able to produce escalating behavior is also able to serve as a vehicle for presenting an internally consistent explanation of the phenomenon to other researchers. In fact, a model-based explanation can be constructed as a dynamic synthesis of the various theories of escalation, or -- perhaps more importantly -- as a medium for weeding-out the factors that may not be critical to the process.

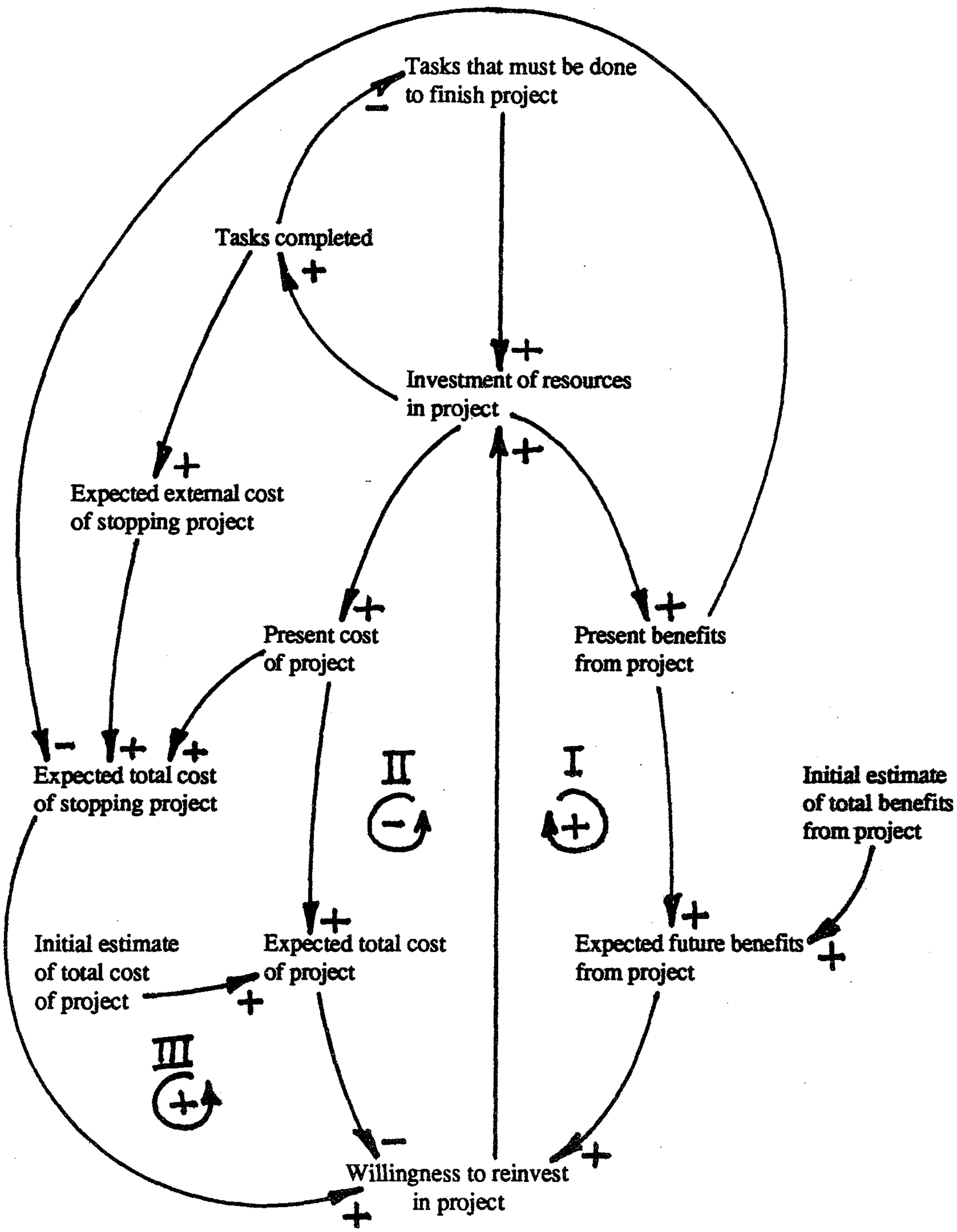

Figure 1. Causal Loop Diagram of Generic Escalation Structure

A Generic Structure

Figure 1 presents a generic feedback structure for the phenomenon of escalation. Although the structure consists of six interacting feedback loops, three are of primary importance to the explanation of escalation behavior. They are:

1) The expected future benefits loop - a positive loop (I): As resources are acquired and put to work, actual dollar benefits from the project appear and begin to be perceived by the project manager. Information from this stream of benefits is continuously combined by the manager with information from his or her initial estimate of the total future benefits from the project, to form updated expectations for the total future benefits from the project. Ceteris paribus, an increase in the manager's expectations for the total future benefits from the project causes an increase in the manager's willingness to continue acquiring and committing resources to the project.

2) The expected total costs loop - a negative loop (II): As resources are acquired, the actual dollar costs of the project begin to accumulate. Information from this stream of costs is continuously combined by the project manager with information from his or her initial estimate of the total cost of the project, to form updated expectations for the total cost of the project upon its completion. Ceteris paribus, an increase in the manager's expectations for the total cost of the project upon its completion will cause a decrease in the manager's willingness to continue acquiring and committing resources to the project. The goal of the loop is to keep the expected cost of the project aligned with its expected benefits.

3) The commitment loop - a positive loop (III): As the project unfolds and resources and completed project tasks begin to accumulate, the project manager's estimate of the external costs of stopping the project increases. (The external costs are those that occur only in the event of project stoppage, and are not part of the investment cost of the project.) Information from this stream of costs is continuously combined by the manager with information on the amount of actual resource costs that have accumulated, net of the actual accumulated dollar benefits from the project, to form his or her updated expected total cost of stopping the project. Ceteris paribus, as the estimate of the expected total cost of stopping the project increases, the manager's willingness to reinvest in the project increases.

One of the modes of behavior that will occur as a result of the interaction and shifting dominance of these three feedback loops is the phenomenon identified by many authors as escalation. This can be seen through an examination of Figure 2 -- a simulation run of a system dynamics model constructed from Figure 1 (the equations that underlie the model are presented in Appendix A). Inspection of Figure 2 reveals that, initially, both the *actual* dollar costs (curve 3) and the *actual* dollar benefits (curve 4) that have been accumulated during the the course of the project are zero, and that the manager *expects* the future benefits from the project (curve 2) to be worth 750 thousand dollars and the total cost of the project (curve 1) to be 500 thousand dollars. In other words, before the project begins to unfold, the manager *expects* the project to net 250 thousand dollars in benefits.

Although it is not accurate to say that the model will escalate for *any* combination of initial values other than the ones presented, it is accurate to say that the model will escalate for a large number of them. The main restriction is that the manager's initial expectations for the total benefits to be derived from the project must be greater than or equal to his or her initial expectations for the total cost of the project. This implies a fundamental assumption that a manager will never undertake a project that he or she initially expects to yield less benefits than costs.

Continuing with the examination of Figure 2, one can see that as the simulation unfolds and the manager begins to invest resources in the project, actual dollar costs and actual dollar benefits begin to accumulate. Because the goal of this particular run of the model is to demonstrate escalation behavior, the marginal cost per resource unit accumulated is set higher than the marginal benefit per resource unit accumulated (i.e., the slope of curve 4 is, at each point in time, greater than the slope of curve 3). Thus, throughout the entire 48 month duration of the project, the actual information feeding back to the project manager is "bad news," -- the marginal cost of reinvestment always exceeds the marginal benefit and the accumulated cost always exceeds the accumulated benefits (curve 4 is, at each point in time, above curve curve 3). It must be pointed out that this formulation of marginal costs and benefits does *not* imply a project with a predetermined total net loss, but merely one that shows bad news before its completion. The bulk of a particular project's benefits, for example, might be realized only after it has been completed.

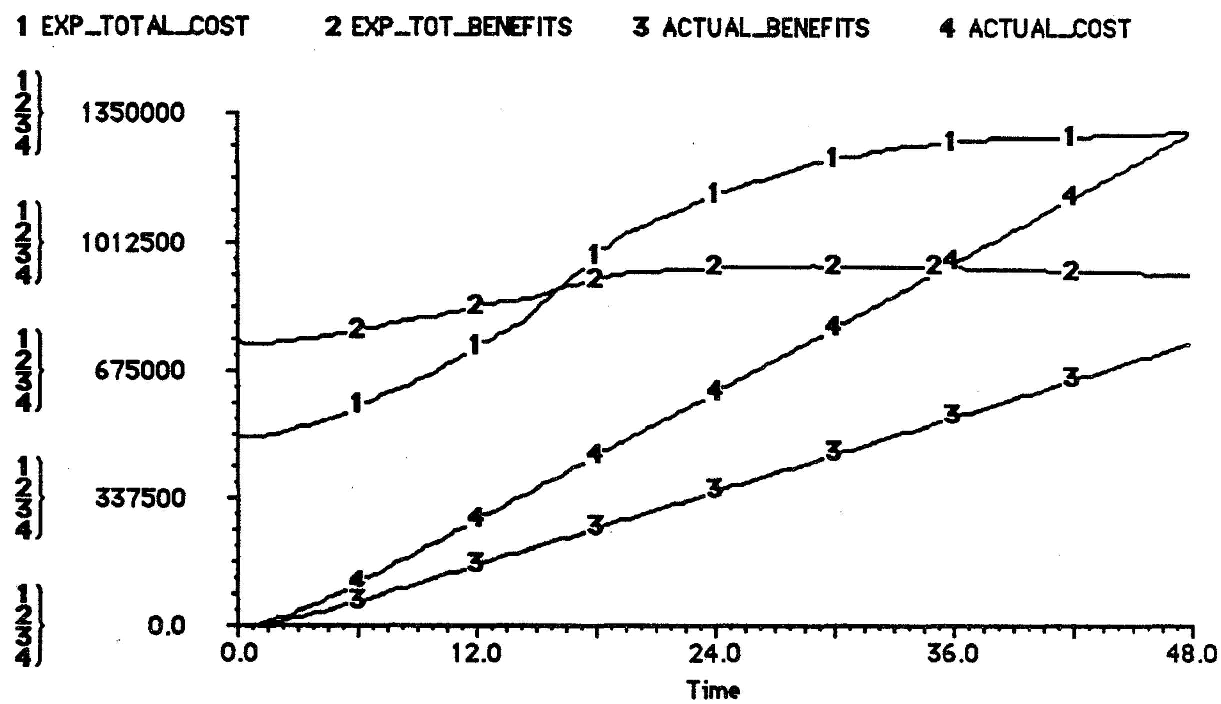

Figure 2: Project Escalation

Yet, despite the stream of bad news, curves 3 and 4 continue to rise throughout the entire simulation run, indicating that the manager sticks with the project through its completion. It is clear however that, at least until the 17th month, the decision to reinvest is rational. This is because the manager's reinvestment decision is based, to a large degree, on a comparison of *expected* future benefits and *expected* total cost, and not on a comparison of *actual* marginal benefits and costs or *actual* accumulated benefits and costs. As a consequence, from month zero to month 17 the manager's estimate of the future benefits from the project exceeds his or her estimate of its total costs, and reinvestment continues. In terms of the generic structure from Figure 1, the recommitment occurs because the positive expected future benefits loop is able to dominate the negative expected total cost loop for the first 17 months of the project.

Past month 17, however, the model exhibits the seemingly irrational behavior that has been defined as escalation. That is, in addition to the other bad news, the manager continues to reinvest while the expected total cost of the project exceeds its expected future benefits. Again, in terms of the generic structure from Figure 1, recommitment to the project continues even after the negative expected future cost loop has begun to dominate the positive expected future benefits loop.

The explanation for why expected future benefits fall below expected total costs after the 17th month, involves a description of how the manager's expectations are formed in the model. The expected future values for benefits and costs are calculated continuously as weighted averages of their initial values (derived from initial cost/benefit studies, knowledge of other similar projects, etc.), and the trend in their actual values as perceived by the manager and projected forward (see: Sterman 1986; and Lyneis 1980, Chapter 5 for a discussion of the technical details and rationale for this formulation). In addition, the manager's initial expectations are given less and less weight (and actual project data more weight) as the project proceeds. This can be explicitly seen through an examination of Figure 3, a table function that determines the weight the manager gives to initial estimates in the model. Through alternative formulations of this function, the consequences of various weighting schemes can be studied -- e.g., the consequences of a manager rapidly discarding initial estimates in the face of bad news, versus the consequences of retaining them. As specified in Figure 3, however, the function eventually gives the continuous stream of bad news enough weight to cause the manager to reverse the initial estimate of the project's net gain.

Although the reversal of the manager's expectations in the model has been explained, the manager's recommitment to the project after this occurs -- a definition of escalation -- has not. Such an explanation is important, however, because it embodies the central point to be made in this paper: escalation behavior can occur without a manager making decision errors or acting irrationally.

Managerial decisions are explicitly represented in a system dynamics model by rate equations. In the escalation model presented in this paper, the manager's decision to reinvest in the project is at all times and explicitly made in a rational manner. The manager will shutdown the project any time two conditions occur simultaneously: 1) expected total costs exceed expected future benefits; *and,* 2) expected total costs exceed the expected total cost of stopping the project.

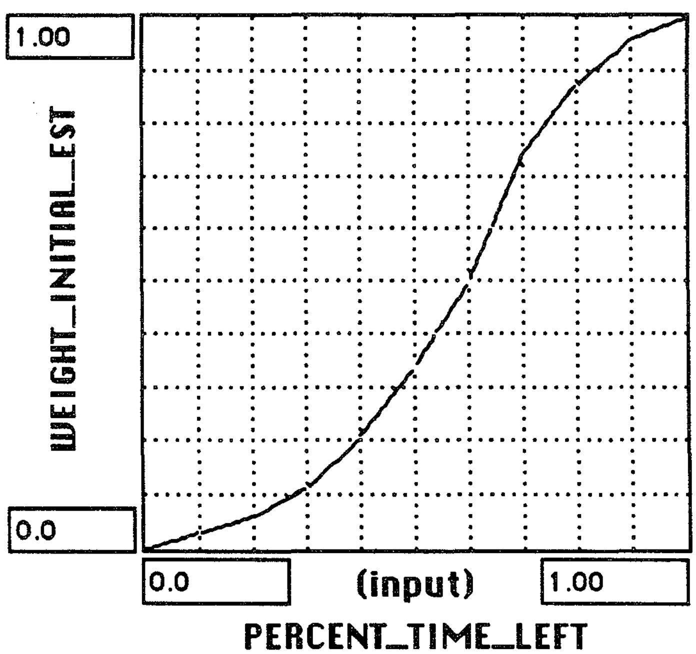

Figure 3: Table Function for Weight given to Initial Cost and Benefit Estimates

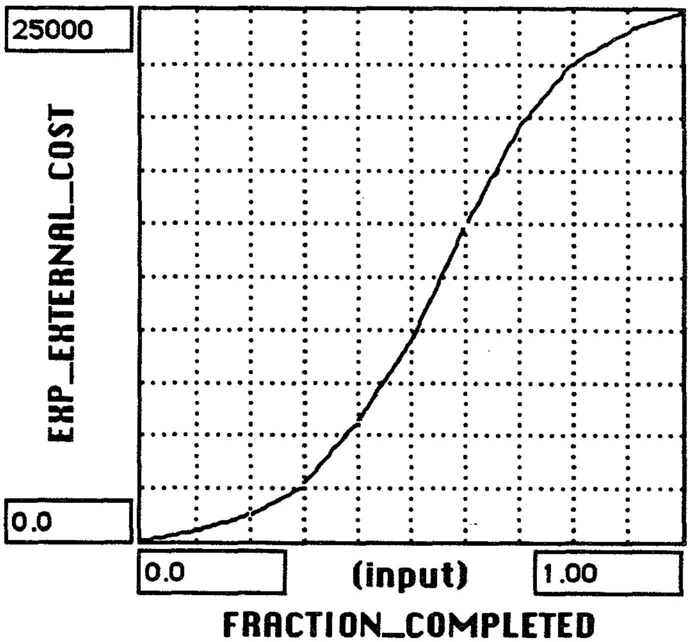

Figure 4: Table Function for Expected External Costs of Stopping Project

The implicit assumption is that a manager faced with a course of action that projects more costs than benefits if continued, will rationally (and correctly) proceed only if the the expected cost of stopping exceeds the expected cost of completion. In terms of the generic structure of Figure 1, these two conditions mean that the project comes to a halt only when the negative expected total cost loop dominates *both* the positive expected future benefits loop and the positive commitment loop.

Viewed in this light, it becomes clear why the escalation phenomenon occurs so often. Although recommittment to a project that generates a stream of bad news *weakens*, and can eventually *reverse*, the dominance of the positive future benefits loop over the negative total cost loop, it also has the effect of continuously *strengthening* the positive commitment loop (this can be seen explicitly through an examination of Figure 4, a table function for the manager's estimate of the external cost of stopping the project at each stage of its completion). The only way a rational manager will stop a project that is generating a stream of bad news therefore, is if the expected total cost loop is able to dominate the expected future benefits loop *before* it is itself dominated by the commitment loop.

The rates at which the strength of the commitment and expected total cost loops change are controlled primarily, but not exclusively, by the table functions presented in Figures 3 and 4. Generally speaking, a project will be stopped when these functions are reformulated to represent a manager that: 1) gives a large amount of weight to the stream of bad news early in the project; and, 2) has low estimates of the external cost of stopping, early in the project. It must be pointed out however that, even if the manager believes that there will be little or no *external* cost incurred by stopping the project, if the rate at which actual costs accumulate is high relative to the rate at which actual benefits accumulate, the *total* cost of stopping the project will still be able to dominate the expected cost of continuing, and the project will not be stopped. Further, in any actual situation, the project manager would face information streams that are less perfect than those provided in the model. For example, a manager would probably not know, at all times in the project, the exact productivity of the resource invested nor the number of tasks successfully completed. The effect of this would be to give the commitment loop more time to gain strength and thus make stopping the project even less likely.

IMPLICATIONS AND CONCLUSIONS

The results of the construction and simulation of the generic escalation model raise important issues regarding some of the explanations that have been given for the escalation phenomenon. First and foremost, they demonstrate in an explicit and internally consistent manner that decision error is not a necessary condition for escalation to occur. Indeed, in the model, the only thing for which the project manager could be faulted is not knowing the future with certainty. At a minimum then, the results lend support to the "no decision error" literature on escalation.

Second, although the results support the no decision error perspective, the structure of the model incorporates, and thus synthesizes, aspects of several of the theories of escalation. For example, the utilization of the adaptive expectation process is in harmony with many of the theories that involve learning, such as attribution or stages of commitment. Also, many of the factors identified by Staw and Ross (1987) in their stages of commitment model could be interpreted as contributing to the strength of the various feedback loops. In fact, each of the stages in Staw and Ross's theory could be reinterpreted in terms of accumulations, loop strength, and shifting loop dominance, instead of as a linear progression from one stage to the next.

Finally, the fact that escalation behavior can now be produced by a desktop computer model means that researchers can use it to trace out the consequences of their own assumptions and alternative structural formations. At this point in time, due to the importance of its role in the escalation phenomenon, the primary candidate for such study is probably the portion of the model's structure that formulates the manager's expectations.

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APPENDIX A

☐ ACTUAL_COST = ACTUAL_COST + dt * (RES_COST_FLOW)
INIT(ACTUAL_COST) = 100*TOTAL_RES_INVESTED {DOLLARS}
☐ TASKS_COMPLETED = TASKS_COMPLETED + dt * (COMPLETION_RATE)
INIT(TASKS_COMPLETED) = 1 {TASKS}
☐ TOTAL_RES_INVESTED = TOTAL_RES_INVESTED + dt * (
INVEST_OF_RESOURCES)
INIT(TOTAL_RES_INVESTED) = 1 {RESOURCE UNIT}
○ ACQUISITION_TIME = 2 {MONTHS}
○ ACTUAL_BENEFITS = TASKS_COMPLETED*BEN_PER_COMPL_TASK {DOLLARS}
○ BEN_PER_COMPL_TASK = .75 {DOLLARS/TASK}
○ COMPLETION_RATE = TASKS_DOABLE_PER_MO*WILLING_TO_REINVEST {
TASKS/MONTH}
○ END_OF_PROJECT = 48 {MONTHS}
○ EXP_COST_RATIO = EXP_TOTAL_COST_STOP/EXP_NET_COST {
DIMENSIONLESS}
○ EXP_NET_BEN_RATIO = EXP_TOT_BENEFITS/EXP_TOTAL_COST {
DIMENSIONLESS}
○ EXP_NET_COST = EXP_TOTAL_COST-EXP_TOT_BENEFITS {DOLLARS}
○ EXP_PROJ_CST_FCST = FORCST(ACTUAL_COST,5,TIME_LEFT_IN_PROJ) {
DOLLARS}
○ EXP_TOTAL_COST = (WEIGHT_INITIAL_EST*INIT_TOTAL_COST_EST)+((1-
WEIGHT_INITIAL_EST)*EXP_PROJ_CST_FCST) {DOLLARS}
○ EXP_TOTAL_COST_STOP = ACTUAL_COST+EXP_EXTERNAL_COST-
ACTUAL_BENEFITS {DOLLARS}
○ EXP_TOT_BENEFITS = (WEIGHT_INITIAL_EST*INITIAL_EST_BENEFIT)+((1-
WEIGHT_INITIAL_EST)*TOT_BENEFITS_FCST) {DOLLARS}
○ FRACTION_COMPLETED = TASKS_COMPLETED/INIT_PROJECT_DEFN {
DIMENSIONLESS}
○ INDIC_AMT_RESOURCE = REQ_TASKS_PER_MONTH/RESOURCE_PRODUCTIV {
RESOURCE UNITS}
○ INITIAL_EST_BENEFIT = 750000 {DOLLARS}
○ INIT_PROJECT_DEFN = 1000000 {TASKS}
○ INIT_TOTAL_COST_EST = 500000
○ INVEST_OF_RESOURCES = ((INDIC_AMT_RESOURCE-TOTAL_RES_INVESTED)/
ACQUISITION_TIME)*WILLING_TO_REINVEST {RESOURCE UNITS/MONTH}
○ PERCENT_TIME_LEFT = TIME_LEFT_IN_PROJ/END_OF_PROJECT {
DIMENSIONLESS}
○ PER_UNIT_RES_COST = 13 {DOLLARS/RESOURCE UNIT/MONTH}
○ PRESENT_TIME = TIME {MONTHS}
○ REINVEST_INPUT = (WGHT_TO_EXP_NET_BEN*EXP_NET_BEN_RATIO)+((1-
WGHT_TO_EXP_NET_BEN)*EXP_COST_RATIO) {DIMENSIONLESS}
○ REMAINING_TASKS = INIT_PROJECT_DEFN-TASKS_COMPLETED {TASKS}
○ REQ_TASKS_PER_MONTH = REMAINING_TASKS/TIME_LEFT_IN_PROJ {TASKS
MONTH}
○ RESOURCE_PRODUCTIV = 10 {TASKS/RESOURCE UNIT/MONTH}
○ RES_COST_FLOW = TOTAL_RES_INVESTED*PER_UNIT_RES_COST*
WILLING_TO_REINVEST {DOLLARS/MONTH}
○ TASKS_DOABLE_PER_MO = RESOURCE_PRODUCTIV*TOTAL_RES_INVESTED {
TASKS/MONTH}
○ TIME_LEFT_IN_PROJ = END_OF_PROJECT-PRESENT_TIME {MONTHS}
○ TOT_BENEFITS_FCST = FORCST(ACTUAL_BENEFITS,5,(TIME_LEFT_IN_PROJ+
10)) {DOLLARS}
○ WGHT_TO_EXP_NET_BEN = IF EXP_NET_BEN_RATIO ≤ 1 THEN 0 ELSE 1 {
DIMENSIONLESS}
○ WILLING_TO_REINVEST = IF REINVEST_INPUT ≤ 1 THEN 0 ELSE 1 {
DIMENSIONLESS}
⊘ EXP_EXTERNAL_COST = graph(FRACTION_COMPLETED)
0.0 -> 0.0
0.100 -> 500
0.200 -> 1250
0.300 -> 2625
0.400 -> 5625
0.500 -> 9500
0.600 -> 14875
0.700 -> 19500
0.800 -> 22625
0.900 -> 24125
1.00 -> 25000

⊘ WEIGHT_INITIAL_EST = graph(PERCENT_TIME_LEFT)
0.0 -> 0.0
0.100 -> 0.0300
0.200 -> 0.0600
0.300 -> 0.115
0.400 -> 0.205
0.500 -> 0.335
0.600 -> 0.495
0.700 -> 0.740
0.800 -> 0.875
0.900 -> 0.960
1.00 -> 1.00