

Association for Information Systems AIS Electronic Library (AISeL)

AMCIS 2005 Proceedings

Americas Conference on Information Systems
(AMCIS)

2005

Differentiating the Effect of Cumulative Experience and Learning: A Field Study of Help Desk Support

Xuefei (Nancy) Deng

Carnegie Mellon University, xdeng@andrew.cmu.edu

Follow this and additional works at: <http://aisel.aisnet.org/amcis2005>

Recommended Citation

Deng, Xuefei (Nancy), "Differentiating the Effect of Cumulative Experience and Learning: A Field Study of Help Desk Support" (2005). *AMCIS 2005 Proceedings*. 341.

<http://aisel.aisnet.org/amcis2005/341>

This material is brought to you by the Americas Conference on Information Systems (AMCIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in AMCIS 2005 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

Differentiating the Effect of Cumulative Experience and Learning: A Field Study of Help Desk Support

Xuefei (Nancy) Deng
Carnegie Mellon University
xdeng@andrew.cmu.edu

ABSTRACT

The phenomenon of learning curves has been widely accepted as a fundamental pattern in organizational behavior. However, few studies focused on understanding the learning curves in professional services. This paper attempted to examine the learning experiences of help desks. The quantitative data of twenty-five educational institutions over five-year period evidenced the learning curve presence in information technology (IT) services context, but failed to demonstrate the variation in learning rates across institutions as anticipated. Qualitative data from our subsequent case studies suggested that institutions adopted similar tools and procedures in their help desk operation, facilitating their learning from past experience. However, help desks differ in their learning from indirect experience. This study applied organizational learning theory to IT services, and contributed to literature by differentiating the effects of cumulative experience and learning from indirect experience. In addition, it provided industry practitioners insights into more effective management of help desk services.

Keywords

organizational learning, learning curve, information technology, help desk support.

INTRODUCTION

The phenomenon of learning curves has been widely accepted as a fundamental pattern in organizational behavior. Echoing the conventional wisdom that “practice makes perfect”, researchers concluded that performance improves with experience of production. However, extensive work on organizational learning curves focused on the production of tangible goods (Argote and Epple, 1990; Darr, Argote, and Epple, 1995; Dutton and Thomas, 1984; Epple, Argote and Devadas, 1991). Much less has been learned about the learning curves in professional services, with a few exceptions (e.g., Pisano, Bohmer, and Edmondson, 2001).

This paper examines the learning experiences of organizations in their help desk operations. Help desk is an internal support group within an organization that responds to users’ computer-related questions, problems, or requests. Similar to the production of tangible goods, organizations are likely to improve their information technology (IT) services quality and productivity as their IT knowledge workers accumulate experience in resolving software and hardware problems. However, unlike in a production setting where adopted procedures and technologies are relatively stable, IT help desk operations are challenged by the unpredictability and novelty of the help desk requests and problems, as a consequence of the rapid development of information technologies and the increasing scope of computer-related products (McBride, 2000). Not surprisingly, organizational help desk groups are under a tremendous pressure to keep up with the rapidly changing technologies while managing to handle the increasing workload. Therefore, it becomes an important issue to understand if the conventional “learning from experience” phenomenon is present in this professional IT service context.

Furthermore, prior research (Dutton and Thomas, 1984; Pisano et al., 2001) suggested that organizations vary tremendously in the rate at which they learn from their experience. Factors contributing to this learning rate difference include the proficiency of individuals who perform the services, and the differences in the organizational technology and structures (Argote, 1999). Since help desk services depend heavily on people and tools to diagnose and solve problems, it will be interesting to examine if help desks learn at different paces.

We investigated the research questions by using the classic learning curve models to analyze the survey data of help desk operation at 25 educational institutions over five-year period. The analysis suggested that learning curves do exist in help desk services, but the data failed to support the variation of learning rates as anticipated. In an effort to explain the surprising

result, we subsequently conducted case studies of six similar organizations to explore factors contributing to the performance improvement in help desk services. The following sections will first introduce the hypotheses and describe our research design, followed by analysis of both quantitative and qualitative data from the field study.

LITERATURE REVIEW AND HYPOTHESES

Numerous studies in organizational learning have documented the link between cumulative experience and some measures of performance improvement. For example, in their longitudinal study of the performance of three truck plants, Argote and Epple (1990) found that the direct labor hours required in producing a truck decreased at a decreasing rate as the plants gained experience from production. Similarly, in a different context, Pisano et al. (2001) found that the time hospitals took to perform a new surgical procedure reduced significantly as the hospitals acquired more experience with the procedure. A recent study of payment processing at a financial institution concluded consistently that the facilities benefit from their past processing experience (Ashworth, Mukhopadhyay and Argote, 2004).

Likewise, we argue that the “learning from doing” phenomenon also exists in professional services such as help desk support. As help desk staff accumulates their experience with solving various computer-related problems, they are able to address users’ future problems more quickly and efficiently. Therefore, we predict that:

H1: Labor hours required to handle a call will decrease as an organization gains experience in its help desk services.

While emphasizing the effects of accumulated experience on performance, studies in organizational learning also control for factors that might affect performance, such as economies of scale or product mix (Argote, 1999). However, even after controlling for the possible factors, many studies on organizational learning curves still found that organizations differ tremendously in the rates at which they learn, such as in the production of trucks (Argote and Epple, 1990), and in the performance of cardiac surgical procedures (Pisano et al., 2001).

Summarizing the studies on learning rate variations, Argote (1999) concluded that factors contributing to the learning rate difference fall under three major categories: 1) people, 2) technology and tools, and 3) organizational structure, routines and coordination methods. Since help desk services rely on the knowledge workers, diagnostic tools and standardized procedures to perform their daily tasks, the variation in the above factors may lead to variation in an organization’s learning curve. Thus, we predict that:

H2: The slope of learning curve will vary significantly across the organizations in their help desk services.

RESEARCH DESIGN AND CONTEXT

The context of help desk services at educational institutions

The study context is help desks at college level of universities. Help desk support is a comprehensive service provided to help users with their computer-related problems. It represents an interesting form of knowledge work as the output of the help desk support includes advice, diagnosis and trouble-shooting solutions (Das, 2003). Help desk calls usually fall under three categories: problem, request, and question (McBride, 2000).

There are two levels of support identified in our field study: the 1st-tier and 2nd-tier support. When a call comes in, it is first handled by the front-liners (the 1st-tier support staff) who try to resolve the call on the phone. If the call is too complicated to be resolved over the phone, then it is passed to a 2nd-tier support staff who follows up with the user to address the problem, either on the phone or on the user site. Each call is assigned a ticket number and recorded in a tracking system. Once a problem is solved or requested services are delivered, the ticket will be closed in the tracking system. In the rest of the paper, we used call and ticket interchangeably.

Source of data

The study adopted a combined approach of using survey data and case studies. The quantitative data are from an annual survey on information technology operations administered by the member association of these institutions. Twenty-five institutions were identified with complete data for the five-year period from 2000 to 2004. Examples of the survey data include help desk operations (e.g. number of full-time equivalent (FTE), total number of calls, implementation of standardization strategies), the characteristics of the institutions (e.g. public vs. private), and the help desk environment (e.g. type of hardware and software supported). The qualitative data are collected from subsequent case studies.

STATISTICAL MODELS AND ANALYSIS

Dependent Variable

To measure productivity in the context of professional support work, we used labor hours per call (ticket) as the performance measure. The call volume of help desk reflects the total number of tickets opened and resolved by help desk staff. It is a direct measure of help desk workload. Since majority of help desk support cost is labor cost (e.g., staff salary), we used labor hours per call (ticket) to measure staff's productivity. Similar measures of "labor hours per unit of work" were used in previous learning curve studies (e.g., Argote and Epple, 1990; Ashworth et. al, 2004).

Independent Variable

To measure institution-specific experience, we used the cumulative volume of help desk calls handled annually by each help desk.

Control Variables

To isolate the effects of cumulative volume on call handing, we need to include in our model as many control variables as possible. First, as we have witnessed technological improvements year after year, it is important to control for the passage of time in analyzing learning rate. Prior researches (Argote, 1999; Darr et al., 1995) suggested that controlling the passage of time will enable one to isolate the effect of experience at a particular organization from the effect of technological improvement in the external environment. Secondly, consistent with prior studies (e.g., Argote, 1999; Ashworth et al., 2004), we also control for economies of scale by including the total number of calls for a given year and its squared term, since economies of scales also contribute to productivity gains. Lastly, we control for the institutional characteristics by including a dummy variable indicating if the institution is a public or private college, because public and private colleges are likely to differ in their funding sources and level of software and hardware standardization.

Statistical Model

The model is estimated by pooling observations across institutions in order to use a larger pool of data. Since time to resolve a help desk ticket can not decline at a linear rate, we perform a log transformation of the dependent variable "labor hours per call" and the independent variable "cumulative call volume". This is an approach suggested by Cohen and colleagues (2003, p250) when evidence of nonlinearity exists and researchers wish to use OLS. To isolate the possible institutional differences, we included dummy variables for institutions. To empirically test the varying learning rate across institutions, we added an interaction term of institution and its accumulated experience. The following model is consistent with classical learning curve model.

$$\ln(\text{Labor Hours}_{it} / \text{Calls}_{it}) = \beta_0 + \beta_1 \text{Year} + \beta_2 \text{calls}_{it} + \beta_3 \text{call_sq}_{it} + \beta_4 \text{public} + \beta_5 (\ln(\text{Cumulative Volume}_{i,t-1})) + \beta_6 \text{Inst}_i + \beta_7 \text{Inst}_i * \ln(\text{Cumulative Volume}_{i,t-1}) + \varepsilon_{it}$$

Labor Hours refer to total staff working time (in hours) for institution *i* in year *t*. *Calls* is defined as the total number of tickets resolved by institution *i* in year *t*. *Year* is a dummy variable for each year, e.g. *t*=0 for year 2000, *t*=1 for year 2001 etc. *Call_sq* is the squared term for the corresponding call volume. *Public* is a dummy variable set equal to one if the organization type is public. *Cumulative volume* is defined as the accumulated annual calls resolved at institution *i* prior to year *t*. *Inst* is a dummy variable for each institution, e.g. *i* < {1, 2, 3, ... 25}. ε is the error term.

The coefficients of the model can be interpreted as follows. β_5 captures the impact of accumulated calls on labor hours required per call across all institutions on average. According to our first hypothesis (H1), we expected to see a negative sign for this coefficient. β_7 captures the extent to which the slope of learning curve for a given institution varies from the average. β_5 - β_7 can be used to reflect the learning curve slope for a particular institution. Significant differences among the β_7 estimates would support our second hypothesis (H2) that the institutions learn at a significantly different rate. Other coefficients are for control variables. For example, β_2 and β_3 are vectors of coefficients that reflect the first and second order economies of scale. β_6 captures how the average labor hours per call vary across institutions.

Results

The results of the statistical models are included in table 1. Model 1 examines the effects of the cumulative volume. The estimated coefficient is negative and statistically significant ($p=0.016$), supporting H1. On average, labor hours required to resolve a call ticket decrease as institutions accumulate experiences in their help desk support.

Model 2 adds a dummy variable for each institution to test if the institution-specific effects on labor hours per call vary significantly across the twenty-five institutions. The coefficient is statistically significant ($P=0.003$). Furthermore, the overall fit of the model 2 was greatly improved as compared to model 1, as reflected from the R-square change p-value of 0.003.

Model 3 addresses the research question of varying learning rate across institutions by adding the interaction term between the institution and its cumulative experience. However, the coefficient of the interaction term is not significant, failing to provide evidence for difference in learning rates. Thus, our second hypothesis (H2) is not supported. Model 3 also shows another interesting result. Even after accounting for institution-specific effects on the learning from accumulated experience, significant differences still persist across institutions.

Variables	Model 1		Model 2		Model 3		VIF
	Standardized Coefficients	p-value	Standardized Coefficients	p-value	Standardized Coefficients	p-value	
Constant	1.76	.003	1.93	.001	2.35	.005	
Year	0.14	.063	0.13	.085	0.12	.1	1.675
Calls	-1.2	.000	-1.2	.000	-1.23	.000	17.302
Calls_Square	0.89	.000	0.87	.000	0.88	.000	10.938
Public	-0.11	.07	-0.14	.026	-0.14	.023	1.147
Cumulative volume	-0.31	.016	-0.27	.026	-0.34	.027	4.626
Institution (Dummy variable)			-0.18	.003	-0.45	.251	1.029
Institution* Cumulative volume					0.71	.478	
F	35.097***		32.872***		28.13***		
R-square	0.596		0.626		0.628		
R-square change			0.03		0.002		
R-square change p-value			0.003		n.s.		

Table 1: Coefficient Estimations for Learning Curve Models (N=125)

(Dependent Variable: Ln (Labor Hours per call) ***: $p<0.001$; **: $p<0.01$; *: $P<0.05$; +: $P<0.1$)

The above models were tested for multicollinearity using variance inflation factors (VIF) (Marquardt, 1970). Regressor coefficients are adequately addressed if their VIF do not exceed a value of 10 (Kennedy, 1992). All VIF values from Model 2 are below 5, except the VIF for variable “calls” and “calls square”.

Nevertheless, the above results were limited by the relatively small sample size of the data (25 institutions over 5 years). In addition, our model may have left out other potential control variables, such as employee turnover and training, because individuals training and working together could improve team coordination and affect team performance (Liang, Moreland and Argote, 1995; Edmondson, Bohmer and Pisano, 2001). In an effort to validate the conclusion from our quantitative analysis, and to explore the unsupported hypothesis of learning rate differences, we conducted case studies subsequently to enhance our understanding (Yin, 1994).

CASE STUDIES

To collect qualitative data, we interviewed nine help desk directors and managers from six institutions, of which three institutions are from the sampling pool of the twenty-five institutions with quantitative data analyzed. The interviews were conducted via phone during May-July 2004. Each interview lasted from 45 minutes to 70 minutes. In an open-ended format, the help desk directors and managers were asked to describe their help desk operation, the problem resolution process, their measurement of performance, and their best practices to meet the challenges in this field. Detailed notes were taken and reviewed within the same day. In addition, we also browsed their websites and press releases for the purpose of triangulation of the interview data.

When analyzing the data, we followed the guidelines suggested by Miles and Huberman (1994), and used an iterative process to develop inferences about the driving factors in improving help desk services. Common themes emerged as an inference, supported by related literature in organizational learning. Evidences are compiled from different data resources, and the inferences are modified or maintained.

Context of the case studies

Among the six participating institutions, there are three public colleges and three private colleges. They vary tremendously in terms of help desk service models, service scope, level of service and staffing. Three colleges adopt the centralized model, where there is no dedicated help desk office for the college; university provides the centralized help desk services to faculty, researchers, staff and students from the colleges. On the other hand, a decentralized model is adopted where the college has its own dedicated help desk office. Partial decentralized model refers to the situation where majority of help desk services is provided by the college's dedicated help desk, but partial services (e.g. networking infrastructure, or financial information system) are provided by university central office. All the three public colleges in the study adopt the centralized model, while all the three private colleges adopt partially decentralized or entirely decentralized model. This difference between public and private colleges supports our model specification of including organization type as a control variable. The following table (Table 2) provides a brief summary of the help desk services at the six institutions. To maintain confidentiality, we use letters A to F to name the six colleges.

College	Type	Model	Services	Service Level	Staffing
A	Public	Centralized	7000 PCs, infrastructure, network, email, web, software applications	Both 1st-tier and 2-tier support	25 staff with average tenure of 5 years
B	Public	Centralized	PCs, wireless, network, emails, phone	1st-tier support	5 staff with tenure ranging from 7 months to 7 years
C	Public	Centralized	Email, remote access, PDAs, laptops, equipment at labs (NO hardware and No printer service)	2nd-tier support	6 staff with tenure ranging from 6 years to 30 years
D	Private	Decentralized (Partial)	PCs, software applications (excluding networking and financial systems), centralized servers, emails, printing	Both 1st-tier and partial 2-tier support	15 staff with maximum tenure of 3 years
E	Private	Decentralized	Software (including financial system), email, networking	Both 1st-tier and 2-tier support	7 staff with tenure ranging from a couple of months to 5 years
F	Private	Decentralized (partial)	1000-1100 PCs, software, email (excluding 1 st -tier help desk, and 2 nd -tier networking infrastructure)	Partial 2nd-tier support	10 staff with maximum tenure of 15 years

Table 2: Description of the Institutions in the Case Studies

Contributing Factors to Improved Performance

The qualitative data revealed three common themes of best practice in IT help desk services. First, institutions are similar in their adoption of diagnostic tools and standardization procedures. Secondly, they all emphasize the importance of employee proficiency in this profession. Lastly, they learn from other units' experience.

Tools and Procedures

The six help desks under study share similarity in their adoption of tools and procedures. The complexity and wide range of technologies supported by help desks make it impossible to accomplish a task without tools and procedures. First, they all use software tools such as “Remedy” tracking system and remote diagnostic tools. The tracking system enables staff to log call details and problem resolution for future references, facilitating their learning from their experiences. Likewise, the remote diagnostic software allows support staff to temporarily take “control” of a computer from the user to handle troubleshooting remotely, and to perform fast and accurate problem diagnosis and resolution. The role of information technologies in translating learning from experience into productivity gains has been suggested by a recent empirical study on payment processing (Ashworth, et. al., 2004).

Secondly, the help desks all credit their improved performance to standardized strategies and routines. For example, they all adopt the standardization strategies on software, hardware and imaging to expedite troubleshooting. In addition, their practice of centralized and automatic anti-virus scanning, patching and updating minimizes the disruption caused by virus threats. User training on basic “How-to” questions releases help desk staff from recurring and mundane questions, and enables them to address complex problems. This echoes the research finding from a study in similar support work environment that pushing the tasks to the cheapest move (e.g., locating information) will help to improve productivity (Das, 2003).

Employee Proficiency

As people are the major resources in providing help desk support, the managers all emphasize the importance of their support staff’s skills. As Simon suggested (1991), organizational learning is fundamentally individual member’s learning, which has influence on an organization. As the employees accumulate experience working with the organization, their tenure and turnover level are found to be significant predictors of organizational performance (Argote and Epple, 1990). Even though help desk industry usually anticipates a high turnover as a result of the increasing customer demands and their subsequent stress (McBride, 2000), the institutions under study indicate that they benefit from a very low employee turnover and high proficiency in their staff, partly as a result of the sluggish IT job market during the last several years.

In addition, help desks adopt similar approach in their search for problem solution. They all emphasize the frequent search of problem solutions logged in the tracking system REMEDY. In addition, the Internet has greatly facilitated the help desk staff in their search for solutions; they also find the vendor databases (e.g. Microsoft and Dell) and search engines (e.g. Google) very useful. The third commonly mentioned approach is to consult colleagues in the same office or use specialized listserv within the university. Equipped with pagers and cellular phones, field engineers often call their colleagues back in office for suggestions and tips to solve a problem. Front-liners are found to ask a colleague sitting nearby when an unfamiliar problem is reported.

Knowledge Transfer From Other Units

Help desks are also found to learn from the experiences of other similar groups or the central help desk at the university, depending on their service levels. When they only offer 1st-tier or 2nd-tier support, learning from the group offering the other tier’s support becomes extremely important, because they both serve the same end users. Learning from other unit’s experience is believed to help improve their services, as the 1st-tier support manager at the central help desk of college C pointed out, *“It is considered a good practice to maintain good relationship with all colleges and sub-units for second-level support, and to learn from them. We know second-level support such as Mike and other technicians at the college very well.”* This evidence suggests that we should pay attention to learning from indirect experiences, as suggested by previous studies (Darr et al., 1995; Epple et al., 1996; Levitt and March, 1988).

However, the extent of learning from other units depends on the characteristics of the knowledge. If the knowledge can be codified and context-free, then help desk staff found it beneficial to transfer knowledge from their experience. For example, colleges are found to benefit from accessing other colleges’ help desk REMEDY systems to search for solutions when other colleges within the university use standardized software and hardware. Prior studies provide evidence that codified knowledge transfers more readily than the knowledge high in “casual ambiguity” (Szulanski, 1996). Conversely, if the knowledge learned is context-specific, then it will be better to learn from direct experience (Argote and Kane, 2003). The help desks serving unique products indicate that they depend on their own resources and experiences given the specific products and services offered.

DISCUSSION

This study confirmed that the traditional learning curve exists in the context of help desk services. As help desk staff resolve more problems and deliver more services, they become more productive in their work. However, according to the regression

results (Table 1), the coefficient for the constant is still significant even after we controlled for the institutions and the interaction term between institutions and their accumulated experience. This implies that our model still left out important factors, which contributed to the improvement in help desk staff productivity. In addition, the statistical analysis failed to support the anticipated learning rate variation across the twenty-five institutions.

Prior research identified tools, routines, and employee proficiency as contributing factors to the varying learning rates from experience (Argote, 1999; Argote and Kane, 2003). However, our case studies provided evidences that institutions in our case studies generally adopt routines and tools of industry best practice. For example, the remote access control software has become an industry best practice (McBride, 2000). In addition, they all benefit from the highly skilled IT professional staff that they are able to retain while the external IT job market is sluggish. This might explain partially why our quantitative data failed to indicate the existence of varying learning rates.

Moreover, our in-depth case studies identified the indirect learning from other organizational units as a possible contributing factor to performance beyond direct experience. When they offer standardized hardware and software, help desks benefit from searching the tracking system of other colleges within the same university. This was echoed by prior research (Levitt and March, 1988) that the key for an organization to learn lies in its ability to retain the knowledge of individual learning within the organization for other people to access and adapt later. The knowledge transfer effects also become apparent when they only offer 1st-tier or 2nd-tier support; knowledge transfer between upper link and lower link proves beneficial to performance improvement.

Furthermore, the educational institutions vary tremendously in terms of their help desk service model, service scope, service levels and staffing. Accordingly, any evaluation of performance and effectiveness should take into account the given circumstances. Given the wide scope of the help desk services, a single performance measure such as call handling volume won't be sufficient, as one manager concluded, *"aggregates don't relate well back to performance"*. Generally, when evaluating the performance of front-liners, objective measures such as Ticket/call ratio, first-level resolution rate, response time, closure rate, length of a phone call are used. For example, help desk managers agreed that twenty minutes is the maximum time spent by front-liners (1st-tier support) to resolve a problem at the point of entry. For field engineers, critical issues need to be fixed within a couple of hours, and majority of problems are expected to be resolved within twenty-four hours. In addition, subjective measures such as customer satisfaction are more often used to evaluate the field engineers. This suggests that multiple performance measures should be considered when studying the learning curves of organizations in their professional services.

CONCLUSION

This paper contributed to learning and IS literature by studying IT services under the lens of organizational learning. It concluded that IT services witness similar learning curves as those in the production of tangible goods. Meanwhile, the qualitative data from our case studies supplemented and enriched the quantitative analysis by demonstrating other organizational-level factors, which are possibly associated with the improvement in help desk productivity. The qualitative data also suggested that help desk staff not only learned from their own experience, but also from the indirect experience of other units within the organizations, depending on the types of knowledge. In addition to the traditional "learning from doing" approach, the results from this paper suggested the importance of "learning from others" in IT services and the significance of knowledge transfer among IT knowledge workers.

The combined method of using both quantitative analysis and case studies provided an in-depth investigation of our research questions in the context of IT help desks. The research findings can be applied to other professional services settings such as software development or management consulting. However, the findings from the study should be applied tentatively. Limited by the availability of quantitative data, we could not examine the effect of other factors, such as employee tenure and turnover identified in previous study (Argote and Epple, 1990). As suggested from the case studies, more detailed data on the level of services (1st-tier vs. 2nd support) and on scope of services will help to distinguish the effect of learning from direct vs. indirect experience. Future studies will further our understanding by incorporating the qualitative results from the case studies into the learning curve model for IT services, and by testing the model in other types of organizations and professional services.

REFERENCES

1. Argote, L. (1999) *Organizational Learning: Creating, Retaining and Transferring Knowledge*. Norwell, MA: Kluwer.
2. Argote, L. and Epple, D. (1990) Learning Curves in Manufacturing, *Science*, 247,4945, February 23, 920-924.
3. Argote, L. and Kane, A. A. (2003) Learning from Direct and Indirect Experience in Organizations: The Effects of Experience Content, Timing and Distribution. In P. Paulus, & B. Nijstad (Eds) *Group Creativity*, 277-303. New York: Oxford University Press.
4. Ashworth, M. J., Mukhopadhyay, T., and Argote, L. (2004) Information Technology and Organizational Learning: An Empirical Analysis, *Proceedings of Twenty-Fifth International Conference on Information Systems*, December 12-15, Washington, DC, USA.
5. Cohen, J., Cohen, P., West, S. G., and Aiken, L. S. (2003) *Applied Multiple Regression / Correlation Analysis for the Behavioral Sciences*, 3rd edition. Mahwah, NJ: Lawrence Erlbaum Associates.
6. Darr, E., Argote, L., and Epple, D. (1995) The Acquisition, Transfer, and Depreciation of Knowledge in Service Organizations: Productivity in Franchises, *Management Science*, 41, 11, November, 1750-1762.
7. Das, D. (2003) Knowledge and Productivity in Technical Support Work, *Management Science*, 49, 4, 416-431.
8. Dutton, J. and Thomas, A. (1984) Treating Progress Functions as a Managerial Opportunity, *Academy of Management Review*, 9,2, April, 235-247.
9. Edmondson, A., Bohmer, R., and Pisano, G. (2001) Disrupted routines: Team learning and new technology implementation in hospitals. *Administrative Science Quarterly*, 46, 685-716.
10. Epple, D., Argote, L., and Devadas, R. (1991) Organizational Learning Curves: A Method for Investigating Intra-Plant Transfer of Knowledge Acquired through Learning by Doing, *Organization Science*, 2, 1, 58-70.
11. Epple, D., Argote, L., and Murphy, K. (1996) An Empirical Investigation of the Micro Structure of Knowledge Acquisition and Transfer through Learning by Doing, *Operations Research*, 44, 77-86.
12. Kenny, P. (1992). *A Guide to Econometrics*: MIT press.
13. Levitt, B. and March, J. G. (1988) Organizational Learning, *Annual Review of Sociology*, 14, 39-52.
14. Liang, D.W., Moreland, R., and Argote, L. (1995) Group versus individual training and group performance: The mediating role of transactive memory. *Personality and Social Psychology Bulletin*, 21, 383-393.
15. Marquardt, D. W. (1970). Generalized Inverses, Ridge Regression, Biased Linear Estimation, and Non-Linear Estimation, *Techometrics*, 12, 591-612.
16. McBride, D. (2000) *A Guide to Help Desk Technology, Tools and Techniques*. Course Technology, a division of Thomson Learning, Cambridge, MA, USA.
17. Miles, Matthew B., A. M. Huberman. 1994. *Qualitative Data Analysis: an Expanded Sourcebook*. Thousand Oaks: Sage Publications.
18. Pisano, G. P., Bohmer, B. M. J., and Edmondson, A. C. (2001) Organizational Differences in Rates of Learning: Evidence from the Adoption of Minimally Invasive Cardiac Surgery, *Management Science*, 47, 6, June, 752-768.
19. Simon, H. A. (1991) Bounded Rationality and Organizational Learning, *Organization Science*, 2, 1, Special Issue, 125-134.
20. Szulanski, G. (1996) Exploring Internal Stickiness: Impediments to the Transfer of Best Practice within the Firm, *Strategic Management Journal*, 17, 27-43.
21. Yin, R. K. (1994) *Case Study Research: Design and Methods*, 2nd edition, Sage, Thousands Oaks, CA, USA.