Do Professional Services Learn, Sustain, and Transfer Knowledge?

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Abstract

Organizational knowledge has become a critical source of competitive advantage for many companies. This is especially true for professional service firms (doctors, designers, consultants, etc.) that use domain knowledge as a key source of differentiation. Using data from a professional service firm, we investigate two questions: (1) At the firm level, do professional service firms learn? Do they sustain knowledge? (2) At the unit-level, do professional service firms transfer knowledge between internal units to solve client problems? The results show significant learning and no knowledge depreciation at the firm level; and that among internal units the knowledge transfer is asymmetric, i.e., some transfer in knowledge but not out; while others do the opposite.

1. Introduction

Organizational knowledge management has become a critical competitive capability for many companies and recent research has confirmed that organizational knowledge can provide an inimitable competitive advantage (Adler, 1990; Zander and Kogut, 1995). Three skills are critical to knowledge management capability: acquiring new knowledge, storing and sustaining acquired knowledge, and disseminating knowledge within the organization to all potential users (Cohen and Levinthal, 1990). This research draws on organizational learning curve theory to examine these knowledge management capabilities in a professional service organization.

Professional services provide a new business context to study the acquisition, retention, and the transfer of knowledge. Professional Services (examples include consultants, engineers, lawyers, etc.) use their knowledge base to develop business solutions to solve client problems. Solutions are often tailored to client needs and the skill set needed for any given project is determined by project context and complexity [1]. The success of professional service firms depend on how well they manage the knowledge they accrue; and how efficiently this accrued knowledge is shared across the firm to solve client problems.

Over the past few years, we have been exploring and drawing upon organizational learning curve theory to examine two critical knowledge management capabilities: knowledge retention (or alternatively depreciation) and diffusion in a professional service organization. In this chapter we summarize some of our past results on retention and depreciation (Boone, Ganeshan, and Hicks, 2008) and provide new ones on diffusion (Boone, Ganeshan, and Hicks, 2010).

We use organizational learning curve theory since it is now a crucial and essential tool to measure and track productivity. Learning curves measure knowledge acquired from production experience via experience based productivity improvements (Yelle 1979). They provide a mechanism for evaluating knowledge sustainability by measuring the rate at which knowledge depreciates. Past research has found that knowledge erodes or depreciates over time, and varies considerably among organizations (Bailey 1989, Darr et. al. 1995). Higher levels of knowledge depreciation appear to be due to several factors, many of which are distinguishing characteristics of professional services. For example, professional service work is typically carried out via projects, and is characterized by high levels of process variety, which has been associated with faster erosion of knowledge (Jaber and Bonney 1997). The models in Section 4.1 examine issues related to learning and depreciation in a professional service firm.

Knowledge diffusion, or intra-firm knowledge transfer, can be evaluated using "spillover models," which evaluate the association between different units knowledge gains. Knowledge transferred into an organization unit enables that unit to improve its own performance by

[1] Prior research has largely focused on manufacturing or mass-service environments where much of the learning is either substantiated in technology (such as process improvements) or via repetition of the same task. See, for example, Argote and Epple, 1990

leveraging the production experience of others within the organization (Jarmin 1994). When knowledge created elsewhere is assimilated into a unit, the result is an association between an organization's performance and the production experience of others. The models in Section 4.2 examine such cross-functional knowledge transfer. Past work indicates that knowledge diffuses more easily between departments that are similar in skills, experiences and function (see Lane and Lubatkin 1998, for example). An imperative of knowledge management, however, is that relevant knowledge diffuse throughout an organization to whomever might need it irrespective of functional or departmental boundaries.

2. Context and Research Questions

The context for this research project is an architecture-engineering (A/E) firm that primarily provides Facilities Engineering services to its clients. The firm has expertise in four disciplines organized into departments or units: architectural, electrical, mechanical, and civil/structural engineering. This firm also designs technical drawings & estimates costs for systems such as power generation & distribution, HVAC, and mechanical.

The organization operates in a project process environment, creating drawings, technical specifications and cost estimates to meet customer requirements. Many of the projects require input from more than one department. In such cases, a multi-disciplinary project team collaborates on the project. Much of the organizations work is collaborative, with workers from a number of the departments working together to complete a project.

Workers typically work on more than one project at any given time although each project may be at a different stage. There is considerable variability among projects, although some project tasks, such as cost estimation and site visits, are similar across projects. And indeed all draw on common bodies of knowledge e.g., architectural and engineering rules seldom change, though designs may.

The firm provided data for all projects started between 1992 and 2000. The data included pages of design output, labor hours, project start and completion dates, and participating engineers from different departments for every project. The analysis focuses on the relationship between productivity improvements and knowledge depreciation and transfer during that time.

Based on this data, we provide summaries of two research questions we have explored in the past three years:

- At the firm level, can we detect a learning curve in this professional service organization? How well does this firm retain any knowledge that is accumulated[2].
- At the department, unit or discipline (these terms are used interchangeably) level, how successful are these units in accruing productivity gains through experience? So for example does an Electrical project take less time than a Mechanical project of the same complexity? *Why?*. To answer the *Why?*, we will investigate if each of the departments are able to transfer the knowledge accumulated from other disciplines into solutions for projects at hand[3].

3. Background Literature

Wright (1936) was the first to document the relation between production experience and productivity improvements. Wright observed that the production time of airplanes decreased at a predictable rate. According to this model, each doubling of cumulative production results in a constant reduction in unit production time. As an organization gains production experience, represented by the cumulative number of units produced, it is able to produce individual units faster and/or at a lower cost.

Most learning curve research has been conducted in manufacturing organizations. Prior to Boone, Ganeshan, and Hicks (2008), learning curves found in service businesses largely involved contexts with relatively stable processes or in service back rooms (Argote and Epple 1990, Dutton and Thomas 1984, Yelle 1979). The distinguishing characteristics of services, however - intangibility, heterogeneity, simultaneous production and consumption and the customer's involvement in the service creation process – may affect the association between production experience and productivity improvements (Lovelock 1992, Morris and Johnston

[2]We originally published these results in Boone, Ganeshan, and Hicks (2008)

[3]Our results are based on the working paper Boone, Ganeshan, and Hicks (2010)

1986).

Professional services have the highest levels of labor intensity, customization, and customer interaction (Schmenner 1986). Professional service organizations must contend with more variable worker skill levels, experience, and knowledge. Much of the work within professional service organizations is carried out via project type processes - one of a kind, long term, resource intensive operations frequently involving several workers from several departments. The defining characteristics of professional services and project processes, i.e. high labor intensity, product variability, process variability, relatively small production volumes, potentially endanger experience based productivity improvements. However, on the other hand, professional service workers are also highly trained, requiring certifications over time to carry out their professional service work. Consequently, as they develop more domain experience, they are able to tackle client problems quicker and in a more efficient way. Since most of the work product – in this case CAD designs – are stored electronically, the ability to codify past work and the ability to retrieve it for current client work also significantly impacts how knowledge is retained in the firm.

The proportion of human labor has been shown to affect the relationship between productivity and production experience in manufacturing organizations. Human labor has demonstrated a greater capacity for learning than machine labor (Hirschmann 1964a, Hirschmann 1964b). Production processes using higher proportions of human versus machine labor typically have steeper learning curves and plateau more slowly than less labor intensive processes (Yelle 1979). This is especially true for professional services were a part of knowledge is tacit and "belongs" to the worker. The rates of learning will depend, in part, on how well firms are able to harness this tacit knowledge.

Sufficient volume is a significant source of experience-based productivity improvements. The more often the task is repeated the better the worker or organization becomes. This implies that a task must be completed some number of times for appreciable improvements to be realized.

Knowledge Depreciation

Experience based productivity improvements depend in part on repeated actions. Productivity improves because as a worker repeats some task he or she gets better at it. Professional service project processes are by their nature highly variable. Each successive product, or project, is likely to be different from the next, although there may be similarities and commonalities among projects. In order for productivity improvements to be realized, the worker and the organization must be able to benefit from past projects that are meaningfully different from the one at hand.

Past empirical studies suggest that all else being equal less process variability results in faster productivity improvements. Forgetting, and unlearning indicate that a disruption has affected the learning curve, whereby current productivity is associated with a lower volume on the present learning curve.

Knowledge depreciation refers to ongoing erosion in the knowledge stock, and indicates that the experience-based knowledge stock is not accurately represented by total accumulated production (see Boone, Ganeshan, Hicks 2008 for review of empirical studies in depreciation). Instead, the learning stock or knowledge, depreciates - even while it is being used, and is better represented by some fraction of total accumulated production. The net result of both forgetting and deprecation is that in order to predict productivity at a given point in the production history, the basic learning curve must be modified to show that not all production experience is reflected in productivity.

Higher levels of labor intensity may make professional services more vulnerable to organizational forgetting or knowledge depreciation as a result of several factors. In professional services especially, much of the process knowledge resides in the workers. When a worker leaves, the unique knowledge he or she has leaves too, unless it has been transferred to the organization. The result is depreciation in the organizational knowledge stock. This may be reflected in lower rates of learning. Darr et. al. (1995) found that the learning rate in a network of pizza restaurants was lower than the 80% learning rate found in most manufacturing firms.

The higher variability of professional services may exacerbate forgetting unless (a) past projects are sufficiently codified so the relevant knowledge is captured; (b) subsequent customers request similar service products, as some time passes before similar service products are reproduced.

Knowledge Diffusion

Knowledge diffusion (or transfer) refers to the productivity improvements due to others' production experience. Researchers have examined knowledge transfer among firms within the same industry, across shifts within a single firm, and among stores in a retail chain (Argote et. al. 1996, Darr et. al. 1995, Epple et. al. 1996). In general, the work has focused on transfers between units performing the same tasks. What happens when the tasks are not the same? Or as in this case, only some tasks are similar, yet the units work closely together. How readily does knowledge diffuse?

Physically closer networks will experience more frequent and rapid knowledge transfer (Rothwell 1994, van Dierdonck et. al. 1991). Organizations or units that are more similar will also experience greater knowledge transfer. Lane and Lubatkin (1998) found that knowledge transfers more frequently and easily among firms that share similar knowledge bases, organizational structures, and policies. Within a single firm, employees with similar professional experiences and training will communicate more easily than employees with different experiences and backgrounds (Goldhar and Jelinek 1985, Leonard-Barton 1995). Members of a common profession tend to share the same skills, jargon and knowledge base, all of which make communication easier (March et. al. 1996). The result is faster, easier and richer knowledge transfers among employees with similar professions, backgrounds, and training.

Knowledge can also be lost in the transfer process. Knowledge transfers incompletely across shifts within a single firm or among stores in a retail chain (Argote et. al. 1996, Darr et. al. 1995, Epple et. al. 1996). Intra-firm knowledge diffusion depends on the ability and willingness of both the recipient and the originator to transfer knowledge. Both parties must want to exchange knowledge. The originator must be willing to share knowledge and the recipient must have the capability to adopt the new knowledge (Szulanski 1996).

Knowledge transfer is made more difficult by formal and informal boundaries between units. Boundaries, whether created formally by organizational structures or informally by alliances and communities, serve to channel knowledge flows. Knowledge flows more easily on one side of an organizational boundary and is more difficult across boundaries (Brown and Paul 1996). Consequently, specific efforts must be made to ensure that important knowledge crosses boundaries.

The characteristics of knowledge will also influence its transferability. Knowledge which can be documented, be it manuals, blueprints or memos, is more easily and rapidly transferred (Nelson and Winter 1982, Nonaka 1994, Polanyi 1967). In addition, articulable knowledge is more easily organized and communicated via a variety of means, which may serve to reinforce one another.

Most research has assumed symmetrical knowledge transfer or spillover throughout industries or within firms. When more than two units are involved, symmetrical models of knowledge transfer do not capture bi-directional knowledge flows among all units. Jarmin (1994) indicated that knowledge is unlikely to diffuse equally to all firms in an industry or to all subunits of a firm. Epple et. al. (1996) found that the knowledge transfer between shifts was not symmetric.

Asymmetric models also capture information that indicates a unit's ability to absorb information. While knowledge diffusion is determined by capabilities of the originating and adopting units, the absorptive capabilities of the adopting unit appear to be more important (Cohen and Levinthal 1990).

4. Models and Results

4.1 Firm-Level learning curve

The traditional form of learning curve is often written as (see Epple, Argote, Devadas, 1991)

$$l_t/q_t = AQ_{t-1}^{-\gamma} \tag{1}$$

where l_t is the labor hours worked by the engineers in month t, q_t is the number of drawings produced in a month t, and Q_{t-1} is the cumulative number of drawings (knowledge stock) up to month t or $Q_{t-1} = \sum_{i=1}^{t-1} q_i$, $q_0 = 0$. A and γ are positive constants. The rate of learning can be expressed by the progress ratio $p = 2^{-\gamma}$ which is the percentage decrease in labor hours to create a drawing, for every doubling of drawings produced. For estimation, (1) can be rewritten in the commonly used form (from Epple, Argote, and Devadas, 1991)

$$ln(q_t) = \alpha + \beta ln l_t + \gamma ln Q_{t-1} + \epsilon_t \tag{2}$$

where $\alpha = 1/ln(A)$, β, and γ are all coefficients that need to be estimated and ϵ_t is the error term. Table 1, column 2, shows the estimated parameters using ordinary least squares for firm-level models of learning and depreciation (see Boone, Ganeshan, Hicks, 2008 for details).

Firm Level Depreciation of Knowledge

The model in (3) allows for depreciation in knowledge stock. If K_t is the stock of knowledge at time t, then $K_t = \lambda K_{t-1} + q_t$, $0 \leq \lambda \leq 1$, and $K_0 = 0$. The parameter λ represents the proportion of knowledge from previous months that is available during future months. (2) can be generalized to:

$$ln(q_t) = \alpha + \beta ln l_t + \gamma ln K_{t-1} + \epsilon_t, \tag{3}$$

where $K_{t-1} = \sum_{i=1}^{t-1} \lambda^{t-i-1} q_i$. Equation (2) is a special case of (3) when $\lambda = 1$. If $0 \leq \lambda < 1$, then some of the knowledge gained from accumulated production is lost, i.e., it is not all available for use in the current month. Column (3) in Table 2 shows the parameter estimates for (3). The value of λ is 0.9934, with a standard error of 0.077 indicating that while some depreciation of knowledge does occur, it is not significant to reject the hypothesis that $\lambda = 1$.

Table 1: Estimates of Model Coefficients (Standard errors in parentheses. ‡= p<.05, †= $.05 \leq p < .10$).

Parameter	Model (2)	Model (3)
Constant	-4.009‡	-4.0354‡
(α)	(.509)	(1.740)
Man Hours	0.8831‡	0.8805‡
(β)	(.051)	(0.052)
Experience	0.1811‡	0.1847‡
(γ)	(0.0429)	(0.058)
Depreciation	1	0.9934‡
(λ)		(0.077)
R^2	0.826	0.825
N	85	85

4.2 Inter Departmental Knowledge Transfer

The second series of models investigate how knowledge flows within the various departments in the organization. When a client hires the firm, the project is allocated to a "focal" department that leads the project. For example, if the project calls for upgrading the HVAC system in a historical building, the lead or focal department will be Mechanical. However the Electrical department will be involved to help with the wiring design and so will the architects to preserve historical integrity. So in this example project, the Mechanical department is the focal department; and the Electrical and Architectural departments are collaborators on the project. In contrast to Section 4.1 (which uses monthly input and effort), we drill the data used in the following models down to the project level (total of N projects) – this allows to explicitly model how experience from previous projects – focused in any discipline – carry over to the project at hand. We will designate the departments in this firm as A, B, C, and D to maintain confidentiality.

Symmetric transfer of knowledge between departments

$$lnq_{i,n_i} = \alpha_i + \beta_i lnl_{i,n_i} + \gamma_i lnK_{i,n_i-1} + \sum_{j \neq j}^{J} \psi_j lnK_{j,i_{n_i}-1} \times A_{ij} + \epsilon_N \tag{4}$$

where $lnK_{j,i_{n_i-1}}$ is the knowledge stock of department j prior to the start of the n_i^{th} project of department i. Further, let $A_{ij} = 1$ if unit j is an active collaborator with unit i on a given project, and is zero otherwise. The departmental subscripts i and j take on values A, B, C, or D depending on the department. To simplify the analysis (and also as a consequence of Model (3)), we assume that $\lambda = 1$.

This specification allows the total experience level to date for a collaborating department to influence the productivity of the focal department, but forces the transfer of knowledge (via the coefficient ψ_j to occur in a similar manner regardless of who a department is collaborating with.)

Table 2: Estimates of Model Coefficients for Symmetric Knowledge Transfer (‡= p<.05, †= $.05 \leq p < .10$).

Parameter	Estimate	Standard Error	t statistic
Man Hours (β)	0.6502	0.0199	32.6213
Focal A	0.3974	0.0473	8.3934
Focal B	0.1383	0.0515	2.684
Focal C	0.2548	0.0318	8.0201
Focal D	0.0895	0.0441	2.0314
NonFocal A	-0.0036	0.0052	-0.701
NonFocal B	0.0096	0.0056	1.7059
NonFocal C	0.0078	0.0053	1.4773
NonFocal D	0.0309	0.0073	4.2277
Constant (α_A)	-5.6273	0.4723	-11.9142
Constant (α_B)	-3.1266	0.4987	-6.2694
Constant (α_C)	-4.0612	0.3275	-12.4003
Constant (α_D)	-2.5126	0.4324	-5.8113
Depreciation (λ)	1		
R^2	0.5551		
N	462		

Table 2 shows the model results for this model. Here knowledge transfer is restricted to occur symmetrically across departments so that the knowledge transfer a collaborating department brings to a project is constant no matter with whom the collaborator is working. This specification allows for departmental heterogeneity in two ways. First, by estimating separate intercept for each department the effect of differing project sizes across departments is dealt with. As for how learning accrues within a department, this specification allows for differing abilities to translate experience into output by estimating a separate experience coefficient for each focal department. The results show that only the experience associated with collaborating department D is able to be leveraged for increases in output.

Asymmetric transfer of knowledge between departments

This model in most respects is similar to equation (4) except in one important aspect. Rather than restrict the knowledge transfer between focal and collaborating department to be constant irrespective of the focal partner, we allow for asymmetric transfer of knowledge by estimating 12 knowledge transfer coefficients (ψ_{ij}) representing how the focal department i can leverage the experience of collaborating partner j into output gains. We estimate the following model

$$lnq_{i,n_i} = \alpha_i + \beta_i lnl_{i,n_i} + \gamma_i lnK_{i,n_i-1} + \delta_i (lnK_{i,n_i-1})^2 + \sum_{j=1}^{J} \sum_{i \neq j}^{J} \psi_{ij} lnK_{j,i_{n_i}-1} \times A_{ij} + \epsilon_N \quad (5)$$

where $A_{ij} = 1$ if unit j is an active collaborator with unit i on a given project, and is zero otherwise.

Table 3 shows our preliminary results for this model and we only report the sign of the significant parameters. Diagonal elements are our estimates of γ_i, and all are positive and significant for every department, indicating that departments are able to capitalize on their own experience. The asymmetric patterns seen in the table are consistent with the findings of Table 2 but shed further light on exactly which knowledge transfer collaborations provide statistically meaningful output gains. Of particular interest is that almost all departments (except for A) appear to be able to transfer the experience of department D when collaborations occur. In only one case (when focal department A collaborates with department B), does a partners' experience actually seem to decrease output.

5. Discussion

Firm-level Learning and Depreciation

Table 1 confirms that professional services exhibit learning curves. From Column 2 of Table 1, the rate of learning is 0.1811. So the progress ratio is $2^{-.1811} = 0.882$ suggesting that for

Table 3: Some Preliminary Results for Asymmetric Knowledge Transfer

		Focal Department			
		A	B	C	D
	A	+	−		
Collaborating	B		+		
Department	C			+	
	D		+	+	+

every doubling of output (drawings), the productivity increases approximately by 12%.

A second significant finding is that there is no appreciable depreciation of learning, at least in this firm. In manufacturing contexts, the percent of knowledge stock retained month to month varies widely. For example, prior results include monthly knowledge retention rates of 67% in Automotive assembly (Epple, Argote, Murphy, 1996), 75% in shipbuilding (Argote, Beckman, and Epple, 1990), 81% in a North American Truck plant (Argote, Epple, and Devdas (1990), and 96% in Aircraft production (Benkard, 2000). In mass service settings, past research estimated that only 47% of the knowledge stock at the beginning of the month was carried to the next month (Darr et. al. 1995's study on pizza franchises).

The results can be explained by two key observations (see also Boone, Ganeshan, Hicks, 2008). First, this firm managed all its work product electronically. Engineers work collaboratively on CAD designs and these are available to all engineers in the firm through an indexed database. So past knowledge is codified, and is easily available for engineers to access past projects for projects at hand. Second, as in any professional service, a portion of the knowledge is tacit, i.e., with the engineer who worked on the project but not in the CAD design itself. For example, designs that did not work; unique aspects of certain clients or projects; "wisdom" acquired through years of exploring different options for a multiple of projects, etc. While such knowledge is not explicit, engineers in this firm seemed to have a general sense who "knew their stuff." So engineers often approached those who were recognized informally as "experts" to seek advice about projects and often the expert gives them a piece of advice that is not documented, enhancing the outcome of the project. While such informal interactions are not explicitly captured by models in (1)-(3), it plays a major role in sustaining the knowledge in this firm. We theorize that larger firms need more formalized procedures to capture the tacit knowledge that is hidden within the professional service worker.

Department-level Diffusion

The results for symmetric knowledge transfer suggest that all departments benefit from their own experience, although at differing levels. This is a function of how well each department is able to codify explicit knowledge and how effective it is in tapping tacit knowledge residing in its workers; and as the asymmetric transfer results show, how well it taps into the experience of collaborating departments. The results also indicate that experience-based knowledge transfer among departments is limited when one assumes symmetric knowledge transfer. Department D is able to increase the productivity of others when it is a collaborator. None of other departments contribute to increases in productivity as collaborators. This suggests that there are barriers to knowledge transfer from departments A, B, and C to the rest of the organization.The analysis of symmetric knowledge transfer, while important, does not provide information on bilateral knowledge transfer between department pairs.

Results of model (5) support Jarmins (1994) assertion that asymmetric knowledge diffusion models provide a more complete and interesting depiction of intra-organizational knowledge flows. Significant and insignificant knowledge transfers are masked by the model which assumes symmetric knowledge transfer.

Two distinct patterns of knowledge transfer are revealed in the data. First, we identify departments who appear to realize more significant outgoing knowledge transfers than incoming. The accumulated experience-based knowledge for departments D is significantly associated with the productivity of B, C, and of course, department D. In other words, this department appears to contribute significantly (in addition to itself) to the productivity of B and C. At the same time, the productivity of D is not significantly associated with the experience-based knowledge of the other departments!

Departments B and C show the opposite behavior. Its productivity was significantly associated with the experience-based knowledge of D, although no other department appeared to benefit from its production experience. It also appears that some departments (in this case A) have negative impact on the productivity of others (B).

While our investigation of knowledge-diffusion is ongoing, conversations with managers in the firm indicate that the findings may reflect the intensity of the departmental relationships, commonalities in department cultures, or informal network structures are not captured by the data. Knowledge diffusion depends in large part on organizational context, e.g. routines, the values and norms of the "transferring" and "receptor" groups. In addition, diffusion is affected by how similar two groups are, the formal and social relationships linking group members, the distance between sharing groups, and the barriers that exist between groups. Although all of the departments reside within the same firm and share a larger organizational context, the departments within the same firm may share significantly different cultures. More importantly, the relationships between pairs of departments are likely to be different. One would expect to see, however, significant bi-directional knowledge transfer where two departments have stronger ties or networks.

The findings also suggest varying levels of absorptive capacity for the different departments. Absorptive capacity would potentially moderate the effect of network ties on knowledge transfers.

6. Conclusion

In this chapter we set out to answer two broad questions: (1) Can we identify learning curves in professional service organizations? Do they sustain the knowledge accumulated; and (2) How does knowledge transfer between departments or units in professional service firms.

Results indicate that experience-based learning is significant; and in contrast to most manufacturing firms, professional firms are able to sustain their knowledge with time. Our results also show that knowledge transfer patterns in this organization are asymmetric. Some departments benefit from the production experience of others without exhibiting significant outgoing knowledge transfer. Some departments exhibit significant outgoing knowledge transfers, without showing productivity benefits from the production experience of others.

Future research can focus on the following key questions:

- Can tour results be duplicated in other professional service industries? Especially interesting would be management consulting firms, that, much like the design firm in this chapter, tackle a wide variety of issues in a multitude of industries.

- Can a generalized set of behavioral patterns explain asymmetric knowledge transfer? Why is that some departments transfer knowledge better than others?
- What can professional service firms do to improve the transfer of knowledge between departments so client problems can be solved cheaper and faster?

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