Co-evolution of Project Stakeholder Networks

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Abstract: Oftentimes a multitude of stakeholders from different backgrounds engages in projects from the onset through to the completion phase. These stakeholders not only offer unique qualities and viewpoints as well as diversely contribute to the success of a project, but simultaneously possess contrasting interests. The presence of common interests serves as the catalyst to the development and formation of what are known as stakeholder networks. Different networks of such evolve and re-develop throughout the different phases of a project. In this study, we aim to explore the impact on a corresponding network that a pre-existing network exerts onto another when the same set of nodes or actors are present. We also explore the impact that stakeholder attributes have on this co-evolution and co-development process. We used the method and concept of social network analysis to construct different stakeholder networks. The social network methods of network correlation and regression have been used to explore the co-evolution of two different stakeholder networks. Results show that different stakeholder networks among the same stakeholders do indeed co-evolve and that socio-demographic factors significantly influence the outcome of this stakeholder network development.

Keywords: Stakeholder network; Network co-evolution; Network correlation; and Network regression

 DOI NUMBER: 10.19255/JMPM02306

1. Introduction and Background

The concepts of stakeholders and stakeholder networks have become central and gained greater moorage within the realm of project management. Initially existing as an abstract concept, references to the notion dates as far back as the eighteenth century when it was recognized by Adam Smith (Smith, 1822). However, it was not until 1963 when the term "stakeholder" first emerged within the management literature when it was recognized by the Stanford Research Institute (Eskerod, Huemann, & Savage, 2015). This convergence has since experienced great development and was formally and most prominently solidified by Freeman in his seminal piece (first published in 1984, subsequently republished), *Strategic Management: A Stakeholder Approach* (Freeman, 2010). Since then, there has been significant development with regards to the identification of stakeholders as being "whom and what really counts"; even extending to the application of social network analysis concepts to the realm of stakeholder networks (Freeman, 2010; Mitchell, Agle, & Wood, 1997; Rowley, 1997; Uddin, 2017). A meta-analysis of project management literature has indicated that stakeholder management and identification can also be role-based (Achterkamp & Vos, 2008). Peripherally, stakeholders can be divided into primary, secondary, tertiary, or key stakeholders depending upon importance. It is known that an understanding of the intricate relationships and dynamics between stakeholders is important, especially as networks become scaled larger in size (Eskerod et al., 2015). The concepts of stakeholder theories are pivotal as they exert a significant impact on the varying demands of stakeholders and the consequential organizational responses (Rowley, 1997). The design of this research study aims to develop and extend the current understanding of the dynamism and inherent connections between stakeholders and the co-existing evolution of analogous networks, specifically within the health sector. Stakeholder information specifically corresponds to the technical support and funding networks within Bangladesh and Sri Lanka.

Studies on stakeholder networks within the industry have focussed on a variety of contexts ranging from those within the tourism industry to contexts relevant to sustainability and natural resources (Newman, 2003; Niemelä et al., 2005; Prell, Hubacek, & Reed, 2009; Strobl & Peters, 2013; Timur & Getz, 2008). Concepts surrounding many of the research studies incorporate the utilization of stakeholder networks to gain economic advantage, improve upon the management of stakeholders, or understand complex systems. Communication is another imperative point that has been communicated as a tool for the management of stakeholders (El-Gohary, Osman, & El-Diraby, 2006). References made with the notion of economic advantage incorporate a range of ideas, including those of entrepreneurship (Brown & Butler, 1995; Strobl & Peters, 2013). For instance, specific studies of stakeholder networks within the wine industry indicate that there exists a proportional relationship between the time spent networking and building relationships for stakeholders with profitability and market share (Brown & Butler, 1995; Timur & Getz, 2008). As the study has indicated, stakeholders who are more centralized and possess a greater number of weak links also tend to possess a greater economic advantage within an entrepreneurial situation. Investigations on economic advantage and entrepreneurship also extend into the tourism industry in which it has been used to determine the effect of stakeholder networks on the capacity of destination networks within the Austrian tourism network (Strobl & Peters, 2013). The findings of this study indicate that the reputation of a stakeholder is impactful within the economic realm. Additionally, another related study has explicated the importance of understanding visitor behavior in the process of managing destination networks as well as increasing attraction for economic advantage in posteriorities to the management design of destination networks. Other research has also considered the effects of cultural districts and the effects of demarcation in terms of economic advantage within the tourism industry (Arnaboldi & Spiller, 2011).

Stakeholder theory and networks have and are also being used as an approach and vantage point through which management and policies are interpreted. Current standards, including PRINCE2, PMBoK, as well as the ICB International Competence Baseline, all have a slightly varied view of what stakeholder management entails as well, and the tools with which are applicable can be significantly refined and developed (Eskerod & Huemann, 2013). Within the natural resource industry, stakeholder networks have been applied to determine the remedy the fragmentation found within a Swiss infrastructure planning process as well as to deepen socio-political-engineering parameters of the network (Lienert, Schnetzer, & Ingold, 2013). On other occasions, stakeholder networks have been used to determine appropriate policies (Kimbu & Ngoasong, 2013), select relevant stakeholders (Prell et al., 2009; Vance-Borland & Holley, 2011), or manage conflicts (Niemelä et al., 2005).

From here, it is apparent that the stakeholder approach has been applied to an extent within the realms of entrepreneurship, tourism, and natural resources, among others (Strobl & Peters, 2013; Timur & Getz, 2008). In spite of this, a majority of analyses have not yielded an understanding of the evolution of stakeholders through time, particularly in regard to scenarios in which more than one network is present. Further to this, the effect on this development and the relationship with the innate individual attributes is not well understood. It is through these elements that this study aims to contribute to within the existing literature framework.

It is also apparent that applications of stakeholder networks in research have been used for a wide variety of reasons, including stakeholder identification. This approach has also been used to gain economic advantage as well as to inform and apply appropriate and relevant management strategies and policies. Despite its wide-reaching applications, the stakeholder network methodologies have largely remained confined within established vantage points. It is because of this that this study has been designed. It aims to contribute to the lacking and insufficient understanding of the founding principles of correlation and regression within a stakeholder management context. The research intends to compare and contrast two parallel networks in the process of determining whether there exists any interdependency or inter-relationship. This applies specifically to the co-evolution of two stakeholder networks and the determination of the relevant characteristics and trends. Research questions which frame this study include the following:

- Do relationship ties within one network serve as an impetus for the development of ties within another network?
- Do socio-demographic attributes influence on the co-evolution of network ties within stakeholder networks?

Developing an understanding of these research questions will inevitably allow greater capacity and expanse to maneuver according to what can be foreseen as necessary (Eskerod et al., 2015). The remainder of the paper has been organized as in the following: Section 2 explores the methodology and computational theories behind the regression and correlation analyses. The results and discussion follow this in sections 3 and 4, respectively. Finally, a conclusion, as well as recommendations, follow in Section 5 with delineation for future work.

2. Research Methodology

2.1 Data Source and Data preparation

The method of data collection implemented by the South Asian Infant Feeding Research Network (SAIFRN) incorporated a Net-Map interview technique (Rasheed et al., 2017). This entailed a process where participants and respondents were contacted through emails, phones and letters. Initial interviewees were selected from high-ranking positions. Through a snowball sampling technique, subsequent stakeholders and respondents were identified and interviewed. The participant constituency has been summarised in table 1. The data is also relevant to preceding studies conducted on young child feeding practices and relates to the identification of networks, as well as the influence and power mapping of stakeholders in the process of promoting positive children feeding practices (Godakandage et al., 2017).

The stakeholders within the networks of both countries of Bangladesh and Sri Lanka could be classified into several different groups. These include donors, government, non-government, as well as research and academia groups. The stakeholder constituency of Bangladesh mainly comprises of donors and government groups for Sri Lanka. The funding and technical support networks of both countries are considered. These networks have been made up of common stakeholders within each country. The network descriptors for the networks of both countries differ significantly and simultaneously possess a similarity. An important and apparent similarity includes the number of stakeholders, in which a smaller number exists for both funding networks (30 and 36 for Bangladesh and Sri Lanka, respectively). However, the corresponding sizes of the technical support networks differ by a higher number (72 versus 57). Apparent differences include the notable large number of edges for both technical support (791) and funding (173) networks of Sri Lanka, when compared to the funding (35) and technical support (36) networks of Bangladesh. Further to this, the networks of Sri Lanka embody a greater difference between the densities with the technical support network of Sri Lanka possessing the highest density at 0.203.

	Study side	
	Bangladesh	**Sri Lanka**
Number of interviewees	29	35
Funding network		
Size	30	36
Edge	35	173
Density	0.063	0.044
Technical support network		
Size	72	57
Edge	36	791
Density	0.065	0.203

Table 1: Basic Information on Research Data.

After the collation of primary data as well the identification of common nodes between the technical support and funding networks, edge lists of the stakeholders were filtered for common nodes and transcribed into Excel. This allowed maintaining consistency throughout the dataset to aid in comparisons and analyses. The processed and resulting lists were then processed and tabulated into matrix form within Excel. Statistical measures for network correlation and regression were computed through UCINET (Borgatti, Everett, & Freeman, 2002) as a final process and this was repeated for both Bangladesh and Sri Lanka. A visual illustration of the networks can be found in figure 1. The findings and identified characteristics applicable to the research dataset are investigated and explored further in the following sections. Statistical measures for each respective country have also been tabulated and compared to determine trends.

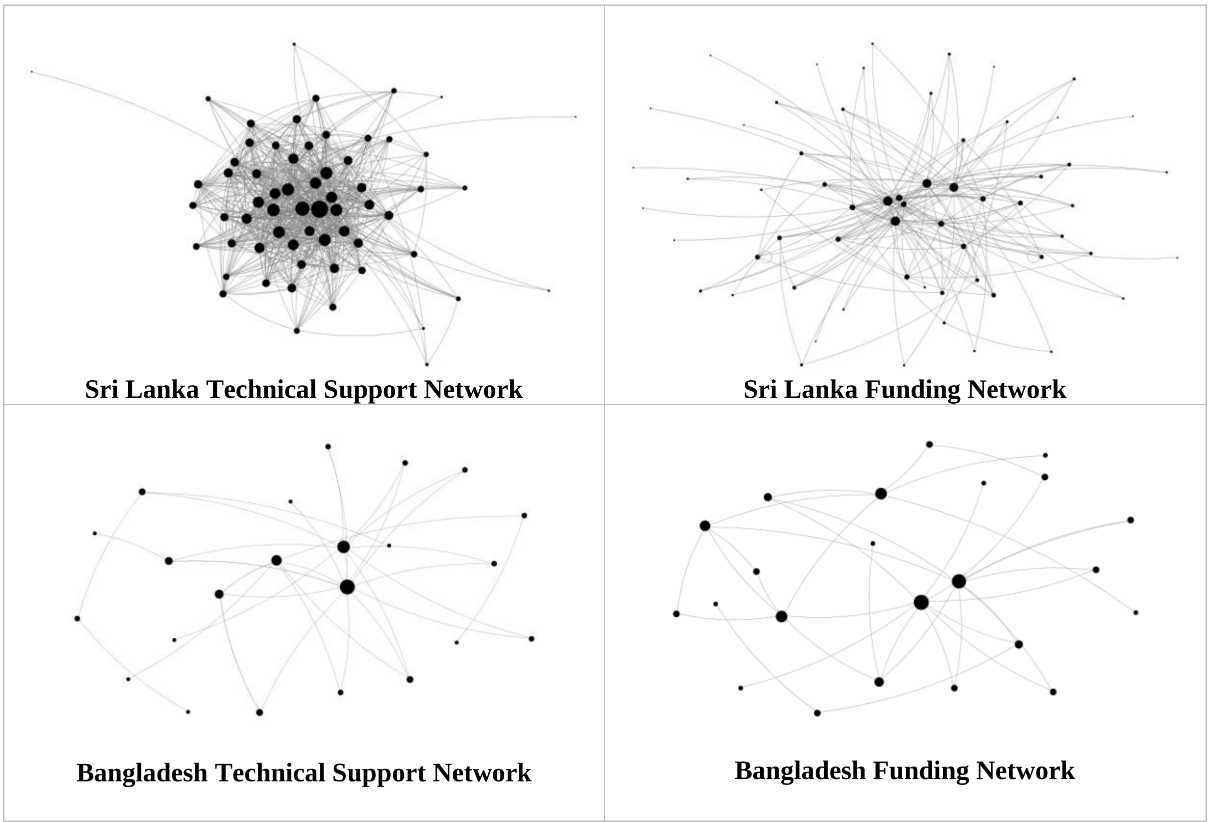

Figure 1: Illustration of four different networks considered in this study. The sizes of the nodes have been scaled according to the out-degree within all four networks.

Three different attribute types were considered within this study. These included the level of support required by stakeholders, socioeconomic status (height of tower), as well as actor type. Level of support as an attribute concerns itself with the extent of support required by each stakeholder- the higher the magnitude, the greater the level of support required in terms of technical skills and knowledge within the technical support networks and funding within the funding network. Level of support is directional, and a higher positive number signals greater support obtained, whereas a higher negative number communicates a greater level of support offered. The absolute differences were determined relative to each corresponding cell for the matrices of this attribute. Height of tower concerns itself with the socioeconomic status of each stakeholder group. A high value is associated with a high socioeconomic status level. This attribute is non-directional; however, the matrix was determined in a similar process as that for the level of support- through computing the absolute differences. The actor type, was another attribute, classified within one of four subcategories- government, research and academia, non-government or donor groups. Each was allocated a corresponding number, which was then converted to a matrix through a function within the analysis software used (cross-products (co-occurrence)).

Since this study set out to conduct a network regression analysis, the three attribute values for different actors were converted into matrix format. The first two attributes (height of tower and level of support) were converted into matrix format through the approach described in figure 2. However, the procedure used for the conversion of the actor type attribute was slightly varied due to the qualitative nature of the information. Hence, a separate column had been allocated for each type of actor which was then be represented through the binary form in which a 1 corresponded to the actor belonging to a specific actor type classification. Using abstract data, this has been illustrated in figure 3.

Actor name	Attribute value
A	4
B	5
C	6
D	2

(a) Attribute information

	A	B	C	D
A	0	1	2	2
B	1	0	1	3
C	2	1	0	4
D	2	3	4	0

(b) Corresponding matrix

Figure 2: Conversion of height of tower and level of support into matrix format: (a) Abstract data of the attribute information for four actors (A, B, C and D); and (b) the corresponding attribute information converted into matrix format. Each cell in (b) represents the absolute difference of the attribute information on the corresponding actors. This same procedure was executed for both height of tower and level of support.

Actor name	Actor type
A	T1
B	T2
C	T2
D	T3
E	T1

(a) Attribute information

Actor name	T1	T2	T3
A	1	0	0
B	0	1	0
C	0	1	0
D	0	0	1
E	1	0	0

(b) Attribute information (binary format)

	A	B	C	D	E
A	1	0	0	0	1
B	0	1	1	0	0
C	0	1	1	0	0
D	0	0	0	1	0
E	1	0	0	0	1

(c) Corresponding matrix

Figure 3: Conversion of attribute type into matrix format: (a) Actor type information of five actors (A, B, C, D and E) based on abstract data; (b) the binary representation of (a); and (c) corresponding matrix for the actor type information. In (b) there are three columns that have been considered for actor type since each actor in the abstract data can be classified as either T1 or T2 or T3.

The framework illustrated in figure 4 has been followed in this study to explore the co-evolution of funding and technical support network and the impact of different node attributes on this co-evolution.

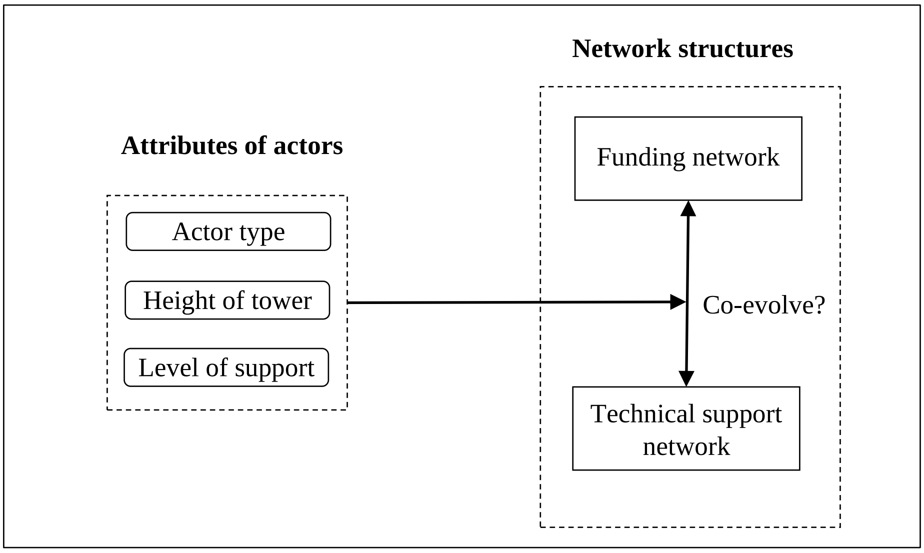

Figure 4: Framework for exploring the co-evolution of funding and technical support networks

2.2 Network correlation and Network regression

The notion of network correlation between two networks involves the determination of the degree of similarity in the connection between nodes of one network when compared to the nodes within a corresponding network (Wasserman & Faust, 2003). This notion has been utilized within this study to determine the level of similarity between two analogous networks mapped at corresponding timeframes with the same node-set. An extended form of correlation involves what is known as network regression in which the nature of the relationship and extent of correlation between networks is also examined and studied (Parker, 2017). Within the intrinsic level, this allows an investigation into the likelihood of the development of a tie or relationship on the basis of a pre-existing connection within a parallel network.

To determine the characteristics and trends (both extrinsic and intrinsic in networks), computational analyses were conducted on data for young children feeding practices obtained by the South Asian Infant Feeding Research Network (SAIFRN) (Godakandage et al., 2017). The initial procedure encompassed processing of the primary data to draw out the common nodes existing in both separate funding and technical support networks to assist in comparison. Subsequent to this, UCINET (Borgatti et al., 2002) was incorporated to determine the correlation and regression statistics for the two aforementioned networks. Additionally, similar computational processes were also applied to node-attributes portraying information on support required, socioeconomic status as well as actor-type. Statistical findings were determined for both countries of Bangladesh and Sri Lanka.

The intent is to understand the connection between the funding and technical support networks and to determine the predictability between node-attributes and parallel networks. With reference to figure 5, correlation and regression allow prediction on network structures at points t_2 and t_3 to be made, if given sufficient data from a further developed parallel network at time t_1 (where $t_3 > t_2 > t_1$). From this, network structures can be designed specifically to context.

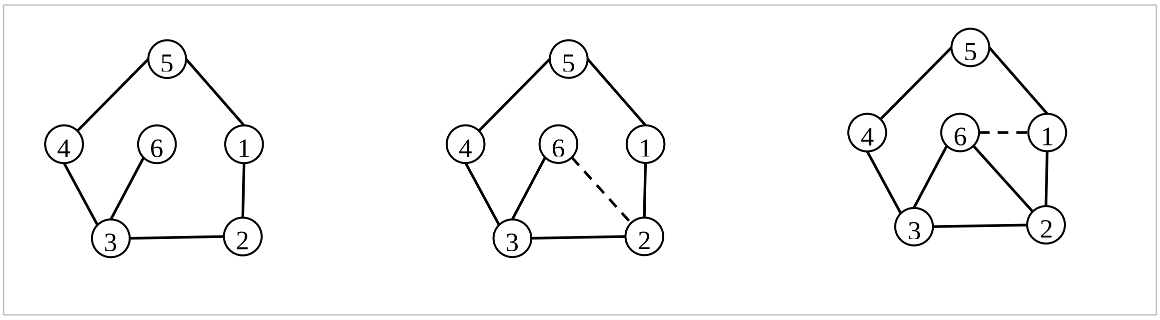

Figure 5: Stakeholder network at t_1 (left); t_2 (centre); and t_3 (right) based on abstract data

UCINET (Borgatti et al., 2002) was employed in the process of analysis. This incorporates the QAP procedure (Dekker, Krackhardt, & Snijders, 2007; Hubert, 1986; Hubert & Schultz, 1976; Mantel, 1967), a developed form of correlation (Pearson, 1897) and regression analysis used to analyses matrices. An advanced form of QAP known as the Double-Dekker Semi-Partialling Multiple Regression Quadratic Assignment Procedure (Dekker et al., 2007; Dunn & Clark, 2009; Parker, 2017) was employed for regression analyses. The relevant processes are specified in the following sections. The findings' results, as well as implications are also explored.

2.2.1 Quadratic Assignment Procedure (QAP)

The Quadratic Assignment Procedure (QAP) is a developed form of analysis that has been incorporated in this investigation to determine the correlation and regression constructs between matrices (Dekker et al., 2007; Hubert, 1986; Hubert & Schultz, 1976; Mantel, 1967). A distinction exists between correlation and regression. Specifically, correlation is defined as a way of determining how patterns of one network are similar to those in another (Parker, 2017) or the "pattern of relationships (of actors) with all other actors" (Hanneman & Riddle, 2005, p. 97). Whereas regression is an extended form of correlation and describes the correlation between two variables (Parker, 2017). Computational data science software can assist in the determination of the associated statistics for correlation and regression (Ong & Uddin, 2020).

2.2.2 Double-Dekker Semi-Partialling Multiple Regression Quadratic Assignment Procedure

One adaptation of the QAP is known as the Double-Dekker Semi-Partialling Multiple Regression Quadratic Assignment Procedure (Dekker et al., 2007; Dunn & Clark, 2009; Parker, 2017). This variation has been applied to various calculation processes, including those used by UCINET (Borgatti et al., 2002). Equations employed in the process of determining correlation (equation 1) and regression (equation 2) from the QAP method are presented in the following. Specifically, the regression coefficient value from equation 2 can be represented by a multiple regression relationship as shown in equation 3 (Keith, 2014; Krackardt, 1987).

$$\Gamma_N(\rho) = \frac{\sum_u^v q(o_u, o_v) C(\rho(u), \rho(v))}{\left[\sum_u^v q(o_u, o_v)^2 \sum_u^v C(\rho(u), \rho(v))^2\right]^{1/2}} \quad (1)$$

Where,
$\Gamma_N(\rho)$= correlation coefficient of a matrix;
$q(o_u, o_v)$= data matrix to a corresponding matrix C; and
$C(\rho(u), \rho(v))$= entries to the permutated matrix of C

$$\hat{\beta}(\pi(\hat{\epsilon}_{XZ}), \mathbf{X}|\mathbf{Z}) = \hat{\beta}(\pi\left(\left(\delta - \hat{\delta}\right)\mathbf{Z} + \mathbf{V}\right)) \quad (2)$$

Where,
$\hat{\beta}$= OLS estimator of β;
π= permutated matrix; and
X, Z, **V**= matrices
$\hat{\epsilon}_{XZ}$, $\delta - \hat{\delta}$= residuals

$$Y = a + b\boldsymbol{X_1} + b\boldsymbol{X_2} + e \quad (3)$$

Where, a= intersection;
b= beta weights;
e= residual; and
$\boldsymbol{X_1}$, $\boldsymbol{X_2}$= matrices

The computational methodology employed in this study is explored further in the following section. The findings and inherent trends and relationships are included within the subsequent sections.

3. Results

With respect to the country of Bangladesh, the results obtained for the Pearson Correlation Coefficient (PCC) observed value is 0.65 (table 2) which is very high, and the corresponding significance value is 0.002 which is very low indicating the importance of the determined correlation value. The PCC average correlation value is 0.0007 and this value is positive and therefore suggests that there exists a level of direct correlation. The standard deviation is 5.7% which points to a minimal differentiation from the average. Because of this, deviations are unable to substantiate a lack of correlation. The determined maximum value is 0.293 which is significantly larger than the minimum value of -0.069. In extension to this, the minimum correlation value is unable to offset the larger maximum value. The No. of observation parameter depicts the total number of permutations that have been used to determine the value. In this particular instance, a total of 5000 permutations have been used. The determined QAP value is 0.65 which is positive and close to 1. This portrays a proportional correlation between the two matrices.

Attributes of Pearson correlation coefficient (QAP Method)	Study side	
	Bangladesh	Sri Lanka
Observed Value	0.65	0.28
Significance	0.0002	0.0002
Average	0.0007	-0.0003
Standard Deviation	0.057	0.032
Minimum	-0.069	-0.087
Maximum	0.293	0.121
No. of observation	5000	5000
QAP	0.6500	0.28

Table 2: The result for network correlation between funding and technical support networks from the quadratic assignment procedure

Within the country of Sri Lanka, the computed PCC is small (0.28) however, it is still positive (table 2). This means that the correlation nonetheless remains directly proportional. The small significance value of 0.0002 explicates that the value is of importance. The determined average PCC value is -0.0003. Although this value is negative and suggests an inverse correlation relationship, as the number is very small, the inverse relationship is negligible. The standard deviation is 0.032 and communicates that a proportion of scores depicts a positive correlation when applied to the average PCC result. The maximum value determined is 0.121 and the minimum value determined is -0.087. Due to this, it can be understood that the majority of values suggest a positive and directly proportional correlation value. The No. of observation depicts that 5000 permutation values were utilized to determine the correlation relationship.

It is imperative to note, however, that the network correlation analyses only provide information on whether a co-evolution exists between the networks and does not provide quantification on the network connectivity or the magnitude of change within one network relative to another.

For the country of Bangladesh, the determined R squared value is 0.43 (table 3), which suggests that there is a positive level of regression between the two parallel networks. The P-value is low, substantiating the significance of the determined regression value. The unstandardized coefficient is

0.65, which is very close to 1, and this communicates an incontestable level of regression. Of note, the standardized coefficient is higher than the unstandardized coefficient. The adjusted R squared is lower than that of the R-square value and this is as expected. The standard error is relatively low (6%), and a total of 2000 permutations had been implemented. The regression link for Sri Lanka is not as strong as it is for Bangladesh. Despite this, the level of regression is nonetheless direct. The determined R^2 and adjusted R^2 values are both small; however they are positive. The standard error value is low, suggesting the high accuracy of the results. Moreover, the low p-value points to the significance of the determined values. The computation has undergone a total of 2000 permutations.

Parameter from network regression analysis	**Study side**	
	Bangladesh	**Sri Lanka**
R Squared	0.43	0.08
Adjusted R Squared	0.43	0.08
P-value	0.0005	0.0005
Number of Observed Values	552	3906
Permutations	2000	2000
Un-standardised	0.65 (intercept 0.02)	0.14 (intercept 0.02)
Standardised Coefficient	0.65	0.28
P-value	0.0005	0.0005
Standard Error	0.06	0.02

Table 3: The result for network regression between funding and technical support networks from double-dekker semi-partialling multiple regression

The previous sections encompassed the analyses of relationships on a macro level. On the other hand, the sections in the following determine the relationships on a nodal-attribute level. Particularly on the level of support required by actors, actor-types as well as socioeconomic background. These inter-relationships are also drawn back to the technical support and funding networks to explicate any affiliations.

Further research has been conducted to determine the relationship between groups situated within the divisions of attribute categories. Analyses have mainly been conducted on the networks of Bangladesh for correlation and regression within both the funding and the technical support networks. The three categories of attribute networks, as previously mentioned include actor type, socioeconomic status (height of tower) as well as the level of support corresponding to each actor of the common nodes shared with the funding and technical support networks of Bangladesh. The findings on multiple regression of attribute networks are conveyed in the following section (table 4).

	Bangladesh		Sri Lanka	
	Adjusted R^2	P-value	Adjusted R^2	P-value
Model	0.4	0.0005	0.08	0.0005
Attribute name	**Coefficient (β)**	**Coefficient (β)**	**Coefficient (β)**	**P-Value**
Actor Type	-0.003	0.007	0.007	0.4
Level of Support	0.1	0.03	0.03	0.04
Height of Tower	-0.2	-0.03	-0.03	0.01
Technical support network	0.7	0.3	0.3	0.0005

Table 4: Regression of actor attributes with the funding network of Bangladesh and Sri Lanka. Note: the above attributes have been regressed with the corresponding funding networks of the listed country

Within the country of Bangladesh, each attribute experienced a varied level of regression with the corresponding funding network. The technical support network experienced the greatest level of similarity with the funding network and the computed standardized coefficient was β = 0.7 (p = 0.3). This was followed by the matrix stipulating the level of support required by each actor (β = 0.1, p = 0.03). However, two of the four attributes experienced negative correlation relationships. With reference to the matrices for actor type and socioeconomic status, the standardised coefficients were β = -0.003 (p = 0.007) and β = -0.2 (p = -0.03), respectively. This suggests that the type of actor and the socioeconomic status (height of tower) are weak predictors when regressed with the funding network, as the standardized coefficients are comparatively small and negative. The level of support required by actors and the level of technical support offered by actors; however, serve as better predictors of the funding network.

The country of Sri Lanka experienced a similar trend when the attribute (actor type, level of support and height of tower) and technical support networks were regressed with the funding network. Similarly, the technical support network experienced the greatest level of similarity (β = 0.3, p = 0.0005), followed by the level of support network (β = 0.03, p = 0.04). Once again, the type of actor and socioeconomic status (height of tower) of the actors served as weak predictors. The regression values for these were even more negligible when compared with the country of Bangladesh with values of $\beta = 0.007$ ($p = 0.4$) and $\beta = -0.03$ ($p = 0.01$), respectively.

Hence, overall the level of support serves as the greatest predictor of the funding network with the largest magnitudes of standardized coefficients. Due to this, the level of support required between actors also affects the funding between actors, and in consequence, the funding network.

4 Discussion

Most current literature and research have centered on the development of statistical measures and theory or are contextually limited (Bao, Zeng, & Tay, 2013; Cimenler, Reeves, & Skvoretz, 2014; Putnik et al., 2016). This study provides an alternate practical application through an empirical analysis of young child-feeding practices within a real-life context and scenario. The correlation and regression analyses provide an understanding of the relationship and co-evolution between networks, which allows practitioners to apply the findings to predict the development of industry stakeholder networks at any particular point within time. The results are applicable to different industrial and practical contexts.

The findings are also functional within the specific context from which the data had been collected from. Notably, the yielded results can be used to support and promote the importance of nutritional children feeding practices (Black et al., 2008) through the developed understanding of funding and technical support evolution as well as distribution on the basis of attribute networks. To summarise, the yielded results have produced trends that support the presence of strong and inherent correlation and similarity between analogous networks.

It is apparent that there exists a level of correlation and regression between two analogous networks. Due to this, the pre-existence of a network serves as a precursor to the development of a corresponding network with the same node data set. Further to this, the socio-demographic attributes of nodes also exert significant influence on the development of stakeholder networks.

There are various causes that affect the presence of this similarity between parallel networks. One prominent and apparent factor includes the effect of the strength of ties. Granovetter's (Granovetter, 1973) concept purports that the close proximity and intimacy of the ties promotes the formation of ties. The existence of a prior tie also promotes the formation of other subsequent ties. This is befitting to the present scenario as the common nodes which have form relationships within the funding network may consequently do so within the technical support network. Further to this, the impetus for the development of ties is affected (to varying degrees), by individual actor attributes.

With reference to the previous, the findings from this investigation have produced results useful for practitioners and academics alike. Practitioners can incorporate data on individual attributes and parallel networks to determine and predict the formation of relationships between common actors. This ability is applicable to the micro- as well as macro-scales. This understanding of the co-evolving relationship is also impactful as it can be used to customize and design networks for specific projects. This knowledge is also useful to foresee and plan ahead, which ultimately provides greater space of improving the success and performance of the project. By monitoring the different phases of a project's progress, greater control can be attained, which enhances the project performance and success criterion. There are also possibilities for further investigation within this realm, as explored in the following section.

5 Conclusion

The findings within this research are significant, however, there are nonetheless some potential limitations within this study. These include; 1) presence of subjective data information, and because of this, the gathered data are prone to human errors during interview, transcription and/ or processing; 2) some computational results such as those corresponding to Sri Lanka, are not aligned with the anticipated expectations. Because of this, it is therefore imperative for further data to be gathered within similar contexts; 3) current literature has also expressed the limitations in the application of QAP (Krackhardt, 1992); hence other forms of analysis should be trialed and applied.

Avenues for further research include; first, application of techniques within other types of projects within the health sector (to clarify the accurateness of the applied research methodology) as well as within other industrial contexts (to confirm the applicability of the determined statistical values); second, other techniques for information and data gathering as well as analysis should be utilized for cross-referencing; 3) more detailed information with regards to each stakeholder attribute should be determined to develop a more refined understanding of the inherent relationships. This study has yielded significant findings, but further investigation will allow a more finessed understanding to be developed. The majority of the results processed have yielded results that produce trends that purport the existence of a level of correlation and regression present within parallel and analogous networks. Moreover, the analysis of nodal attributes suggests that relationship formation does form on the basis of individual actor attributes. Despite this, there have been occasional data and results which contradict this overall trend. Hence, further analysis will clarify and produce and shortcomings in the processed results within this investigation. The investigation has yielded detailed characteristics of the evolution of parallel networks. It is evident that information and knowledge on the development of one independent network can be employed to predict the structural pattern of a parallel social network structure.

The results additionally demonstrate that a network structure can be utilized to predict the co-evolution of a less-developed parallel network. Further to this, correlation and statistical regression measures assist in understanding the intrinsic dynamics of network structures. Consequently, managers can employ this understanding for use in predicting the co-evolution of analogous networks.

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Declaration

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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