Mutual dependency grid for stakeholder mapping: a component-based approach to supply chain participant analysis

Mutual Dependency Grid for Stakeholder Mapping
A Component-Based Approach to Supply Chain Participant Analysis

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Abstract: Stakeholder analysis plays a critical role in business analysis. However, the majority of the stakeholder identification and analysis methods focus on the activities and processes and ignore the artefacts being processed by human beings. By focusing on the outputs of the organisation, an artefact-centric view helps create a network of artefacts, and a component-based structure of the organisation and its supply chain participants. Since the relationship is based on the components, i.e. after the stakeholders are identified, the interdependency between stakeholders and the focal organisation can be measured. Each stakeholder is associated with two types of dependency, namely the stakeholder's dependency on the focal organisation and the focal organisation's dependency on the stakeholder. We identify three factors for each type of dependency and propose the equations that calculate the dependency indexes. Once both types of the dependency indexes are calculated, each stakeholder can be placed and categorised into one of the four groups, namely critical stakeholder, mutual benefits stakeholder, replaceable stakeholder, and easy care stakeholder. The mutual dependency grid and the dependency gap analysis, which further investigates the priority of each stakeholder by calculating the weighted dependency gap between the focal organisation and the stakeholder, subsequently help the focal organisation to better understand its stakeholders and manage its stakeholder relationships.

1 INTRODUCTION

Stakeholder analysis is the process of identifying all of the stakeholders that may affect or be affected by the proposed action or decision of a focal organisation (Freeman, 2010). Stakeholder analysis can therefore help an organisation understand its stakeholders' interests, in order to influence, facilitate or hinder their interaction with the organisation (Brugha and Varvasovszky, 2000). The majority of stakeholder analysis methods define the relationship between the organisation and its stakeholders by the degree of influence that the stakeholder has on the organisation, or by the activities performed by stakeholders.

Activity theory (Engestrom et al., 1999) adopted an activity as an analysis unit and stated that an activity model contains subject, object and tool. The object of one activity model can be the object or tool of another activity model. A set of objects and tools can be categorised as artefacts, which allows them to be distinguished from human subjects and activities. Hence, elements within an organisation include: activities, artefacts and human beings. Human beings are the stakeholders, and activities are the tasks the stakeholders perform. Whilst the majority of stakeholder analysis methods focus on the activities and human beings, there is little attention paid to artefacts. Artefacts are the materials, parts, services, components and products, which are the objects that are modified and processed by activities. The interdependence between those artefacts represents the artefact view of organisation process. For artefacts to move along the production flow, every artefact instance depends on a process; normally involving human being to process it. As artefacts are often directly involved with human activity, the relationship between artefact instances can further reveal the relationship between artefacts and human beings; i.e. artefacts can be used as the base for stakeholder identification and analysis (Pan et al., 2012).

In this paper, we adopt a novel approach that focuses on the dependency between outputs and components, and propose a mutual dependency grid for stakeholder mapping. We first define the relationship between outputs, components and supply chain participants as stakeholders, in order to

develop an artefact-oriented conceptual structure of the supply chain. The component-based structure can be further utilised to examine an organisation's relationship with its primary stakeholders who are also the supply chain participants. Information concerning the focal organisation's dependency on the stakeholder, and the stakeholder's dependency on the focal organisation, helps us generate a grid to categorise stakeholders into four groups, namely critical stakeholder, mutual benefits stakeholder, replaceable stakeholder and easy care stakeholder. The result of the stakeholder dependency grid supports an organisation to better manage its relationship with its primary stakeholders.

2 STAKEHOLDERS AND COMPONENTS

2.1 Stakeholders and Supply Chain

The first step of stakeholder analysis is normally stakeholder identification. Numerous approaches of stakeholder identification have been developed and the approaches include engaging domain expert, brainstorm self-selection, engaging internal staff, analysing existing documents and reports, or using a pre-defined stakeholder checklist (Chevalier and Buckles, 2008, Calvert, 1995). Stakeholder identification generally produces a list of interest groups and individuals to be assorted and managed in the later stages of production. It is difficult to identify all of the stakeholders, however, because there can be so many stakeholders that the organisation might not even know about. Instead of trying to identifying an endless list of stakeholders, most stakeholder analysis techniques aim to cover the key stakeholders that actually influence the organisation.

In principle, stakeholders can be categorised into primary stakeholders and secondary stakeholders; by considering the level of their direct involvement in an organisation's economic transactions (Darnall et al., 2010). Primary stakeholders include supply chain participants and internal members of an organisation (Freeman, 2010). Supply chain stakeholders include all participants in the supply chain; i.e. from the raw materials suppliers to the end consumers. Secondary stakeholders are not involved directly in the organisation's primary activity; and include social stakeholders, such as public interest groups, professional groups, and environmental regulators (Mitchell et al., 1997, Darnall et al., 2010, Waddock and Graves, 1997, Etzion, 2007). Supply chain is the network of organisations, people, activities, services, technologies, information, materials and resources involved in the making of a final goods or services required by the end customer (Mentzer et al., 2001). Supply chain is theoretically rooted in the theories of value chain, which is used to understand where value is being added when a product is made or an activity undertook. Value chain analysis enables an organisation's management to understand where the most value or profit is achieved, and therefore decide what part of the chain can be improved. The value chain was initially developed by Porter (1985) in the manufacturing domain, and it has been adopted in various contexts, including examining service based organisations (Rieple and Singh, 2010). A value chain covers all of the activities and individuals required to produce the final product, i.e. from the very beginning of production to its end consumer through various actors (Chopra and Meindl, 2010, Porter, 1985). Closely related to the value chain, supply chain encompasses the entire value chain, but focuses, however, only on the strategically important suppliers in the value chain (Tan et al., 1999). Accordingly, supply chain management refers to the strategic relationship management between all of the participants in the chain, and the comprehensive arrangement of value-adding activities and materials processed in the network (Tan, 2001, Croom et al., 2000). Since all of the organisations and people in the supply chain are inevitably involved with each other to various degrees, an organisation's stakeholders shall include all of the participants in the organisation's supply chain.

Stakeholders are those who interact with an organisation, and supply chain participants include all of the organisations and people involved in the entire production process; i.e. from the raw materials and services to the final product delivered to its end consumer. Hence, supply chain naturally provides a path to link all stakeholders. In this paper, we focus on the primary stakeholders due to their direct financial and operational influences on the organisation.

2.2 Outputs, Components and Stakeholders

A 'product' is the final artefact of a company's processes, and is the output that is received by an organisation's customer (Rummler and Brache, 1995). An organisation can be considered as a

system, which has specific inputs and outputs. The system itself may consist of sub-systems that perform selected parts of the tasks required within the production process, in order to make the product. Materials and parts are therefore modified and passed from one sub-system to another, which ultimately defines the total supply chain of the final product output. By viewing the output supply chain as an analysis unit, an organisation, as well as its supply chain, can be conceptually structured into segments based on the parts that each supply chain produces. The end-output requires various raw materials, parts and components, which are processed and modified along the chain. Products can therefore be broken, down into components; which in itself is the output product of a specific supplier. Each component is formed by sub-components, which can also be seen as components at a smaller scale. The term 'component' refers to any type of raw materials, parts or services that is required in order to deliver a product that is desired by the end customer of an organisation. The breakdown of the final output into components could reflect the interaction of suppliers in the supply chain, and should stop at the level where the component is still meaningful to the organisation. For example, if laptop is considered as the final output, several components are required in the production process, including: the processor, operating system, LED screen, webcam, memory, hard disk drive, battery, etc. A processor is a component, but it has sub-components, such as ALU (Arithmetic Logic Unit), control unit and registers. In the context of a laptop, a combined chip is required to produce the product; so separated discussion concerning ALU and control unit design is not required as this is not meaningful to the organisation.

There is, therefore, an interdependent relationship between the output and its components. Components are needed to produce an output and the component would not be produced if there were no demand for it. A component, however, can be used within the production of more than one output. The more products a component contributes to, the less dependent a component is on the production of a specific product. If, however, a component becomes unavailable, potentially the production of the product would have to stop, unless an alternative equivalent component could be sourced. The alternative component might already exist within the system supply chain, yet may have to be sought from an external supplier. If there is no alternative for a specific component, then output production is highly dependent on securing future component production.

3 COMPONENT-BASED STAKEHOLDER IDENTIFICATION

3.1 Output Identification

Our method of stakeholder mapping focuses on the focal organisation's supply chain participants. In order to identify the focal organisation's supply chain participants, it is necessary to first identify the outputs; which might be goods, services or even a combination of both, depending on the nature of the focal organisation, a full list of focal organisation output should be produced.

3.2 Component-Based Structure

The concept of product breakdown structure (Lock, 2007) was adopted to develop the component-based structure, which helps us understand the relationship between an output and its components. The development of a product breakdown structure hierarchy focuses on only components that are critical to completing the final product. By viewing the project as the organisation's final output, the product breakdown structure can be used to define a hierarchy structure that considers only the output and its specific components. The principle of product breakdown structure can be used to demonstrate the structure of an output and the relationship between the output and its components. Instead of a project, the focal organisation output sits at the top of the hierarchy tree.

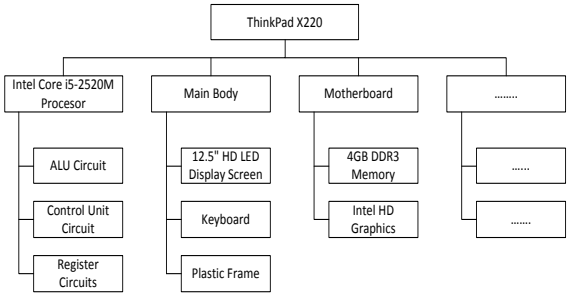

Figure 1 Component-Based Structure

Figure 1 shows a component-based output structure for the ThinkPad X220 laptop. Not only does it show the physical construction of an output, but

generates a mirror of the output structure in the conceptual world. It forms a network of interdependent artefacts, i.e. the conceptual counterpart of the relationship map describing outputs and components in the real world. Each component in the component-based structure contains rich information about the components in terms of producers, sub-components, related products, location etc. The data and information is not treated as an object in the component-based structure, but as part of the component. This rich information, which is contained at the component level, can then be used to provide analysis concerning each component part and/or the output as a whole.

3.3 Component Description

Once the component-based structure is produced, a component description is needed to identify related stakeholders, and the dependence of the focal component within the focal output. A component description should contain information including component name, unique identifier, sub-components, place / date of production, producer, current location, lead-time and products. Component name is the term that is known to people. Unique identifier is a unique combination of letters and numbers, which is machine-readable. Sub-components are a list all of sub-components required to produce this component. Producer is the maker who put the required sub-components together to produce the component. Place/date relates to manufacture, and location relates to components current position in the supply chain. Lead time shows how long it takes for the component to be delivered to the output making location once requested and ordered. Output list shows outputs that depend on this component. More columns can be added as required to support supply chain analytics. The component description provides essential information based on the component and therefore enables component-based stakeholder identification, analysis and component planning.

Table 1 is an example component description for a computer motherboard. We take a laptop manufacturer as the focal organisation of the analysis, so that the related outputs are the laptop and tablet models, from this particular manufacturer. However, the related products would cover laptops and tablets from other manufacturers, if the focal organisation of the analysis is the whole laptop industry, instead of a particular laptop manufacturer. Accordingly, it can be seem that it depends significantly on the scope of the stakeholder analysis that the analyst intends to cover.

Table 1 Component Description Example

Component description	
Component name	Motherboard
Unique identity	P8Z68-V PRO/GEN3
Sub-components needed	4GB DDR3 Memory, Intel HD Graphics chip
Producer(s)	Intel
Location	Penang, Malaysia
Lead time	5 working days
Contributes to (which output(s))	ThinkPad X1, X220 Tablet, X220, W520, T420s, T420, T520
Alternatives	XKT-1155 Z68AP-D3 P8H61-M LE/USB3

3.4 Stakeholder Identification

By identifying the components within an output, the stakeholders related to output are naturally identified due to the direct link between components and its producer/supplier. Hence, an output to components structure diagram inevitably reveals the stakeholder relationship map of a given set of outputs, components and sub-components. Figure 2 demonstrates a simple transformation from a component-based structure to a stakeholder relationship map. By replacing the component with the producer/supplier of each component, a stakeholder map of an output can be produced, as shown on the right hand side of the diagram. Not only does the stakeholder map show the relevance of stakeholders, by considering the interdependence between outputs and components, it is possible to see the degree of influence that stakeholders have, and the level of dependency that the focal organisations have, upon the stakeholder.

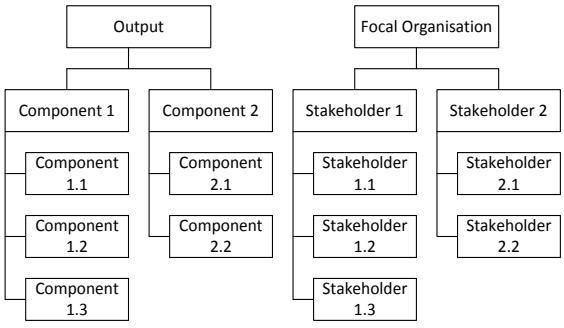

Figure 2 Components and Stakeholders

Stakeholder information is included within the component description, i.e. producer. Analysis can therefore identify all of the stakeholders, and

production processes, through the component description and relationship between components.

4 MUTUAL DEPENDENCY GRID FOR STAKEHOLDER MAPPING

Based on the information in the component-based structure and component description, the analyst can measure the dependence of components on the output, and the dependence of the output on the component. The interdependency between output and components directly reflects the importance of the relationship between the focal organisation and its stakeholders. There are two types of dependence to be measured for each stakeholder. One is the stakeholder's dependence on the focal organisation, and the other is the focal organisation's dependence on the stakeholder. Stakeholder's dependency on the focal organisation indicates whether the stakeholder needs the transactions with the focal organisation to sustain its operation; e.g. if the focal organisation is the sole customer of the stakeholder, the stakeholder would not be able to operate without the consumption of the focal organisation. In contrast, the focal organisation's dependency on the stakeholder shows whether the input from the specific stakeholder is essential to the focal organisation; e.g. if the specific stakeholder is the sole supplier of a major component in a focal organisation's product, the focal organisation would have a high degree of dependence on the stakeholder producing that component. Both types of dependency are affected by a number of factors, which will be considered in the next sections.

4.1 Stakeholder's Dependency on the Focal Organisation

A stakeholder's dependency on the focal system can be measured by considering the importance of the component to the stakeholder, the availability of alternative organisation consumers of the component, and whether the focal organisation is the key consumer of the component.

4.1.1 Importance of the Component to the Stakeholder

The importance of the component to the stakeholder also plays a key role in assessing the stakeholder's dependency on the focal organisation. This is the key factor impacting the stakeholder's dependency on the focal system; as the stakeholder relationship and dependency is essentially built around the component, and the overall dependency is tightly based on the importance of the component to the stakeholder. If the component, as an output of the stakeholder, only accounts for a small part of the stakeholder's output portfolio, change related to the transaction of the component between the stakeholder and focal system will not have a great influence on the stakeholder. However, if the component is responsible for the majority of the stakeholder's operation, any change to the supply of the component to the focal organisation could severely influence the stakeholder's operation. In addition to the above issues, other social and economic factors should be also taken into consideration whilst assessing the importance of the component to the stakeholder; e.g. the long term development of the component and the brand value of the component. Hence, an index can be generated, considering all of the factors, which represents the importance of the component to the stakeholder. The index should range from 0 to 5; with 5 indicating that the component is critically important to the stakeholder, and 0 indicating that the component has no importance to the stakeholder at all.

4.1.2 Alternative Organisation for the Stakeholder

The number of the alternative customers for the component indicates whether the stakeholder can supply the component to other customers if the focal organisation was to stop buying this specific component. If the focal organisation is the only consumer of the component, this particular stakeholder's operation potentially relies on the focal organisation; since there will be no demand for the component when the focal organisation stops consuming the component. However, the stakeholder might supply the component to other organisations apart from the focal organisation. In this case, the stakeholder's dependency on the focal organisation would be much lower; especially if the focal organisation is not the stakeholder's major customer, and/or the stakeholder supplies most of the output to other organisations.

Instead of the actual number of alternative component customers, an alternative component consumer index should be generated; using a scale from 0 to 10. 10 refers to little or no alternative customer for the component, and 0 means significant availability of alternative customers for the

component. The actual number of alternative component customers can vary significantly for each component; hence it is necessary to use a generated index number in order to keep the overall dependency index in a rational and comparative range.

4.1.3 Focal Organisation's Consumption of the Component

The percentage of components consumed by the focal organisation, out of the total sum of components produced by the stakeholder, indicates the importance of the focal organisation as a customer of this specific component to the stakeholder. Although focal organisation consumption is perceived as being less significant, it still provides useful information when assessing the overall dependency of the stakeholder on the focal organisation. The focal organisation's consumption of the component should also be defined using an index range from 0 to 10. 0 implies that the focal organisation has no consumption of the component, and 10 means that the focal organisation consumes the majority of the component.

4.1.4 Overall Stakeholder's Dependency on the Focal Organisation

Accordingly, a stakeholder dependency index (SDI) number for each stakeholder can be calculated. The component importance index is presented as SF1 (from 0 to 5); alternative organisation index as SF2 (from 0 to 10); and focal organisation's consumption index as SF3 (from 0 to 10) respectively. Since the dependency is essentially based on the relationship developed, the component importance index (SF1) is used to weight the other two factors of stakeholder's dependency on the focal organisation. The overall stakeholder's dependency on focal organisation can therefore be calculated using the equation:

$$SDI = SF1 \times (SF2 + SF3) \quad (1)$$

The calculated stakeholder's dependency on the focal organisation index should range from 0 to 100. Each stakeholder, which is identified through a component, should be measured for this dependency index. The index indicates one side of the dependence between the focal organisation and its stakeholders. Once this dependency has been measured, the other type of dependency needs to be measured through the factors that influence the focal organisation's dependency on the specific stakeholder.

4.2 Focal Organisation's Dependency on the Stakeholder

The focal organisation's dependency on each stakeholder indicates whether the specific stakeholder has a major influence on the related outputs and the focal organisation. The dependency can be determined by considering the importance to the outputs that use the component to the focal organisation, the availability of alternative components, and the portion of the component consumed by the focal organisation.

4.2.1 Importance of the Output to the Focal Organisation

If the outputs/products that require the component are the main outputs to the focal organisation, the focal organisation relies on the stakeholder to meet the majority of its customer's needs. An output importance index can be generated on the scale of 0 to 5, which reflects the importance of the dependant outputs to the focal organisation. The greater the number, the higher the perceived importance of outputs, to the focal organisation is, which require the specific component. The assessment of the importance of outputs should take into consideration factors including: the profits generated from the outputs, the long-term strategy for the outputs, and factors concerning diplomatic, cultural and financial dimensions.

4.2.2 Alternative Component Availability

The availability of an alternative component determines whether the focal organisation can continue producing the output, by sourcing an alternative component if the original component becomes unavailable. The cost of using an alternative component has to be taken into consideration. If the cost of an alternative component is high, i.e. it makes the total cost of output uncompetitive in the market; the availability of the component should be marked as low, even if there is an alternative available. If the focal organisation cannot get hold of an alternative component, the stakeholder who produces the component is deemed as being vital to the operation and viability of the focal organisation. In addition to the cost of the alternative component, the quality of the alternative component has to be also taken into consideration. The alternative component has to pass the quality control of the focal organisation to be eligible as an alternative supplier. For the alternative

component index, 0 means a supply of alternative component is not a concern, and 10 means no or a very limited number of alternative components is available.

4.2.3 Component's Importance as a Resource to the Focal Organisation

If stakeholder components represent a high proportion of resources consumed by the focal organisation, it implies the focal organisation currently has a high dependency on the stakeholder; i.e. the greater the proportion, the stronger the dependency of the focal organisation on the stakeholder. If the focal organisation uses a large portion of the specific component within the manufacturing of its product, production is much more likely to be under threat; there is a bigger change of risk, if the supplier stops production. Hence, this factor addresses whether this particular component accounts for the major input of the focal organisation. The component's importance as a resource to the focal organisation should be assessed in the form of index ranging from 0 to 10. 10 means that the component is a very significant resource to the focal organisation, and 0 means that the component is responsible for no part of the resources required by the focal organisation.

4.2.4 Overall Focal Organisation's Dependency on Stakeholder

The three factors described above can be used to decide the focal organisation's dependency index (FDI). The importance of the output to the focal organisation is presented as FS1 (0 to 5); the availability of alternative component as FS2 (0-10); and the component's importance as a resource to the focal organisation as FS3 (0-10). The stakeholder relationship and dependency is developed on the component, and the component is related to the focal organisation through the related outputs. More importantly, the stakeholder's influence on the focal organisation is entirely based on the outputs that require the component from the stakeholder. Hence, the importance of the related outputs to the focal organisation is used to weight the other two factors, in order to measure the focal organisation's dependency on the stakeholder. Hence, the focal organisation's dependency on the stakeholder can be measured using the equation:

$$FDI = FS1 \times (FS + FS3) \quad (2)$$

The calculated focal organisation's dependency on the stakeholder should also range from 0 to 100.

4.3 Stakeholder Dependency Grid

Once both dependency indexes have been measured for each identified stakeholder, i.e. SDI and FDI, this can be placed into a two dimensional grid. Depending on the dependence between the focal organisation and the stakeholders, stakeholders can therefore be categorised into four different types, namely critical stakeholder, mutual benefits stakeholder, replaceable stakeholder, and easy care stakeholder; as shown in Figure 3.

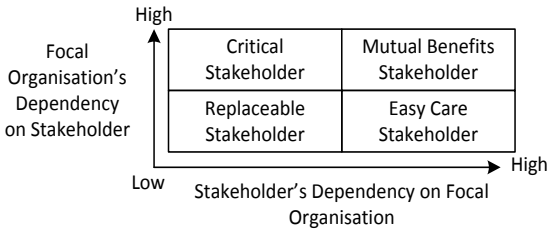

Figure 3 Mutual Dependency Grid

4.3.1 Critical Stakeholder

Critical stakeholder refers to stakeholders who have a low level of dependency on the focal organisation, but on which the focal organisation has a high level of dependency. This type of stakeholder does not heavily rely on the focal organisation and can still operate well without the focal organisation. However, the focal organisation relies on the stakeholder significantly and might not be able to operate without the stakeholder. The focal organisation should pay more attention to the relationship between this type of stakeholder and itself, because the focal organisation needs the stakeholder much more than the stakeholder needs the focal organisation.

4.3.2 Mutual Benefits Stakeholder

Mutual benefits stakeholders rely on the focal organisation heavily, and the focal organisation also relies on the mutual benefits stakeholders significantly. Because the focal organisation and the stakeholder rely on each other, and cannot afford to lose each other, the relationship between them tends to be stable and requires less attention from both sides. The strong interdependency between mutual benefits stakeholders and the focal organisation could sometimes lead to the strategic alliance or

integration to maximise the benefits of this mutual relationship.

4.3.3 Replaceable Stakeholder

Replaceable stakeholders are the stakeholders who have mutually low dependent relationship with the focal system. This type of stakeholder does not necessarily require the focal organisation's consumption of its output, which is a component to the focal organisation, to survive, because there are other organisations that consume the component. On the other hand, the focal organisation can replace the stakeholder with other component producers easily, because there are plenty of alternatives sources of the component. The relationship between a replaceable stakeholder and the focal organisation can be reasonably stable but not particularly solid.

4.3.4 Easy Care Stakeholder

Easy care stakeholders are those who depend on the focal organisation significantly, but the focal organisation does not depend on them much. Due to the unbalanced dependence in favour of the focal organisation, this type of stakeholders would normally be keen on keeping its relationship with the focal organisation. A stable relationship between the stakeholder and the focal organisation means much more to the stakeholder than to the focal organisation. In this case, it requires little attention from the focal organisation to maintain the relationship.

4.4 Dependency Gap Analysis

The four types of stakeholders demonstrate an overall picture of stakeholder relationship mapping. Moreover, the priority of each stakeholder can be further calculated using FDI and SDI. The focal organisation's dependency gap (FDG) uses the weighted difference between FDI and SDI, shown in Equation 3, to reveal the priority of each stakeholder.

$$FDG = FDI \times (FDI - SDI) \quad (3)$$

When FDI minus SDI is a minus result, the focal organisation is at a more powerful position than the stakeholder; a positive figure indicates the stakeholder is in a stronger position that the focal organisation; and a zero means the equal mutual benefit to both sides. By weighting the difference with FDI, FDG shows the dependency from the perspective of the focal organisation. The higher the FDG is, the higher prioritised the stakeholder should be.

In contrast, the dependency gap can also be viewed from the stakeholder's perspective using the equation, calculating stakeholder's dependency gap (SDG):

$$SDG = SDI \times (SDI - FDI) \quad (4)$$

Both FDG and SDG range from -1000 to 1000, and they demonstrate the priority of stakeholders for the focal organisation and the priority of the organisations to each stakeholder. Due to the original purpose of the analysis, it is likely that a focal organisation, rather than a stakeholder, would conduct the gap analysis, since the component-based stakeholder identification and stakeholder dependency grid are to help a focal organisation understand its stakeholders. However, SDG still provides a different insight into the stakeholder's perspective. To sum up, this dependency gap analysis helps an organisation further prioritise its stakeholders and vice versa. Even when the differences between FDI and SDI are the same for two stakeholders, their priorities still can be distinguished.

5 DISCUSSION AND CONCLUSION

Most business analysis methods use activities or processes as the basis of analysis and modelling. By separating the elements in an organisation into artefacts, activities and human beings, we suggest that artefacts can also be used as a basis for analysis and modelling. The artefact-centric approach focuses on an organisation's conceptual structure based on artefacts. Unlike activity-focused modelling, artefact-centric modelling does not rely on the sequence of activities. The artefacts are linked via their interdependency. When the relationship between artefacts is output-component relationship, the component will need to be sourced or produced before the production of the output can take place. However, the existence of the component does not necessarily lead to the production of the output, and the relationship between them is not sequential. Between the artefacts, as components, required by the same artefact (output) there is also no sequential relationship at all. There is no specific order in which the components need to be sourced for the production of the output. As long as the required components are sourced, the production of the

output can be done, and the sequence of components is irrelevant. Therefore, the artefacts can be viewed and modified independently without affecting other artefacts, while they are still ontologically interdependent. This feature enables the flexibility of artefacts as a base for business process modelling and analysis.

Following the artefact-centric approach, the component-based structure and component description can provide an alternative approach for stakeholder identification production planning, whilst the mutual dependency grid provides a novel approach to stakeholder mapping. More importantly, the component-based structure and the rich information contained in component naturally form a network of connected artefacts, which enables analysts to view the organisation through the artefacts being processed. This network view of organisation can be used to simulate the supply chain of each end output, and produces an output structure based on its components. All supply chain participants, i.e. primary stakeholders, can therefore be identified through the component-based structure of each output. Compared to other commonly used stakeholder identification methods, component-based stakeholder identification provides a solid and systematic foundation to stakeholder analysis, due to the dependent relationship between components and the final outputs. Since the supply chain relationship is essentially formed through the exchange of components, an artefact-focused approach can provide an alternative pathway to stakeholder analysis. As stated above, this method considers primary stakeholders, and it would require adoption in order to consider secondary stakeholders. Since there are many well established stakeholder analysis methods that help analyst identify secondary stakeholders, the analyst can choose a suitable one that fits the purpose of the analysis. The mutual stakeholder dependency grid distinguishes itself from other stakeholder mapping grids by focusing on the direct link between an output, its components, and the related supply chain participants identified through this direct link. Although two dimensional grids are commonly used to group stakeholders, the mutual stakeholder dependency grid focuses on the interdependency between an organisation and its stakeholders, which has not been used as stakeholder grouping parameter. Furthermore, the component-based stakeholder dependency analysis grid provides a new insight into the relationship between an organisation and its stakeholders, which provides the organisation with a better understanding of its supply chain participants. The mutual dependency grid could help an organisation decide how to prioritise its various stakeholders. An organisation can plan their long-term strategy with their supply chain stakeholders according to the type of the stakeholders in the mutual dependency grid.

The business environment is dynamic and constantly changing, and the relationship between an organisation and its stakeholders would not stay the same forever. Hence, periodical reassessment of stakeholder dependency is necessary to ensure the accuracy of the stakeholder mapping in the mutual dependency grid. Additionally, the dependency gap analysis further defines the priority of stakeholders by considering the gap between two types of dependency indexes with the related dependency index as a weighting parameter. Overall, the component-based method for stakeholder analysis and the mutual stakeholder dependency grid presents a novel approach in the field of stakeholder analysis and supply chain management. The method presented in this paper can be used as the principle foundation for the development of a more advanced analysis method for more complex business environment. Future research should focus on the further development of this method for more dynamic and complex supply chain environment, and apply it to real world examples for empirical validation.

Nevertheless, the mutual stakeholder dependency grid provides an artefact centric view of an organisation, which can facilitate the capture of information about components. By using the information stored in each component, an organisation can keep track of all stakeholders and/or processes involved in the production of each specific instance of an output. If a problem occurs with a component, or sub-component, then the producer knows instantly which stakeholders / processes are affected, and potentially which end output customers will be affected; supporting future improvements in the supply chain, and appropriate risk assessment concerning product recall.

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