IT, Knowledge Transfer, and Organization of Work

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Introduction

Drucker (1999) has stated that the most important contribution management needs to make in the 21st Century is to increase the productivity of Knowledge Work and Knowledge Workers. Correspondingly, studies suggest that human capital and learning are the source of sustainable competitive advantage (e.g., Hatch and Dyer, 2004). Similarly, a significant body of research in knowledge management studies how knowledge is developed, stored, and shared (Alavi and Leidner, 2001). In this regard, Nonaka (1994) suggests that knowledge is shared (converted) in four modes: (i) socialization, (ii) externalization, (ii) internalization, and (iv) combination. Socialization is the process of sharing tacit knowledge through interpersonal interaction. Externalization refers to the process converting tacit knowledge into explicit knowledge through codification. Internalization on the other hand is the act of developing tacit knowledge by processing and assimilating explicit knowledge stored in repositories. Finally, combination refers to transforming explicit knowledge from one form to another.

Given the importance of knowledge work and the productivity of knowledge workers, what is the role of IT in the development of skill and expertise of knowledge workers? From one point of view since IT is used to standardize and automate processes, IT reduces interpersonal interactions, shrinks the level of autonomy of individuals and leads to deskilling (Ritzer, 1996). From this point of view, though IT may improve productivity, IT does not directly affect the skill and expertise of knowledge workers. Oher research suggests that firms that adopt IT tend to use more skilled labor (Bresnahan, Brynjolfsson and Hitt, 2002). This may suggest that skilled labor may be required to leverage the benefits from IT. Similarly, the research on skill-biased technological change suggests that IT may be a substitute for structured routine tasks (i.e., low skill labor/work) and IT may complement non-routine analytical (i.e., high skill labor/work) task (Autor et al, 1998). Similarly, literature in IS examines how employee education and training contributes to human capital development and affects employee productivity and wages (e.g., Bapna et al., 2013; Kim et al., 2014; Mehra et al., 2014; Mithas and Krishnan, 2008).

However, the above streams of literature do not examine if and how IT may be associated with the generation/transfer of human capital. We address this question using a specific context where field technicians engaged in the service of industrial HVAC systems distributed across the United States use an IT system to seek technical support from a centralized help desk. These field technicians are knowledge workers as they use their knowledge and expertise of HVAC systems to fix problems in the functioning of these systems. In this context IT can enable these field technicians to develop their knowledge and expertise in two different ways. First, field technicians can acquire/develop technical skills by accessing and internalizing technical documents stored in a knowledge repository. Second, these field technicians
also have access to a centralized help desk where they can call and speak to a technical support engineer (TSE). Thus, the field technicians can also develop their skills through socialization with TSE.

In this study we examine whether internalization (i.e., reading documents) and socialization (i.e., talking to different TSE) helps field technicians develop human capital that affect their work. Specifically, by analyzing the repository accesses and calling behavior of 18,020 field technicians over 1,086 days we study whether internalization and socialization affect the calling behavior of the field technicians. The analysis suggests that internalization of specific knowledge is negatively associated with a likelihood of making a call, the total number of calls made, and the number of high complexity calls made on a given day. However, the internalization of general knowledge is negatively associated with the number of low complexity calls made on a given day, but positively associated with a number of high complexity calls made on a given day. Similarly, we find that socialization is associated with a decrease in the total number of calls made as well as the number of low complexity calls made on a given day but socialization is associated with an increase in the number of high complexity calls made on a given day. This study provides evidence that field technicians develop human capital through internalization of general and specific knowledge and through socialization in ways that affect knowledge work.

Theory and hypotheses

Field technicians can develop their expertise by accumulating knowledge over the course of their tenure. Kim et al. 2012 studied technical support in a computing call center and found that consultants learn over time by answering more calls. Likewise, Subramanyam and Krishnan (2001) examined customer service /technical support in the IT arena and found that the capability/expertise of the support staff reduced response/resolution time. In our context also field technicians can learn over time by servicing more HVAC systems. However, in this study we are particularly interested in understanding if field technicians develop skill and expertise in two specific ways: (i) internalization, and (ii) socialization (Nonaka, 1994). Field technicians can acquire knowledge and develop expertise through internalization by accessing and reading documents stored in the knowledge repository. Field technicians can develop general knowledge (Becker, 1992) by reading product documents and user manuals. Likewise, field technicians develop specific knowledge (Becker, 1992) by reading more problem solution documents. Field technicians can acquire knowledge through socialization when field technicians call the technical support center and interact with TSEs. The social interaction between the field technician and the TSE transfers tacit knowledge from the TSE to the field technician.

As field technicians acquire knowledge through internalization and socialization they are likely to be able to solve more problems on their own and not need to call the technical support center. Thus, we expect that as field technicians’ access and read a greater number of general and specific documents they acquire explicit knowledge stored in the knowledge repository, they need to call the technical support center less and less. Similarly, as the field technicians interact with a larger number of TSEs, they acquire tacit knowledge from the TSEs and they need to call the technical support center less and less. This is
consistent with Aral et al. (2012) who find that knowledge worker performance improves with access to heterogeneous knowledge. Thus we hypothesize the following:

**H1a (Internalization of General Knowledge):** As the cumulative number of general documents accessed by a field technician increases; the less likely that that field technician will call the technical support center.

**H1b (Internalization of Specific Knowledge):** As the cumulative number of specific documents accessed by a field technician increases; the less likely that that field technician will call the technical support center.

**H1c (Socialization of Tacit Knowledge):** As the cumulative number of different TSEs a field technician interacts with increases; the less likely that that field technician will call the technical support center.

Prior literature on technical support (Das 2003) views technical support as comprising of four categories of problem solving tasks – information retrieval, plan synthesis, state abstraction, and abductive diagnosis. This categorization of problem solving tasks and corresponding problem solving actions is useful in clarifying both the nature of field technician tasks and the work of TSEs. The four types of tasks involve increasing levels of problem complexity – information retrieval being the simplest with plan synthesis, state abstraction and abductive diagnosis increasing in the level of problem complexity, and this classification of types of problem solving tasks maps closely with the problem solving actions i.e., the location of prior solutions, adaptation of prior solutions and generation of new solutions.

For information retrieval problems field technicians often need specific information to perform field maintenance. The dominant move to address information retrieval tasks is locate – looking up the knowledge repository to find prior incidents of a problem and retrieving details of solutions used in the past. For plan synthesis problems the field technician needs to formulate a plan to perform specific tasks or achieve particular goals. For state abstraction problems the field technician needs to formulate the logic and reasoning to assess the current state so that the problem at hand can be addressed. Solving plan synthesis and state abstraction tasks involve a combination of locate and adapt moves. For abductive diagnosis problems the field technician needs to formulate a diagnostic explanation so that the problem at hand can be addressed. Abductive diagnosis involves a deeper understanding of cause-effect relationships. Solving problems of this kind largely involves generate moves i.e., the creation of a new solution to the specific problem at hand.

Field observation at Aircom’s technical support center and interactions with field technicians indicated that the ability of field technicians to access the knowledge repository influenced the nature of their calls to technical support. Field technicians are often able to address simple information retrieval and plan synthesizes problems through information location in the repository without needing to call the technical support center. However, field technicians sought the expertise of technical support engineers when facing more complex state abstraction and abductive diagnosis problems. This is consistent with the prior research on call centers. Using case study of two call centers Schefe and Timbrell (2004) found that
problems of uncertainty are about the lack of information and that they can be addressed using repository searches; whereas problems of ambiguity and equivocality are about the lack of knowledge and such problems can be solved by rich interactive conversation with experts i.e., TSEs.

The literature on task - technology fit (Goodhue, 1995) also helps us understand which type of knowledge acquisition strategies may help the field technician improve their performance in specific circumstances. The task-technology fit concept may indicate that the simpler information retrieval and plan synthesis problems may be solved by accessing and internalizing general documents whereas accessing and internalizing specific documents may help solve the more complex state abstraction and abductive diagnosis problems. Likewise, socialization, which helps in transferring tacit knowledge from TSEs to the field technicians, may be more helpful in addressing the more complex state abstraction and abductive diagnosis problems. This is consistent with the findings of Becerra-Fernandez and Sabherwal (2001) who found that socialization may be useful for broader tasks whereas internalization may be more appropriate for narrow focused tasks; and the findings of Kowtha (2008) who found that socialization enables engineers to develop mastery. Thus we state the following hypotheses:

\( H2a \) (Internalization of General Knowledge): As the cumulative number of general documents accessed by a field technician increases; the less likely that that field technician will call the technical support center for simple problems.

\( H2b \) (Internalization of Specific Knowledge): As the cumulative number of specific documents accessed by a field technician increases; the less likely that that field technician will call the technical support center for complex problems.

\( H2c \) (Socialization of Tacit Knowledge): As the cumulative number of different TSEs a field technician interacts with increases; the less likely that that field technician will call the technical support center for complex problems.

Firm-specific human capital improves firm performance (Hatch and Dyer, 2004). However, firms have to provide incentive to knowledge workers to develop firm specific human capital (Fairburn and Malcolmson, 1994). Promotion to a higher paying job is one way for firms to incent field technicians to develop firm-specific human capital (Prendergast, 1993). As discussed above the level of internalization and socialization may affect the likelihood and nature of calls to the technical support center i.e., improve field technician performance as they solve problems in the field without needing to call the technical support center. This is the immediate impact of internalization and socialization. However, by internalizing documents in the knowledge repository and by transferring tacit knowledge from the TSE by socialization, if field technicians improve their skill and expertise then such accumulation of skill and expertise may be rewarded with a promotion. Thus, we expect that the field technicians who access and read a cumulatively greater number of general and specific documents are more likely to be promoted. Similarly, the field technicians who interact with a larger number of TSEs are more likely to be promoted. Thus, we test the following hypotheses.
H3a (Internalization of General Knowledge): As the cumulative number of general documents accessed by a field technician increases; the likelihood of promotion for the field technician increases.

H3b (Internalization of Specific Knowledge): As the cumulative number of specific documents accessed by a field technician increases; the likelihood of promotion for the field technician increases.

H3c (Socialization of Tacit Knowledge): As the cumulative number of different TSEs a field technician interacts with increases; the likelihood of promotion for the field technician increases.

Data and variables

As discussed earlier the setting for our research is the technical support unit of Aircom, a large North American engineering firm that manufactures, sells and services heating, ventilation and air conditioning (HVAC) systems for commercial clients. The warranty and ongoing maintenance services to US customers are provided by around 18,000 field technicians spread across 617 office locations throughout the 50 states. Our data was collected from 2008 to 2011. The field technicians have access to a central document repository that provides access to expertise in the form of documents related to equipment maintenance and troubleshooting. Field technicians were encouraged to look up solutions in the knowledge repository over the web before calling the technical support group. In this research we are interested in examining whether the field technicians accumulate knowledge by internalizing the documents accessed from the repository and whether socialization with TSEs affects their calling behavior. We are also interested in studying whether the accumulation of knowledge through internalization and socialization is related field technician with promotion.

Dependent variables

We track field technicians from the first day they started work at the company to the last day they worked for the company. Our first dependent variable is whether a field technician calls on a given day. If field technicians develop sufficient knowledge and skills by internalizing documents and by socialization with TSEs, they are less likely to call on a given day. Thus, the most basic way internalization and socialization would affect the field technician is to affect the likelihood of calling the technical support center on a given day. Our second dependent variable is the total number of calls made by the field technician on a given day. In the dataset, if a field technician calls on a given day the average (standard deviation) of the number of calls on a given day is 1.28 (0.67). The complexity of the call was coded on a five point scale based on the Call Reason field recorded in the ticket management system. This 5-point system mapped very closely with the information retrieval – plan synthesis – state abstraction – abductive analysis scale discussed earlier. For example, product information calls were considered simple (and coded as having a complexity of 1) and problem diagnosis calls were considered the most complex (and coded as 5). Thus we divided the company’s 5-point scale into low and high complexity call where calls of complexity from 1 to 3 were more like information retrieval and plan synthesis calls and were classified as low complexity calls, and calls of complexity of 4 and 5 were more like state abstraction and
abductive analysis calls and were classified as high complexity calls. Thus we also examine the impact of internalization and socialization on the number of high complexity as well as the number of low complexity calls made by a field technician on a given day.

The first sets of dependent variables (likelihood of making a call on a given day, total number of calls on a given day, the number of low complexity and high complexity calls on a given day) reflect the immediate short-term effects of knowledge accumulation. We also examine the long-term effect of knowledge accumulation. Specifically, we examine if the accumulation of knowledge is related with field technician promotion. Thus, the second main dependent variable – field technician promotion is an event that reflects the quality of the field technician’s performance over time.

Whenever a field technician gets promoted their designation changes. We had quarterly records on field technicians and coded changes in designation as “1” whenever a field technician was promoted.

**Independent variables**

Our main independent variables are the measures of socialization, and internalization. We operationalize socialization as the number of different technical support engineers that the field technician has interacted with over the phone. Thus, the measure of socialization on a given day is the cumulative number of distinct TSEs a field technician has talked to till today. Even if a field technician calls and talks to a TSE multiple times over their tenure we effectively only count / consider the last interaction between the field technician and the TSE. We operationalize internalization using two variables representing the extent to which the field technician had accessed different kinds of codified knowledge available in the repository. The company distinguishes between two kinds of documents in the repository – (i) general documents such as technical brochures, wiring diagrams and field repair manuals for products that were typically authored by the marketing group, the quality control group and the training group and (ii) problem solution documents containing descriptions of problems reported for different products and their suggested solutions that were authored by technical support engineers and accepted into the repository after a technical review. Using the repository search records that contained details of all logins and searches of the repository by field technicians, we use the cumulative number of general documents accessed till today as the measure for internalization of general knowledge, and the cumulative number of problem solution documents accessed till today as the measure for internalization of specific knowledge.

**Control variables**

The experience of a field technician may influence the ability of a field technician to solve problems in the field and their need to call the technical support center. Hence, we control for the work experience of the field technician by taking into account the number of days that the field technician has been working for the organization. Field technicians may also differ in their strategy to solve problems in the field. Some field technicians may strive harder on their own before calling the technical support center whereas other field technicians may resort to calling the technical support center much earlier. Thus we
control for the propensity to call by including the total number of calls made by the field technician prior to the current call. A field technician’s ability to solve a problem is likely to be influenced by the level of codified knowledge in the repository. If the repository includes the general and specific knowledge a field technician requires to solve a problem, it may reduce a field technician’s need to call the technical support center. Thus, we also include the number of repository documents as a control variable since this reflects the level of formalization of knowledge in the firm that is likely to influence the likelihood of call. The number of calls to the technical support center are also likely to be influenced by the volume of equipment supported in the field and the total number of field technicians available to support the equipment. Thus we also control for the total volume of equipment supported by including the monthly dollar value of maintenance contracts and we control for the number of field technicians available to support the equipment in the field using the actual number of field technicians available to support the equipment. Finally, field technicians may call the technical support center if there are TSEs available in the technical support center to answer field technicians’ calls. We control for the TSEs’ availability using the totals hours of TSE time available on a given day.

Our analysis employs a fixed effect model at the field technician–day level. This controls for individual specific, unobserved field technician factors. We used Stata version 14 for the analysis. Please see table 2 for the results with regard to the impact of internalization and socialization on calls.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1: Made a Call fixed effects</th>
<th>Model 2: Total # calls fixed effects</th>
<th>Model 3: Total # of High Complexity Calls fixed effects</th>
<th>Model 4: Total # of Low Complexity Calls fixed effects</th>
</tr>
</thead>
<tbody>
<tr>
<td># TSEs contacted by Filed Technician</td>
<td>0.964*** (0.018)</td>
<td>-0.020*** (0.005)</td>
<td>0.014** (0.006)</td>
<td>-0.021*** (0.006)</td>
</tr>
<tr>
<td># Issue Documents Accessed</td>
<td>-0.128*** (0.007)</td>
<td>-0.008*** (0.002)</td>
<td>-0.004** (0.002)</td>
<td>-0.001 (0.002)</td>
</tr>
<tr>
<td># General Documents Accessed</td>
<td>-0.030*** (0.007)</td>
<td>-0.000 (0.002)</td>
<td>0.005** (0.002)</td>
<td>-0.005** (0.002)</td>
</tr>
<tr>
<td>Field Technician Experience</td>
<td>-0.891*** (0.005)</td>
<td>-0.022*** (0.001)</td>
<td>-0.011*** (0.001)</td>
<td>-0.004*** (0.001)</td>
</tr>
<tr>
<td>Propensity to Call</td>
<td>0.826*** (0.011)</td>
<td>0.073*** (0.004)</td>
<td>0.018*** (0.004)</td>
<td>0.029*** (0.004)</td>
</tr>
<tr>
<td>Total Available Documents</td>
<td>-1.099*** (0.022)</td>
<td>-0.092*** (0.007)</td>
<td>-0.099*** (0.007)</td>
<td>0.035*** (0.007)</td>
</tr>
<tr>
<td>Number of Field Technicians (Head#)</td>
<td>8.060*** (0.133)</td>
<td>0.487*** (0.050)</td>
<td>0.825*** (0.043)</td>
<td>-0.426*** (0.047)</td>
</tr>
<tr>
<td>Volume of Equipment Supported (Sales)</td>
<td>-0.035** (0.018)</td>
<td>-0.009 (0.006)</td>
<td>0.009** (0.004)</td>
<td>-0.015*** (0.005)</td>
</tr>
<tr>
<td>Available Technical Support (Total Labor)</td>
<td>0.054*** (0.003)</td>
<td>0.001** (0.001)</td>
<td>0.001 (0.001)</td>
<td>0.001 (0.001)</td>
</tr>
</tbody>
</table>

Table 1: Impact of internalization and socialization on calls
We use a logit model (xtlogit) for model 1 where the dependent variable is binary: whether a field technician made a call on a given day; and regression models (xtreg) for models 2, 3 and 4 where the dependent variables are the total number of calls on a given day (model 2), the number of high complexity calls on a given day, and the number of low complexity calls on a given day, respectively. We used models 1 and 2 to test hypothesis 1 and models 3 and 4 to test hypothesis 2. Please see table 2 for the impact of internalization and externalization on promotion of field technicians.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 5: Promotion</th>
</tr>
</thead>
<tbody>
<tr>
<td># General Documents Accessed</td>
<td>-0.27 (0.21)</td>
</tr>
<tr>
<td># Issue Documents Accessed</td>
<td>0.52** (0.28)</td>
</tr>
<tr>
<td>Field Technician Experience</td>
<td>-0.26* (0.15)</td>
</tr>
<tr>
<td>Number of TSEs contacted by Field Technician</td>
<td>1.02* (0.58)</td>
</tr>
</tbody>
</table>

Table 2: Impact of internalization and externalization for promotion of field technicians

Model 5 in table 2 tests hypothesis 3. Across all the models the dependent and independent variables were logged for ease of interpretation (except for the dependent variable in model 1 and model 5). Being a panel dataset, we need to test for the possibility of both heteroskedasticity and autocorrelation. White’s general test indicates the necessity to correct for heteroskedasticity; we therefore use robust standard errors in the models. The Wooldridge test for autocorrelation fails to reject the null hypothesis of no autocorrelation; autocorrelation is thus not a concern in the data. As mentioned earlier, we also control for the unobserved, individual characteristics of technical support engineers. We opt for the fixed effects model since the Hausman test leads to a rejection of the null hypothesis that the random effects model provides consistent estimates.

We first discuss the results in table 1. Across all the 4 models, the experience of the field technician is negatively related with the likelihood of making a call on a given day and the total number of calls, and the number of high and low complexity calls. Similarly, a field technician’s propensity of making a call is positively associated with the likelihood of making a call on a given day and the total number of calls, and the number of high and low complexity calls. The total number of documents available in the repository is negatively related with the likelihood of making a call on a given day and the total number of calls, and the number of high complexity calls. Finally, the volume of equipment supported is positively associated with the number of high complexity calls on a given day. These findings provide prima facie support for the face validity of the empirical models.

To examine the relationship between internalization and socialization and field technician’s promotion, we use a rare event logistic regression. In the field technician force of around 417 technicians in our sample, we observed only 48 promotions indicating that a promotion within the 36-month period

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1 We have run panel count data models (xtpoisson) which also produces consistent results.
of our data is an infrequent occurrence. Hence, we use rare event logit, an alternative estimation method developed for contexts where events of interest such as wars, infectious disease outbreaks etc. may be observed a few thousand times less frequently than non-events such as peace and no disease outbreak (King and Zeng 2001a, King and Zeng 2001b). This analysis is presented in table 2. The dependent variable is whether a field technician got promoted in a given quarter. All the independent variables are also at the quarter level. Table 2 indicates that the number of general documents accessed is not related with promotion. So there is no support for H3a. However, the number of problem solution documents accessed ($p = 0.05$ level) and the number of unique TSEs talked to ($p = 0.1$ level) are positively related with promotion. This is consistent with H3b and H3c, respectively.

Conclusion

Knowledge work and the productivity of knowledge workers are increasing in importance. In this research we examine how field technicians develop skill and expertise and how this skill and expertise affects their immediate and long term performance. The analysis suggests that internalization of general knowledge by a field technician is associated with a reduced likelihood of making a call on a given day and a reduction in the number of low complexity calls in a given day. This suggests that accessing and reading general documents helps field technician develop general knowledge and solve low complexity problems. However, developing general knowledge is not associated with promotions. It is likely that field technicians are expected to solve the low complexity problems using all the resources at their disposal such as the general knowledge in the repository but they are not rewarded for solving low complexity problems i.e., solving low complexity problems is a satisficing condition for employment as field technicians and solving such problems is not rewarded with promotions. However, quite surprisingly, accumulation of general knowledge is associated with more high complexity calls on a given day (see model 3 in table 2). This may suggest that accessing general knowledge increases the capability to recognize symptoms and frame problems but does not provide the necessary capability to solve complex problems, and this capability to frame problems just encourages field technicians to call the technical support center.

In contrast with general knowledge, reading problem solution documents i.e., internalization of specific knowledge is associated with the reduced likelihood of making a call on a given day, reduction in the total number of calls on a given day, and the reduction in the number of high complexity calls on a given day. This suggest that accessing and reading problem solution documents helps field technician develop firm specific knowledge and expertise that helps field technicians to solve a large number of problems including high complexity problems without calling the technical support center. Thus, we find that the accumulation of specific knowledge is also positively related with promotion for field technicians.

Finally, we find that though socialization is associated with reduction of total number of calls on a given day and the number of low complexity calls on a given day, socialization of tacit knowledge is positively associated with calling the technical support center on a given day and the number of high complexity calls on a given day.
complexity calls on a given day. This suggests that socialization of tacit knowledge helps field technicians in solving a significant number of low complexity problems. Thus, the influence of socialization in reducing a significant number of calls to the technical support center is associated with promotion for the field technician. But quite surprisingly socialization encourages field technicians to call the technical support center for more complex calls. It is plausible that with socialization field technicians develop tacit knowledge and develop a better understanding of the problem domain and are able to identify complex problems. With socialization field technicians also become familiar with the expertise of TSEs. Hence, when they recognize complex problems they are more prone to calling the TSE. Hence, for more complex problems field technicians with higher levels of socialization reach out to the technical support center more frequently thereby increasing their number of calls of higher complexity.

REFERENCES


Schefe, N., & Timbrell, G. (2004). A Tale of Two City Call-Centres. Australian CIS.