Engineers Seeking Knowledge: The Effect of Control Systems on the Accessibility of Tacit and Codified Knowledge

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Abstract

Engineering and construction organizations realize that knowledge sharing between employees is essential to be competitive, yet few understand how knowledge sharing is affected by management choices. This paper examines how managerial control systems, the structures and routines used to influence organizational activities, influence knowledge accessibility, defined as the effort that one takes to request and access knowledge from another person. Specifically, this research examines and compares the effects of clan and bureaucratic control on the accessibility of tacit versus codified knowledge. The researchers propose that individuals who perceive greater clan control, or governance through common values and beliefs, will perceive greater accessibility of both tacit and codified knowledge; while individuals who perceive greater bureaucratic control, or governance through rules and procedures, will perceive increase in codified knowledge only.

To test the role of alignment between control systems and knowledge types in affecting knowledge accessibility, a questionnaire was administered to all engineers located in North America (855 people) within one engineering organization, and data collected from 298 responses were analyzed using linear regression analysis. The results in this research improve our understanding of knowledge accessibility and is an important step toward integrating control systems, knowledge type and knowledge accessibility.

Introduction

The Engineering Procurement and Construction (EPC) industry is primarily knowledge-based, which means that the competitive advantage of organizations is significantly determined by how effective organizations are at knowledge sharing. For example, to meet client needs, engineers seek knowledge from each other when they encounter design challenges, take an unfamiliar technical approach, or need someone to collaborate with them to solve a problem (Robinson 2010). However, while practitioners acknowledge the critical nature of knowledge sharing for the success of the organization, it is not readily apparent how organizations can govern knowledge sharing in a way that best benefits project teams. Many organizations have focused on tools and knowledge management systems that attempt to capture knowledge; but many of these systems, lessons learned databases, and skills matrices fail to achieve their intent in practice (Storey and Barnett 2000). As a result, additional work is needed to determine how organizations can facilitate knowledge sharing. To address this need, this research analyzes how control systems, the formal and informal structures and routines used to influence organizational activities (Long et al. 2002), affect perceptions of knowledge accessibility, or the effort that one takes to request and access knowledge from another person (Woudstra et al. 2012). Knowledge accessibility is the initial step in knowledge sharing, and is essential in project teams where engineers must access knowledge

quickly from their peers to meet project deadlines (Poleacovschi et al. 2017). Past work has acknowledged the importance of knowledge accessibility by showing that teams and individuals who have higher knowledge accessibility were more likely to have increased project and individual performance (Cross and Cummings 2004; Haas 2006; Poleacovschi and Javernick-Will 2016).

While literature has increased focus on the mechanisms facilitating knowledge sharing and knowledge accessibility (e.g., Hertzum 2014; Javernick-Will 2012; Wanberg et al. 2015), there has been little work that investigates how the control systems initiated by management influence an employee's ability to find and access knowledge needed to complete their projects. Managers within EPC organizations adopt different control systems to influence individual behavior in a way that best aligns with project and organizational goals (Tuuli et al. 2010a). Two forms of control systems—clan and bureaucratic control— have been identified as distinct and critical systems to govern individual behavior (Ouchi 1980). Clan control emphasizes the collective and, as a result, values collaboration to achieve individual goals. In contrast, the management within bureaucratic control systems monitors if employees follow the rules and procedures during their work (Long et al. 2002). Both control systems operate through mechanisms or methods by which individual action is governed (Cardinal et al. 2004). For instance, clan control relies upon common values, traditions and beliefs, while bureaucratic control relies upon rules, standards and formal procedures to complete work (Ouchi 1980). We theorize that control systems will influence knowledge accessibility as they affect individuals' motivation in the process of knowledge seeking. However, the relationship will also depend on the knowledge type. One of the most important differentiating characteristics of knowledge is whether the knowledge is tacit or explicit (Levin and Cross 2004; Nonaka 1994; Polanyi 1967). Tacit knowledge is knowledge that is difficult to articulate in writing and can be explained easier through verbal and social interactions

(Polanyi 1967). Conversely, codified knowledge can be easily written down and does not necessarily require social interactions for transferring (Polanyi 1967). Because knowledge applied in EPC organizations can be both codified and tacit, the overall goal of the research is to contrast the effects of clan and bureaucratic control on the accessibility of tacit and codified knowledge.

The research uses survey data and linear regression analysis to test whether clan and bureaucratic control increases accessibility of tacit and codified knowledge. We administered the survey questionnaire to 855 engineers located in North America within one EPC organization, and analyzed responses using linear regression analysis for knowledge accessibility and control systems. Based upon the 298 responses received, we show that increased clan control is positively associated with accessibility of tacit and codified knowledge, while bureaucratic control is positively associated with accessibility of codified knowledge only.

Literature Review

This work falls at the intersection of control systems, knowledge accessibility, and knowledge type, which are reviewed briefly below before developing the hypotheses.

Control Systems

The concept of control systems was proposed by Ouchi (1980) to describe how organizational control mechanisms manage individual behavior. The bureaucratic and clan systems are two distinct and important control mechanisms in EPC organizations (Tuuli et al. 2010a; b). Bureaucratic control encourages employees to follow organizational and management procedures to access knowledge from others in the organization. This approach emphasizes structure and rules of the management (Lam 2000; Weber et al. 1958). In bureaucracies, seekers tend to work according to formal organizational charts and procedures. Thus, bureaucratic control emphasizes the importance of documentation, reporting, and standardization as ways of executing

everyday work. In contrast, clans are groups of people who have common understanding, values, and beliefs. In clans, collaboration, reciprocity and common understanding become the norm among team members (Kirsch et al. 2009). Individuals work towards a common goal, which becomes an individual value. A culture of collaborative work de-emphasizes a hierarchy of actors and emphasizes the importance of the parts (people) to the whole (project). In EPC organizations, both control mechanisms are used to influence individual behavior, although managers choose to use bureaucratic control mechanisms more frequently than clan control (Tuuli et al. 2010b; a). Because control systems cannot be disconnected from individual behavior and motivation (Foss et al. 2010; Grandori 1997; Turner and Makhija 2006), the research presented in this paper studies how control systems influence knowledge accessibility.

Knowledge Accessibility

Past research on knowledge accessibility has primarily focused on the antecedents of knowledge accessibility between two individuals. This work has shown that accessibility is influenced by individual attributes (e.g. gender, tenure, hierarchy level) (Borgatti and Cross 2003) and dyadic attributes, or attributes regarding the relationship between the knowledge seeker and knowledge provider (Hertzum 2014; Vancouver and Morrison 1995). For instance, men were likely to perceive decreased knowledge accessibility compared to women (Lee 2000); and relationship quality (Vancouver and Morrison 1995), tie strength (Levin and Cross 2004) and trust (Abrams et al. 2003; Levin and Cross 2004) were found to be important, as people who have close relationships can communicate and access knowledge easily. While individual- and dyad- level attributes are essential, this research addresses another important factor – control systems implemented by management – to determine the influence of managerial control systems on knowledge accessibility among employees.

Building on previous research, Woudstra et al. (2012) proposed an integrative framework to define and measure accessibility based upon the social, cognitive and physical effort that people take when seeking for knowledge. Social effort represents the level of psychological comfort that people experience when interacting with the knowledge source. For instance, an engineer may perceive decreased accessibility with a provider because he or she does not want to reveal his/her lack of knowledge to the provider. Cognitive effort refers to the effort that arises based on people who speak different professional languages or who have a different perspective of the project work, requiring additional time to interpret their expertise. Cognitive effort can occur between two engineers who have different technical expertise because they speak different professional language. Physical effort is important for accessibility based upon the potential inconvenience that occurs as a result of accessing knowledge from people who are located in different locations and time zones. For instance, two engineers who work virtually may exert additional effort to communicate compared to two engineers who work in the same office location. The framework is theoretically and analytically suitable for the concept of knowledge accessibility, as it examines the different forces that may influence people's desire to approach other people for knowledge.

Knowledge Type

Knowledge type influences the ways employees interact to access and obtain needed knowledge. The most common knowledge type emphasized in the literature is tacit and codified knowledge (Kogut and Zander 1996; Lam 2000; Nonaka and von Krogh 2009; Polanyi 1967; Su and Contractor 2011). Tacit knowledge is knowledge that is contextual, requiring rich descriptions of the problem's context and ease of communication between the knowledge seeker and provider. Tacit knowledge is frequently used within project-based organizations where project members need to share complex knowledge and create innovative solutions to project details. Codified

knowledge is also important in the context of EPC organizations, as quality control processes and checklists are often needed to ensure compliance with professional standards and codes.

Because of the importance of the two characteristics of knowledge for everyday construction engineering tasks, previous work identified the antecedents of transferring tacit and codified knowledge (Hansen 1999; Holste and Fields 2010; Levin and Cross 2004). For instance, Hansen (1999) showed that transferring tacit knowledge requires strong ties, or connections that have frequent interactions, while codified knowledge can be transferred using weak ties, or connections that have less frequent interactions. Holste and Fields (2010) have shown that individuals need to build trust in order to easily share tacit knowledge. Nevertheless, these studies have primarily focused on the relational and individual level antecedents of seeking and transferring knowledge, leaving the effect of control systems on knowledge accessibility understudied.

Hypotheses Development

The study of control systems on accessibility is primarily rooted in studies researching the fit between control systems and organizational outcomes. While not directly using the term "accessibility", the accessibility of knowledge is implied in this past work when using the term "fit" and "alignment" (Lam 2000; Osterloh and Frey 2000; Turner and Makhija 2006). For instance, scholars identified the alignment between control systems and the dominant knowledge type (tacit or codified) that described the work conducted by the organization (Lam 2000; Osterloh and Frey 2000; Turner and Makhija 2006). It was theorized that clans would be appropriate for the accessibility of tacit knowledge, while bureaucratic control would be the best fit for the accessibility of codified knowledge (Lam 2000; Osterloh and Frey 2000; Turner and Makhija 2006). In other words, if the complexity of a construction project is reduced to more specialized

and repetitive work, or codified knowledge, then the management could adopt a bureaucratic approach with increased rules and procedures. However, this past work did not empirically evaluate the effects of control systems on knowledge accessibility at the dyad level.

Bureaucratic control encourages employees to follow organizational and management procedures to access knowledge from others in the organization. Within bureaucracies, individuals may have autonomy, but they have more difficulty transferring tacit knowledge with others due to the increased formality of the working processes (Lam 2000). Specifically, tacit knowledge is more difficult to transfer as it is often context-specific and requires close social relationships and frequent communication with the knowledge provider. For instance, Levin and Cross (2004) have shown that people need to trust the knowledge provider in order to seek knowledge from them. In bureaucracies, seekers tend to work according to formal organizational charts and procedures, which may not facilitate verbal and *ad hoc* conversations necessary for accessing and transferring tacit knowledge. Thus, bureaucracies advantage formality and create communication channels that allow the easy transfer of knowledge that is written, or codified, such as standards and codes. As such, we expect that knowledge seekers will perceive increased accessibility of codified knowledge.

Hypothesis 1: *Bureaucratic control will be positively associated with accessibility of codified knowledge but not tacit knowledge.*

In clans, collaboration becomes the norm among team members who seek to function based on trust and reciprocity (Kirsch et al. 2009). Within clans, individuals will value other employees' expertise and provide their knowledge to whomever needs it, rather than relying on formal hierarchical or social positions. This is expected to increase the accessibility of knowledge. Specifically, we expect tacit knowledge to be accessed easily due to increased social interactions

within clans. Similarly, we expect that the accessibility of codified knowledge will also be increased among clans, as the transfer of codified knowledge requires minimal effort given the well-established communication channels present in clans. As a result, we can expect that in an environment in which clan control is enhanced, knowledge accessibility of both tacit and codified knowledge will increase.

Hypothesis 2: *Clan control will be positively associated with accessibility of tacit and codified knowledge.*

Methods

The context of this research is one large EPC organization. The organization focuses primarily on providing design and construction services in water and wastewater.

Data Collection

Initially, a pilot survey was sent to a random sample of 50 employees at the organization to validate the clarity of the survey questions and to check the reliability of the measures for key variables (knowledge accessibility, control systems). Based upon the feedback received, the order of the survey questions was rearranged from two sections into three sections, allowing respondents to reflect between sections. The Cronbach's alpha for the items for measuring variables of knowledge accessibility and control systems was always above 0.7, which validated the use of the items for the final survey.

The final survey was administered to 855 employees in the company who represented the entire group of technical employees (e.g. engineers, architects, scientists) in the North America region. 298 valid responses were returned, representing a survey response rate of 34.8%. In the questionnaire, individuals were asked to identify two people from the organization whom they sought knowledge from (Borgatti and Cross 2003; Cross and Cummings 2004): "*During our work,*

we sometimes encounter problems we do not know how to solve and need additional information and advice. Please identify two people at [the company] that you have approached for information or advice to solve a problem." Afterwards, the respondents were asked to evaluate knowledge accessibility, attributes of the knowledge provider and themselves (the knowledge seeker), and to rate the level of clan and bureaucratic control employed by their managers. The unit of analysis of the independent variable represents the respondent's assessment of clan and bureaucratic control, and the unit of analysis of the dependent variable represents the accessibility of the knowledge providers. 41 respondents rated only one provider, but these respondents' answers were included in the empirical analysis for completeness. As a result, the analyses in this paper is based on 555 dyads.

Variables and Measurement

Dependent Variable

Our dependent variable is *Knowledge accessibility*. Woudstra et al. (2012) proposed a three-item framework to measure knowledge accessibility, defined as the effort, including physical, cognitive and social, that one takes to ask and request knowledge from another person. Drawing on Woudstra et al.'s (2012) framework, the following eight items were used to measure accessibility: *1. This person's information and advice is easy to comprehend and use* (Anderson et al. 2001); *2. The person's information and advice is easy to understand* (Xu et al. 2006); *3. I feel comfortable approaching this person* (Morrison and Vancouver 2000); *4. I feel nervous approaching this person* (Xu et al. 2006); *5. I do not feel comfortable revealing my lack of knowledge to this person* (Fidel and Green 2004); *6. I feel indebted to this person when asking questions from them* (Borgatti and Cross 2003); *7. Approaching this person takes significant physical effort* (adapted from Woudstra et al., 2012); *8. Approaching this person takes significant*

time (adapted from Woudstra et al., 2012). Respondents were asked to assess the eight items based on the following scale (from 1 to 5): "Strongly disagree, Disagree, Neither agree not disagree, Agree, and Strongly agree." The dependent variable, *accessibility*, was calculated by averaging the eight items. The Cronbach's alpha for the items was 0.78, which showed the reliability of the items measuring accessibility.

Independent Variables

The two independent variables related to control systems (*Bureaucratic control* and *Clan control*) were measured by following Long et al.'s (2011) approach. To measure the level of bureaucratic control and clan control, respondents were asked to assess five items each using the scale of "Strongly disagree, Disagree, Neither agree not disagree, Agree, and Strongly agree". Specifically, for bureaucratic control, respondents were asked to assess the following five items, where "X" represents the name of the connection indicated by the respondent: *(1) X (supervisor) primarily monitors how well I execute standardized rules and procedures when I do my work;* (*2) X (supervisor) emphasizes the need for employees to follow rules and procedures in doing their job; (3) X (supervisor) rewards employees who accurately follow rules and procedures in doing their jobs. (4) Whether I succeed or not in this organization is largely determined by how well I execute formal rules and procedures; (5) In doing my job, I spend most of my time executing rules and procedures*. For clan control, respondents were asked to assess the following five items: *(1) X (supervisor) primarily monitors how well I get along with my co-workers; (2) X (supervisor) emphasizes the need for employees to get along with each other; (3) X (supervisor) rewards employees who get along well with their co-workers. (4) Whether I succeed or not in this organization is largely determined by how well I get along with my co-workers. (5) In doing my job, I spend most of my time collaborating with colleagues on work activities.* Given that all items

were theorized to have equal weight in measuring control systems (Long et al. 2011), the two independent variables, *Bureaucratic control* and *Clan control*, were calculated as an average of the first set of five items, and the second set of five items, respectively.

Another independent variable, *Knowledge tacitness*, was measured by using three items from Hansen (1999): *(1) How much of the information/advice that came from X was explained to you in writing (in written reports, manuals, e-mails, faxes, etc.) [None, Almost none, Less than half, Half, More than half, Almost all, All]; (2) How well documented in writing, was the information/advice that you received from X? Consider all the information or advice. [Not well documented, Less documented, Somewhat less documented, Somewhat well documented, Documented, Well documented, Very well documented]; (3) What type of information/advice came from X? [7=mainly reports, manuals, documents; 4=half knowledge explained verbally, half reports/documents; 1=mainly personal practical knowledge explained verbally]*. The variable *Knowledge tacitness* was calculated by averaging the three items.

Control Variables

Based on previous literature, the following variables were controlled for that may affect knowledge accessibility:

- Similar age (*Sim_age*): Respondents were asked to indicate their age in number of years. They were also asked if they were in the same age group as the knowledge provider (plus or minus 5 years). The variable was treated as dichotomous. It was coded as "1" while difference of age was coded as "0". This control variable was included since people of similar age may have similar ways of sharing knowledge (Sanaei et al. 2013).
- Similar race (*Sim_race*): Respondents were asked to identify their race (Hispanic or Latino, Black or African-American, White, Asian Pacific Islander, or Other) and if they were of

the same race as the knowledge provider. The variable was treated as dichotomous. It was coded as "1" while difference of race was coded as "0". This control variable was included because previous work has shown that similarity of race is essential to how people form friendship relationships that may affect knowledge sharing (Mollica et al. 2003).

- Similar expertise (*Sim_expertise*): The primary area of expertise for the knowledge seeker and provider was obtained from the database provided by the focal organization. The database included areas of expertise in civil engineering, mechanical engineering, electrical engineering, process engineering, environmental engineering, structural engineering, architecture and construction. The variable was treated as dichotomous. It was coded as "1" while difference in expertise was coded as "0". This control variable was included because people with similar expertise have a good mutual understanding of their expertise, facilitating their knowledge seeking (Borgatti and Cross 2003).
- Similar hierarchy level (*Sim_level*): A provider's hierarchical level was obtained by asking respondents to specify the provider's level in the hierarchy, in relation to the provider ("*He/she is the same hierarchy level; He/she is higher hierarchy level; He/she is in lower hierarchy level; or We do not work together*"). The variable was treated as dichotomous. It was coded as "1" while difference in level was coded as "0". This control variable was included because people seeking knowledge from providers in higher levels may not want to reveal their lack of knowledge to them.
- Similarity of office location (*Sim_location*). Respondents were asked if they worked in the same office location as the provider. The variable was treated as dichotomous. It was coded as "1" while difference in location was coded as "0". This control variable was included

because people in the same location are likely to share and transfer knowledge more frequently (Wanberg et al. 2015).

- Gender (*Seeker_gender*) and similarity of gender (*Sim_gender*). Previous work (Poleacovschi et al. 2017) showed that the knowledge seeker's gender (Lee 2002) and similarity in gender between the seeker and provider play an important role in knowledge seeking.
- Tie strength (*Tie_strength*): Respondents were asked to assess the frequency of interactions with providers using the following scale: "*Once every 3 months - Once every 2 months - Once a month - Twice a month - Once a week - Twice a week - Once a day*". The measure for tie strength was taken from previous research (Hansen 1999; Levin and Cross 2004). The variable was coded on a continuous scale from 1 to 7. This control variable was included as past work has shown that knowledge accessibility increases with the frequency of communication (Hertzum 2014).

Statistical Approach

Data were analyzed using linear regression analysis. To test the hypotheses on the effects of *Bureaucratic control* (H1) and *Clan control* (H2) on the accessibility of codified and tacit knowledge, respectively, the coefficient estimates of the two independent variables and their significance levels were examined by performing subsample analysis, with the split of the full sample at the mean value of *Knowledge tacitness*. This created a "Codified Knowledge Subsample" where observations have a below-the-mean value of knowledge tacitness, as well as a "Tacit Knowledge Subsample" where observations have an above-the-mean value of knowledge tacitness. Subsample analysis is widely used for comparing coefficients between groups due to the many advantages it offers (Greene 2008): subsample analysis does not require that unexplained

variances be identical between the two groups of firms, and it allows the effects of the right-hand-side covariates to differ between the groups, leading to consistent within-group estimates (Hoetker 2007).

In addition to comparing the signs and significance levels of the estimated coefficients on *Bureaucratic control* and *Clan control* across the subsamples, another analysis was performed to test the two hypotheses formally. Specifically, using the full sample (all observations), an interaction term was created between an independent variable (*Bureaucratic control* or *Clan control*) and a dummy variable (*Tacit subsample*) indicating whether a focal observation was in the Tacit Knowledge Subsample (taking the value 1) or the Codified Knowledge Subsample (taking the value 0). Regressions were run, and the sign and significance level of the estimated coefficient on the interaction term was examined (*Bureaucratic control* * *Tacit sample*, or *Clan control* * *Tacit sample*). This approach provides a more formal test of whether the estimated coefficient on *Bureaucratic control* (or *Clan control*) is significantly different between the two subsamples.

Results

Table 1 reports descriptive statistics for the variables.

Table 1: Descriptive Statistics

	Number of Observations	Mean	Standard deviation	Min.	Max.
Accessibility	555	4.3	0.56	1.25	5.12
Sim_race	555	1.70	0.47	1	3
Sim_age	555	1.38	0.51	1	3
Sim_gender	555	1.63	0.49	1	3
Sim_location	555	1.59	0.53	1	3
Sim_level	555	1.13	0.34	1	2
Tie_strength	555	5.17	1.74	1	7
Seeker_gender	555	1.63	0.48	1	2
Bureaucratic control	555	3.23	0.69	1	5

Clan control	555	3.30	0.57	1	5
Knowledge tacitness	555	4.60	1.21	1	7
Tacit subsample	555	0.53	0.50	0	1

Table 2 presents hypotheses testing results. Models 1-3 report results testing Hypothesis 1, and Models 4-6 report results testing Hypothesis 2. Specifically, Models 1 and 4 are the Codified Knowledge Subsample, Models 2 and 5 are the Tacit Knowledge Subsample, and Models 3 and 6 are the Full Sample with all observations.

Table 2: Results for the Effects of Bureaucratic and Clan Control on the Accessibility of Codified and Tacit Knowledge

	(1) Codified Knowledge Subsample	(2) Tacit Knowledge Subsample	(3) Full Sample	(4) Codified Knowledge Subsample	(5) Tacit Knowledge Subsample	(6) Full Sample
Sim_race	-0.052	-0.043	-0.040	-0.030	-0.020	-0.017
	(0.070)	(0.074)	(0.050)	(0.070)	(0.074)	(0.051)
Sim_age	0.068	0.177*	0.115*	0.043	0.175*	0.103*
	(0.064)	(0.073)	(0.048)	(0.063)	(0.072)	(0.047)
Sim_gender	0.116	0.144	0.120*	0.109	0.142	0.116*
	(0.077)	(0.092)	(0.059)	(0.076)	(0.091)	(0.058)
Sim_location	-0.060	-0.080	-0.072	-0.043	-0.098	-0.072
	(0.073)	(0.074)	(0.052)	(0.072)	(0.074)	(0.052)
Sim_level	-0.007	0.109	0.071	-0.029	0.142	0.081
	(0.107)	(0.098)	(0.072)	(0.106)	(0.098)	(0.072)
Tie_strength	0.035	0.070**	0.051**	0.041	0.074**	0.056***
	(0.022)	(0.023)	(0.016)	(0.022)	(0.023)	(0.016)
Seeker_gender	-0.131	-0.233*	-0.179**	-0.122	-0.233[4]	-0.175**
	(0.079)	(0.092)	(0.059)	(0.078)	(0.091)	(0.059)
Bureaucratic control	0.109*	-0.0001	0.115*			
	(0.052)	(0.049)	(0.052)			
Tacit subsample			0.398†			0.186
			(0.230)			(0.278)
Bureaucratic control * Tacit subsample			-0.119†			
			(0.069)			

Clan control				0.169** (0.060)	0.130* (0.059)	0.168** (0.061)
Clan control * Tacit subsample						-0.051 (0.083)
Constant	3.876*** (0.293)	3.956*** (0.287)	3.707*** (0.239)	3.630*** (0.318)	3.448*** (0.329)	3.461*** (0.270)
N	260	295	555	260	295	555
R^2	0.049	0.077	0.058	0.062	0.093	0.070
F value	1.619	3.025	3.363	2.086	3.716	4.126

Standard errors in parentheses. † p<0.10, * p<0.05, ** p<0.01, *** p<0.001.

In Model 1, the coefficient on the variable *Bureaucratic control* is positive and significant (p<0.05), suggesting that bureaucratic control is associated with increased accessibility of codified knowledge. In Model 2, the coefficient on *Bureaucratic control* is not significant, thus bureaucratic control is not associated with accessibility of tacit knowledge. Taken together, results in Models 1 and 2 provide support for our H1 that bureaucratic control will be positively related to the accessibility of codified knowledge but not that of tacit knowledge. In Model 3, the coefficient on the interaction term *Bureaucratic control* * *Tacit subsample* is negative and modestly significant (p<0.10), suggesting that the effect of bureaucratic control on tacit knowledge is significantly different (lower) than its effect on codified knowledge. This result also validates the significantly positive coefficient on *Bureaucratic control* in Model 1 (codified knowledge) but the insignificant coefficient in Model 2 (tacit knowledge). Overall, results in Model 3 provide further support for H1.

In Model 4, the coefficient on the variable *Clan control* is positive and significant (p<0.01), suggesting that clan control is associated with increased accessibility of codified knowledge. In Model 5, the coefficient on the variable *Clan control* is similarly positive and significant (p<0.05), thus clan control is also associated with increased accessibility of tacit knowledge. Taken together, results in Models 4 and 5 provide support for our H2 that clan control will be positively related to

the accessibility of both codified and tacit knowledge. In Model 6, the coefficient on the interaction term *Clan control * Tacit subsample* is not significant, suggesting that the effect of clan control on tacit knowledge is not significantly different than its effect on codified knowledge. This result is consistent with the finding earlier that the coefficient on *Clan control* is positively significant in both Model 4 (codified knowledge) and Model 5 (tacit knowledge), and that the size of the coefficient estimates (and standard errors) for *Clan control* in both models is relatively close to each other. Overall, results in Model 6 provide further support for H2.

Discussion

This research sought to understand the influence of control systems (clan and bureaucratic control) on knowledge accessibility based on knowledge types. The results showed that the effect of clan control on accessibility was positive and significant for both tacit and codified knowledge. This means that whenever respondents perceived clan control, they were likely to experience less social, cognitive, and physical effort in accessing knowledge providers regardless of the type of knowledge to seek. In contrast, bureaucratic control had a positive effect on the accessibility of codified knowledge only, meaning that bureaucratic control is not systematically related to the accessibility of tacit knowledge. While control systems have been shown to influence individual behavior, existing literature has not yet studied the link between control systems and knowledge sharing. This study is an important step toward integrating control systems, knowledge type and knowledge accessibility at the dyad level. This research showed that, after controlling for relational attributes (e.g. similarity of gender), the control mechanisms applied by management played an important role on the accessibility of both tacit and codified knowledge. Specifically, people perceived knowledge to be more accessible, regardless of knowledge type, whenever they perceived a clan environment. The results contribute to literature on knowledge sharing and control

systems by analyzing the effect of two control systems and on the accessibility of tacit and codified knowledge. As such, this research emphasizes the knowledge *context* as an important variable in the relationship between control systems and knowledge accessibility (Agarwal et al. 2011; Hertzum 2014). While existing work in construction and engineering has primarily focused on the social relations and individual motivation as essential for knowledge sharing (Javernick-Will 2012; Poleacovschi and Javernick-Will 2017; Sanaei et al. 2013), the findings from this research show the importance of control effects on knowledge sharing, and emphasize inclusion of control systems as an important variable in knowledge sharing behavior.

For practitioners, the link between control systems and knowledge accessibility presents important managerial implications. Decisions of control systems should include thought regarding the types of knowledge that employees need to access to complete their work. If their tasks are complex and require them to access tacit knowledge, then clans would be more suited to enhance knowledge accessibility. If the task can be completed based upon existing, codified knowledge within the firm, then either clans or bureaucracies can be implemented. Nevertheless, project managers should consider the costs of fostering bureaucratic and clan control. Employing clan control is expected to be more expensive and time consuming due to socialization among clan members and emotional labor to foster a clan identity. The costs should be especially considered and compared in the case of codified knowledge which can be transferred using both control systems.

Limitations and Future Work

As with any research, this research contains limitations. First, the assessment of control systems represents the perceptions of the respondents. Future work can evaluate ways to measure control systems using a more objective scale. Alternatively, the assessment of control systems can

409 be validated through an inter-rater reliability rating, where several employees who have the same
410 supervisors assess the control systems in the survey. Second, clan and bureaucratic control were
411 included, but not market-based control, because monetary compensation has minimal influence on
412 how people share and transfer knowledge (Javernick-Will 2012), and there is a lack of
413 organizations that employ market-based control mechanisms. This work is based on the US market
414 so that cultural differences in knowledge accessibility and control systems could be controlled for,
415 which limits the generalizability of the findings.

416 ## Conclusion

417 In knowledge-based EPC organizations, knowledge accessibility is critical for employees
418 to complete their work effectively. While advances have been made in better understanding how
419 individual and dyadic attributes between a knowledge seeker and provider influence knowledge
420 accessibility, there has been a dearth of research that investigates how managerial control
421 mechanisms influence knowledge sharing and accessibility. Thus, the goal of this research was to
422 determine how different control systems—bureaucratic and clan—influenced knowledge
423 accessibility based on knowledge type. To achieve this goal, a survey was administered to 855
424 technical specialists (i.e., engineers, architects and scientists) within North American offices in an
425 engineering organization and linear regression analysis was used to validate the hypothesis that
426 clan control, or developing an environment supportive of collaboration, positively affected
427 accessibility of both tacit and codified knowledge. In contrast, bureaucratic control affected the
428 accessibility of codified knowledge only. Theoretically, this research improves understanding of
429 knowledge accessibility by showing the link between the control systems and knowledge
430 accessibility, and by specifying that the type of knowledge is important factor in this relationship.
431 Practically, project managers who want to increase accessibility among employees may foster one

of the control systems based on the nature of the project work. If the work requires frequent access to tacit knowledge, then they should consider governing through clan control.

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References

Abrams, L. C., Cross, R., Lesser, E., and Levin, D. Z. (2003). "Nurturing interpersonal trust in knowledge-sharing networks." *The Academy of Management Executive*, 17(4), 64–77.

Agarwal, N. K., Xu, Y. (Calvin), and Poo, D. C. C. (2011). "A context-based investigation into source use by information seekers." *Journal of the American Society for Information Science and Technology*, 62(6), 1087–1104.

Anderson, C. J., Glassman, M., McAfee, R. B., and Pinelli, T. (2001). "An investigation of factors affecting how engineers and scientists seek information." *Journal of Engineering and Technology Management*, 18(2), 131–155.

Borgatti, S. P., and Cross, R. (2003). "A Relational View of Information Seeking and Learning in Social Networks." *Management Science*, 49(4), 432–445.

Cardinal, L. B., Sitkin, S. B., and Long, C. P. (2004). "Balancing and Rebalancing in the Creation and Evolution of Organizational Control." *Organization Science*, 15(4), 411–431.

Cross, R., and Cummings, J. N. (2004). "Tie and Network Correlates of Individual Performance in Knowledge-Intensive Work." *The Academy of Management Journal*, 47(6), 928–937.

Fidel, R., and Green, M. (2004). "The Many Faces of Accessibility: Engineers' Perception of Information Sources." *Inf. Process. Manage.*, 40(3), 563–581.

Foss, N. J., Husted, K., and Michailova, S. (2010). "Governing Knowledge Sharing in Organizations: Levels of Analysis, Governance Mechanisms, and Research Directions." *Journal of Management Studies*, 47(3), 455–482.

Greene, W. (2008). *Econometric Analysis*. Pearson/Prentice Hall: Upper Saddle River.

Haas, M. R. (2006). "Acquiring and Applying Knowledge in Transnational Teams: The Roles of Cosmopolitans and Locals." *Organization Science*, 17(3), 367–384.

Hansen, M. T. (1999). "The Search-Transfer Problem: The Role of Weak Ties in Sharing Knowledge across Organization Subunits." *Administrative Science Quarterly*, 44(1), 82–111.

Hertzum, M. (2014). "Expertise seeking: A review." *Information Processing & Management*, 50(5), 775–795.

Hoetker, G. (2007). "The use of logit and probit models in strategic management research: Critical issues." *Strategic Management Journal*, 28(4), 331–343.
Holste, J. S., and Fields, D. (2010). "Trust and tacit knowledge sharing and use." *Journal of Knowledge Management*, 14(1), 128–140.
Javernick-Will, A. (2012). "Motivating Knowledge Sharing in Engineering and Construction Organizations: Power of Social Motivations." *Journal of Management in Engineering*, 28(2), 193–202.
Kirsch, L. J., Ko, D.-G., and Haney, M. H. (2009). "Investigating the Antecedents of Team-Based Clan Control: Adding Social Capital as a Predictor." *Organization Science*, 21(2), 469–489.
Kogut, B., and Zander, U. (1996). "What Firms Do? Coordination, Identity, and Learning." *Organization Science*, 7(5), 502–518.
Lam, A. (2000). "Tacit Knowledge, Organizational Learning and Societal Institutions: An Integrated Framework." *Organization Studies*, 21(3), 487–513.
Lee, F. (2002). "The Social Costs of Seeking Help." *The Journal of Applied Behavioral Science*, 38(1), 17–35.
Levin, D. Z., and Cross, R. (2004). "The Strength of Weak Ties You Can Trust: The Mediating Role of Trust in Effective Knowledge Transfer." *Management Science*, 50(11), 1477–1490.
Long, C. P., Bendersky, C., and Morrill, C. (2011). "Fairness Monitoring: Linking Managerial Controls and Fairness Judgments in Organizations." *Academy of Management Journal*, 54(5), 1045–1068.
Long, C. P., Burton, R. M., and Cardinal, L. B. (2002). "Three Controls are Better than One: A Computational Model of Complex Control Systems." *Computational & Mathematical Organization Theory*, 8(3), 197–220.
Mollica, K. A., Gray, B., and Treviño, L. K. (2003). "Racial Homophily and Its Persistence in Newcomers' Social Networks." *Organization Science*, 14(2), 123–136.
Morrison, E. W., and Vancouver, J. B. (2000). "Within-Person Analysis of Information Seeking: The Effects of Perceived Costs and Benefits." *Journal of Management*, 26(1), 119–137.
Nickerson, J. A., and Zenger, T. R. (2004). "A Knowledge-Based Theory of the Firm: The Problem-Solving Perspective." *Organization Science*, 15(6), 617–632.
Nonaka, I. (1994). "A Dynamic Theory of Organizational Knowledge Creation." *Organization Science*, 5(1), 14–37.
Nonaka, I., and von Krogh, G. (2009). "Perspective—Tacit Knowledge and Knowledge Conversion: Controversy and Advancement in Organizational Knowledge Creation Theory." *Organization Science*, 20(3), 635–652.
Osterloh, M., and Frey, B. S. (2000). "Motivation, Knowledge Transfer, and Organizational Forms." *Organization Science*, 11(5), 538–550.
Ouchi, W. G. (1980). "Markets, Bureaucracies, and Clans." *Administrative Science Quarterly*, 25(1), 129–141.
Polanyi, M. (1967). *The Tacit Dimension*. London, Routledge & K. Paul.
Poleacovschi, C., and Javernick-Will, A. (2016). "Spanning information and knowledge across subrgoups and its effects on individual performance." *Journal of Management in Engineering*.

Poleacovschi, C., and Javernick-Will, A. (2017). "Who Are the Experts? Assessing Expertise in Construction and Engineering Organizations." *Journal of Construction Engineering and Management*, 143(8), 04017033.
Robinson, M. A. (2010). "An empirical analysis of engineers' information behaviors." *Journal of the American Society for Information Science and Technology*, 61(4), 640–658.
Sanaei, M., Javernick-Will, A. N., and Chinowsky, P. (2013). "The influence of generation on knowledge sharing connections and methods in construction and engineering organizations headquartered in the US." *Construction Management and Economics*, 31(9), 991–1004.
Storey, J., and Barnett, E. (2000). "Knowledge management initiatives: learning from failure." *Journal of Knowledge Management*, 4(2), 145–156.
Su, C., and Contractor, N. (2011). "A multidimensional network approach to studying team members' information seeking from human and digital knowledge sources in consulting firms." *Journal of the American Society for Information Science and Technology*, 62(7), 1257–1275.
Turner, K. L., and Makhija, M. V. (2006). "The Role of Organizational Controls in Managing Knowledge." *The Academy of Management Review*, 31(1), 197–217.
Tuuli, M. M., Rowlinson, S., and Koh, T. Y. (2010a). "Dynamics of control in construction project teams." *Construction Management and Economics*, 28(2), 189–202.
Tuuli, M. M., Rowlinson, S., and Koh, T. Y. (2010b). "Dynamics of control in construction project teams." *Construction Management and Economics*, 28(2), 189–202.
Vancouver, J. B., and Morrison, E. W. (1995). "Feedback Inquiry: The Effect of Source Attributes and Individual Differences." *Organizational Behavior and Human Decision Processes*, 62(3), 276–285.
Wanberg, J., Javernick-Will, A., Taylor, J. E., and Chinowsky, P. (2015). "The effects of organizational divisions on knowledge-sharing networks in multi-lateral communities of practice." *Engineering Project Organization Journal*, 5(2–3), 118–132.
Weber, M., Gerth, H., and Mills, C. W. (1958). *From Max Weber: essays in sociology*. Oxford University Press, New York.
Woudstra, L., van den Hooff, B., and Schouten, A. P. (2012). "Dimensions of quality and accessibility: Selection of human information sources from a social capital perspective." *Information Processing & Management*, 48(4), 618–630.
Xu, Y. (Calvin), Tan, B. C. Y., and Yang, L. (2006). "Who will you ask? An empirical study of interpersonal task information seeking." *Journal of the American Society for Information Science and Technology*, 57(12), 1666–1677.