Achieving Desired Project Outcomes with Control Modes amidst Technical Uncertainty

Vijay V. Raghavan
Information Systems & Analytics
College of Informatics
Northern Kentucky University
Highland Heights, KY 41099, USA

Lakshman Mahadevan
Information Systems, Analytics, and Supply Chain
Lutgert College of Business
Florida Gulf Coast University
Fort Myers, FL 33965, USA
Email: lmahadevan@fgcu.edu

Abstract

Organizations aim to achieve successful project outcomes in information systems development (ISD) projects by managing the technical uncertainties that arise with adopting innovative technologies. This study, guided by control theory, investigates various control modes—namely, behavior, outcome, clan, and self-control—and their role in enhancing internal efficiency and psychological outcomes among project members in the presence of technical uncertainty. Our findings reveal that outcome and clan control modes are particularly effective at promoting favorable project results amidst the technical uncertainty surrounding innovative technology development, whereas behavior and self-control modes show no significant impact. As a result, prioritizing outcome and clan control modes is recommended for managing ISD projects characterized by technical uncertainty.

Keywords: control modes, technical uncertainty, internal efficiency, psychological outcomes, information systems development project.

1 Introduction

In the dynamic landscape of information systems development (ISD), the ever-evolving nature of technology introduces a myriad of challenges, with technical uncertainty being a prominent one. Technical uncertainty is described as the lack of familiarity and experience among project members when working with new, complex, or rapidly evolving technologies (Ragatz et al., 2002; Lewis et al., 2002). As organizations increasingly rely on ISD projects to drive innovation and gain a competitive edge, understanding and effectively managing technical uncertainty becomes paramount (Codex, 2023). This argument advocates for the necessity to study technical uncertainty in ISD projects, asserting that doing so is essential for optimizing project outcomes, ensuring resource efficiency, and fostering innovation (Dönmez & Grote, 2018).

Organizations invest in innovative technologies such as generative artificial intelligence, quantum computing and virtual reality to leverage existing solutions or create new ones with a goal of gaining competitive advantage and improving their innovation process and performance (Spanjol et al., 2018). Nearly half (49%) of the 1000 business leaders around the

Received 23 Aug 2023, accepted 3 Oct 2024 after 4 round of review with Karlheinz Kautz as accepting Editor.

world at enterprise-level organizations believe that the inability to keep up with technology innovation compared to their competition as one of the greatest threats to their organizations (Mullen, 2023). Innovative technologies comprise of enhanced products and processes, which are either entirely novel or substantially improved in terms of quality, performance, and technological advancements (Dasgupta et al., 2011).

However, innovative technologies are often unrefined, and these technologies change over time as new solutions are developed and tested (Lynn & Akgün, 1998). To make full use of the technology, there needs to be a good understanding of its capability and the advantages it can deliver. However, technological advancements are happening at a rapid pace which requires companies to embrace constant innovation through accelerated development cycles to 1) stay ahead of the competition (Jain et al., 2019) and 2) target profitability within a short span of time (Gnanasambandam et al., 2018).

The introduction of innovative technologies can create challenges for companies, hindering their ability to bring new designs to market (Lewis et al., 2002). This issue often arises because the workforce may not possess the necessary knowledge to effectively utilize these innovations (Jalonen, 2012). Such problems can adversely affect internal efficiency, as companies need to release innovative technology quickly, on schedule, and to meet user satisfaction, particularly in environments marked by technical uncertainty (Laine et al., 2016). Furthermore, the success of a project is influenced by psychological factors, which includes each team member's motivation and the satisfaction they gain from participating in the Information Systems Development (ISD) process (Stewart & Gosain, 2006). Psychological outcomes perceived by team members depend on how much control they have over uncertain conditions (Gerber, 2009). In situations where team members have more control, they experience greater interest, higher creativity, less pressure, and tension (Deci & Ryan, 1987; Gerber & Carroll, 2012).

Control has been thought of as an attempt to impact the behavior of another individual or group to accomplish planned objectives (Cram et al., 2016) and categorized into two distinct modes: formal and informal control (Kirsch, 1997). While there are a sufficient number of studies that have researched project performance using control theory, Remus et al. (2020) show that previous research has been limited 1) by conceptualizing the use of controls as either authoritative or enabling (Weiner et al., 2016) and 2) finding inconsistent results on the use of various control modes due to focus on project level unit of analysis (Henry et al., 2015; Wiener et al., 2016). However, Remus et al. (2020) recommend that future studies consider researching technical uncertainty which is a major contextual influence especially in the case of ISD projects deploying innovative technologies. While informal controls provide effective support for innovation (Beese et al., 2023), an organizational level study conducted by Liu (2015a) on Chinese companies found that in highly risky and complex situations, behavior and self-control have low effects on performance, but outcome and clan control have higher effectiveness. In contrast, our research aims to understand the control modes that help individual team members achieve project outcomes in the presence of technical uncertainty. Thus, we ask the following research question.

RQ: *How can expected project outcomes be achieved by effectively adapting appropriate control modes in the presence of technical uncertainty?*

To answer this question, we conducted a survey among software professionals who had recently participated in ISD projects under technically uncertain conditions. The findings from our research indicate that in innovative technology-driven development environments characterized by technical uncertainty, both clan and outcome control offer adequate internal efficiency and psychological outcomes. However, behavior and self-control do not yield significant benefits.

In the following sections, we first discuss the theoretical foundations of this study by elaborating on the different modes of control employed by management in companies to get ISD projects completed. Second, we develop the research model and present the hypotheses. Third, the measurement model is evaluated, and we empirically test the hypotheses through structural equation modeling. Finally, we present the results of the hypothesis testing and discuss the theoretical and managerial implications of the findings.

2 Theoretical Foundations

ISD is a complex, knowledge-intense activity that often use innovative technologies leading to less desired project outcomes. In such an environment, control modes help to ensure alignment of ISD teams with firm performance (Nidumolu & Subramani, 2003). Control theory (Ouchi, 1979) provides a useful theoretical foundation to conceptualize controller and controlee relationships and their effects on internal efficiency and psychological outcomes in the presence of technical uncertainty. Control modes attempt to converge the divergent views that the controller and the controlees have about project completion (Eisenhardt, 1985). Control can be broadly referred to as a set of process and rules that a controlee implements to promote desirable controller behavior (Choudhury & Sabherwal, 2003). In an organization, the term controller refers to the team of individuals responsible for the conception and implementation of controls. The term controlee refers to the individuals who are tasked with systems development (Choudhury & Sabherwal, 2003).

As technologies become more sophisticated, an accurate assessment of their functionality requires extensive knowledge, which makes the choices difficult for organizations (Bakos, 1991; Duan et al., 2009) resulting in increased technical uncertainty. However, appropriate fit between the technical uncertainty and interorganizational interaction leads to more effective integration of innovative technology (Stock & Tatikonda, 2008). Research by Ens et al. (2023) has shown that controls on digital platforms is uniquely dynamic and requires the use of both formal and informal controls. As much as there is need for flexibility to deal with uncertainty in the ISD process, there is a need for control modes to ensure compliance with organizational goals. To this end, control modes such as behavior, outcome, clan and self-control provide organizations with the ability to manage the flexibility versus control standoff often experienced in ISD projects (Harris et al., 2006). However, "When a project has both unknowns and tight control, controlees respond to tight controls instead of unknowns. Controlees behave as controllers expect leading controllers to be unaware of brewing problems" (Chen et al., 2022. p 309).

2.1 Behavior Control

Behavior control refers to how project participants' expected behaviors are specified through formal documents, and members are expected to follow the prescribed rules and procedures (Jaworksi & MacInnis, 1989; Kirsch, 1996). These may include requirements documents that are written and accepted, change procedures, approval processes, coding standards, and testing methodologies (Remus et al., 2020; Saxena & McDonagh, 2020). For behavior control procedures to be successful, the project behavior specified must be observable, and there must be monitoring modes to ensure conformity with expected behavior (Eisenhardt, 1985). Behavior control assumes the presence of a single control hierarchy (McCarthy et al., 2023) and is implemented through modes such as a ISD procedure or those that permit the controller to assess behavior (Kirsch, 1997). While behavior control has been proposed for virtual teams (Townsend et al., 1998) and for collocated teams (Henderson & Lee, 1992; Kirsch, 1997), research by Piccoli and Ives (2003) has shown that behavior control negatively impacts trust in virtual teams since team members' failure to uphold their obligations can be easily detected.

2.2 Outcome Control

In this formal mode of control, project managers independently decide on the outcomes, such as when the projects or subtasks are expected to be completed and what resources are available. The controller focuses on the output without regard to the process used to achieve these outputs (Choudhary & Sabherwal, 2003). The performances of the participants are measured based on the outcome or goals set by the controller (Kirsch, 1997). Outcomes can be the completion of functional specifications and completing the project on target. Both behavior and outcomes control modes are directed toward aligning the participants' goals with the goals of a project or its manager and are grouped under the general label of formal modes of control. Outcome measurability is defined as the capability of controllers to evaluate and measure the ability of controlees to achieve the desired results and outcomes (Kirsch et al., 2002).

2.3 Clan Control

The knowledge of ISD is often dispersed within the organization. The project members (Chua et al., 2012) are usually drawn from varied stakeholders, such as customers, consultants, and information technology (IT) professionals, to work in unison for project delivery. The project manager's role is to facilitate a shared understanding of organizational objectives and processes. The notion of clan control is based on the premise that formal modes of control described earlier are unlikely to be as effective as control arising from shared norms of a team. ISD projects are intensive team environments where participants are drawn from multiple organizations, including individuals with diverse skills and expertise. In such cases, it is realistic to expect how the performance of the project can be positively influenced by members working toward a common goal. The extent of trust amongst project members and the expectation to do their part of the project well is the underlying theme of clan control. The ability of a project team to direct members' behavior in this direction is known as clan control. Further team-based clan control is a conceptualization fostered by team members and enabled by managers who are clan members themselves (Kirsch et al., 2010).

2.4 Self-Control

When a project's members exercise self-control, they independently set explicit goals for themselves without the contribution of a team manager. Self-control is a mode by which an individual relies on self-monitoring and regulation (Kirsch & Cummings, 1996). Individuals undertake a particular task by controlling their own actions (Kirsch, 1997) and proceed to evaluate themselves to whether they have achieved their goals and reward or sanction themselves correspondingly (Jaworski, 1988; Kirsch, 1997). Flexibility and self-control are essential in a complex project environment where it is expected that everyone would do their part with little monitoring by anyone outside or within the project. Heales et al. (2007) report that informal controls such as self-control play a major role in ensuring successful project outcomes and are effective for the performance of different stakeholders in an IT project (Liu, 2015b; Wright et al., 1993) including developers (Henderson & Lee, 1992).

2.5 Technical Uncertainty

Uncertainty in the plain English sense of the word means a lack of sureness about someone or something (Uncertainty, n.d.). It is the conditional volatility of a disruption that is unpredictable (Jurado et al., 2015). Uncertainty is a sense of ambiguity associated with a lack of clear picture about the behavior of relevant project members, lack of procedures to consider issues, lack of knowledge about the presence of known and unknown sources of bias, lack of familiarity about the amount of effort required to resolve the condition (Ward & Chapman, 2003) and information deficiency (Klir, 2006). Uncertainty reflects a person's lack of knowledge of the goals of the project and the environment (Shenhar & Dvir, 2007) such as the ISD process. Project uncertainty is mostly evident in ISD tasks that are usually complex (Jun et al., 2011; Mehta et al., 2014). However, most project management practices do not consider the uncertainty of the project for determining strategies relevant to task completion (Maes et al., 2022). The lack of critical knowledge about various aspects of the project can derail ISD leading to uncertainty (Mehta et al., 2014). Technical uncertainty is a major challenge faced by high-tech companies (Yu & Chiu, 2013) and refers to the project members' unfamiliarity and the lack of experience in dealing with technologies that are new, complex and/or rapidly changing (Ragatz et al., 2002; Lewis et al., 2002).

Technical uncertainty has been considered in organizations that consider research and development as part of their process (Atanassov et al., 2024), where a strong correlation existed in situations where a team had to choose between various available technologies (Holland et al., 1976). There is no more fertile ground than ISD for technical uncertainty to affect the outcome. Varieties in design along with the skill and competence of the developer can fuel technical uncertainty. Although it is not possible to foresee issues during ISD projects, project managers can employ tactics that mitigate those possible problems by managing uncertainties. (Marinho et al., 2018). Variations in the design refer to the challenges that frequently occur due to variations in skilled worker levels and their technical competence and capabilities. These uncertainties in technology affect project budgets, workloads, and other indicators to varying degrees related to project performance.

2.6 Project Outcomes

We consider project outcomes from two dimensions: the internal efficiency of the project and its psychological outcomes. Psychological outcomes are the team members' satisfaction level with the work associated with the project (Aladwani, 2002). Innovative technologies can usually provide challenges to team members that can be quite motivating and interesting. Iacovou et al. (2005) show that good, open communications will lead to better interactions and superior team performance, thus, leading to positive psychological outcomes.

The criteria of project cost, project time, and project quality have been generally used (Shenhar et al., 1997; Baccarini, 1999) as project management internal measures of efficiency. The findings of a study by Banker & Kemerer, (1992) concluded that timeliness in delivering the project and user satisfaction with the project are important matrices in determining project success. Internal efficiency measures how well resources are utilized to complete the project within the assigned time and achieve desired user satisfaction. While a study by Cheng et al. (2018) found that the relative lack of internal control significantly lowered an organization's operational efficiency, organizations engaged in ISD projects with innovative technologies could prioritize on-time completion and gaining user satisfaction to achieve organizational excellence and competitive advantage.

3 Research Model and Hypotheses

The research model is presented in Figure 1. The direct effect of the control modes on ISD project outcomes is assessed followed by the examination of the mediating effect of technical uncertainty on the association between each control mode with internal efficiency and psychological outcome. Unlike moderators which affect the strength or direction of a relationship between two variables, a mediating variable clarify how external physical events take on internal psychological significance and accounts for the relationship between the independent and dependent variable (Baron & Kinney, 1986). Technical uncertainty can directly impact the execution of tasks (Song & Montoya-Weiss, 2001) affecting the ISD process.

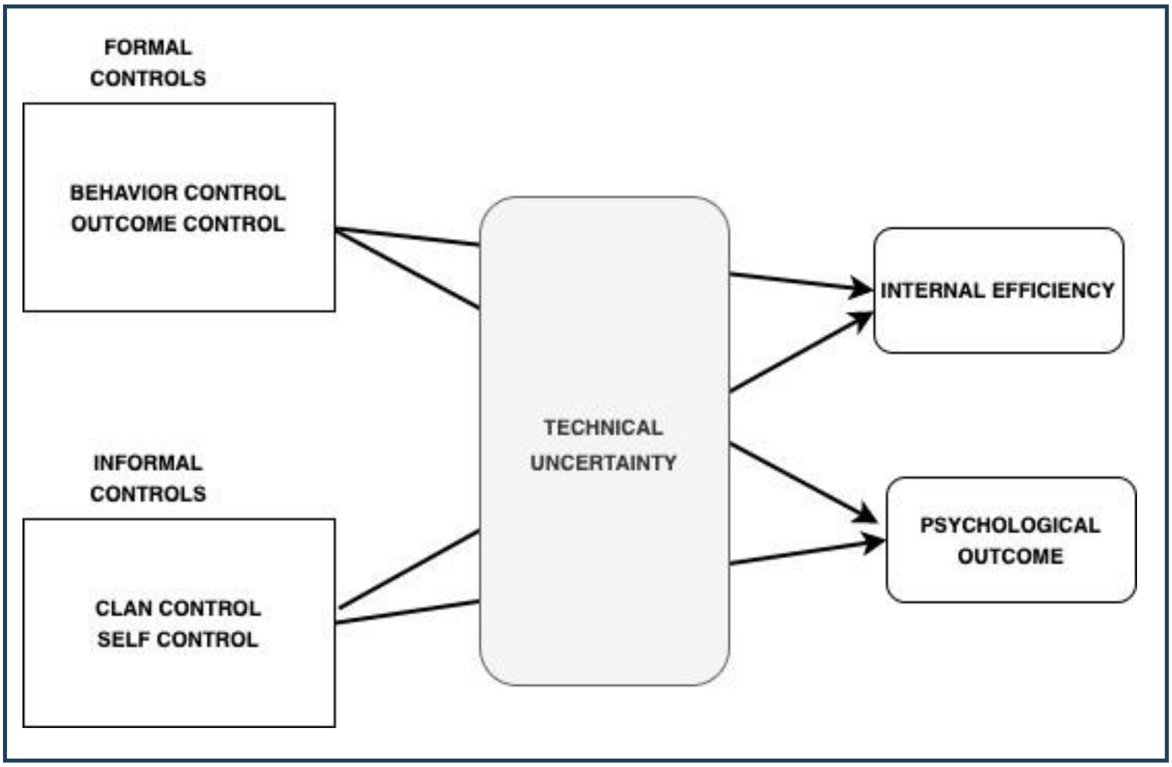

Figure 1. Theoretical Model Showing Direct Relationships and Mediation of Technical Uncertainty on Project Outcomes

3.1 Hypotheses

Successful ISD projects usually score well on efficient use of time and budget (Aladwani, 2002). Project managers, who are entrusted with the task of ensuring time and budget objectives may resort to behavior control to achieve internal efficiency. In this type of control, managers are very 'hands-on' by nature in providing a written sequence of procedures that need to be followed by the project team. In ISD, behavior control involves specifying methods for tasks such as project management, analysis, design, programming, testing, and documentation (Kirsch, 1996). Research by Kanwal et al. (2017) has found that behavior control is positively related to ISD project performance. Such interventions generally result in the project achieving higher efficiencies. Managers who exhibit behavior control are heavily involved in the process of change and often closely monitor the progress made by their team. These managers are usually quite experienced and have had previous experience working hands-on on similar projects. Establishing behavior control involves developing management processes to define and oversee behaviors, as well as implementing incentives and rewards to encourage appropriate conduct (Nidumolu & Subramani, 2003). However, behavior control has difficulty in predicting the desired output in the presence of complexity (Chua et al., 2012). Teams are unable to respond quickly to issues arising out of the complexity of certain ISD projects (Chien et al., 2007). Though Patterson et al. (1997) showed that uncertainty will have a negative association with performance perceptions, it is possible that the manager can come up with procedures to standardize the change process, enabling the codification and formalization of information to manage processes (Kirsch, 1996). However, such procedural interventions may not be enough to nullify the impact of technical uncertainty on internal efficiency. Thus, we hypothesize that:

H1a: *Technical Uncertainty mediates the effect of behavior control on internal efficiency.*

When team members are expected to follow procedures and are regularly assessed on how they performed tasks, they often find themselves in tightly controlled situations where their expertise is dominated by the sequence of steps prescribed by the manager. This can lead to dissatisfaction among team members resulting in less than expected positive psychological outcomes. Most notably, information system workers reported significantly lower professional efficiency and lower job satisfaction in firms where the dominant formal form of control is behavior control (Ply et al., 2012). The adherence to the rules and regulations set by the manager along with the close monitoring of the project's progress can lead to dissatisfaction among the team members. Focusing on the material consequence of the ISD project without bearing in mind the social situation ignores the fact that an ISD project is completed within a highly interactive situation (Aladwani, 2002). The introduction of technical uncertainty further lowers expectations of achieving good psychological outcomes such as satisfaction (Ferris, 1977) since the manager and the team members are not on the same page about either the technical object or the technology to achieve project goals. Thus, we hypothesize that:

H1b: *Technical Uncertainty mediates the effect of behavior control on psychological outcomes.*

In the case of outcome control, project managers evaluate team members for their timely and within-budget completion of the project regardless of the process or behaviors followed (Kirsch, 1996). Team members have more freedom and can complete their responsibilities without much monitoring or having to follow procedures and routines set by the manager. However, the manager evaluates whether the outcomes were met, which are known and measurable (Kirsch, 1996). Team members can put their knowledge and expertise to full use without any restrictions being placed by the manager. This can lead to a better project outcome since team members have the independence to devise their methods to achieve their targets, the resultant outcome being evaluated by the manager. Liu and Wang (2014) report that the outcome control used by team members is effective in the process performance of IT projects. Managers do not provide any procedures or sequences for completion and do not 'breathe down the neck' of the developers at every step of the way. Outcome controls synergistically increase process performance (Rijsdijk & van den Ende, 2011). Additionally, outcome control should be adopted in technologically complex situations (Lin et al., 2019) since team members may have ideas on how to resolve the problem and do not need to worry about much managerial intervention. However, the presence of technical uncertainty can lower the efficiency of the project. Thus, we hypothesize that:

H2a: *Technical Uncertainty mediates the effect of outcome control on internal efficiency.*

Outcome control helps alleviate uncertainties (Kreutzer et al., 2016) since team members can apply their knowledge and skills to resolve the issue on their own and with minimal intervention from management. Since the manager gives a free hand to the team to understand the technical objectives and the technology needed to accomplish the goal, team members have the satisfaction that they were able to apply their expertise and know-how to complete the tasks without any external pressure. IT professionals in situations of higher outcome control mentioned lower role uncertainty and higher job satisfaction relative to their counterparts in organizations with higher behavior controls (Ply et al., 2012). However, the presence of technical uncertainty could result in lower satisfaction since the project's outcomes may not meet the required levels. Thus, we hypothesize that:

H2b: *Technical Uncertainty mediates the effect of outcome control on psychological outcomes.*

Clan control is a team phenomenon (Kirsch et al., 2010) and takes shape with support from the organization (when team members enter into an informal agreement about the goals, values, and norms for the project. Clan control, a type of informal control, functions when behavior is driven by shared values, rules, and common goals (Ouchi, 1979). There is a lot of trust among members of the team and some of the processes and procedures are unique to the team and not part of any established procedures in the organization (Goldbach & Benlian, 2015). Such informal contact among the team members and mutual trust leads to a sense of prioritizing team goals over the individual, thus leading to efficient completion of the project. However, in the presence of technical uncertainties, the clan may require time to resolve how to go forward with solving the problem. This can lead to the need for the escalation of the issue to management either for more financial spending on technology or expertise. We hypothesize that:

H3a: *Technical Uncertainty mediates the effect of clan control on internal efficiency.*

Members of a clan feel accepted and have a sense of satisfaction that their contributions are acknowledged by their peers. Team-based clan control is employed by managers who lack in-depth ISD experience and knowledge (Kirsch et al., 2010). As part of the informal group, they can express their opinions and disagreements about how the project is headed without fear of any reprisal since fellow team members understand that their opinions are for the good of the team. A clan control system is likely to produce high levels of job satisfaction (Jaworski et al., 1993). Technical uncertainties can lead to intense discussions within the clan on how to approach the issue and could result in tensions among members lowering their satisfaction levels. Hence, we hypothesize that:

H3b: *Technical Uncertainty mediates the effect of clan control on psychological outcomes.*

In the case of self-control, each project participant devises a mechanism to achieve their targets, appraise themselves and apply rewards or punishments based on their performance (Kirsch & Cummings, 1996). The manager plays a minor part in the process of setting goals for the team member. Self-control can lead to effective project teams (Henderson & Lee, 1992).

Self-control positively impacts the process performance of IT projects (Liu, 2015b). In the presence of technical uncertainty, an individual who is highly skilled in their line of work will have the opportunity to resolve the situation on their own. The project output can be impacted even though Kirsch & Cummings (1996) report that the use of self-control is often suggested in a situation that has task complexity and uncertainty. Thus, we hypothesize that:

H4a: *Technical Uncertainty mediates the effect of self-control on internal efficiency.*

Self-control involves agents regulating their actions by cultivating a coherent sense of themselves (Xu et al., 2018). However, projects require that they are part of a group within the organization. It has been found that formal control within complex projects can be balanced by self-control (Liu & Chua, 2020). At times, organizational and team rules at the client site supplant the goals and objectives of the individual. However, in certain projects where the individual is solely responsible for the delivery of solutions, self-control could provide an effective method and as task complexity increases, professionals' self-control perceptions increase (Kirsch & Cummings, 1996). Since the individual is responsible for resolving technical uncertainties, there can be situations where they are successful which leads to a feeling of satisfaction and accomplishment in the individual. Self-control is related to improved satisfaction or performance (Hwang, 2005; Kirsch & Cummings, 1996). However, the presence of technical uncertainty can push the individual to exert self-control to consider the issue and find a solution. This can provide either a sense of satisfaction or a feeling of worth in the individual if there is a satisfactory project outcome. Thus, we hypothesize that:

H4b: *Technical Uncertainty mediates the effect of self-control on psychological outcomes.*

4 Methods

We collected data from employees working in ISD projects for companies situated in the Midwest of the United States. A survey was designed using the scales mentioned in Table 1. In addition to the two project outcome measures and four control modes, the survey collected demographic data, such as gender, and information on whether the respondent is a regular team member or a consultant. We enlisted the help of contact persons to distribute the survey to respondents who had recently participated in ISD projects that involved technical uncertainty. The survey asked specific questions on how project leaders and team members exercised control behavior in managing the just completed project. The contact persons themselves were students enrolled in ISD graduate classes and concurrently employed in ISD companies. The graduate students who acted as intermediaries were all from a university situated in the Midwest of the United States. They distributed the questionnaire among their colleagues who had recently participated in a development project. This form of convenience sampling was used to ensure that the survey was completed by people who had recently participated in a completed project. An Institutional Review Board approval was obtained, and an informed consent was taken when participants completed the survey. Each student received less than 10 questionnaires to avoid overrepresentation from a single organization. No formal reminders were necessary and a total of 210 questionnaires were distributed by the students.

A total of 156 responses were received from which 103 usable responses for an overall response rate of 49.04% after 8 weeks that were then used for analysis. The excluded responses did not contain enough information to warrant further analysis. The respondent profiles indicated a good distribution of gender, national origin, team member/consultant mix, and a good distribution of the technical complexity of the projects. Following Hedt and Pagano (2011) strategy to eliminate bias in convenience sampling, we compared the demographics of our sample and verified using secondary data to ensure that it matches the population of software developers on age and gender.

Table 1 below shows how the constructs were developed and measured. The model was controlled for gender and whether the team participants were team members or consultants. We conducted our mediation analysis using Warp PLS version 7.0, a variance-based structural equation modeling software. PLS has established its capability as a good application for examining human behaviors (Cyr et al., 2009) and is appropriate for this study as our theorized model is focused on how project participants react to different control modes to possibly influence project outcomes. We first evaluated the proposed model for model fit using the suggested procedures for PLS. The average R-squared (ARS) was found to be equal to 0.166, (P=0.020) while the average block VIF (AVIF) and average full collinearity VIF (AFVIF) value was observed to be 1.272 and 1.637 which are well lower than 3.3, the recommended levels for these model fit indices.

Behavior Control (Kirsch, 1997; Kirsch et. al., 2002)
The project manager expected me to follow a written sequence of steps.
The project manager assessed the extent written procedures were followed.
Outcome Control (Kirsch, 1997; Kirsch et. al., 2002)
The project manager placed significant weight on project completion to the satisfaction of the client.
The project manager evaluated my performance by the extent to which goals were accomplished, regardless of how the goals were accomplished.
Clan Control (Kirsch, 1997; Kirsch et. al., 2002)
The team members had common goals, values, and norms for the project.
There was a clear expectation from other team members to do my part of the project well.
The project climate was such that there was trust among team members.
Self-Control (Kirsch, 1997; Kirsch et. al., 2002)
Project members set specific goals for themselves without the involvement of the project manager.
Project members defined specific procedures to follow without the involvement of the project manager.
It was expected that project members would do their part of the project well without much monitoring by the project manager.
Routine monitoring of project work was done mostly by the team members.
Technical Uncertainty (Lewis et al., 2002)
Actual Experience with the project's technology.
Familiarity with technical objectives for the project.
Familiarity with the technology used in the project.
Understanding of the technical objectives for the project.
Psychological Outcome (Aladwani, 2002)
Members of our project were satisfied with their work.
Members were satisfied with the kind of work they did in the project.
Internal Efficiency (Banker & Kemerer, 1992)
The project was delivered in the least possible time.
Users are satisfied.
The system is simple and easily maintainable compared to other projects of this scope.

Table 1. Constructs and Measures

5 Results

5.1 Measurement Model

Discriminant validity was assessed by comparing the square of the Average Variance Extracted (AVE) correlations between the construct and other constructs (Barclay et al., 1995; Chin, 1998). As indicated in Table 2, the square root of the AVE (diagonal elements) exceeded the correlations (off-diagonal elements) between the constructs, confirming adequate discriminant validity.

	BEH	OC	Clan	Self	IE	PO	TU	AVE	CR	α
BEH	**0.93**	0.029	0.363	-0.06	0.098	0.026	0.014	0.865	0.927	0.844
OC	0.029	**0.851**	0.305	0.007	0.287	0.224	-0.338	0.725	0.841	0.621
Clan	0.363	0.305	**0.861**	0.336	0.229	0.205	-0.265	0.742	0.896	0.825
Self	-0.06	0.007	0.336	**0.832**	0.009	0.002	-0.009	0.693	0.900	0.852
IE	0.098	0.287	0.229	0.009	**0.792**	0.767	-0.258	0.627	0.834	0.702
PO	0.026	0.224	0.205	0.002	0.767	**0.874**	-0.421	0.764	0.906	0.844
TU	0.014	-0.338	-0.265	-0.009	-0.258	-0.421	**0.840**	0.705	0.905	0.859

BEH -Behavior control, OC - Outcome Control, Clan - Clan Control, Self - Self Control, IE - Internal Efficiency, PO - Psychological Outcomes, TU - Technical Uncertainty, AVE- Average Variance Extracted, CR - Composite Reliability, **α -** Cronbach Alpha

Table 2. Outer model loadings and cross-loadings.

In addition, Convergent validity was evaluated by comparing the item loadings with the suggested minimum value of 0.6 (Chin et al., 1997) as shown in Table 3. The item that loaded lowest against its construct was 0.673, sufficiently demonstrating convergent validity.

5.2 Structural Model

The mediation hypotheses were tested using the approach outlined by Baron and Kenny (1986). According to their method, mediation is established if: (1) the relationship between the independent variable and the dependent variable is significant; (2) the relationship between the independent variable and the presumed mediator is significant; and (3) when controlling for the mediator, the previously significant relationship between the independent variable and the dependent variable diminishes in significance or strength.

H1a hypothesized that technical uncertainty significantly mediates the effect of behavior control on internal efficiency. As shown in Figure 2, without the mediation of technical uncertainty, the effect of behavior control was not significant (β=0.004, P= 0.48) on internal efficiency.

However, with mediation, the link between (1) behavior control and uncertainty (β=0.12, P< 0.10), (2) uncertainty and internal efficiency were significant (β=-0.16, P=0.04), and (3) behavior control and internal efficiency (β= 0.02, P= 0.41) was not significant. Thus, H1a is unsupported since technical uncertainty does not mediate the effect of behavior control on internal efficiency.

	BEH	OC	Clan	Self	IE	TU	PO
BEH1	**0.866**	0.026	0.365	-0.072	0.114	-0.024	0.074
BEH2	**0.908**	0.026	0.276	-0.032	0.059	0.05	-0.047
OC1	0.195	**0.772**	0.305	-0.026	0.291	-0.314	0.256
OC2	-0.17	**0.877**	0.188	0.042	0.172	-0.236	0.120
Clan1	0.315	0.206	**0.829**	0.215	0.226	-0.193	0.180
Clan2	0.283	0.257	**0.803**	0.389	0.111	-0.185	0.101
Clan3	0.285	0.277	0.802	0.230	0.210	-0.259	0.179
Self1	-0.057	-0.078	0.320	**0.932**	0.088	0.018	0.054
Self2	-0.124	0.001	0.22	**0.923**	-0.092	0.041	-0.176
Self3	-0.028	0.051	0.362	**0.921**	0.046	-0.108	0.054
Self4	-0.002	0.062	0.334	0.883	-0.014	0.020	0.049
IE1	0.130	0.165	0.194	-0.024	**0.869**	-0.050	0.398
IE2	0.099	0.258	0.194	-0.050	**0.673**	-0.274	0.587
IE3	0.003	0.197	0.126	0.090	**0.729**	-0.200	0.602
TU1	-0.027	-0.437	-0.307	0.033	-0.163	**0.750**	-0.345
TU2	0.017	-0.178	-0.177	-0.037	-0.247	**0.872**	-0.307
TU3	-0.016	-0.328	-0.249	0.061	-0.175	**0.816**	-0.312
TU4	0.069	-0.198	-0.155	-0.083	-0.264	**0.868**	-0.282
PO1	0.029	0.165	0.178	-0.028	0.541	-0.305	**0.741**
PO2	-0.004	0.187	0.109	0.018	0.558	-0.256	**0.758**

Table 3. Measurement model assessment

H1b hypothesized that technical uncertainty significantly mediates the effect of behavior control on psychological outcomes. As shown in Figure 3, without the mediation of technical uncertainty, the effect of behavior control was not significant (β=-0.10, P=0.14) on psychological outcomes. However, with mediation, the link between (1) behavior control and uncertainty (β=0.12, P=0.10), (2) uncertainty and psychological outcomes was significant (β=-0.37, P<0.01), and (3) behavior control and psychological outcomes (β=-0.05, P=0.30) were not significant. Thus, H1b is unsupported since technical uncertainty does not mediate the effect of behavior control on psychological outcomes.

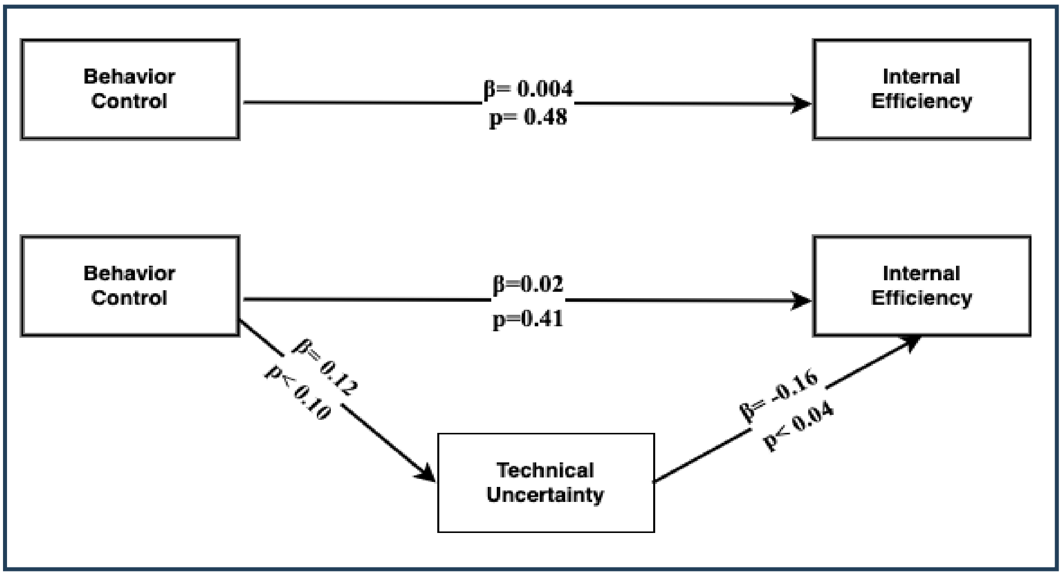

Figure 2: H1a

H2a hypothesized that technical uncertainty significantly mediates the effect of outcome control on internal efficiency. As shown in Figure 4, without the mediation of technical uncertainty, the effect of outcome control was significant (β=0.25, P<.01) on internal efficiency. However, with mediation, the link between 1) outcome control and uncertainty (β=-0.26, P<0.10), 2) uncertainty and internal efficiency was significant (β=-0.16, P=0.04) and 3) outcome control and internal efficiency (β=0.21, P=0.01) were significant. Thus, H2a is supported since technical uncertainty partially mediates the relationship between outcome control and internal efficiency.

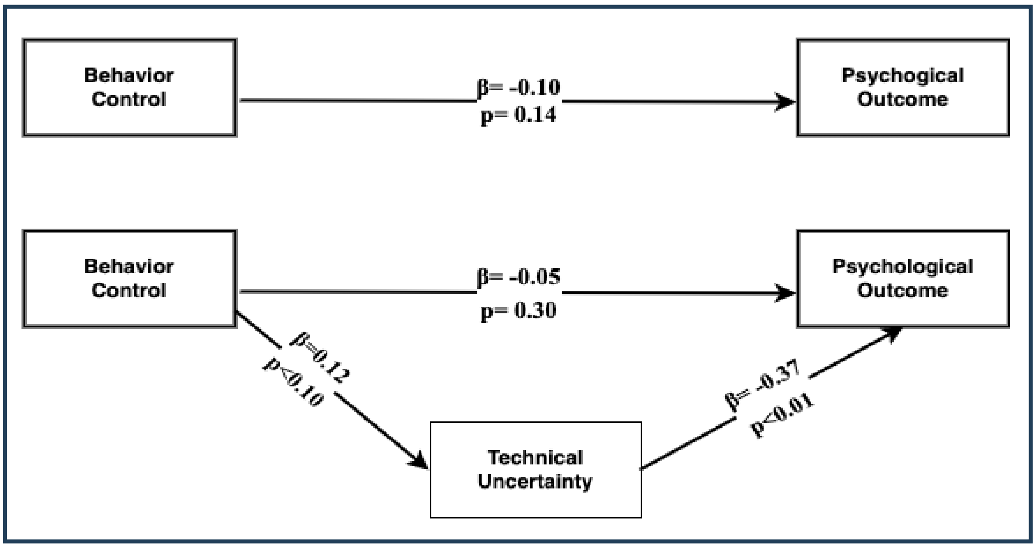

Figure 3: H1b

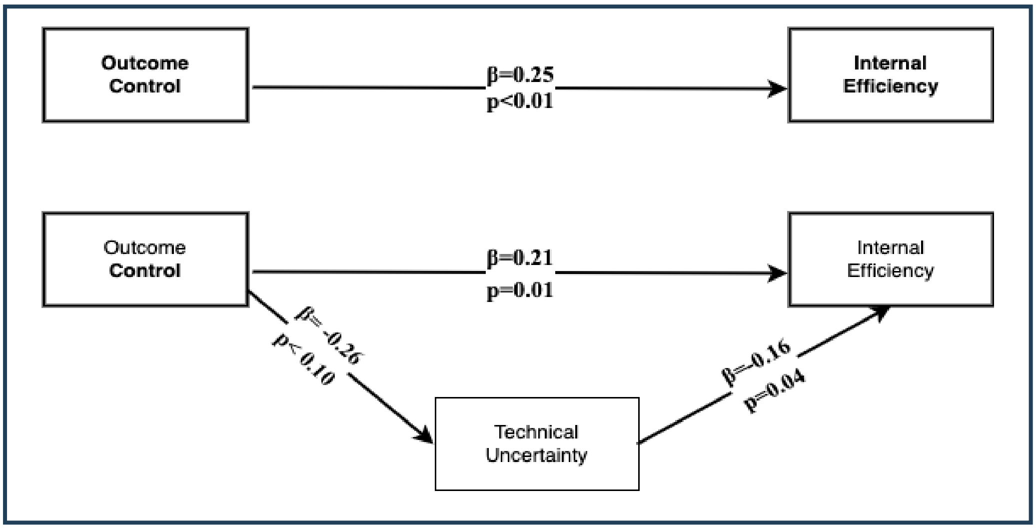

Figure 4: H2a

H2b hypothesized that technical uncertainty significantly mediates the effect of outcome control on psychological outcomes. As shown in Figure 5, without the mediation of technical uncertainty, the effect of outcome control was significant (β=0.20, P=0.02) on psychological outcomes. However, with mediation, the link between 1) outcome control and uncertainty (β=-0.26, P<0.01), 2) uncertainty and psychological outcome control was significant (β=-0.37, P<0.01), and 3) outcome control and psychological outcomes (β=0.09, P=0.18) was not significant. Thus, H2b is supported since technical uncertainty fully mediates the relationship between outcome control and psychological outcomes.

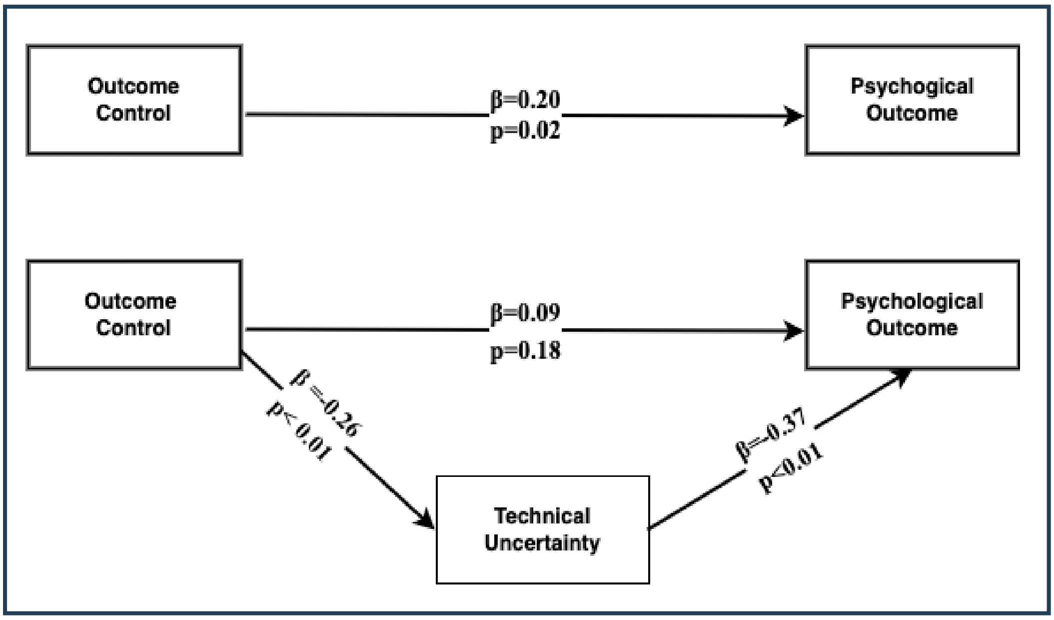

Figure 5: H2b

H3a hypothesized that technical uncertainty significantly mediates the effect of clan control on internal efficiency. As shown in Figure 6, without the mediation of technical uncertainty, the effect of clan control was significant (β=0.16, P=0.04) on internal efficiency. However, with mediation, the link between 1) clan control and uncertainty (β=-0.26, P<0.01), 2) uncertainty and internal efficiency was significant (β=-0.16, P<0.05), and 3) clan control and internal efficiency (β=0.12, P=0.10) was significant. Thus, H3a is supported since technical uncertainty partially mediates the relationship between clan control and internal efficiency.

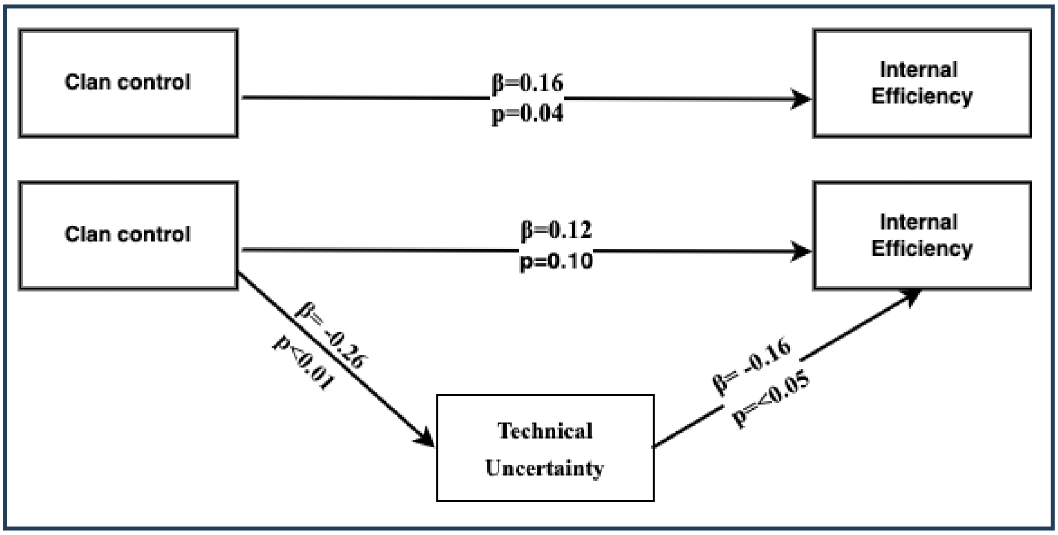

Figure 6: H3a

H3b hypothesized that technical uncertainty significantly mediates the effect of clan control on psychological outcomes. As shown in Figure 7, without the mediation of technical uncertainty, the effect of clan control was significant (β=0.19, P=0.02) on psychological outcomes. However, with mediation, the link between 1) clan control and uncertainty (β=-0.26, P<0.01), 2) uncertainty and the psychological outcome was significant (β=-0.37, P<0.01), and 3) clan control and psychological outcomes (β=0.11, P=0.13) was not significant. Thus, H2b is supported since technical uncertainty fully mediates the relationship between clan control and psychological outcomes.

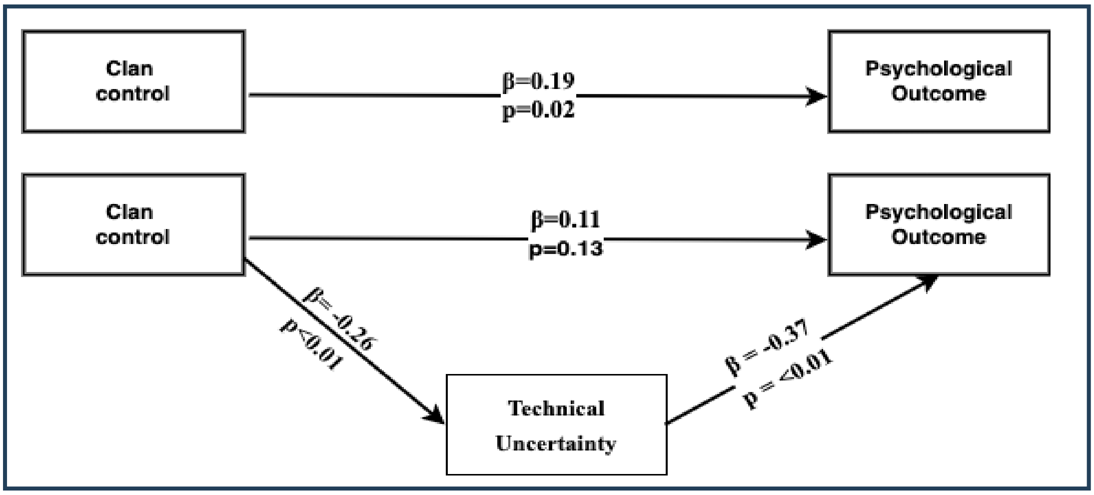

Figure 7: H3b

H4a hypothesized that technical uncertainty significantly mediates the effect of self-control on internal efficiency. As shown in Figure 8, without the mediation of technical uncertainty, the effect of self-control was not significant (β=-0.04, P=0.35) on internal efficiency. However, with mediation, the link between 1) self-control and uncertainty (β=0.09, P=0.18) was not significant, 2) uncertainty and internal efficiency were significant (β=-0.16, P<0.05), and 3) self-control and internal efficiency (β=-0.02, P=0.41) was not significant. Thus, H4a is unsupported since technical uncertainty does not significantly mediate the relationship between self-control on internal efficiency.

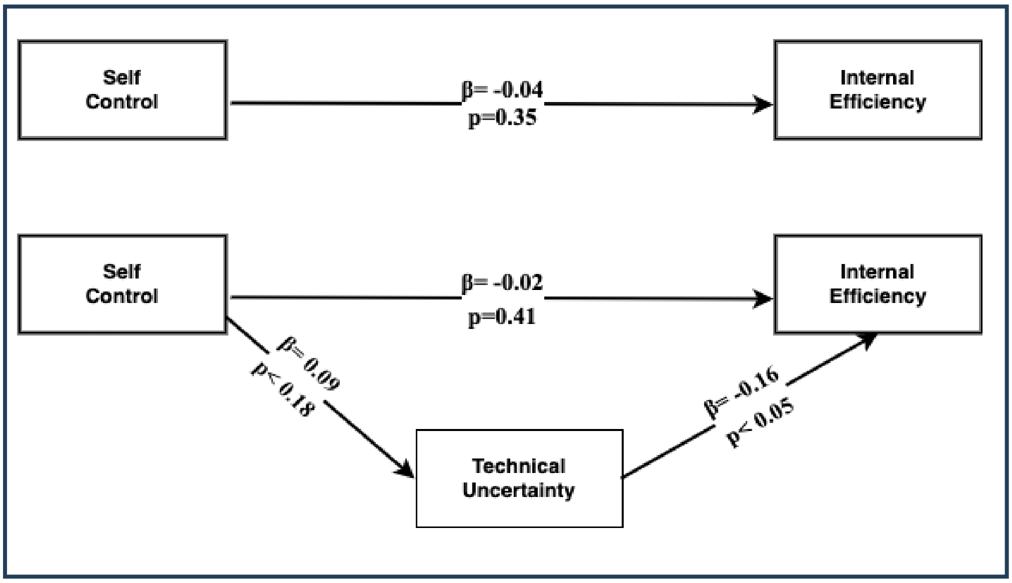

Figure 8: H4a

H4b hypothesized that technical uncertainty significantly mediates the effect of self-control on psychological outcomes. As shown in Figure 9, without the mediation of technical uncertainty, the effect of self-control was not significant (β=-0.06, P=0.35) on psychological outcomes. However, with mediation, the link between 1) self-control and uncertainty (β=0.09, P=0.18) was not significant, 2) uncertainty and the psychological outcome was significant (β=-0.37, P<0.01), and 3) self-control and psychological outcomes (β=-0.02, P=0.39) was not significant. Thus, H4b is unsupported since technical uncertainty does not significantly mediate the effect of self-control on psychological outcomes. Table 4. Summarizes the results of hypothesis tested in this study.

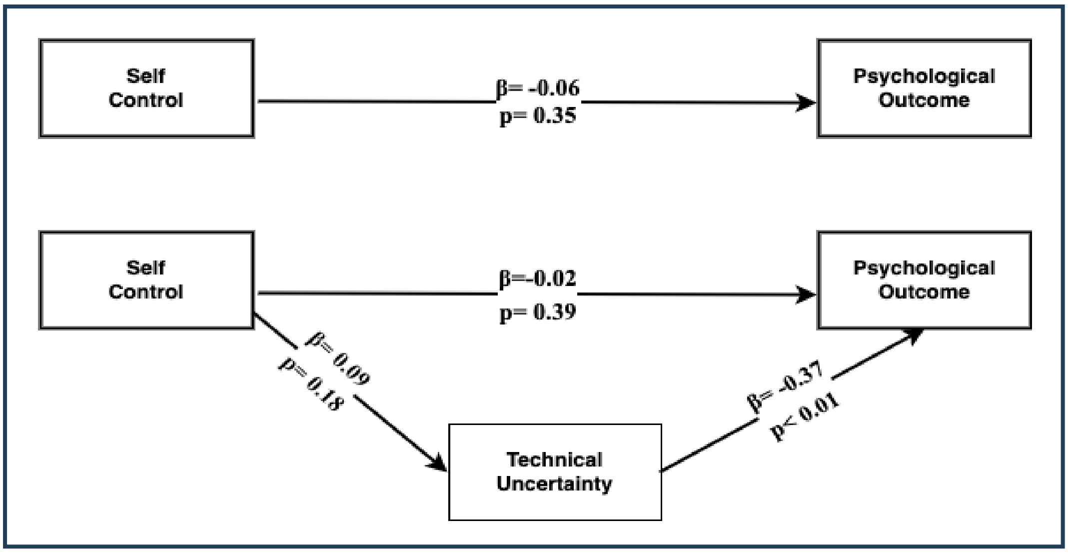

Figure 9: H4b

Hypothesis	Independent Variable	Dependent variable	Result
H1a	Behavior Control	Internal Efficiency	Not Supported
H1b	Behavior Control	Psychological Outcomes	Not Supported
H2a	Outcome Control	Internal Efficiency	Supported
H2b	Outcome Control	Psychological Outcomes	Supported
H3a	Clan Control	Internal Efficiency	Supported
H3b	Clan Control	Psychological Outcomes	Supported
H4a	Self-Control	Internal Efficiency	Not supported
H4b	Self-Control	Psychological Outcomes	Not supported

Table 4. Results of hypothesis testing. (mediated by Technical Uncertainty)

6 Discussion

The ever-changing technology landscape presents immense challenges to organizations, mainly in the form of technical uncertainty as they attempt to keep up with the changes and derive value. In this study, we examined the control modes best suited to achieve internal efficiency and psychological outcomes in the presence of technical uncertainty. The successful completion of any organizational endeavor relies on 1) internal efficiencies (Shenhar et al.,1997; Baccarini, 1999), which are the effectiveness of an organization's internal process and 2) psychological outcomes, which refers to the team members' satisfaction level with the work required to be completed for the ISD project (Aladwani, 2002). Analysis of responses from team members based in the US reveals that, out of the four control modes, clan and outcome control modes are best suited to achieve internal efficiencies and psychological outcomes in the presence of technical uncertainty. The results of this study provide new theoretical insights for the ISD project management literature and generate practical implications for managers in implementing technically uncertain projects effectively.

6.1 Theoretical Implications

Our research contributes to the ISD project literature by studying the effects of the four control modes on two project outcomes: psychological outcomes and internal efficiency. As theorized, our results show that clan and outcome control were the two control modes appropriate to realize project outcomes when the relationships are mediated by technical uncertainty. Our findings show that technical uncertainty 1) fully mediated the relationship between clan and outcome control with psychological outcomes, 2) partially mediated the relationships between clan and outcome control with internal efficiency and 3) is not relevant in the case of behavior and self-control since these two control modes had no significant direct relationship with the project outcomes even in the absence of technical uncertainty. Earlier studies using control theory have shown the impact of behavior, outcome, self and clan control on project performance (Keil et al., 2013) and how clan and outcome control are effective for project performance amidst high complexity risk (Liu, 2015a).

Our findings demonstrate that outcome and clan control are significant antecedents of psychological outcomes and that both control modes have no significant outcome on psychological outcomes over and above the effects mediated by technical uncertainty. In the case of psychological outcome, clan and outcome control retain their significant relationship with internal efficiency over and above the effects mediated by technical uncertainty. Thus, the project outcomes depend on the freedom provided by the controller to the controlees to provide the solution (e.g., outcome control) or the following of shared values and informal agreed-upon behaviors (e.g., clan control).

Our results show that clan and outcome control lose their direct effect on psychological outcomes in the presence of technical uncertainty. However, the control modes significantly lessen technical uncertainty which in turn reduces the quality of psychological outcomes. In the case of internal efficiency, the control modes (clan and outcome) still retain some of their direct effect even while reducing technical uncertainty. However technical uncertainty results in reduced internal efficiency.

No support for the relationship between behavior control with the project outcomes could be due to the lack of importance for effectiveness and satisfaction as criteria for formal documentation and procedures prescribed to the ISD project. Similarly, in the case of self-control, the controlee may be focused more on getting the project completed and may not be particularly interested in deriving satisfaction or ensuring process effectiveness.

6.2 Managerial Implications

The study of technical uncertainty in ISD project control is not just a proactive measure but a strategic imperative. It empowers organizations to optimize project outcomes, enhance resource efficiency, and foster a culture of innovation. Driven by the need for innovation and competitive advantage, organizations initiate projects that incorporate new technologies. Integration of such software and hardware can result in technical uncertainty since team members have limited training or are unsure how such technologies integrate with the existing infrastructure. Our results show that both clan and outcome control deliver internal efficiency and psychological outcomes, which are highly desired by organizations. Most team members have the knowledge and are quite skilled at managing uncertainties posed by new technologies. Though they lack familiarity with the newly introduced technology, they bring their experience and learning to find solutions with innovative technologies. Our findings show that managers could employ outcome and clan control since they provide modes for such experienced team members to work with their peers to provide new solutions using innovative technology. Team members have the freedom to discuss issues and workarounds without the intervention of their controller(s).

Our results show that regardless of use of either clan or outcome control, managers shouldn't expect increased internal efficiency and psychological outcomes in the presence of technical uncertainty. In the case of internal efficiency, both clan and outcome control reduce technical uncertainty. Although technical uncertainty results in reduced internal efficiency, certain aspects of previously adopted procedures of achieving internal efficiency developed in the absence of technical uncertainty still apply. However, managers should note that previous ways of achieving psychological outcomes are not effective in the presence of technical uncertainty in the case of both outcome and clan control. Though both clan and outcome control mode reduce technical uncertainty, satisfaction is lowered and only related to how the technical uncertainty is resolved. This is probably due to the complexity associated with implementing the new technology (Johnson et al., 2008). Team members may find less satisfaction having to adapt the innovative technology to implement the solution.

Interestingly, our results support the use of both formal and informal modes of control which may help organizations that have more controller-oriented culture to decide using outcome control compared to clan control which can be used by organizations that provide more freedom to the controlee.

Furthermore, the findings indicate that managers should refrain from implementing behavior or self-control modes, as these modes demonstrate no significant impact on internal efficiency or psychological outcomes, even in the absence of technical uncertainty. This could stem from the resistance of experienced team members to adhere strictly to protocols and procedures, especially when they possess their own ideas and concepts for resolving issues.

6.3 Limitations and Future Research

Our study is not without limitations. First, our study surveyed team members who possibly work on different projects of various complexities. The complexity of the project is a dimension that should be explored in future studies. Second, our study sample raises concerns about common method bias. This can be resolved by a future study where a controller-controlee pairwise design is applied to understand the phenomenon. Third, culture can influence how team members respond to control modes. Future research could undertake a comparative study of team members in different cultures to understand which control modes are best suited to reduce technical uncertainty. Fourth, technical uncertainty in different industry verticals could be researched to unearth more definitive methods to apply suitable control models. Fifth, research on different levels of technical uncertainty also could provide a richer understanding of the interaction between the control model with psychological outcomes and internal efficiency.

7 Conclusion

As the ISD landscape continues to evolve, understanding and addressing technical uncertainties will be a defining factor in the success of projects and the competitiveness of organizations in the digital era. In this technically uncertain environment, mainly created by the focus on building innovative solutions, the issue of control modes between the management and the team is an issue of importance. Project efficiencies and psychological outcomes play a critical role in the successful completion of any organizational endeavor. The objective of this study was to comprehend how technical uncertainty mediates the effect of different control types on internal efficiency and psychological outcomes. Given that projects face technical uncertainty and apply different control tactics, the identification of outcome and clan control having a favorable influence on technical uncertainty helps organizations maintain their competitive advantage and team member morale. Clan control is shaped by interactions among team members towards achieving project goals through peer sanctioned norms, rituals, and ceremonies (Chua et al., 2012). In the case of outcome control, the controller evaluates the output without much regard to the process used to achieve it (Choudhary & Sabherwal, 2003). The results indicate that in technically uncertain conditions, companies should let the team decide and figure out the solution, implying reliance on clan control and outcome control. Thus, the guidance our results provide is to rely less on behavior and self-control but more on outcome and clan control.

References

Aladwani, A. M. (2002). An integrated performance model information systems project. *Journal of Management Information Systems*, *19*(1), 185–210. doi.org/10.1177/87569728221089831

Atanassov, J., Julio, B., & Leng, T. (2024). The bright side of political uncertainty: The case of R&D. *The Review of Financial Studies*, hhae023. doi.org/10.1093/rfs/hhae023

Baccarini, D. (1999). The logical framework method for defining project success. *Project Management Journal*, *30*(4), 25–32. doi.org/10.1177/875697289903000405

Bakos, J. Y. (1991). A strategic analysis of electronic marketplaces. *MIS Quarterly*, 295–310. https://www.jstor.org/stable/249641

Banker, R. D., & Kemerer, C. F. (1992). Performance evaluation metrics for information systems development: A principal-agent model. *Information Systems Research*, *3*(4), 379-400. doi.org/10.1287/isre.3.4.379

Barclay, D., Higgins, C., & Thompson, R. (1995). The partial least squares (PLS) approach to casual modeling: personal computer adoption ans use as an Illustration. Technology Studies, 2, 285–309.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173. https://psycnet.apa.org/doi/10.1037/0022-3514.51.6.1173

Beese, J., Haki, K., Schilling, R., Kraus, M., Aier, S., & Winter, R. (2023). Strategic alignment of enterprise architecture management–how portfolios of control mechanisms track a decade of enterprise transformation at Commerzbank. *European Journal of Information Systems*, *32*(1), 92-105. doi.org/10.1080/0960085X.2022.2085200

Chen, W., Huang Chua, C. E., Young, R., & Xu, X. (2022). Explaining Reverse Outcome Tight Control: A Case Study of Mindless/Mindful Governance. *Project Management Journal*, *53*(3), 309–324. doi.org/10.1177/87569728221091484

Cheng, Q., Goh, B. W., & Kim, J. B. (2018). Internal control and operational efficiency. *Contemporary Accounting Research*, *35*(2), 1102-1139. doi.org/10.1111/1911-3846.12409

Chien, S. W., Hu, C., Reimers, K., & Lin, J. S. (2007). The influence of centrifugal and centripetal forces on ERP project success in small and medium-sized enterprises in China and Taiwan. *International Journal of Production Economics*, *107*(2), 380–396. doi.org/10.1016/j.ijpe.2006.10.002

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. *Modern Methods for Business Research/ Lawrence Erlbaum Associates*.

Chin, W. W., Gopal, A., & Salisbury, W. D. (1997). Advancing the theory of adaptive structuration: The development of a scale to measure faithfulness of appropriation. *Information Systems Research*, *8*(4), 342-367. doi.org/10.1287/isre.8.4.342

Choudhury, V., & Sabherwal, R. (2003). Portfolios of control in outsourced software development projects. *Information Systems Research*, *14*(3), 291–314. doi.org/10.1287/isre.14.3.291.16563

Chua, C. E. H., Lim, W. K., Soh, C., & Sia, S. K. (2012). Enacting clan control in complex IT projects: A social capital perspective. *MIS Quarterly*, 577-600. doi.org/10.2307/41703468

Codex, A. C. (2023, June 16). *Managing the challenges of software development projects with high levels of technical uncertainty.* Reintech Media. https://reintech.io/blog/managing-challenges-of-software-development-with-technical-uncertainty

Cram, W. A., Brohman, K., & Gallupe, R. B. (2016). Information systems control: A review and framework for emerging information systems processes. *Journal of the Association for Information Systems*, *17*(4), 2. https://aisel.aisnet.org/jais/vol17/iss4/2/

Cyr, D., Head, M., Larios, H., & Pan, B. (2009). Exploring human images in website design: a multi-method approach. *MIS Quarterly*, 539–566. doi.org/10.2307/20650308

Dasgupta, M., Gupta, R. K., & Sahay, A. (2011). Linking technological innovation, technology strategy and organizational factors: A review. *Global Business Review*, *12*(2), 257–277. doi.org/10.1177/097215091101200206

Deci, E. L., & Ryan, R. M. (1987). The support of autonomy and the control of behavior. *Journal of Personality and Social Psychology*, *53*(6), 1024.

Dönmez, D., & Grote, G. (2018). Two sides of the same coin–how agile software development teams approach uncertainty as threats and opportunities. *Information and Software Technology*, *93*, 94-111. doi.org/10.1016/j.infsof.2017.08.015

Duan, W., Gu, B., & Whinston, A. B. (2009). Informational cascades and software adoption on the internet: an empirical investigation. *MIS Quarterly*, 23–48. doi.org/10.2307/20650277

Eisenhardt, K. M. (1985). Control: Organizational and economic approaches. *Management Science*, *31*(2), 134-149. doi.org/10.1287/mnsc.31.2.134

Ens, N., Hukal, P., & Blegind Jensen, T. (2023). Dynamics of control on digital platforms. *Information Systems Journal*, *33*(4), 890–911. doi.org/10.1111/isj.12429

Ferris, K. R. (1977). Perceived uncertainty and job satisfaction in the accounting environment. *Accounting, Organizations and Society*, *2*(1), 23–28. doi.org/10.1016/0361-3682(77)90004-6

Gerber, E. (2009). Prototyping: facing uncertainty through small wins. In *DS 58-9: Proceedings of ICED 09, the 17th International Conference on Engineering Design, Vol. 9, Human Behavior in Design, Palo Alto, CA, USA, 24.-27.08. 2009*, 333–342.

Gerber, E., & Carroll, M. (2012). The psychological experience of prototyping. *Design Studies*, *33*(1), 64-84. doi.org/10.1016/j.destud.2011.06.005

Gnanasambandam, C., Miller, A., & Sprague, K. (2018, April 9). *Grow fast or die slow: The role of profitability in sustainable growth.* Mckinsey. https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/grow-fast-or-die-slow-the-role-of-profitability-in-sustainable-growth

Goldbach, T., & Benlian, A. (2015). How informal control modes affect developers' trust in a platform vendor and platform stickiness. *Wirtschaftsinformatik Proceedings 2015. 89.* https://aisel.aisnet.org/wi2015/89

Harris, M., Hevner, A. R., & Collins, R. W. (2006, January). Controls in flexible software development. In *Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06)* (Vol. 9, pp. 216a–216a). IEEE. https://ieeexplore.ieee.org/abstract/document/1579732/citations

Heales, J., Susilo, A., & Rohde, F. (2007). Project Management Effectiveness: the choice-formal or informal controls. *Australasian Journal of Information Systems*, *15*(1). doi.org/10.3127/ajis.v15i1.480

Hedt, B. L., & Pagano, M. (2011). Health indicators: eliminating bias from convenience sampling estimators. *Statistics in medicine*, *30*(5), 560-568. doi.org/10.1002/sim.3920

Henderson, J. C., & Lee, S. (1992). Managing I/S design teams: A control theories perspective. *Management Science*, *38*(6), 757-777. doi.org/10.1287/mnsc.38.6.757

Henry, R. M., Narayanaswamy, R., & Purvis, R. L. (2015). Effect of control on information systems development performance: A meta-analysis. *Journal of Computer Information Systems*, *55*(3), 46–54. doi.org/10.1080/08874417.2015.11645771

Holland, W. E., Stead, B. A., & Leibrock, R. C. (1976). Information channel/source selection as a correlate of technical uncertainty in a research and development organization. *IEEE Transactions on Engineering Management*, (4), 163–167. https://ieeexplore.ieee.org/abstract/document/6447184

Hwang, Y. (2005). Investigating enterprise systems adoption: uncertainty avoidance, intrinsic motivation, and the technology acceptance model. *European Journal of Information Systems*, *14*(2), 150-161. doi.org/10.1057/palgrave.ejis.3000532

Iacovou, C., Smith, J., & Thompson, R. (2005). The linkage between reporting quality and performance in information systems projects. *ICIS 2005 Proceedings.* 34. https://aisel.aisnet.org/icis2005/34

Jain, N. K., Celo, S., & Kumar, V. (2019). Internationalization speed, resources and performance: Evidence from Indian software industry. *Journal of Business Research*, *95*, 26-37. doi.org/10.1016/j.jbusres.2018.09.019

Jalonen, H. (2012). The uncertainty of innovation: a systematic review of the literature. *Journal of Management Research*, *4*(1), 1-47. http://dx.doi.org/10.5296/jmr.v4i1.1039

Jaworski, B. J. (1988). Toward a theory of marketing control: environmental context, control types, and consequences. *Journal of Marketing*, *52*(3), 23–39. doi.org/10.1177/002224298805200303

Jaworski, B. J., & MacInnis, D. J. (1989). Marketing jobs and management controls: toward a framework. *Journal of Marketing Research*, *26*(4), 406–419. doi.org/10.1177/002224378902600403

Jaworski, B. J., Stathakopoulos, V., & Krishnan, H. S. (1993). Control combinations in marketing: conceptual framework and empirical evidence. *Journal of Marketing*, *57*(1), 57-69. doi.org/10.1177/002224299305700104

Johnson, D. S., Bardhi, F., & Dunn, D. T. (2008). Understanding how technology paradoxes affect customer satisfaction with self-service technology: The role of performance ambiguity and trust in technology. *Psychology & Marketing*, *25*(5), 416–443. doi.org/10.1002/mar.20218

Jun, L., Qiuzhen, W., & Qingguo, M. (2011). The effects of project uncertainty and risk management on IS development project performance: A vendor perspective. *International Journal of Project Management*, *29*(7), 923–933. doi.org/10.1016/j.ijproman.2010.11.002

Jurado, K., Ludvigson, S. C., & Ng, S. (2015). Measuring uncertainty. *American Economic Review*, *105*(3), 1177-1216. https://www.aeaweb.org/articles?id=10.1257/aer.20131193

Kanwal, N., Zafar, M. S., & Bashir, S. (2017). The combined effects of managerial control, resource commitment, and top management support on the successful delivery of information systems projects. *International Journal of Project Management*, *35*(8), 1459–1465. doi.org/10.1016/j.ijproman.2017.08.007

Keil, M., Rai, A., & Liu, S. (2013). How user risk and requirements risk moderate the effects of formal and informal control on the process performance of IT projects. *European Journal of Information Systems*, *22*(6), 650–672. doi.org/10.1057/ejis.2012.42

Kirsch, L. J. (1996). The management of complex tasks in organizations: Controlling the systems development process. *Organization Science*, *7*(1), 1-21. doi.org/10.1287/orsc.7.1.1

Kirsch, L. J., & Cummings, L. L. (1996). Contextual influences on self-control of IS professionals engaged in systems development. *Accounting, Management and Information Technologies*, *6*(3), 191-219. doi.org/10.1016/0959-8022(96)00018-5

Kirsch, L. J., Ko, D. G., & Haney, M. H. (2010). Investigating the antecedents of team-based clan control: Adding social capital as a predictor. *Organization Science*, *21*(2), 469–489. doi.org/10.1287/orsc.1090.0458

Kirsch, L. J., Sambamurthy, V., Ko, D. G., & Purvis, R. L. (2002). Controlling information systems development projects: The view from the client. *Management Science*, *48*(4), 484–498. doi.org/10.1287/mnsc.48.4.484.204

Kirsch, L. S. (1997). Portfolios of control modes and IS project management. *Information Systems Research*, *8*(3), 215–239. doi.org/10.1287/isre.8.3.215

Klir, G. J. (2006). Uncertainty and information: foundations of generalized information theory. *Kybernetes*, *35*(7/8), 1297–1299. doi.org/10.1108/03684920610675283

Kreutzer, M., Cardinal, L. B., Walter, J., & Lechner, C. (2016). Formal and informal control as complement or substitute? The role of the task environment. *Strategy Science*, *1*(4), 235–255. doi.org/10.1287/stsc.2016.0019

Laine, T., Korhonen, T., & Martinsuo, M. (2016). Managing program impacts in new product development: An exploratory case study on overcoming uncertainties. *International Journal of Project Management*, *34*(4), 717-733. doi.org/10.1016/j.ijproman.2016.02.011

Lewis, M. W., Welsh, M. A., Dehler, G. E., & Green, S. G. (2002). Product development tensions: Exploring contrasting styles of project management. *Academy of Management Journal*, *45*(3), 546-564. doi.org/10.5465/3069380

Lin, L., Müller, R., Zhu, F., & Liu, H. (2019). Choosing suitable project control modes to improve the knowledge integration under different uncertainties. *International Journal of Project Management*, *37*(7), 896-911. doi.org/10.1016/j.ijproman.2019.07.002

Liu, G. H. W., & Chua, C. E. H. (2020). The reinforcing effects of formal control enactment in complex IT projects. *Journal of the Association for Information Systems*, 21(2). doi.org/10.17705/1jais.00603

Liu, S. (2015a). Effects of control on the performance of information systems projects: the moderating role of complexity risk. *Journal of Operations Management*, *36*, 46–62. doi.org/10.1016/j.jom.2015.03.003

Liu, S. (2015b). How team risk and planning and control risk moderate the effects of clan and self control on the process performance of IT projects: the perspective of user liaisons. *Information Development*, *31*(1), 27–39. doi.org/10.1177/0266666913501682

Liu, S., & Wang, L. (2014). User liaisons' perspective on behavior and outcome control in IT projects: Role of IT experience, behavior observability, and outcome measurability. *Management Decision*, *52*(6), 1148–1173. doi.org/10.1108/MD-08-2013-0430

Lynn, G. S., & Akgün, A. E. (1998). Innovation strategies under uncertainty: a contingency approach for new product development. *Engineering Management Journal*, *10*(3), 11–18. doi.org/10.1080/10429247.1998.11414991

Maes, T., Gebhardt, K., & Riel, A. (2022). The relationship between uncertainty and task execution strategies in project management. *Project Management Journal*, *53*(4), 382–396. doi.org/10.1177/87569728221089831

Marinho, M., Sampaio, S., & Moura, H. (2018). Managing uncertainty in software projects. *Innovations in Systems and Software Engineering*, *14*, 157–181. doi.org/10.1007/s11334-017-0297-y

McCarthy, S., O'Raghallaigh, P., Li, Y., & Adam, F. (2023). Control enactment in context: Understanding the interaction of controlee and controller perceptions in inter-organisational project teams. *Information Systems Journal*, *33*(5), 1029–1084. doi.org/10.1111/isj.12434

Mehta, N., Hall, D., & Byrd, T. (2014). Information technology and knowledge in software development teams: The role of project uncertainty. *Information & Management*, *51*(4), 417-429. doi.org/10.1016/j.im.2014.02.007

Mullen, J. (2023, April 25). *2023 Insight intelligent technology report: Are we entering a new era of innovation?* Insight. https://www.insight.com/en_US/content-and-resources/gated/insight-intelligent-technology-report-ac1252.html

Nidumolu, S. R., & Subramani, M. R. (2003). The matrix of control: Combining process and structure approaches to managing software development. *Journal of Management Information Systems*, *20*(3), 159–196. doi.org/10.1080/07421222.2003.11045774

Ouchi, W. G. (1979). A conceptual framework for the design of organizational control mechanisms. *Management Science*, *25*(9), 833–848. doi.org/10.1287/mnsc.25.9.833

Patterson, P. G., Johnson, L. W., & Spreng, R. A. (1997). Modeling the determinants of customer satisfaction for business-to-business professional services. *Journal of the Academy of Marketing Science*, *25*, 4–17. doi.org/10.1007/BF02894505

Piccoli, G., & Ives, B. (2003). Trust and the unintended effects of behavior control in virtual teams. *MIS Quarterly*, 365–395. doi.org/10.2307/30036538

Ply, J. K., Moore, J. E., Williams, C. K., & Thatcher, J. B. (2012). IS employee attitudes and perceptions at varying levels of software process maturity. *Mis Quarterly*, 601–624. doi.org/10.2307/41703469

Ragatz, G. L., Handfield, R. B., & Petersen, K. J. (2002). Benefits associated with supplier integration into new product development under conditions of technology uncertainty. *Journal of Business Research*, *55*(5), 389–400. doi.org/10.1016/S0148-2963(00)00158-2

Remus, U., Wiener, M., Saunders, C., & Mähring, M. (2020). The impact of control styles and control modes on individual-level outcomes: a first test of the integrated IS project control theory. *European Journal of Information Systems*, *29*(2), 134–152. doi.org/10.1080/0960085X.2020.1718008

Rijsdijk, S. A., & van den Ende, J. (2011). Control combinations in new product development projects. *Journal of Product Innovation Management*, *28*(6), 868-880. doi.org/10.1111/j.1540-5885.2011.00850.x

Saxena, D., & McDonagh, J. (2020). The Evolving Nature of Information Systems Controls in Healthcare Organisations: The Case of a Blood Banking Enterprise System from Western Europe. *Australasian Journal of Information Systems*, *24*. doi.org/10.3127/ajis.v24i0.2635

Shenhar, A. J., & Dvir, D. (2007). *Reinventing project management: the diamond approach to successful growth and innovation*. Harvard Business Review Press.

Shenhar, A. J., Levy, O., & Dvir, D. (1997). Mapping the dimensions of project success. *Project Management Journal*, *28*, 5-13. https://www.wcu.edu/pmi/1998/J97JUN05.PDF

Song, M., & Montoya-Weiss, M. M. (2001). The effect of perceived technological uncertainty on Japanese new product development. *Academy of Management journal*, *44*(1), 61–80. doi.org/10.5465/3069337

Spanjol, J., Xiao, Y., & Welzenbach, L. (2018). Successive innovation in digital and physical products: Synthesis, conceptual framework, and research directions. *Innovation and Strategy*, *15*, 31–62. doi.org/10.1108/S1548-643520180000015004

Stewart, K. J., & Gosain, S. (2006). The impact of ideology on effectiveness in open source software development teams. *MIS Quarterly*, 291–314. doi.org/10.2307/25148732

Stock, G. N., & Tatikonda, M. V. (2008). The joint influence of technology uncertainty and interorganizational interaction on external technology integration success. *Journal of Operations Management*, *26*(1), 65–80. doi.org/10.1016/j.jom.2007.04.003

Townsend, A. M., DeMarie, S. M., & Hendrickson, A. R. (1998). Virtual teams: Technology and the workplace of the future. *Academy of Management Perspectives*, *12*(3), 17–29. doi.org/10.5465/ame.1998.1109047

Webster, N. (1916). *Webster's collegiate dictionary*. G. & C. Merriam Company.

Ward, S., & Chapman, C. (2003). Transforming project risk management into project uncertainty management. *International Journal of Project Management*, *21*(2), 97–105. doi.org/10.1016/S0263-7863(01)00080-1

Wiener, M., Mähring, M., Remus, U., & Saunders, C. (2016). Control configuration and control enactment in information systems projects. *MIS Quarterly*, *40*(3), 741–774. https://www.jstor.org/stable/26629036

Wright, P. M., George, J. M., Farnsworth, S. R., & McMahan, G. C. (1993). Productivity and extra-role behavior: The effects of goals and incentives on spontaneous helping. *Journal of Applied psychology*, *78*(3), 374. https://psycnet.apa.org/buy/1993-37472-001

Xu, Y., Tong, Y., & Liao, S. S. (2018, January). Self-Control Matters: Examining Indirect Use of Hospital Information Systems and its Control Mechanisms. In *ACIS* (p. 26).

Yu, S. H., & Chiu, W. T. (2013). Social networks and corporate performance: The moderating role of technical uncertainty. *Journal of Managerial Issues*, 26–45. https://www.jstor.org/stable/43488156

Copyright

doi: https://doi.org/10.3127/ajis.v28.4669