Journal of Applied Economic Sciences
Issue 4 (6)/Volume III /Winter 2008

THE RELATIONSHIP BETWEEN TEAMWORK EFFECTIVENESS AND INFORMATION TECHNOLOGY

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Abstract:

Even organizations that are better served by a team model find disadvantages. These include an increase in time to communicate, poor communication between members and groups, poor coordination between group members, and competing objectives. Some self–managed teams never reach their full potential or fail to be functional altogether, because they were not set up correctly and the other aforementioned negative results occur. Other teams increase productivity and quality in organization. In this article the authors have investigated how information technology can increase teamwork effectiveness.

Keywords: teamwork, organization, information technology, development.

1. Introduction

In today‘s world of work, fundamental transformation in complex structures are taking place. Organizations face complex and dynamic environments that have been attributed to increases in the globalization and competitiveness of the global economy.

As most every body knows, change is constant within teamwork productivity and effectiveness. The emergence of new technologies, coupled with escalating demands from business, has brought about both instability as well as new challenge.

In turn, teamwork must now look for new ways to adapt quickly, operate more efficiently and better prepare themselves for future. Not surprisingly, many organizations believe redesigning the structure of their organization is the solution, on the other hand, as well designed and planned, organization can have dramatic benefits for the enterprise, including increased profitability, greater overall efficiency and better alignment of teamwork to business needs.

Many studies have indicated that variation in team performance can be explained by differences in team structure [Cohen, and Bailey, (1997); Hackman, (1987), Manz, and Sims, (1987); Murray, and Stewart, (2000), Wageman, (1995)].

Tranfield and Smith [Tranfield, and Smith, (2002)] examined, in depth, the form of team working which take in a number of teamworking organizations across the study to ascertain their similarities and differences.

The performance in team–based working also largely depends on the employee's authorities and function design [Doorewaard, Huys, and Van Hootegem, (2002)]; i.e. to which extent the planning, performing and controlling responsibilities integrated in the team tasks.

Delarue, Gryp & Van Hootegem [Delarue, Gryp, and Van Hootegem, (2003)] investigated the impact of specific structure team types on the performance of the organization, measured by labour productivity.

> When a new project starts, one of the most difficult tasks is to choose the most suitable members of the work team. The most relevant factors may be grouped into three categories: I) Individual characteristics; П) Social characteristics; Ш) Temporal and economic costs [Moreno, Valls, and Marin, (2004)].

Advances in information technology have enabled new organizational forms and new ways to structuring work.

In the age of the knowledge economy, most tasks accomplished as part of one's job require some forms of communications [Watson–Manheim, and Belanger, (2002)].

For long, researchers have investigated organizational communications, both formal and informal. Yet, we still need to understand better how communication based tasks can be better supported to lead to efficiencies in an environment where individuals are distributed. Regardless of specific type of work environment, individuals must manage multiple relationships to work productively [Watson–Manheim, and Belanger, (2002)].

Team can enable a company to execute more quickly changes, are made easily, allowing the company flexibility [Mohrman, Cohen, and Mohrman, (1995)].

Each member of a group adds more information, perspective, experience and competencies [Gmelch, (1984)].

Even organizations that are better served by a team model find disadvantages. These include an increase in time to communicate, poor communication between members and groups, poor coordination between group members and competing objectives [West, Borrill, and Unsworth, (1998)].

This paper is organized as follows, we explain the assumptions of the proposed model in section 2. Section three introduces the parameters, used in the model. Section four presents a model that can be used to determine the value of teamwork performance versus information technology and team size factors. Section five includes a sensitivity analysis to the model, based on information technology, and Section six summarizes the contribution of the paper.

2. The model assumptions

Although the model can be used for any team structure (with any division), in our proposed model we assume, there is a particular assembly line (Figure 1). Also it's assumed, teamwork size is n and divided in 4 parts: I) Assembly Line 1; with $\left(\frac{n-1}{3}\right)$ members (Group 1), П) Assembly Line 2, 3; each one with $\left(\frac{n-1}{3}\right)$ members (Group 2) and Ш) One supervisor for all above assembly lines' members.

Each assembly line has full information interaction between members separately and all members have information interaction with supervisor.

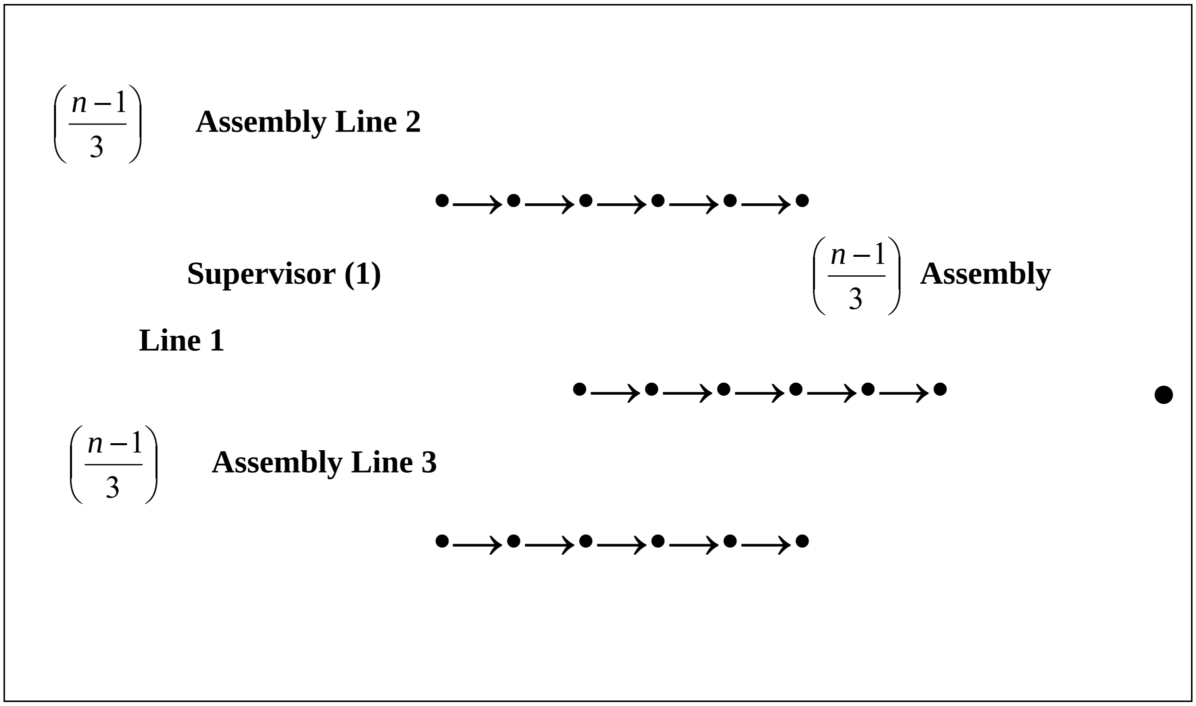

Figure 1 : An Assembly Line With star Structure

General assumptions

- An individual divides his/her time between production and information processing.
- If one unit is exclusively devoted to production, exactly one unit of output is generated.
- For each unit of output, there is also a unit of information generated.
- Each individual has to process all information received from the other team members in order to coordinate the team task.
- It takes less than one time unit to process one unit of information.

3. Parameters used in the considered model

n : The number of team members. Also, $n \geq 4$ and *(n–1)* is multiplier of *3*.

α : The fraction of a time unit it takes to process a unit of information provided by other team members about their production. Also, $0 < \alpha < 1$.

$\Omega(n)$: The fraction of time an individual can spend on production after processing the information received from the other members.

$P(n)$: Output of team (Quantity of production).

a. The model

It is assumed that all received information must be processed, so the processing of information during one time period can be computed as follows:

(I) For each assembly line:

$$\alpha\Omega_1(n)\left(\frac{n-1}{3}\right) \text{ units of each individual's time} \tag{1}$$

(Π) For supervisor:

$\alpha\Omega_2(n)(n-1)$ unit of individual's time

(2)

The remaining fraction of the time period which can be spent on production, is given by:
For each assembly line:

$$\Omega_1(n) = 1 - \alpha\Omega_1(n)\left(\frac{n-1}{3}\right) \quad (3)$$

$$\Omega_1(n) = \frac{1}{1+\alpha\left(\frac{n-1}{3}\right)} \quad (4)$$

For supervisor:

$$\Omega_2(n) = 1 - \alpha\Omega_2(n)(n-1) \quad (5)$$

$$\Omega_2(n) = \frac{1}{1+\alpha(n-1)} \quad (6)$$

So equations (1) and (2) are equilibrium conditions on information generation and information processing. As the size of team increases, each individual will spend a larger proportion of his/her time processing information provided by other team members and, hence, the time left for production is reduced. In practical terms, this implies that as the team size grows, the individual team members get saturated with information and productivity drops [Hilz, and Turoff, (1985)]. (7)

The total production of the team during one time period is the n:

$$\mathrm{P}(n) = \frac{n-1}{1+\alpha\left(\frac{n-1}{3}\right)} + \frac{1}{1+\alpha(n-1)} \quad (8)$$

Theorem 1: $P(n)$ is a concave, monotonically increasing function of n for all value $0<\alpha<1$ and $n \geq 4$

Proof:

$$\frac{dP(n)}{dn} = \frac{1+\frac{\alpha}{3}(n-1)-\frac{\alpha}{3}(n-1)}{\left[1+\alpha\left(\frac{n-1}{3}\right)\right]^2} + \frac{-\alpha}{[1+\alpha(n-1)]^2} \quad (9)$$

$$= \frac{1}{\left[1+\alpha\left(\frac{n-1}{3}\right)\right]^2} - \frac{\alpha}{[1+\alpha(n-1)]^2} > 0 \quad , \quad 0<\alpha<1 \quad (10)$$

$$\frac{d^2P(n)}{dn^2} = \frac{\frac{-\alpha}{3}}{\left[1+\alpha\left(\frac{n-1}{3}\right)\right]^3} + \frac{2\alpha^2}{\left[1+\alpha(n-1)\right]^3} < 0 \qquad , \qquad 0<\alpha<1 \quad \text{and} \quad n \geq 4 \tag{11}$$

Hence, $P(n)$ is a concave, monotonically increasing function in n.

Theorem 1 indicates that team output can be increased by adding members to the team. However, the marginal product of team members is decreasing due to the increased coordination effort required so that for each added team member, there is a smaller and smaller increase in output.

Beyond some value of *n*, the marginal cost of an additional team member exceeds the marginal value of the team's production.

Theorem 2: For any non zero α , $P(n)$ is a bounded function.

Proof: From theorem 1, $P(n)$ is a concave and monotonically increasing function of n. Also, $P(0) = 0$.

$$\lim_{n\to\infty} P(n) = \lim_{n\to\infty} \frac{n-\mathbf{1}}{\mathbf{1}+\alpha\left(\frac{n-\mathbf{1}}{\mathbf{3}}\right)} + \frac{\mathbf{1}}{\mathbf{1}+\alpha(n-\mathbf{1})} = \frac{\mathbf{3}}{\alpha} \tag{12}$$

Hence, $P(n)$ is a bounded function.

The practical implication of Theorem 2 is that the maximum total production of a team during one time period depends on the speed at which the team members can coordinate their activities with their peers.

To increase the team's maximum production capacity, it is necessary to change the communication and processing technology (i.e. decrease the value of α) or, the work has to be reorganized so that each team member does not process all of the information provided by the other members.

Theorem 3: The marginal product of team size is asymptotically zero.

Proof:

$$\lim_{n\to\infty} \frac{dP(n)}{dn} = \lim_{n\to\infty} \frac{\mathbf{1}}{\left[\mathbf{1}+\alpha\left(\frac{n-\mathbf{1}}{\mathbf{3}}\right)\right]^2} - \frac{\alpha}{\left[\mathbf{1}+\alpha(n-\mathbf{1})\right]^2} = \mathbf{0} \tag{13}$$

Theorem 1 shows that the marginal product of team size is decreasing and theorem 3 states that the marginal product of team size is asymptotically zero. These two facts imply that for a one–period production effort, there is a single optimal team size if the cost per team member is positive and marginally non–decreasing. This condition is equivalent to the well–known profit maximum condition that marginal cost equals marginal revenue in economic theory.

b. Sensitivity Analysis:

In the following the effect of changing information technology on team output is studied. An improvement in information technology implies that the time it takes to communicate and process a unit of information is reduced. Thus, as information technology improves the parameter α decreases.

Although information technology improvements are likely to occur in discrete increments, it is useful to study the first order derivative of the total team output.

Theorem 4: $P(n,\alpha)$ is monotonically decreasing function of α for all values of $0<\alpha<1$.

Proof:

$$0<\alpha<1\ ,\quad \frac{\partial P(n,\alpha)}{\partial\alpha}=\frac{-(n-\mathbf{1})^2}{\mathbf{3}\left[\mathbf{1}+\alpha\left(\frac{n-\mathbf{1}}{\mathbf{3}}\right)\right]^2}+\frac{-(n-\mathbf{1})}{[\mathbf{1}+\alpha(n-\mathbf{1})]^2}<\mathbf{0} \qquad (14)$$

Hence, $P(n,\alpha)$ is monotonically decreasing in α.

Thus, as information technology improves (α is reduced), team output increases. This result is consistent with expectation since less time spent on information processing implies more time spent on production.

Similarly, as information technology improves, so does the maximum output of the team. Let Δ be the reduction in processing time of one unit of information so that $\alpha'=\alpha(1-\Delta)$. Then, the increase in maximum team output is:

$$\frac{3}{\alpha'}-\frac{3}{\alpha}=\frac{3}{\alpha(1-\Delta)}-\frac{3}{\alpha}=\frac{\Delta}{1-\Delta}\frac{3}{\alpha} \qquad (15)$$

In marginal terms, there is a trade–off between adding manpower to a team and improving the information technology support to the team.

The following example will illustrate the concept. Consider a team with 22 members and information technology which allow team members to process information at a rate of 22 units per time period (i.e. $\alpha=0.05$). According to (8) the output of this team is 16.o5 per time period. If the team size is increased to 28 members it's output will be 19.05.

The same output per time period can be achieved by information technology improvement with rate of information technology processing (i.e. $\alpha=0.02$).

If the cost of 6 new team members is higher than the cost of upgrading the information technology, then an information technology upgrade is the best decision. If there is a number of technology improvement options, there may be a mix of technology improvement and team size increase that will yield the most cost efficient solution to increase team output.

Similarly, if demand for the organization output is fixed, the organization can achieve a productivity increase by investing in improved communication and processing technology and reduce the number of team members. If technology investments change the information processing rate (i.e. $\alpha=0.02$), In this Example, the team size can be reduced to 22 members without reducing production. Thus, by investing in communication and information processing technology, labor cost can be reduced by 21.5% considering the significant price reduction trends in communication and information processing technology, this explains the substantial reduction in team size, often referred to as corporate downsizing, taken in modern post–industrial economies.

1. Conclusions:

In this paper, a model has been presented that can be used to determine the value of teamwork performance versus information technology and team size.

According to this model, team output can be increased by adding members to the team. But beyond some value of team size, the marginal cost of an additional team member exceeds the marginal value of team's production. Also to increase the team's maximum production capacity, it is necessary to change the communication and processing technology.

If the cost per team member is positive and marginally non decreasing, there is a single optimal team size.

If there is a number of technology improvement options, there may be a mix of technology improvement and team size increase that will yield the most cost efficient solution to increase team output.

5. References:

[1] Benders, J. & Van Hootegem, G., (1999), T*eams and their content: moving the team discussion beyond existing dichotomies*, Journal of Management Studies, 26, 5, pp. 609–628.

[2] Cohen, S.G. & Bailey, D.E., (1997), *What makes team work? Group effectiveness research from the shop floor to the executive suite*, Journal of Management, 23, pp. 13–43.

[3] Cohen, S.G. & Ledford, G.E., (1994), *The effectiveness of self–managing teams: A quasi–experiment*, Human Relations, 47, 1, pp. 13–43.

[4] Delarue, A.; Gryp, S. & Van Hootegem, G., (2003), *Productive outcomes of teamwork as an effect of team structure*, Working Paper (in progress) Steunpunt 00I

[5] Doorewaard, H.; Huys, R. & Van Hootegem, G., (2002), *Team responsibility structure and team performance*, Personnel Review, 31(3), pp. 356–370.

[6] Glassop, L.I., (2002), *The organizational benefits of teams, Human Relations*, 55(2), pp. 225–249.

[7] Gmelch, W.H., (1984), *Productivity Teams: Beyond Quality Circles*, Toronto, Canada, John Wiley & Son, Inc.

[8] Gupta, Y.P. & Asf, D., (1994), *Excellence at Rohm and Haas Kentucky: A case study of work team introduction in manufacturing*, Production and Operation Management, 3(3), pp. 186–200.

[9] Hackman, J.R., (1987), *The design of work teams*, in J.W. Lorsch(ed.), Handbook of organizational behavior, pp. 315–452, Prentice–Hall, Englewood Cliffs.

[10] Hilz, S.R. & M. Turoff, (1985), *Structuring Computer–Mediated Communication Systems to Avoid Information Overload*, Communication of the ACM 28(7), 680–689.

[11] Katzenbach, J.R. & Smith, D.K., (1993), *The wisdom of teams: Creating the high performance organizations*, Harper Collins, New York.

[12] Manz, C.C. & Sims, H.P., (1987), *Leading workers to lead themselves: The external Leadership of self–managing work teams*, Administrative Science Quarterly, 32, pp. 106–128.

[13] Mary Beth Watson–Manheim & France Belanger, (2002), *Exploring Communication–Based Work Processes in Virtual Work Environment*, Proceeding of the 35th Annual Hawaii International Conference on System Science (HICSS–3502).

[14] Mohrman, S.A., Cohen, S.G. & Mohrman, Jr., A.M., (1995), *Designing team–based organizations: New forms for knowledge work*, San Francisco, CA: Jossey–Bass.

[15] Moreno, A., Valls, A. & Marin, M., (2004), *Multi–agent simulation of work teams*, Computer Science & Mathematics Departments, University Rovira i virgili ETSE.

[16] Murray, R.B. & Stewart, G.L., (2000), *Team structure and performance: Assessing the mediating role of intrateam process and the moderating role of task type*, Academy of Management Journal, 2000, 43(2), 135–148.

[17] Neck, C, Connerly, M. Zuniga, C. & Goel, S., (1999), *Family Therapy Meet Self Managing Teams: Explaining Self–Managing Team Performance Through Team Member Perceptions*, The Journal of Applied Behavioral Science, 35, 2, pp. 245–259.

[18] Tranfield, D. & Smith, S., (2002), *Organization designs for teamworking*, International Journal of Operations & Production Management, 22, 5, pp. 471–491.

[19] Wageman, R., (1995), *Interdependence and group effectiveness*, Administrative Science Quarterly, 40, pp. 145–180.

[20] West, M.A., Borrill, C.S. & Unsworth, K.L., (1998), *Team effectiveness in organizations*. Sheffield, England.