HOSPITAL ADOPTION OF MEDICAL TECHNOLOGY: A MULTI-STAGE MODEL

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ABSTRACT

This study investigates the adoption of technological innovations in community hospitals as a three-stage process. To test the model, we track 300 innovation adoption proposals in 25 hospitals over a six-year period. Multivariate analyses suggest that each stage differs by participants, forms of rationality, and predictor variables.

INTRODUCTION

Technological innovations infiltrate organizations, moving through phases such as awareness, interest, evaluation, adoption, implementation, and institutionalization (Beyer and Trice, 1978; Meyer and Goes, 1988). Nearly every theory concerning the adoption of technological innovations in organizations conceives of the process as a chronological series of decision-making stages or phases (Rogers, 1983). According to this view, innovations are not adopted instantaneously by single decision makers. Instead, multiple decision makers participate, adoption decisions crystallize gradually, and implementation always remains problematic.

Although multi-stage/multi-actor models have intuitive appeal and enjoy widespread conceptual acceptance, surprisingly little empirical research has investigated the existence or characteristics of distinct stages in the adoption and implementation of technology. Stages are more often adduced in retrospect than observed in process. Little is known about what forces propel potential technologies between adoption stages (Mohr, 1982), or about what causal variables become salient at different stages (Meyer and Goes, 1988). In short, the literature "lacks a single acceptable theory to describe how decision processes flow through organizational structures" (Mintzberg et al., 1976: 274). This paper's objective is to evaluate one such theory.

HOSPITAL ADOPTION OF MEDICAL TECHNOLOGY: A CONCEPTUAL MODEL

For six years, an multi-disciplinary team (including the third author) studied decision processes flowing through hospitals' organizational structures to crystallize in the form of capital budgets for medical equipment (Meyer, 1984). The central objective of that research was building a grounded theory of innovation adoption (Glaser and Strauss, 1967) by continuously comparing theory and data until satisfactory conceptual categories were developed.

Meyer and Goes (1988) argued that technology-adoption processes are divisible into the three decision-making stages. Three stages were proposed—rather than two, four, or some other number—because prior research (Meyer, 1984) showed that two pivotal events partition the process into three distinct stages. The first is the submission of a formal, written request for the allocation of capital funds to purchase a given technology. This event marks the end of the "Knowledge-Awareness Stage"—a period of relatively informal information gathering, evaluation, and choice among individual participants, principally physicians. It also marks the beginning of "the Evaluation-Choice Stage" —a period of programmed organizational decision making. The second pivotal event is the technology's acquisition by the organization. Acquisition marks the end of bureaucratic decision making, it signifies the equipment's actual arrival in the organization, and it begins the the "Adoption-Implementation Stage."

Multiple Rationalities

Hospitals are inhabited by diverse professional groups that pursue competing goals and bring different forms of rationality to bear upon decisions. Our qualitative analyses (Meyer, 1984) suggest that hospitals' adoption decisions emerge from the interplay between the four forms of rationality.

Clinical rationality. Undergirding medical decision making is an ethic that exhorts the physician to advance medical knowledge and to promote each individual patient's welfare, but to disregard any concern about efficiency or distributive justice. A spirit of senatorial courtesy prevails when doctors apply the clinical model to medical equipment adoption decisions. Claims of therapeutic benefits for patients are evaluated partly on the basis of proponents' medical credentials. Professional deference is the norm. The clinical model's most influential adherents are specialists requesting equipment such as fetal monitors for treating their private patients (Meyer, 1985).

Fiscal rationality. Fiscal decision making seeks to improve the hospital's financial position by investing in technologies promising the highest returns. Its primary adherents are healthcare administrators and hospital-based physicians, who use financial models to project cash flows and calculate payback periods. Fiscal rationality is especially prominent when new equipment is proposed for hospital departments of radiology, anesthesiology, or pathology (Meyer, 1985).

Political rationality. Political behavior enjoys more legitimacy in hospitals than in most organizations. Medical staffs are "organized like parliaments, riddled with

committees, and headed by elected officers" (Meyer, 1984: 8). When costly equipment is proposed, amicable collegiality often gives way to coalitional bargaining among physicians, administrators and board members. Politicization depends partly upon who or what must be transported in order to use proposed equipment: patients between hospitals, patients within hospitals, equipment within hospitals, or patient specimens. Decisions are most political when equipment affects patient admissions and discharges and least political when equipment affects only flows of tissue specimens or blood samples. Thus, political rationality is most evident when high-ticket technologies that influence admissions are on the docket (e.g., MRI scanners).

Strategic rationality. Investments in medical technology create portfolios of health services that address particular market niches. Strategic decision making extrapolates from market research, demographic analyses, and predictions of competitors' actions and regulatory constraints to inform decisions about technology acquisitions. Strategic rationality is especially apparent in the evaluation of requests for equipment enabling entry into new domains (e.g., coronary by-pass facilities or neonatal intensive care nurseries).

Our qualitative analyses of technology adoption processes (Meyer, 1984, 1985) found that hospitals' budgetary cycles activate participants' decision models in a characteristic sequence: Clinical decision making is prevalent in the Knowledge-Awareness Stage, fiscal and political decision making predominate during the Evaluation-Choice Stage, and strategic assessments are postponed until the Adoption-Implementation Stage.

HYPOTHESIZED RELATIONSHIPS

The most fundamental premise of our conceptualization of hospitals' adoption of medical technology is the existence of discrete stages. Accordingly, we hypothesize that *(H1) the process through which hospitals adopt medical technology is partitioned into three distinct stages by (1) the request for capital allocation and (2) the initial acquisition of equipment.*

A second premise of the decision-stage model holds that the forces propelling potential adoptions vary from stage to stage, with different causal variables determining outcomes at different stages. In Stage I, the Knowledge-Awareness Stage, decision making occurs primarily at the individual and interpersonal levels. Clinical rationality has its greatest influence in this stage. Accordingly, we hypothesize that *(H2) levels of climincal risk and requisite skill will be positively associated with termination of technology adoption processes at Stage I.*

Two central issues arising during the Knowledge-Awareness Stage are: (1) the fit between a proposed technology and the interests and abilities of physicians who are potential sponsors and prospective users, and (2) the extent to which the technology affects patient flows in ways that are readily observable. We hypothesize that *(H3) compatibility of technology with medical specialties and observability of patient flow effects will be negatively associated with termination of adoption processes at Stage I.*

Technologies that proceed to the Evaluation-Choice Stage are subjected to sequences of programmed budgetary analyses activated by temporal schedules. In hospitals whose capital budgeting systems are highly complex, a greater investment of attention and energy is required to keep proposals advancing. In hospitals where capital budgeting authority is highly centralized, higher financial return thresholds are typically required for approval (Meyer, 1985). Accordingly, we hypothesize that *(H4) capital budgetary complexity and centralization will be positively associated with the termination of technology adoption processes at Stage II.*

Hospitals' capital budgetary systems vary in the extent to which proposed technology acquisitions are subjected to rigorous financial analysis. They also differ in the extent to which proposals are scrutinized in pluralistic forums where the various medical departments' competing interests are represented. Both of these forms of evaluation have been found to reduce chances of approval (Meyer, 1985). We hypothesize that *(H5) salience of fiscal and political criteria in capital budgeting will be positively associated with the termination of technology adoption processes at Stage II.*

We have argued that political evaluation becomes most prominent during the Evaluation-Choice Stage of technology adoption processes. The hospital's CEO is a particularly influential political actor, and we expect his or her tenure in the organization, years of education, and personal advocacy for a particular medical technology to encourage its adoption. Thus, *(H6) CEO tenure, education, and advocacy will be negatively associated with the termination of technology adoption processes at Stage II.*

The complexity of a hospital's active medical staff is related to the extent of physicians' demand for technology, and to their influence in decisions about its adoption. A complex staff encompassing a large variety of medical specialists and subspecialists will typically engage in a greater number and variety of technologically-based procedures. Another factor influencing demand for technology is the recency of physicians' medical education, which is proxied by their age. Medical students and residents are usually exposed to the very latest equipment, and become strong proponents for its adoption when they join community hospitals' medical staffs. We hypothesize that *(H7) the complexity and median age of a hospital's medical staff will be negatively associated with the termination of technology adoption processes at Stage II.*

Our model contends that strategic implications of medical technology come to the fore during the Adoption-Implementation Stage. At this stage, the process is driven by decisions about when and how extensively to utilize the technology, and whether to "readopt" it. In effect, these decisions evaluate the innovation's fit with both the characteristics of the organizational context and the external context (as represented by demand derived from physicians and their patients). Extensive utilization and readoption of technology are most likely within large urban hospitals serving markets where affluence is increasing and where relatively few patients rely on Medicare and Medicaid for reimbursement of care. Therefore we hypothesize that *(H8) the termination of technology adoption processes at Stage III will be negatively associated with hospital size, urbanization, markets where affluence is increasing, and markets where reliance on federal health insurance is limited.*

METHODOLOGY

We obtained a sample of 300 organizational decision processes by observing adoptions and non-adoptions of twelve medical innovations within 25 community hospitals. A panel of local and national medical experts assisted us in identifying a set of technologies that satisfied four criteria: (1) embodied in mechanical equipment, (2) at an early stage in the diffusion process, (3) varied in terms of attributes reported to affect adoption, and (4) sufficiently costly and complex to preclude adoption by individual physicians. Each innovation represented a significant departure from previous techniques for diagnosis, treatment, or prevention of illness. Data on technology-adoption processes were collected over a six-year period. Multiple methods were used, including structured interviews with 378 participants, non-participant observations, and analyses of organizational budgets and other documents (Meyer, 1985; Meyer and Goes 1988). The dependent variable for this study was obtained by triangulating between these data. Each of the 300 potential adoptions studied was classified as terminating in one of the model's three stages.

Data Analysis

First, we use multivariate analysis of variance (MANOVA) to determine whether differences observed among technology adoption proposals terminating at each of the three decision-stages are likely to have occurred by chance. Each stage can be conceptualized as having a set of seventeen means, since there are seventeen antecedent variables.

Next, we use discriminant analysis to evaluate which of the seventeen variables are better predictors of a proposal's termination at particular stages. Discriminant analysis will assign linear weights to variables such that terminated proposals are distinguished from those that survive. One discriminant function will be constructed for each stage.

To infer the importance of individual predictor variables at each stage, we interpret the loading matrix. Larger values denote greater degrees of discriminating power, with negative coefficients indicating the variable is associated with earlier termination, and positive coefficients indicating association with later termination or promotion to the next stage.

RESULTS

Results of MANOVA indicate that the three decision-making stages are characterized by significantly different sets of means (Wilks' Lambda = 0.35; p=0.00). It is also of interest to evaluate pairwise differences between the stages. The MANOVA results show that the pairwise differences are statistically significant: Stage I and II differ (Wilks' Lambda =0.548; p=0.00), Stage II and III differ (Wilks' Lambda = 0.81; p=0.001), and Stage I and III differ (Wilks' Lambda = 0.324 ; p=0.00). Taken together, these findings offer considerable support for our assertion that the three proposed stages are empirically distinct (H1).

For each stage, a separate discriminant function was estimated to differentiate innovations that terminated from those that continued. Table 1 summarizes the results. All three discriminant functions are statistically significant (p-values ≤ 0.05), indicating that the overall set of independent variables yields reasonably good predictions of the fate of proposed adoptions at each of the three stages.

In the Knowledge-Awareness Stage, owing to the strong influence of clinical rationality, we suggested in H2 and H3 that the most important predictors of termination would be attributes of the innovation. Table 1 shows that all four innovation attributes loaded at $\geq .30$ with signs in the predicted direction, indicating strong support for both H2 and H3. Unexpectedly, the hospital's CEO appeared to be influential at this early stage, as evidenced by the high loading on CEO advocacy. These results suggest that an innovation was most likely to be terminated in Stage I if it posed higher risks, required more skill, had lower observability, did not fit the hospital's pattern of medical specialization, and received less support from the hospital's CEO. Proposals to adopt innovations with the opposite characteristics were more likely to progress to Stage II .

In the Evaluation-Choice Stage, we expected the most important discriminating factors to be political and fiscal variables. However, Table 1 shows that three of the four innovation attributes still loaded at $\geq .30$ at Stage II, suggesting clinical rationality continued to exert strong

Table 1.
Results of Discriminant Analysis

Predictor Variables	Correlations with discriminant functions [a]		
	Stage I	Stage II	Stage III
Clinical Variables			
risk	**0.62**	**0.54**	0.07
skill	**0.40**	**0.32**	-0.14
observability	**-0.31**	**-0.40**	0.10
compatibility	**-0.31**	-0.21	-0.01
Fiscal Variables			
budgetary complexity	-0.17	-0.06	-0.02
budgetary centralization	-0.12	-0.08	0.10
salience of fiscal criteria	0.12	-0.21	**0.54**
salience of political criteria	-0.12	0.13	**-0.49**
Political Variables			
CEO advocacy	**-0.48**	**-0.60**	0.05
CEO tenure	0.05	0.13	0.00
CEO education	-0.12	0.02	**-0.38**
medical staff complexity	-0.24	0.02	**-0.48**
recency of medical staff's education	0.02	-0.09	0.20
Strategic Variables			
size	-0.27	-0.02	**-0.49**
urbanization	-0.19	-0.04	**-0.66**
income change	0.19	-0.00	**0.51**
federal health insurance	-0.05	-0.09	**-0.33**
Canonical correlation	0.77	0.43	0.41
Eigenvalue	1.45	0.24	0.20
Wilk's lambda	0.41	0.81	0.83
P-value of dicriminant fxn.	0.00	0.001	0.05
Sample size	300	201	163

[a] Correlations greater than 0.30 are shown in boldface

influence. Contrary to expectations, fiscal variables were not significant. In other words, there was no support for H4 and H5. Nonetheless, CEO advocacy remained an important factor at Stage II. Therefore, there was partial support for H6 but no support for H7. In sum, the results show that an adoption proposal was most likely to be terminated in Stage II if it lacked CEO support, posed higher risks, had few observable consequences, and required extensive skill to use.

In the Adoption-Implementation Stage, we expected strategic variables to emerge as key factors leading to an innovation's utilization, full acceptance, and re-adoption. The data offered considerable support for Hypothesis 8; all four strategic factors are loaded at ≥ .30 and two variables -- size and urbanization-- bear the predicted direction. As we anticipated, technologies tended to be implemented less completely at smaller hospitals in less densely populated urban areas. Contrary to our prediction, technologies were also less likely to be utilized in affluent markets where there was more rapid growth in family income and fewer residents qualified as Medicare/ Medicaid recipients.

In summary, the results of MANOVA provided strong support for the three-stage model we propose. The multiple discriminant analyses offered further evidence for the existence of significant differences between stages. The loading patterns of the discriminating variables clearly show that different sets of predictors became salient as proposed adoptions progressed through the stages of Knowledge-Awareness, Evaluation-Choice, and Adoption-Implementation. Generally, the data fit our expectations regarding which classes of variables were likely to become important at Stage I and III of the decision-making process. However, results of discriminant analyses showed that salient variables at Stage II were mostly the same as Stage I.

DISCUSSION

Our results may have implications for theory and research on organizational innovation. Four findings seem especially noteworthy. One is that organizations' awareness, evaluation, and choice of new technologies appear to be highly contingent on attributes of the particular innovation in which a technology is embodied. Although this finding hardly seems remarkable, relatively few studies have systematically assessed the impact of multiple innovation attributes on organizational adoption. Future research should make this a priority.

Secondly, our results suggest that the support or opposition of an organization's Chief Executive Officer substantially shapes the outcome of a innovation proposal. The CEO's influence appears greatest during the official phase of bureaucratic decision making (Stage II), but it was also important in propelling a proposal from the informal organization into the formal choice arena (Stage I). This result also may seem unsurprising, but it contrasts with studies concluding that leaders have minimal impact on the decisions or actions taken by their organizations (Lieberson and O'Connor, 1972).

Thirdly, a striking change was observed at the point in the process where proposed innovations were actually acquired. Innovation attributes, after serving as highly significant predictors of outcomes throughout the Knowledge-Awareness and Evaluation-Choice stages abruptly ceased to matter. At the same time, upon acquisition, strategic factors, which were latent during the former stages, emerged as the most potent predictors of the innovation's utilization and readoption. For taxpayers and those concerned with maximizing social welfare, this implies that at least in hospitals, many technical innovations are acquired with little consideration given to the levels of demand for the innovation existing in the organization's environment.

Finally, our findings suggest that multiple rationalities shape hospitals' adoption decisions. No single rationality drives outcomes at all three decision stages. This study provides support for the use of multiple lenses to characterize, filter, and make sense of confusing and puzzling events in organizations.

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