An Exploratory Study on the Intra-Organizational Network during Restructuring: An Email Network Analysis

Antonio Lau[1], Hisato Tashiro[2], Yuya Kajikawa[2]
[1] School of Management, Kyung Hee University, Seoul - Korea
[2] Innovation Policy Research Center, Institute of Engineering Innovation,
Graduate School of Engineering, the University of Tokyo, Tokyo - Japan

Abstract--**Organizational restructuring is a disruptive process that damages the communication patterns of surviving employees, in which the organizational networks could significantly affect a company performance, in particular its total quality management (TQM) performance. However, existing studies on how the employees of a TQM organization cope with lost communication linkages, and form new linkages are unclear. The study is designed to test the relationships of multiple network attributes of employees before and after the organizational restructuring due to the 2008 global financial crisis between 2008 (T1), 2009 (T2), and 2010 (T3). It utilized internal company e-mail log data to detect the network attributes of over 2,468 employees in a major TQM manufacturer through PLS analysis. The results show that during the organizational restructuring, the employee's closeness decreased, but the degree and the betweenness recovered. The degree in 2008 is positively related to that in 2009-2010 as well as and the closeness in year 2010. The betweenness in 2008 is positively related to that in 2010. The closeness in 2008 is positively related to that in 2009. The paper explores how an organizational internal network changes during the organizational restructuring through a set of longitudinal data using social network analysis.**

I. INTRODUCTION

Companies have to continually adapt in order to sustain competitiveness under economic, social, and environmental uncertainties. The Center for Research on the Epidemiology of Disasters reported 364 natural and 188 technical disasters in 2012 worldwide, leading to the deaths of 9,656 people and US$ 157,570 million worth of economic damage. In addition, the 2008 global financial crisis has had a harmful and long-term effect on global business, reducing potential production outputs between 1.5% and 2.4% on average across OECD countries, mainly due to declining capital and potential employment opportunities [23]. The credit conditions and international trade were also constrained by companies [17], leading to the companies' disinvestment of international businesses [3]. Companies with financial constraints spent less on technology development, employment, and capital investment during the period [14]. Such crises pose threats to the sustainability of an organization's operations, and the organization's survival depends greatly upon their resiliency in the face of these threats [7, 11].

Many organizations restructured to cope with the financial crisis. For example, there were over 240,000 jobs lost across all sectors of the US economy since 2008 [21]. Organizational restructuring is a disruptive process that damages the communication patterns, perceptions, and attitudes of surviving employees, where changes to the organizational social networks could significantly affect company performance [44, 45] due to the human and social capital losses [43]. In total quality management (TQM) organizations, changes to an employee's social and communication networks could be particularly damaging because TQM organizations depend on the employees' positive attitude toward both their communication relationships, and the quality of information received from top management. A strong and consistent intra-organizational communication network develops these positive attitudes [4]. The open, trusted, and long-term intra-organizational networks are important for open communication, knowledge sharing, employee empowerment, and committed leadership, leading to better performance [40, 38]. However, the impact of the financial crisis on organizational network changes in a TQM firm is unknown.

Applying social capital theory, some literature shows that employee turnover reduces human capital accumulation and creates problems in maintaining organizational controls, leading to poor production performance [43]. It also decreases the social capital at the organizational level, impeding instrumental action among employees, and reducing information flow, resource exchange, and internal knowledge shared freely and efficiently throughout the employees' communication networks [19, 48]. Social capital is a valuable asset stemming from resource accessibility through social relationships [25, 26], constituting cognitive, structural, and relational elements [32, 36]. The cognitive element of social capital refers to the assets that provide employees with shared representations, interpretations, and systems of meaning in an organization. The structural element involves social interactions and communications due to the centrality, diversity, and configuration of employees in the organizational structure. The relational element refers to the assets embedded in the relationships based on trust, obligation, and reciprocity [48, 25]. In this study, we focus on the relational element of social capital measured by the employees' email communication, as we believe that one of the most destructive effects of an organizational restructuring is the loss of the employees' social and communicative relationships [20].

From the social network perspective, some intra-organizational linkages such as bridging linkages (i.e. betweenness centrality) are more critical than the absolute size of employees' networks (network density) [12]. Structural bridges improve the efficiency and effectiveness of communication flow and information exchange by reducing

information overload and redundancy [13]. Employee downsizing or turnover among employees who occupy key organizational network positions should be more damaging to organizational performance [43, 20]. This study examines different types of important network attributes, including density, closure, and betweenness centralities [8, 12, 19], since these have different impacts on company performance.

In addition to the loss of social capital due to employee turnover, the survivors of the organizational restructuring have to deal with many changes in their work environment, including the loss of ties to information sources, power, and influence in the intra-organizational network [44]. Changes in network relationships influence the survivors' organizational commitment, role ambiguity, perceptions of uncertainty and openness to change, and friendship and advice networks [42, 9, 10]. The loss of the survivors' network negatively affects the work environment and performance. As the network changes, employees in the network may rely on their transactive memory to help them acquire information sources in the changed environment [29, 52]. After an organizational restructuring, the organizational network changes as some employees are dismissed and the survivors make changes to the new environment, reconfiguring communication and interaction networks to contain the loss and/or addition of communication linkages [42, 45], eventually leading to a reconfigured network [44]. Thus, it is important to identify how the organization can recover from the loss of social network structures. However, the manner in which the employees of a TQM organization cope with lost communication linkages and form new ones is underexplored in existing studies.

Therefore, the paper explores the changes to an organization's internal network during an organizational restructuring using social network analysis. This study explores the question: How does the intra-organizational network change of a TQM company during an organizational restructuring? This study was designed to test the relationships of multiple network attributes of employees before and after the organizational restructuring due to the 2008 financial crisis between 2008 (T1), 2009 (T2), and 2010 (T3), using a TQM company's internal e-mail log data to detect the network attributes of over 2,468 employees in a major TQM manufacturer.

By exploring the organizational network changes, this study aims to improve our understanding of intra-organizational network dynamics, as we explore the evolution of intra-organizational network structures [1, 29, 39, 51], during the crisis that could affect the employee's psychological safety [41]. For example, as the bridging (i.e. betweenness centrality) and closure (i.e. closeness centrality) roles of employees can significantly affect company performance [6], it is interesting to know if and how these roles can be recovered after an organizational restructuring. It helps scholars to forecast and recognize the changes in the distribution of advantages and disadvantages from the network, and the network sustainability [1]. To study the dynamics of the organizational network, we collected objective data from the three time periods, which also help examine the causal relationships during network changes. In the next section, we explain the methodology used in this work.

II. METHOD

The study is designed to test the relationships of multiple network attributes of employees before and after the organizational restructuring due to the financial crisis between 2008 (T1), 2009 (T2), and 2010 (T3). A network is a viewpoint to model community structure with nodes and links among nodes. By applying the network view, we can analyze invisible community structure in an organization in a clear and visible form. Multiple objective data were used to measure the network attributes and control variables. It utilized company internal e-mail log data to detect the network attributes in a major manufacturing firm. Objective data (e.g. gender, year of services) was also used to measure the control variables.

A. Participants and E-mail network analysis

The study constructed e-mail networks from e-mail log data. The data were collected from a global Japanese manufacturer. The company has over 2,000 formal employees with annual sales over US$ 2,000 million across the Americas, Europe, Asia, and Australia. The company has implemented TQM practices for over 15 years. To sample the e-mail network data, this study collected three sets of e-mail logs for the entire company for the months of September 2008, June 2009, and September 2010. The employees' characteristics are shown in Table 1.

TABLE 1 PARTICIPANTS' PROFILE

	Freq.	***Valid percent (%)***
Gender		
Male	1914	90.3
Female	205	9.7
Recruiting		
Graduate	1434	69.8
Mid-Career	621	30.2
Academic record		
Junior high or below	4	0.2
High School	504	24.7
Technical School or junior college	221	10.8
University Bachelor		
University Postgraduate	1139	55.7
	176	8.6
	Mean	***S.D.***
Age	43.5	8.9
Years of Service	18.5	10.0

The email network analysis extracted the information about the sender and receiver from each e-mail. Senders and receivers are users, corresponding to a node in the network. If there was at least one e-mail communication between users, an edge was drawn between these users. We collected the e-mail data of all employees for all departments in the company whose total number of emails is over than 4,000 during each measured time period, though it does not imply that all of

them used e-mail with the other employee. The employees included in our data represent all levels of the organization, including executives, managers, and workers in factories. This study obtained the e-mail network as a sum of the nodes and edges. Since a sender was distinguished from a receiver, an e-mail network was expressed as a directed graph. Given the network, the study found a maximal complete sub-graph, a clique that became the target of the following network analysis. Overall, the number of nodes, or senders and receivers of e-mails, was 2,882 in 2008, 2,459 in 2009, and 2,468 in 2010. Network attributes were calculated for all employees included in the maximal complete sub-graph. In order to create panel data and enable a comparison between different periods, data existing in both periods were used for a statistical test of the communication network change in the organization.

After extracting the e-mail network among employees, we characterized each node with multiple network centralities, including degree centrality (DC), closeness centrality (CC), betweenness centrality (BC), and clustering centrality (CL). DC is the number of links received and sent of a node. When an employee has many colleagues exchanging e-mails, the DC is high. CC is defined as the average distance from a given node to all other nodes, and therefore an employee with high CC is at the central position in the whole network. BC is the number of node pairs passing through a node. An employee with high BC locates at a position in the network bridging different communities, for example, different departments in the company. CL represents the local density of a link around a node. An employee with high CL has intense communication in a tightly knit local group in the network.

This study used only e-mails that had an internal origin and destination within the firm for the e-mail network analysis, as the focus is on how an employee communicates with others within the company. Internal e-mails should be used as they directly reflect the internal communication pattern of each member within the company. In this way, not only could the study accurately measure centralities, it also avoided junk e-mail and bias toward managers with external-oriented tasks, such as marketing and sales.

B. Control variables

This study used 5 control variables, i.e., age, gender, recruiting, academic status, and year of service. Employee age was controlled as the social relationship of an employee might be affected by their seniority in the company. Gender was controlled. Type of recruitment was also controlled, which indicated whether the employees joined the company as a fresh graduate from educational institutes. We graded a fresh graduate as 1, and a mid-career hire as 2. We also graded academic status on the following scale: junior high school as 1, high school as 2, technical school and junior college as 3, bachelor as 4, and master and doctor as 5. Academic background affects communication skills, and therefore, the educational background of the employee might affect their relationship building and recovery. Finally, the number of years the candidate worked for the company was controlled. With more experience in the company, they could obtain a better understanding of the people and culture of the company.

C. Evaluation

We investigated the relationship of network attributes in different periods using Partial Least Squares (PLS) structural equation modeling. We also verified the explored relationships through interviews with the company employees.

PLS is widely used in the information systems and technology management literature [46, 33, 35, 2]. It is a second-generation multivariate technique that can assess and estimate both measurement and structural models at once, an alternative to covariance-based methods, for example, LISREL [50, 30, 54]. PLS modeling analysis as a variance-based analysis avoids the limitations of covariance-based analysis, such as parametric assumption, the large sample size requirement, model complexity, identification of reflective and formative variables, and factor indeterminacy [27, 16]. PLS predictive modeling uses the variance in the items to predict the relationships among the latent variables. The relationships between the latent variables that are single-item measures are similar to the least squares regression [15, 16, 5, 54]. PLS is particularly useful for exploratory studies without prior extensive theoretical supports. Its estimation is highly robust in different situations, such as high model complexity, correlated independent variables, small sample size, non-normal data source and so on [15, 31]. However, compared with covariance-based analysis, PLS parameter estimates are less than optimal for bias and consistency and require a re-sampling procedure for significance tests. Taking into account the novel topic under study, and the new data sources used with a small sample size available, the adoption of PLS is justified. In PLS modeling, SmartPLS 2.0 was used to estimate the network attribute relationships in the three periods. In this analysis, all of the measures are objective and single-item measures, so we tested the structural model directly [15].

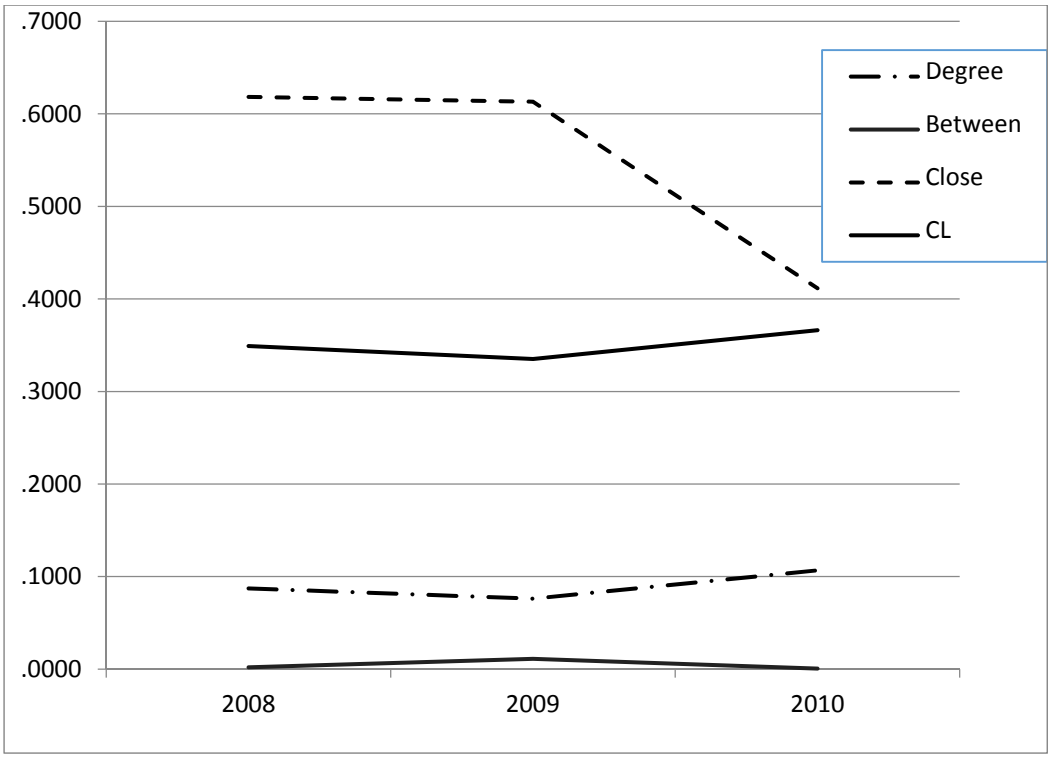
III. RESULTS

Table 2 shows the mean, standard deviation, and correlations between network attributes. As discussed previously, the network attributes were highly correlated as they were calculated with similar equations (see above) using the same data source. The adoption of PLS had an advantage in this situation as it was highly robust, even if the correlations among network attributes were high [31]. Furthermore, the correlations show that the employee's communication channel in terms of DC was quite stable during the organizational restructuring ($r = 0.691$-0.763), as was CL ($r = 0.609$-0.612). However, the employee's BC from T1 to T2 was very unstable ($r = 0.145$) and but recovered in T3 ($r = 0.948$). Similarity, the employee's CC was not stable ($r = 0.017$-0.350). Fig. 1 shows the trends of the mean values of the four network attributes across the three periods.

TABLE 2 MEAN, STANDARD DEVIATIONS AND CORRELATIONS OF NETWORK ATTRIBUTES

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12
1. T1 Degree	501.822	527.993	1											
2. T2 Degree	477.543	522.321	0.763	1										
3. T3 Degree	573.080	566.364	0.691	0.772	1									
4. T1 Betweenness	0.001	0.006	0.132	0.038	0.128	1								
5. T2 Betweenness	0.001	0.002	0.291	0.340	0.242	0.145	1							
6. T3 Betweenness	0.000	0.014	0.058	0.001	0.112	0.948	0.012	1						
7. T1 Closeness	2.529	0.287	-0.301	-0.245	-0.222	-0.128	-0.185	-0.079	1					
8. T2 Closeness	2.692	0.342	-0.321	-0.299	-0.358	-0.065	-0.263	-0.034	0.350	1				
9. T3 Closeness	2.037	0.124	0.185	0.087	-0.022	-0.155	0.012	-0.174	0.017	-0.027	1			
10. T1 CL	0.349	0.170	-0.333	-0.273	-0.237	-0.108	-0.229	-0.051	0.370	0.342	-0.090	1		
11. T2 CL	0.335	0.175	-0.267	-0.260	-0.249	-0.074	-0.269	-0.032	0.283	0.431	-0.036	0.609	1	
12. T3 CL	0.366	0.157	-0.364	-0.347	-0.408	-0.105	-0.261	-0.061	0.369	0.555	0.007	0.612	0.675	1

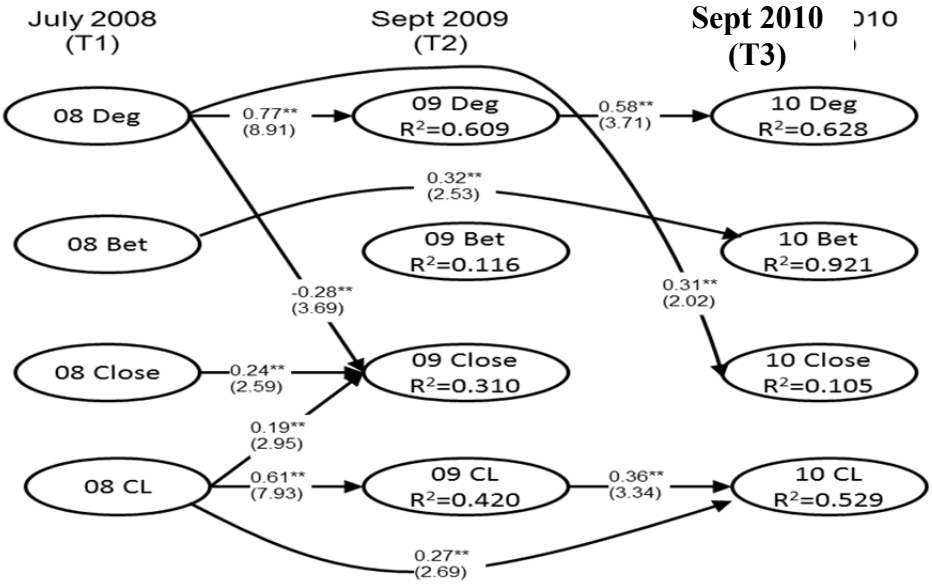
Note: Deg: Degree Centrality, Close: Closeness Centrality, Bet: Betweenness Centrality, CL: Clustering Centrality.
T1= year July 2008, T2= July 2009, T3= Sept 2010. Correlations above 0.17 or less than -0.036 are significant at p-value < 0.01.



Note: For comparison, the normalized mean value for each network attribute is shown.

Fig. 1 The trend of an employee's network attributes during 2008-2010

Fig. 1 shows that, descriptively, the mean value of an employee's CC was unstable and dropped heavily after the organizational restructuring. While the employee's BC value was also not stable, it could be recovered quickly. However, with correlations, it is difficult to determine how prior network attributes relate to subsequent network attributes during the organizational restructuring. To address this, we used a PLS model.



Deg: Degree Centrality, Close: Closeness Centrality, Bet: Betweenness Centrality, CL: Clustering Centrality.
The path coefficients represented the mean of the re-samples and the t-statistics in parentheses were generated from a bootstrap resample of 500 (casewise deletion). For clarity, the insignificant relationships (including control variables) are not shown.

Fig. 2 Results of PLS modeling

Fig. 2 shows the PLS results. The variance of subsequent network attributes in T2 was explained by R^2 = 0.116 - 0.609, and in T3 was explained by R^2 = 0.105 – 0.921. To determine the contribution of the addition of independent variables (i.e. network measures) into the model, the effect size was calculated [15]. It was assessed by inputting the R^2 of the models with and without the independent variables using [18]'s effect size formula:

Effect size in Degree (T3) = [0.6286-0.0263] / [1-0.6286] = 1.6217.

Effect size in Betweenness (T3) = [0.9212-0.0061] / [1-0.9212] = 11.6129.

Effect size in Closeness (T3) = [0.1049-0.0153] / [1-0.1049] = 0.1001.

Effect size in CL (T3) = [0.5295-0.0533] / [1-0.5295] = 1.0121.

The values of 0.02, 0.15, or 0.35 indicated weak, moderate, or large effects of the variables in the model, respectively. Our model had an effect size between 0.100 and 11.612, suggesting that there is a sufficient explanatory power in the study.

Furthermore, while PLS path modeling does not provide a global validation of the overall model fit [16, 5], recent literature suggests a global criterion of goodness of fit (GoF) and Stone-Geisser Q^2 [47]. GoF is the geometric mean of the average communality and the average R^2 of endogenous variables that serves as a diagnostic function and takes values between 0 and 1. Stone-Geisser Q^2 using the blindfolding cross-validation method in SmartPLS was used to assess the PLS model's predictive relevance [47]. The Stone-Geisser Q^2 suggests that that PLS model must provide a certain predication of the endogenous latent variable (i.e. four network attributes in T3) [16]. If the cross-validated redundancy value of the latent variable is larger than zero, its explanatory variables provide predictive relevance. In this model, the value of GoF is 0.55, which is acceptable for a model with a moderate effect size [53]. The cross-validated redundancy value of each endogenous variable (i.e. Degree (T3) = 0.63, Betweenness (T3) = 0.92, Closeness = 0.11 and CL = 0.52) is larger than zero, suggesting that the model has certain predictive relevance [54].

A bootstrapping approach was used to estimate the significance of the path coefficients. A random sample of 200, 500 and 1000 observations were generated from the original dataset to estimate the parameter means and standard errors for calculating the significance of the coefficients and assessing the stability of the significance [16].

Fig. 2 provides the path coefficients and their significances for the relationship between network attributes and management performance. The path coefficients represented the mean of the re-samples and the t-statistics in parentheses were generated from a bootstrap resample of 500. The significances of the path coefficients of the re-sample of 500 were consistent with that of the resample of 200 and 1000.

The PLS model showed that some of employee's prior communication network attributes in terms of DC [i.e. Degree (T1→T2): b=0.77, p-value<0.05, Degree (T2→T3): b=0.58, p-value<0.05] and CL [i.e. CL (T1→T2): b=0.61, p-value<0.05, CL (T2→T3): b=0.36, p-value<0.05] were sustained constantly during the entire organizational restructuring. Employees with better CL in T1 also helped sustain their CC in T2 [i.e. CL (T1)→Closeness (T2): b=0.19, p-value<0.05]. Employees' CC could only be maintained to T2 [i.e. Closeness (T1→T2): b=0.24, p-value<0.05].

Furthermore, employees with a higher DC in T1 had a negative impact on their CC in T2 [i.e. Degree (T1)→Closeness (T2): b=-0.28, p-value<0.05], but helped recover this in T3 [i.e. Degree (T1)→Closeness (T3): b= 0.31, p-value<0.05]. Employees with better BC in T1 were able to recover their BC in T3 after the restructuring [i.e. Betweenness (T1)→Betweenness (T3): b=0.32, p-value<0.05].

IV. DISCUSSION

In this paper, we analyzed the network dynamics of a TQM manufacturing company during an organizational restructuring period. Multiple objective data were used to measure the network attributes with control variables. It utilized internal company e-mail log data to detect the network attributes for over 2,468 employees in a world-class TQM manufacturer. The relationships were analyzed using a PLS model. The results show that during the organizational restructuring, the employee's CC decreased, but the DC and BC recovered. The DC in 2008 is positively related to that in 2009-2010, and the CC in year 2010. The BC in 2008 is positively related to that in 2010. The CC in 2008 is positively related to that in 2009.

The bridging role of the employee's network is important as it allows employees to access diverse information and resources from non-redundant network actors and broker new information and resources between unconnected actors [12, 26], as well as creating opportunities to find new combinations and variations within the information [37]. The employees who develop knowledge catalysts in bridging positions will have the greatest influence on the diffusion of knowledge [28]. This study shows that this type of bridging role can be resilient after the organizational restructuring and the employees who previously held the bridging role could sustain this afterward.

This study also explored the density, DC, and closure, CC, roles of the employee's network. The CC and DC are critical, as close and dense interactions among the employees can reduce employees' opportunistic behaviors [19]. It generates reputational and self-enforcing governance mechanisms that encourage conformity of common goals and norms [49]. It removes the barriers to cooperation and communications, and creates a safer environment for knowledge exchange and acquisition [24]. This study shows that while the employee's density can be recovered after organizational restructuring,

the employee's closure cannot be recovered. However, a prior dense communication network can improve an employee's closure. We also found that an employee with intense communication in a tightly knit local group in the network can recover closure effectively after organizational restructuring. Generally, these results support the proposition that a prior network structure can affect a future network structure generated by an organizational restructuring triggered by a global financial crisis. Closure may be difficult to recover, as it takes time to build intense relationships among employees. Alternatively, while close and dense networks facilitate the sharing of highly contextual and complex information [34, 49], the organizational restructuring does reduce highly redundant communication linkages, overcoming information overload and improving network efficiency [12].

A company is as good as its people, who create the communities within the organization [46]. Each community has employees, and their effectiveness in business operations greatly depends on the employees' abilities. One of the biggest challenges for a global manufacturing organization today is to develop a capable intra-organizational network that balances different roles and dynamics of social network attributes for sustainable competitive advantage. Our study explores the dynamics of intra-organizational networks of an organization, and expects that this will lead to further studies.

V. CONCLUSION

In this paper, we analyzed the network dynamics of a TQM manufacturing company during an organizational restructuring period. Multiple objective data were used to measure the network attributes with control variables. It utilized internal company e-mail log data to detect the network attributes for over 2,468 employees in a major TQM manufacturer. The relationships were analyzed using a PLS model. The results show that during the organizational restructuring, the employee's CL decreased, but the DC and BC recovered. The DC in 2008 is positively related to that in 2009-2010, and also to the CC in 2010. The BC in 2008 is positively related to that in 2010. The CC in 2008 is positively related to that in 2009. Further research will be conducted to examine how the changes in the intra-organizational network affects employee performance, and how the structural dimensions of social capital (e.g. formal position of the employees in the organization) affects the communication networks.

This study has a number of limitations for future research. First, to analyze a full set of objective data, we limited the scope of our analysis to a network of e-mail communication, which did not include factors such as face-to-face communication, private email exchanges, and friendship. Thus, we focused on the formal working relationship of the employees. Second, the weight of communication was not considered, so the network was regarded as non-weighted. However, there is no definite reason to say that the number of emails affects the weight in the communication networks. If data confidentiality can be assured, further research using email content should be conducted. Third, in order to obtain detailed longitudinal data from successful TQM organizations during organizational restructuring in the year 2008, this study elected to collect data from a single firm. While it may limit its statistical generalizability, the study results are useful for similar TQM companies. The single case study approach also allows this study to provide detailed empirical evidence to the areas under consideration [22]. To improve the generalizability, network data from more organizations is required. Finally, other demographic and organizational variables, such as the characteristics of the business unit, were not included in our analysis. These issues are open for future research.

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