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The Role of Managers in R&D Organizational Networks. Are They Knowledge Workers or Bureaucrats?

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Abstract. *In today's competition-driven world, competitive advantage is the only way for an organization to survive. There are various ways to gain a competitive edge through the application of knowledge, technology, and science. Indonesian public research and development (R&D) faces numerous challenges, one of which is researchers' low productivity in terms of international journal publications. To boost research productivity and performance, efforts must be made to streamline knowledge flows within public R&D institutions. Additionally, data from dynamic information flows in networks can be used to evaluate bureaucratic effectiveness and identify potential knowledge talents or actors within R&D organizations. The purpose of this study is to determine the role of managers at all levels in a public R&D organization in coordinating information flow through knowledge networks and bureaucratic relationships. The social network analysis (SNA) technique was used to map managers' role in aligning knowledge flows in an Indonesian public R&D organization. Individuals were classified according to their type and centrality in the network, and network metrics such as "degree of centrality," "eigenvector centrality," and "clustering coefficient" were determined. It was found that the organization has some issues with knowledge flows and power distribution. The two distinct knowledge flow patterns, one for knowledge-seeking and the other for administrative knowledge, do not appear to be synchronized. The director of the R&D center is assumed to be less influential than the top manager in terms of knowledge and bureaucratic influence. At the managerial level, clique tendency is lower, while it is higher at the nonmanagerial level. Such centralization and cliques are dangerous because managing knowledge cannot be handled by a single person in a knowledge-intensive organization such as an R&D institution. Additionally, it was discovered that middle managers are critical for knowledge-seeking purposes, whereas administrative managers dominate the bureaucratic role. The research implications are dependent on deciphering the complexities of knowledge flows among employees and the variables that influence the knowledge-transfer process within an organization. This issue will exacerbate the problem by decreasing productivity and increasing reliance on a small number of people. Additional research is required to generalize the findings to other Indonesian R&D institutions.*

Keywords: *Bureaucracy, knowledge management, social network analysis*

1. Introduction

Organizations should pay attention to various types of knowledge, such as explicit, tacit, individual, organizational, and group knowledge, as affected by diverse organizational elements and networks (Nezafati, Afrazeh, & Jalali, 2009). A knowledge-intensive organization is responsible for creating, capturing, storing, modifying, transferring, sharing, and developing its valuable knowledge through a knowledge-management system. Efforts should be made to avoid diminishing the value of knowledge (Nonaka, 1994; Kaur, 2015).

In a knowledge-intensive R&D organization, the role of managing knowledge cannot be handled by one person. Formal and informal tasks, both in capturing external knowledge and disseminating it throughout the organization, should be conducted by different individuals (Whelan, Collings, & Donnellan, 2010). These tasks are crucial to ensuring the availability of a sufficient stock of knowledge to enable organizational competitiveness. Furthermore, Cross and Parker (2004) have stated that one crucial aspect of managing individual competency in an R&D organization is managing knowledge flow within the organization, something that is not limited to formal organizational structures.

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However, the main problem regarding managers' role in aligning personal knowledge in R&D organizations with managerial competencies is not yet clear. In the context of a knowledge network, a manager's specific individual role cannot be identified by a manager, so the R&D organization cannot fully exploit its resources to maximize innovative capabilities. In R&D organizations, knowledge-management processes are provided by at least three actors or team members; knowledge officers (top managers), knowledge engineers (middle managers), and knowledge practitioners (front-end employees) (Nonaka & Takeuchi, 1995). Compared to most public organizations, in public R&D organizations the managers play more significant bureaucratic and administrative roles. However, the middle manager's role in particular in a knowledge-intensive organization is imperative in determining knowledge-management strategies leading toward innovation (AL-Hakim & Hassan, 2011; Whelan *et al.*, 2010).

In the context of a public organization, data on dynamic information flow in its networks will also help in assessing the effectiveness of its bureaucracy and exploring the potential of knowledge workers or actors to improve R&D performance. Social network analysis (SNA) has important principles that outline the distance between individuals (seen as nodes or vertices), illustrating the strength or degree of closeness. In this study, an SNA approach provides and interprets patterns of social relations among actors. We assess the role of managers in two types of network—bureaucratic and knowledge-seeking—in facilitating the flow of knowledge in an organization. Degree of centrality, eigenvector centrality, and clustering coefficients are determined as the metrics that map the information flow in the organization. In contrast, the individuals in the respective networks are categorized as "central connectors," "boundary-spanners," "information brokers," and "peripheral players" respectively, as defined by Aydin (2018); Durland and Fredericks (2005); Hoppe and Reinelt (2010); Kassiri and Belouadha (2020); and Scott (2000). Considering the type and centrality of key knowledge workers in these networks, the results of the study are relevant for the future development of potential employees at their respective positions.

Therefore, the purpose of this study is to identify the role of managers at all levels in a public R&D organization in aligning information flows in knowledge networks and bureaucratic relationships.

2. The of Social Network Analysis in Managing Knowledge, A Literature Review

Knowledge is one of the essential resources in an organization. Vernardakis (2016) asserts that knowledge is the ability of an organization to comprehend the causal relations concerning facts and phenomena of its environment and assimilate changes to these causal relations. Company knowledge is built through experience and is hard to duplicate as long as it has no definitive source. At the same time, knowledge can stimulate a sustainable competitive advantage (Paraponaris, 2003; Kumar, Singh, & Haleem, 2014).

The terms "management" and "governance" refer to the process of attempting to manage a resource. Management, on the other hand, is distinct from social dynamics, whose processes and systems appear to be unplanned (Maulana, Setiawan, Hartiningsih, & Kusbiantono, 2014). The resources mentioned above include an organization's existing knowledge.

The management of knowledge within an organization is now known as knowledge management, which is the effort to manage knowledge across the members of the organization or company in such a way that every employee clearly understands their duty, is able to provide information to customers and co-workers, and, in the end, is

happy at work (Oyefolahan & Dominic, 2010; Rauter *et al*., 2019; Shettar, 2007). The trick is to make as much knowledge and information within an organization explicit and to use it to increase the organization's competitive advantage.

R&D organizations generate knowledge as a final product. As a result, knowledge serves as the foundation for all processes within such organizations, making effective knowledge management necessary (Setiawan, 2012). To carry out this knowledge management, it is necessary to understand the flow of knowledge within R&D organizations in order to make efforts to smooth or control this flow (Cross, Parker, & Borgatti, 2002). However, such an attempt can necessitate change-management efforts aimed at effecting organizational changes, which may result in numerous shocks (Romadona & Setiawan, 2021).

Ikbal *et al*. (2014) have already investigated management efforts within a research institution. However, no study of the flow of knowledge within a public R&D organization has been conducted.

SNA is one methodology used to assess an organization's knowledge flows. It is used in this study to monitor the flow of knowledge within an Indonesian public R&D organization.

Other methodologies exist, including APQC and KoFI, but they are more qualitative in nature. SNA, meanwhile, is more quantitative, and was chosen for this study.

SNA is an aspect of complex systems theory used in the third generation of knowledge management. It is a theory of social relationship networks consisting of nodes and relationships (Zaphiris & Pfeil, 2007). SNA is also critical in determining how a problem can be solved, how an organization works, and how individuals can achieve their objectives (Aydin, 2018). SNA can be applied on a broader scope to analyze kinship structure, social mobility, scientific citations, contacts among members of nonstandard groups, corporate power, terrorism, international trade exploitation, class structure, and many other areas (Durland & Fredericks, 2005; Curran & Curran, 2014; Aydin, 2018; Christidis, 2020) Thomas N. Friemel (2017) has also noted that SNA encompasses a large set of methodological, statistical, and theoretical approaches developed to analyze relational data with broader purposes, for instance regarding talent management (Whelan *et al*. 2010), types of leadership (Hoppe & Reinelt, 2010; Molano & Polo, 2015; Aydin, 2018), social media and email-based networks (Kassiri & Belouadha, 2020; Himelboim, 2017; Waters, 2014; Christidis, 2020), data mining (Deng & Mao, 2013), telecommunication (Al-Molhem *et al*. 2019); platforms of application (Adnan *et al*., 2019), and application in business sectors (Putritamara *et al*., 2020; Altuntas & Gök, 2020; Massey, 2016; Valente *et al*., 2015). Furthermore, Kassiri and Belouadha (2020) have noted that as with conventional maps that describe the geographical distance between cities, the distance and thickness of graphic relations in an SNA study illustrate the relationships between objects or individuals spatially and in terms of intensity.

3. Methodology

In this study, the SNA approach was applied to identify the role of managers in aligning the knowledge flows in an R&D organization. The study was conducted in 2012, and both primary and secondary data were collected.

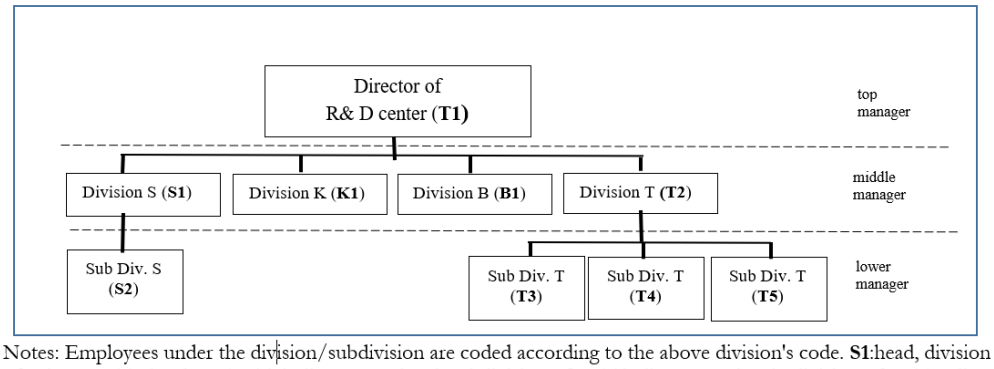
Primary data were obtained via a questionnaire distributed to all employees in a public R&D center in Jakarta, Indonesia, while secondary data were obtained from related literature and online sources. Respondents were staff members in the public R&D center and consisted of managers, researchers, and administrators. Researchers belong to the divisions that conduct research, and administration refers to the division that deals with administrative

matters. All staff were given a special code according to their position. The coding can be seen in Table 1.

Table 1.
Respondent codes

No.	Code	Explanations
1	T1	Director
2.	Sx	1st research division; x is the number of the respondent - Number 1 (S1) is head of division - Number 2 (S2) is head of subdivision - The rest are research staff
3	Kx	2nd research division; x is the number of the respondent - Number 1 (K1) is head of division - The rest are research staff
4.	Bx	3rd research division; x is the number of the respondent - Number 1 (B1) is head of division - The rest are research staff
5.	Tx	Administrative division; x is the number of the respondent - Number 2 (T2) is head of division - Number 3 (T3) is head of 1st subdivision - Number 4 (T4) is head of 2nd subdivision - Number 5 (T5) is head of 3rd subdivision - The rest are administration staff

As noted in Table 1, the top manager or director of the R&D center was coded T1 and supervises four divisions, which consist of three research-related divisions, coded S, K, and B, and one administration division coded T. In total there were 77 employees at the R&D center; the number and the code indicate the division or subdivision in which the employee works. Employees and managers from research-related divisions and subdivisions are coded with K, B, and S. In contrast, the director of the R&D center and the managers of administrative divisions and subdivisions are coded with T. The general structure of the R&D center can be seen in the following organizational chart (Figure 1):



Notes: Employees under the division/subdivision are coded according to the above division's code. **S1**:head, division of Science & Technology (S&T) indicator, **S2**: head, subdivision of S&T indicator, **K1**:head, division of S&T Policy, **B1**:head, division and subdivision of S&T management, **T2:**head, division of Administration, **T3**:head, subdivision of R&D services, **T4**:head, subdivision of Finance & General Affairs, T5:head, subdivision of Human Resource

Figure 1.
Organization chart of the R&D center

Respondents were asked two crucial questions. The first was to list the first five names that they related to administrative, bureaucracy, and task-assignment issues. In comparison, the second question was to list the first five names relating to research content issues. An SNA graph is a map of the particular relationships among actors in a network.

In this study, the network graph produced by administrative, bureaucracy, and task-assignment issues was named the bureaucratic network, while the second network, representing research content issues, is the knowledge network. SNA mapping was carried out using NodeXL commercial software (Hansen *et al.*, 2020). Quantitative and qualitative analysis was conducted using the conceptual framework of individual types and matrices in networks, adapted from Cross and Parker (2004) and Durland and Fredericks (2005).

The individuals in the knowledge and bureaucratic networks were identified with the roles of "central connectors," "peripheral players," "information brokers," and "boundary-spanners." SNA underpins two main outputs in diagrams and metrics, calculated using the statistical theory of distance. In a network diagram, SNA can be categorized according to the nodes and the nature of the connections (Cross & Parker, 2004). The metrics of the network were determined as "degree of centrality," "eigenvector centrality," and "clustering coefficient," drawing on Batura (2012); Kassiri and Belouadha (2020); and Zaphiris and Pfeil (2007). The type of individual and their centrality in the networks was categorized (Friemel, 2017). Secondary data was collected from formal R&D documents (organizational strategic planning and organizational performance reports) to confirm individuals' types in the networks.

Further data analysis was conducted to assess the role of managers in facilitating the flow of knowledge in the organization, both in terms of bureaucratic and knowledge-seeking positions. The study's results are also relevant to the potential future development of employees at their current positions regarding their type and centrality in the networks.

Figure 2 illustrates the research process. There were only two phases—namely data collection and analysis—and they were carried out using NodeXL as a data processing tool. Centrality, eigenvector centrality, and coefficient clustering were all computed using NodeXL. All of this was processed to demonstrate the organization's knowledge flows, with particular focus on the role of managers in the knowledge flows of a public R&D organization.

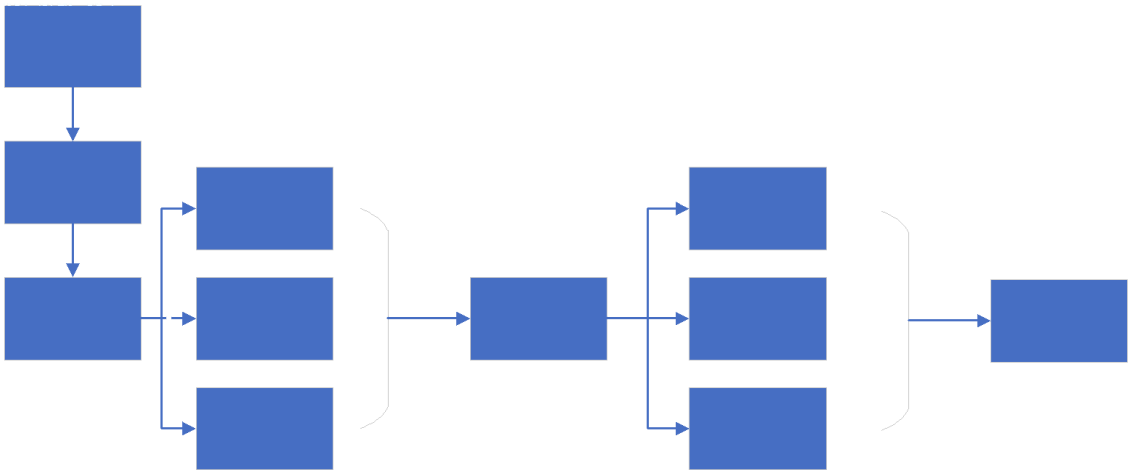


Figure 2.
Research process

4. Findings and Discussion

4.1 R&D Knowledge Network

The output of the SNA commercial software (NodeXL ver. 1.01) showed a knowledge network map of the R&D organization that included a total of 63 out of 77 employees (Figure 3). The term "vertex" indicates each individual node or employee analyzed for knowledge-seeking purposes.

Graph Metric	Value
Graph Type	Directed
Vertices	63
Unique Edges	195
Edges With Duplicates	0
Total Edges	195
Self-Loops	0
Connected Components	1
Single-Vertex Connected Components	0
Maximum Vertices in a Connected Component	63
Maximum Edges in a Connected Component	195
Maximum Geodesic Distance (Diameter)	6
Average Geodesic Distance	2,75
Graph Density	0,05

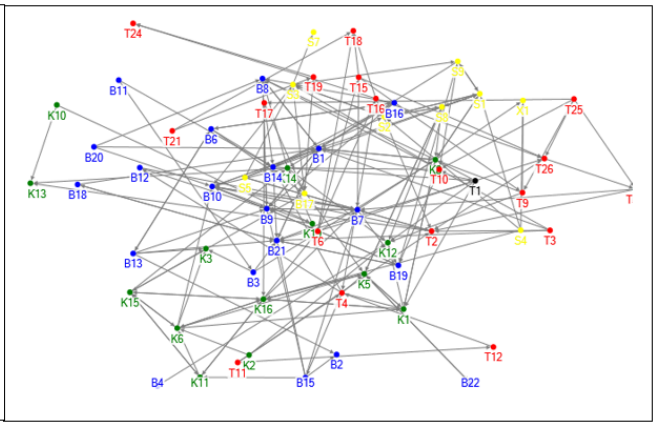


Figure 3.
Map of knowledge network

The map also contains no self-loops, a phenomenon where a connection that comes from an individual returns to them. The geodesic distance is 6, which means that information can immediately spread in the knowledge network through six individuals or vertices—although the organization's IT system can minimize the geodesic distance such that information and knowledge can be managed more efficiently and transferred immediately to more recipients.

According to Table 1, the knowledge network is likely split among the four divisions (coded K, B, T, and S). However, the members seem partly scattered in the divisions T and B. Other significant findings in the knowledge network are: (1) the director of the R&D center (top manager, code T1) is more likely to be in the B and K division networks; (2) there are individuals scattered far from their original divisions—for instance, employee S4 is in the divisions B and T, while employee B12 is more likely to be in the areas of division K; (3) divisions B and K exhibit intermingling with each other.

4.1.1 Centrality in the Knowledge Network

According to the output, the highest degree of centrality in the knowledge network is contributed by nonmanager employees. The most central employees of the R&D knowledge network are the five employees B7, B10, K14, T4, and T2, with the values of 443, 402, 358, 345, and 295 respectively. Among the centralities, only T2 holds a middle-manager position and T4 a lower-manager position. Understandably, the main task of T2 (head, division of Administration) and T4 (head, subdivision of Finance and General Affairs) is to deliver internal administrative services to employees and other managers. The manager T2 is also responsible for managing correspondence, organizational standards and systems, communication, HR and finance services, IT services, and research dissemination and collaboration (R&D services), while T4 handles work in finance, assets, and general affairs.

The results also show that the top manager in the organization (director) ranks 30th for centrality, with a value of 83.750 below average, but above the median. This value indicates that statistically, the director has fewer activities in knowledge-sharing or is not considered to have sufficient expertise as a source of knowledge in the organization.

At the middle-manager level, the heads of divisions obtain excellent centrality ranks, except for one middle manager, S1, who is below average but above the median. This indicates that middle managers tend to be more connected to other employees through any activities and are assumed to be reliable sources of knowledge. Among the middle managers, T2 represents the most reliable source of administrative knowledge, while B1 represents the most reliable source of research-related knowledge. Most of the lower managers are below the average and median values, except for T4, who ranks fourth in centrality. This indicates that the lower managers are considered insufficient in terms of sharing their knowledge with other employees or subordinates.

In the context of the role of managers in the organization, T4, T2, and B1 appear to be more connected to more employees than other managers, with centrality ranks of fourth, fifth, and sixth respectively. Other than internal administrative services delivered by T4 and T2, other factors influence the level of centrality. This also explains why other internal administrative managers (T3 and T5) do not obtain similar centrality. Considering their respective positions, T3 and T4 should actively interconnect with more employees in delivering their tasks. The results show that T5 possesses the lowest degree of centrality in the network. A lower degree of centrality of individuals in the organizational network thus indicates barriers in interpersonal communication and knowledge-sharing. (Kaur & Suri, 2014; Kumar *et al*., 2014).

Holste and Fields (2010) have stated that trust, both affect-based and cognition-based, significantly affects willingness to share and use tacit knowledge. From a network perspective, trust in an attitude of hope, with the expectation to achieve common goals through all members' participation, is a basic foundation of relationships that should be nurtured in a community (Molano & Polo, 2015). Furthermore, organizational factors (including organizational culture and climate, management support, rewards and incentives, and organizational structure), interpersonal and team characteristics, cultural and individual characteristics, and motivational characteristics. Motivational factors can be rooted in beliefs of knowledge ownership, perceived benefits and costs, interpersonal trust and justice, and individual attitudes (Helmi, 2020; Kaldeen, 2019; Lin, 2007; Ofori, 2015; Paulin *et al*., 2012; Swift *et al*., 2010; Tan & Noor, 2013).

4.1.2 Eigenvector Centrality in the Knowledge Network

Eigenvector centrality is a measure that not only takes into account the number of connections of a vertex but is also influenced by the degree to which a vertex is connected (vertex popularity); more simply, it indicates the degree of popularity of a person in a social network (Cross & Parker, 2004). According to the SNA in this study, the five employees who achieved the highest degree of eigenvector centrality are B1 (0.048), B7 (0.045), B9 (0.042), B10 (0.037), and B21 (0.037). Interestingly, all the employees in this category are in the same division, with B1 being head of S&T management. Various possible factors may influence centrality level in the network, leading to popularity.

In terms of eigenvector centrality, the director of this R&D organization (T1) is well known as the source of knowledge, even if they have less centrality than a middle manager (B1). The heads of divisions achieved good eigenvector centrality, which indicates popularity among subordinates in terms of providing knowledge. Among lower managers, two (S2 and T5) are below the average and median values, which indicates that they are less popular than the other two lower managers (T3 and T4). The manager's role is crucial to facilitating the climate and culture required for knowledge transfer throughout the organization (AL-Hakim & Hassan, 2011; Frost, 2014; Sezgin & Iplik, 2018) so that subordinates are motivated to learn from the network; if they are not, it will eventually affect the R&D organization's performance.

4.1.3 Clustering Coefficients in the Knowledge Network

The clustering coefficient describes the tendency to create a knowledge-based clique, that is, a situation where some people tend to exchange knowledge only in a smaller group. The coefficient value ranges from 0 to 1, where 0 indicates that no clique occurred, and 1 suggests a clique.

In the organization's network, the five highest cluster coefficients were obtained by B18 (1.00), B20 (0.667), T12 (0.500), K10 (0.500), and B16 (0.400), none of whom had managerial positions. Due to the presence of more employees in division B (S&T management), more cliques occurred there.

The R&D top manager (director) statistically obtained the highest rank in terms of clustering coefficient (8), which means that the director is more likely to establish a clique or a closed group than middle and lower managers; for example, lower-group manager T3 possesses the lowest degree of clique formation. A disadvantage of a high level of clique tendency is the occurrence to some extent of a barrier in knowledge and information flow in an organization. A manager who tends to establish a clique will receive valuable information or knowledge and merely forward it to the closed group or to selected subordinates. On the other hand, a manager with the lowest degree of clique formation may either cause information and knowledge to disseminate among their subordinates or not pass on the information to others. Willingness to share valuable information and knowledge is an essential attitude for a manager at any level to improve an organization's performance. Personal issues such as interpersonal trust, knowledge self-efficacy, and learning motivation will significantly affect the knowledge-sharing ability of an organization (Lin, 2007; Swift *et al.*, 2010). Therefore, top managers should pay attention to middle and lower managers and encourage their organizations and IT systems to be knowledge-management enablers in the knowledge-sharing process (Tan & Noor, 2013; Kumar, Singh, & Haleem, 2014).

4.2 R&D Bureaucratic Network

The second SNA map is related to organizational bureaucratic connections, and enabled delivery of a bird's-eye view of the bureaucratic effectiveness of managers within the R&D organization. The following map (Figure 4) exhibits 69 interconnected vertices in the R&D bureaucratic network.

Graph Metric	Value
Graph Type	Directed
Vertices	69
Unique Edges	241
Edges With Duplicates	0
Total Edges	241
Self-Loops	0
Reciprocated Vertex Pair Ratio	0,06
Reciprocated Edge Ratio	0,12
Connected Components	1
Single-Vertex Connected Components	0
Maximum Vertices in a Connected Component	69
Maximum Edges in a Connected Component	241
Maximum Geodesic Distance (Diameter)	5
Average Geodesic Distance	2,44
Graph Density	0,05
Modularity	0,28

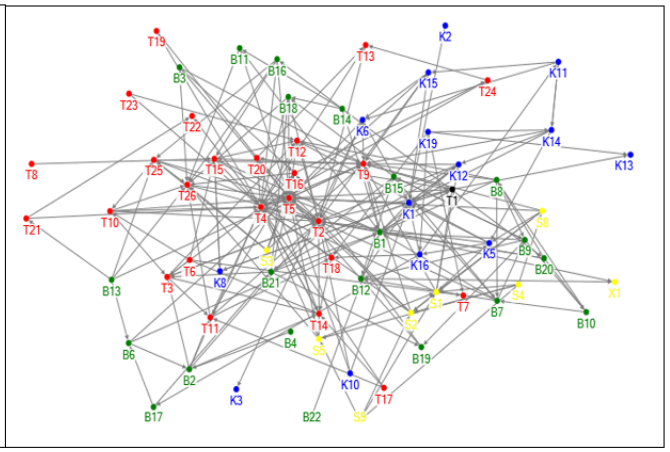


Figure 4.
R&D bureaucratic network

Employees in the bureaucratic network are less segregated in their respective divisions than is the case in the knowledge network (Figure 2). In the bureaucratic network,

information can spread to the organization through five vertices, as indicated by the maximum geodesic distance of 5. The divisions B and S are segregated, while the top manager (T1) tends to be more connected with the K division. The bureaucratic and hierarchical relationships in the organization are more tangible than the knowledge relationships. In the hierarchical network, the formal assignment relation between managers and subordinates is determined, so segregation of employees across divisional boundaries might be caused by cross-divisional assignment.

4.2.1 Centrality in the Bureaucratic Network

The employees who have the highest degrees of centrality are T4 (876.928), T5 (873.090), T2 (840.571), B1 (540.430), and K1 (412.913). All the highest centralities were contributed by middle and lower managers, and the top three were contributed by T-division managers (administrative division).

Centrality measurement demonstrates some interesting findings. Despite being a top manager, the director of the R&D center, T1, ranks merely 10th in centrality. In contrast, the middle managers possess a much higher degree of centrality in the bureaucratic network.

This presumably indicates the less bureaucratic style of a top manager, since the administrative system and standards of the organization have been established before their arrival. As an organization under a public research institution in Indonesia, the R&D center fully complied with state regulations for managing administrative work, including concerning its treasury, personnel, assets, procurement, stock, and households.

Nevertheless, to some extent, T1 and employees in the T division remain interconnected to ensure compliance with regulations by approving the processes and documentation in administrative work. In coordinating administrative work, T2 (as a middle manager) tends to be more interconnected directly with employees in the T division and other relevant bureaus and offices outside the center. T1 tends to delegate the most bureaucratic work to subordinates (mainly middle managers), reflecting the higher degree of centrality shown by the middle managers, except S1. T4, who handles finance and general service work, has the highest degree of centrality in the bureaucratic network and the organization. T4 is thus seemingly more powerful in the bureaucratic network than other managers.

4.2.2. Eigenvector Centrality in the Bureaucratic Network

According to the measure of popularity expressed by eigenvector centrality in the bureaucratic network, the five highest degrees of centrality were contributed by the following employees: T5 (0.056), T2 (0.053), T4 (0.047), T9 (0.038), and B1 (0.032). This result is consistent with the previous results, in which employees of the T division dominated centrality. B1 is one of the research-related managers who is in a non-T division. The most central employees are managers at middle and lower levels, except for the employee T9.

Most manager levels have eigenvector centrality values above the mean and median. The top manager is less popular in the bureaucratic network than five managers (B1, T5, S2, T4, and T2) but more popular than the other three (K1, S1, T3). The measurement of popularity in the bureaucratic network revealed that the T division remained dominant.

4.2.3 Coefficient Clustering in the Bureaucratic Network

Coefficient clustering measurement of the 69 employees presents a tendency toward clique formation in the bureaucratic network. The employee with the highest potential in this category is T19, with the coefficient value of 1.0, while B3, T23, T17, and K10 follow, all reaching the similar coefficient value of 0.5. The data also revealed that no managers rank among the top five for coefficient clustering.

The results reveal that the top manager (T1) and six subordinates (B1, S1, K1, T5, T4, and T2) have a lower degree of clique tendency. In comparison, two subordinates (S2 and T3) have a higher degree of clique tendency. In this area, we can conclude that most managers play an essential role in managing information throughout the organization.

4.3 Map Analysis: The Role of Managers

Regarding knowledge-seeking, no single individual acted as the most critical and popular in the knowledge network. The knowledge map also revealed that more than 15% of employees are marginalized as knowledge sources. Moreover, in the other type of network—the bureaucratic network—the most influential division is the administrative division (T). The Finance and General Affairs Manager (T4) is also the most central person in the bureaucratic network. In terms of bureaucratic centrality, the top manager (T1) is less powerful than most managers in the administrative division. There was no clique tendency in the bureaucratic network among the managers, indicating that the information flows can be adequately managed.

The comparison of the different types of individuals between the knowledge network and the bureaucratic network is summarized in Table 2.

Table 2.
Comparison of types of individual between knowledge network and bureaucratic network

No	Type	Knowledge network	Bureaucratic network
1	Central connector	● The top five employees (B7, B10, K14, T4, and T2) have the most connections and sometimes have an imbalance (overloaded connection) in the number of direct relationships in a network, potentially leading to bottlenecks or lack of recognition of existing resources.	● The first type of central connection is a bottleneck contributed by employees in administrative positions (T4, T2, T5, T9) and research-related positions (B1, K1). The bottleneck is mainly caused by an overloading of the employees, not the intentional creation of a barrier to information flow. ● The second type of central connection is the "unsung hero." The employees B7, B10, and the bottleneck are the administration officials. The unsung heroes are not in place, or are volunteers who create connections between network elements so that the network can interact smoothly.
2	Boundary-spanner	● There is no single individual who plays a boundary-spanner role in the knowledge network that connects to all four divisions. ● The heads of divisions (K1, S1, B1, and T2) play boundary-spanner roles and	● There is no single individual who plays a boundary-spanner role in the bureaucratic network that connects to all four divisions. ● T2, T4, and T5 act as boundary-spanners that connect employees across divisions.

No	Type	Knowledge network	Bureaucratic network
		facilitate interconnection between divisions. ● Among the heads of divisions, S1 plays the most minor role as a boundary-spanner.	
3	Information broker	● The employees B9, T26, S8, and K6 play the information broker role in divisions B, T, S and K respectively. ● These persons tend to integrate important subgroups, while the most central people or those in formal positions of power sometimes cannot do so.	● The heads of divisions (K1, S1, B1, and T2) play boundary-spanner roles and facilitate interconnection between divisions. ● B9, T26, S8, and K6 play information broker roles in B, T, S, and K divisions.
4	Peripheral players	● Three employees (S7, B4, and B22) have only one connection, and five have only two connections (T12, T24, K10, T21, B11). ● Most of the peripheral positions in the network are held by new employees (B22, T12, T21, T24, B11), while the exception is a marginalized position held by a person who has intentionally retreated from the network to pursue his personal goals. ● The peripheral players remain in their respective divisions.	● More employees in the bureaucratic network remain peripheral than in the knowledge network. ● The reasons for this are as follows: o some individuals pursue their own personal goals (B11, K2, B12, and B3) and are intentionally peripheral; o personal characteristics: employees K10, S9, B22, S7, and T12 tend to seclude themselves; o demotivation of the network (B18, B4, T23).

It has been shown that the interconnectivity among individuals in the two networks demonstrates distinct and unsynchronized patterns. The lines that appear in the knowledge network represent only the flow of knowledge, while the bureaucratic network constitutes hierarchical relations that connect bureaucratic officials with their employees. No formal system exists to manage the organization's knowledge flows, and this asynchronization may impact the effectiveness of the knowledge-dissemination process. Instead of bearing the bureaucratic burden, the top management neglects to focus on directing the knowledge outcomes. In contrast, the organization's valuable knowledge could provide it with a competitive advantage. However, the outcomes of this valuable knowledge depend significantly on the employees' capabilities and informal behavior.

5. Conclusions

The purpose of this study was to identify the role of managers at all levels in a public R&D organization in aligning information flows, both in its knowledge network and in bureaucratic relationships.

In terms of social network analysis, the R&D organization was examined with regard to two different knowledge flow patterns. The first pattern concerned administrative and bureaucratic purposes, while the second

pattern centered on knowledge-seeking purposes. The two patterns did not seem to synchronize. As the top manager, the director of the R&D center appears to have less centrality in both knowledge and bureaucratic influence than expected. The middle managers play pivotal positions in knowledge-seeking, while the administrative managers are central in administrative roles. Clique tendency was found to be lower at the managerial level but higher at the nonmanagerial level. The top manager should therefore establish a reward-and-punishment system to minimize the peripheral employees and observe the managers, who cannot be a source of knowledge in the organization. This system should rectify both intentionally peripheral individuals and underutilized employees. Furthermore, the top management should note the rising stars among the central employees, who could be repositioned as future managers.

SNA is a preliminary approach to collecting initial data in designing knowledge management in an organization. Further study is needed to formulate strategies and action plans in order to develop valuable knowledge in this R&D organization. This research relied on unraveling the complexity of knowledge flows among employees and the variables that affected the knowledge-transfer process in the organization.

This study provides information on the flow of knowledge within a public, governmental R&D institution in Indonesia. With these findings, appropriate policies can be developed to further improve this flow of knowledge and thus the capacity of public or governmental R&D institutions more generally.

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