

ASSESSING STAKEHOLDER NETWORK ENGAGEMENT

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Structured Abstract

Purpose: With the popularity of social media platforms, firms have now tangible means not only to reach out to their stakeholders, but also to closely monitor those interactions. Yet, there are limited methodological advances on how to measure a firm's stakeholder networks, and the level of engagement firms have with these networks. Drawn upon the customer engagement and stakeholder theory literature, this study proposes an approach to calculate a firm's Stakeholder Network Engagement (SNE) index.

Design: After deriving the SNE index formula mathematically, we illustrate how the SNE index functions using eight firms' online Corporate Social Responsibility (CSR) networks across four diverse industries.

Findings: We propose and illustrate a new approach of capturing the SNE in a stakeholder network for use by academic and practical researchers.

Research limitations/implications: Researchers can use the SNE index to assess engagement in stakeholder networks in various contexts.

Practical implications: Managers can use the SNE index to assess, benchmark and improve the nature and quality of their CSR strategies to derive greater return on their CSR investments.

Originality: Building on the stakeholder, communication and network analysis literatures, we conceptualise SNE in four theoretical dimensions: diffusion, accessibility, interactivity, and influence. Then, we mathematically derive and empirically illustrate an index that measures SNE.

Keywords: Stakeholder Network Engagement; Corporate Social Responsibility (CSR); Stakeholder Relationships; Social Media; Stakeholder Multiplicity Theory; Metric Development

Suggested citation:

Okazaki, S. Plangger, K., Roulet, T., & Menendez Benito, H. (2020). "Assessing stakeholder network engagement." *European Journal of Marketing*, volume and page numbers forthcoming.

Assessing Stakeholder Network Engagement

Introduction

In the broader management literature, the concept of stakeholder has been used to understand how firms should address the demands of their environment and fulfil a societal mission beyond the relationship with their shareholders (Freeman, 1984). Besides defining and classifying stakeholders, research on stakeholder theory has increasingly conceptualised the facets of the relationship between the firm and its constituents as a network (Rowley, 1997) beyond the dyadic level (Alexander et al., 2018). Stakeholders expect firms to address not only their short-term needs (e.g., products, services, employment, financial support, etc.), but also their long-term needs (e.g., operating ethically, improving environmental and safety standards, contributing to society, etc.) that exist outside of transactions. While short-term needs can be identified through market and organisational research, long-term needs remain often hidden, thus requiring managers to establish relationships with stakeholders to discover and address these needs (Laplume et al., 2008). By conceptually examining these relationships from a network engagement perspective, this paper develops and tests a measurement index to aid the assessment of stakeholder engagement strategies on social media.

Mapping out a firm's stakeholder networks provides effective paths for building, cultivating, and sustaining stakeholder engagement through more participative corporate social responsibility (CSR) activities and dialogues (Korschun and Du, 2013). In the marketing literature, the concept of customer engagement has stressed the importance of interactions and co-creation with such audience (Broadie et al., 2011; Hollebeek et al., 2019; Naumann et al., 2020). Stressing the importance of a broader set of stakeholders to shape a firm's interaction with its environment, Svendsen and Laberge (2005) define a stakeholder

network as “a web of groups, organisations and/or individuals who come together to address a complex and shared cross-boundary problem, issue or opportunity” (p. 92). Within this web of relationships, Stakeholder Network Engagement (SNE) is seen a “whole system approach” of engaging stakeholders as a network rather than as individual actors (Svendsen and Laberge, 2005).

Conceptualising stakeholder engagement as engagement with a network accounts for the interrelated nature of different stakeholders' perceptions of the firm (Shymko and Roulet, 2017; Skilton and Purdy, 2017). While stakeholder networks depict how stakeholders are linked with each other and where the firm positions itself within this structure, stakeholder engagement captures the way firms mobilise those stakeholders and capitalise on their networks to build deeper relationships (Husted and Allen, 2011; Strand and Freeman, 2015). The network perspective has been used to considerably expand or refine a variety of constructs such as reputation or status (Van de Bunt and Groenewegen, 2007), but its application to the stakeholder relationship remains to be fully developed (Frooman, 1999). Thus, SNE is still in its infancy, not only in terms of conceptualisation, but also in terms of operationalisation (Korschun and Du, 2013; Svendsen and Laberge, 2005). While stakeholder networks are characterised by their centrality and density (Rowley, 1997), it is unclear how they reflect the way a firm engages with its network. Stakeholder network engagement may translate into positive stakeholder evaluations of the firm's CSR (Skilton and Purdy, 2017), but there certainly is much variation in the quality of that engagement (Dawkins, 2015). How can firms effectively engage with their network of stakeholders? What are the different aspects and levers of SNE? How can the level of SNE be empirically explored?

Social media platforms offer opportunities to further explore this concept and the operationalisation of SNE (Brodie et al., 2011; Hollebeek, 2011a, b; Hollebeek et al., 2014; Hollebeek et al., 2019; Pitt et al., 2019). Aguinis and Glavas (2012) stress the importance of identifying mediating mechanisms leading stakeholders to positively perceive, and engage with, CSR activities. Media, especially when non-hierarchical and participative, offer a way to preserve and foster relationships with stakeholders (Castelló et al., 2015; Roulet and Clemente, 2018). Social media, in particular, can enable favourably inclined individuals to pass on the information communicated by firms and thus create self-reinforcing mechanisms of information diffusion (Hollebeek et al., 2014; Clemente and Roulet, 2015). Some firms are already experimenting with social media platforms, such as Twitter, to further engage stakeholders in dialogues around their CSR activities (Lee et al., 2013; Okazaki et al., 2019). However, more research is needed to understand how firms develop deep relationships with stakeholders (Gambetti et al., 2017), which this article aims to address.

This article investigates the concept of SNE by identifying four key dimensions that distinguish different stakeholder engagement strategies, namely, diffusion, accessibility, interactivity, and influence. We mathematically represent those dimensions and simulate the dynamics of SNE by creating an index. In practice, the SNE index helps us improve the mediating mechanisms through which stakeholder communication on social media can effectively lead to positive outcomes for both firms and stakeholders alike. Second, we engage in an empirical application of this index to evaluate different stakeholder networks of eight existing companies on Twitter. We build on this empirical illustration to show how the SNE index can be used to dynamically assess the effectiveness of their stakeholder communication efforts.

This article makes several contributions to stakeholder theory, and more broadly to the customer engagement literature, both from the perspectives of theory and methodology, as well as provides an empirical application and practical guidance. Theoretically, by going beyond the network structure to focus on how firms use their stakeholder network, this article offers a systematic conceptualisation of SNE based on insights derived from the stakeholder, marketing, communication, and network literatures. Through the SNE index, firms can assess their stakeholder communication investments that would benefit them (e.g., more positive stakeholders' perceptions, increases in firm reputation, additional co-creation of value, etc.) by engaging the multiplicity of stakeholders in a two-way dialogue. Methodologically, this article operationalises SNE by constructing an index of SNE based on sophisticated network metrics. In doing so, it offers a novel, objective measure of stakeholder communication effectiveness beyond counting or self-reported metrics. Finally, managerially, the proposed index can provide quantitative assessments of the effectiveness of stakeholder communication activities. By enabling firms to capture the evolution of their stakeholder engagement through the SNE index, they can directly assess the effectiveness of their communication initiatives. In other terms, this index can be used by managers to not only assess the amount of SNE, but also to evaluate communication strategies.

Engaging with Stakeholder Networks

Stakeholder theory has become the primary paradigm for managers to consider and take action concerning the interests of stakeholders (McWilliams and Siegel, 2001). This theory advocates the firm's understanding of, and subsequent firm response to, relevant stakeholders and takes a broader approach to the firm's environment than some economic theories

(Donaldson and Preston, 1995). Freeman (1984, p. 46) is credited with beginning the discussion of the stakeholder concept in the management literature by broadly defining the stakeholder as “any group or individual who can affect or is affected by the achievement of the organization’s objectives.” Since then, the literature has argued about the exact meaning of stakeholders and many definitions have been proposed (Mitchell et al., 1997). Mitchell et al. (1997) narrow this definition to only those stakeholders with whom managers ought to concern themselves. They posit that power to influence the firm and the legitimacy of their relationship with the firm are the two key attributes in evaluating the salience of stakeholders (Mitchell et al., 1997; see also Dawkins, 2015; Neville et al., 2011). In identifying salient stakeholders, both researchers and managers aim to better understand value creation and exchange, and ethical implications of business activities, as well as to rethink firms’ responsibilities (Parmar et al., 2010; Maignan et al., 2005; Rivera-Camino, 2007).

By extending agency theory’s application to firms, stakeholder theory broadens the scope of managerial responsibility beyond shareholders to include other relevant stakeholders (Hill and Jones, 1992; Hult, 2011). There are six primary stakeholder groups of varying importance depending on the specific context—including customers, suppliers, employees, shareholders, regulators, and the local community—that are often examined with regards to their dyadic relationship with the firm (Hult et al., 2011; Payne et al., 2005). In the marketing literature, a range of work has focused on interaction and co-creation with customers as key stakeholders (Brodie et al., 2011; Hollebeek et al., 2019) with a focus on how they engage with the firm (Hollebeek, 2011b). More broadly, stakeholder theory has built upon the assumption that stakeholders form networks within which the firm positions itself (Rowley, 1997).

However, mobilising and capitalising on this network, its structure, and the firm’s position within this network, resides in another facet of stakeholder management: stakeholder engagement (Husted and Allen, 2011; Strand and Freeman, 2015). While marketing has led the way in engagement research in the customer context (c.f., Hollebeek, 2011a), the concept of engagement remains under researched in the stakeholder context.

Stakeholder Networks and Stakeholder Engagement

Firms often respond to, and communicate with, each stakeholder or stakeholder group discretely (Neville and Menguc, 2006). Yet, the focus on these dyadic relationships does not capture the wider stakeholder picture that stakeholder theory promotes. Firms often devote considerable resources to shared value co-creation and stakeholder engagement around their CSR initiatives (Frow and Payne, 2011; Donaldson and Preston, 1995; Mitchell et al., 1997). CSR describes the firm’s actions, over and above statutory requirements and self-interests that are intended to promote public goods (Besley and Ghatak, 2007).

Stakeholders exist in networks both within the stakeholder group and between groups, thus relationships can be very complex, and a dyadic perspective may be a potentially dangerous oversimplification of reality (Alexander et al., 2017). Rowley (1997) was the first to integrate the network aspect of stakeholder relationships, thus acknowledging the fact that stakeholders’ behaviours are interconnected beyond their individual links with the firm. Firms have to simultaneously manage multiple and potentially contradictory stakeholders’ expectations (Frooman, 1999). Recent theoretical developments keep pushing the focus away from the dyadic relationship perspective to a stakeholder multiplicity perspective (Danso et al. 2020; Hillebrand et al., 2015; Neville and Menguc, 2006).

Multiplicities are assemblages comprised of many individual elements and can be observed either as discrete or continuous (Deleuze, 1988; Hillebrand et al., 2015). Consider a forest as a multiplicity, as it is comprised of many individual trees. A forest can be viewed either discretely by counting the trees as individual homogenous elements, or continuously by appreciating the heterogeneity and diversity of the forest as a whole. In a similar manner, managers can observe groups of stakeholders either discretely and respond to their individual needs and concerns, or continuously and respond to the collective needs and concerns of all stakeholders together (Hillebrand et al., 2015). Such a whole system or network approach to the management of a firm's web of stakeholders requires the engagement of the network rather than isolated stakeholders (Svendsen and Laberge, 2005) involving two-way interactions (Hollebeek et al., 2011a) with various parts of the network. Customer engagement represents a smaller part of this jigsaw puzzle as it captures interactions with one set of stakeholders. Studies on customer engagement show engagement is dynamic and generated through an iterative process and multidimensional in nature (Brodie et al., 2011; Brodie et al., 2013). These are critical insights to understand how to dynamically engage with stakeholder networks.

Formally, *stakeholder engagement* is defined as "practices the organisation undertakes to involve stakeholders in a positive manner in organisational activities" (Greenwood, 2007, p. 315). This broad definition points out that stakeholder engagement is not the exclusive domain of any one business function, nor is it solely a concern for socially responsible firms. The network approach is justified by the different stakeholders' perceptions of the firm, which are deeply intertwined (Shymko and Roulet, 2017; Skilton and Purdy, 2017). One stakeholder group's perception of a firm's CSR depends not

only on how the firm addressed the needs of that group, but also on how it addresses the whole set of stakeholder constituents (El Akremi et al., 2015). Thus, taking a network approach to stakeholder engagement, the firm is more likely to translate CSR into positive stakeholders' evaluation towards the firm, which is the main managerial goal of CSR activities. The multiplicity perspective suggests, both theoretically and empirically, that firms must look at the dialogue of *all* stakeholders instead of responding to individuals or groups of stakeholders.

While Rowley (1997) investigated the characteristics of stakeholder networks, the literature offers little advice on how those characteristics translate into firms successfully engaging with their stakeholders. The network approach has considerably progressed since its first use in the field of stakeholder theory (Van de Bunt and Groenewegen, 2007), but stakeholder theorists can further build on this approach to develop instrumental prediction methods (Frooman, 1999). Beyond the exploratory work of Svendsen and Laberge (2005), the literature has only a vague conceptualisation of SNE and therefore there is little practical advice on the measurement and successful operationalisation of SNE to advance positive stakeholder and firm outcomes. Engagement relies on a multiplicity of dimensions (Hollebeek, 2011b; Brodie et al., 2013) and understanding how this multidimensionality can be applied to stakeholder network is key to strengthen our conceptualization of SNE. More specifically, understanding how stakeholders can positively perceive and engage with firms' CSR activities is a key mediator to understand the economic consequences of CSR (Aguinis and Glavas, 2012, Oh et al. 2016). By conceptually fleshing out the notion of SNE, both academics and practitioners can better understand the variance in firms' stakeholder engagement and how firms can transform their CSR investments into

positive stakeholders' judgments (El Akremi et al., 2015; Skilton and Purdy, 2017).

Stakeholder Network Engagement and Value Co-Creation

We envisage SNE as the extent of network interactions among stakeholders and with the firm. Considering that the objective of SNE is to positively affect stakeholders' evaluation of the firm, we turn toward the concept of value co-creation to further explore the concept of SNE and derive its theoretical dimensions. Stakeholder value co-creation has been the recent focus of marketing literature primarily centred around the customer (Grönroos and Voima, 2013; Hollebeek et al., 2014). Vargo (2011, p. 220) suggests that a "value co-creation model [. . .] sees all actors as resource integrators, tied together in shared systems of exchange." Stakeholders have an important, active role in shared value creation, and it is essential that managers understand how to co-create value with all stakeholders, not just customers and shareholders (Lusch and Webster, 2011).

The marketing and management literature often focus on customers or employees as dominant stakeholder groups, but those also include useful frameworks, models, and evidence that can assist in the understanding of stakeholder value co-creation in a broader sense. There are co-creation studies that investigate new product development (Hoyer et al., 2010), online brand communities (Brodie et al., 2013; Islam et al., 2018), co-created advertising (Berthon et al., 2008; Thompson and Malaviya, 2013), customer participation (Chan et al., 2010; Parent et al., 2011), customer empowerment (Füller et al., 2014), firm co-creation (Payne et al., 2009), and learning in customer-firm relationships (Payne et al., 2008). Shared value is produced by all stakeholders through a process of mutual adjustment (Ballantyne et al., 2011; Flint and Mentzer, 2006). However, without stakeholder

engagement, CSR stakeholder co-creation is not possible and investments CSR activities are not fully capitalised on (Okazaki et al., 2019; Visser, 2010).

Stakeholder engagement provides the required relationships, social capital, and stakeholder dialogues for any co-creation of CSR (Greenwood, 2007; Maak, 2007; Frow and Payne, 2011). Stakeholder dialogues are dynamic conversations within a stakeholder network that include a diverse collection of salient stakeholders and a firm. Previous research (Korschun and Du, 2013; O'Riordan and Fairbrass, 2008) into CSR and stakeholder dialogues provides a qualitative basis for investigation. Moreover, engagement can be measured not only with behavioural and attitudinal indicators, but also with customer network metrics (Kumar et al., 2010). These customer networks play a central role in new customer acquisition, both through influential opinion leaders' initiatives that spread word-of-mouth messages and also through building knowledge via active customer participation (Kumar et al., 2010). From a broader perspective, stakeholder engagement is also contingent on stakeholder network metrics. This article goes further by fleshing out the conceptual dimensions of engagement within stakeholder networks and then supplementing this work by providing an engagement index based on network metrics.

The Emerging Role of Social Media Platforms in CSR Communications

How can firms engage with their stakeholder networks? Over the last decade, aided in part by social network technology, research has increasingly looked at how firms interact with their stakeholders on online platforms and forums (Korschun and Du, 2013; Hollebeek et al. 2014; Islam et al., 2018; Roulet and Clemente, 2018; Pitt et al. 2019; Hollebeek et al. 2020). Practically, researchers have only recently started building knowledge and understanding of how firms interact and

exchange with their stakeholders on social media concerning the firms' social activities (e.g., CSR investments; Castelló et al., 2015; Orazi et al., 2017). CSR activities benefit the firm by protecting its public image (Fombrun, 2005; Orazi et al., 2017), in particular, by considering salient stakeholders' interests and concerns (Basu and Palazzo, 2008). In this sense, looking specifically at CSR initiatives and the message they imply is particularly useful to assess the SNE. A wide range of research has shown that CSR is clearly related to positive stakeholders' social evaluations, such as legitimacy (Castelló et al., 2015; Du and Vieira, 2012; Skilton and Purdy, 2017), authenticity (Orazi and Newton, 2018), transparency (Leitch, 2017) or reputation (Fombrun, 2005).

The translation of CSR activities into positive stakeholders' perceptions and the related mediation mechanisms remain to be fully understood (Aguinis and Glavas, 2012; Okazaki et al., 2019). In his critical essay, Visser (2010) theoretically examines the state of CSR and proposes new directions that incorporate Web 2.0 technology, or Internet-based applications that facilitate information sharing and collaboration, which have the potential to overcome some of the fundamental limitations traditional CSR has been facing. Key to this Web 2.0 inspired revolution is shared value co-creation and stakeholder engagement. The emergence of social media platforms has thus enabled firms to directly engage with their stakeholder network and communicate on their CSR activities (Okazaki et al., 2019). Furthermore, social media platforms provide a resource to evaluate closely how firms' communication initiatives reach stakeholders and how those stakeholders react as a system.

The Four Facets of Stakeholder Network Engagement

The network approach of stakeholder theory highlights the impact of various structural elements of the

stakeholder network on firm behaviour (Frooman, 1999; Phillips, 2010; Rowley, 1997). For example, Rowley (1997) argues that the stakeholder network's density (or the accessibility of the network to individuals) and the firm's centrality (or influence) in that network affect the firm's resistance to stakeholder pressures. The density of the stakeholder network and the position of the firm within its web of stakeholders provide a specific network configuration that "influences how the focal firm will respond to stakeholder demands" (Rowley, 1997, p. 901), which is key to building and maintaining firm–stakeholder relationships. A focal firm is more or less accessible for stakeholders depending on how easily those stakeholders can connect to the firm (Scott and Lane, 2000). Complementarily to how accessible is the firm, the nature of the relationship with its stakeholders is determined by the mutual influence they exert on each other (Frooman, 1999; Pajunen, 2006). This leads us to believe that SNE would be partly formed by stakeholder network accessibility and the influence of the firm within that network. However, these two dimensions do not fully describe stakeholder engagement within the network in particular because they solely capture the dyadic level and not the relationship between the firm and stakeholder as a whole.

Along with network accessibility and the firm's influence, the communication literature reports that message or content diffusion (i.e., spread) and the level of interactivity between individuals in that network are essential for co-creation to occur (Porter, 2009; Slatin, 2006). We argue that SNE is thus composed of four theoretical dimensions—diffusion, accessibility, interactivity, and influence—and these dimensions are essential to enable stakeholder value co-creation within that network. We acknowledge that those dimensions are not necessarily orthogonal to each other, as they might not be fully independent; however, we argue these

dimensions capture four key aspects of SNE. Below, we theoretically explore and define each dimension.

Diffusion refers to the content sender's intention either to encourage or to limit distribution of the content to other individual stakeholders that may not have been in the original audience (Porter, 2009). Many researchers (Hosanagar et al., 2010; Khelil et al., 2002) theoretically conceptualise diffusion using a virus metaphor or epidemic diffusion models, where infectious diseases are diffused from the infector vector or individual and spread through a population. Individual actors in a social network are similarly responsible for creating content materials and then diffusing them to other individuals who may pass that content on to others within the network. Diffusion acknowledges the agentic power of the focal firm to include or exclude parts of its stakeholder network into its communication (Hill and Jones, 1992). This is especially true for social (or ethical) norms created, diffused, and enforced within a social network (Phillips, 2010). Encouraging content diffusion may be quite simple on social media. For example, individuals posting content on Twitter can ask their followers to "retweet" their post. Via electronic word of mouth, new messages can diffuse rapidly, so are recommendations of actors (Brodie et al., 2013). However, limiting the diffusion of content on social media can be quite challenging as the make-up of the original audience may be hidden to the content sender.

Accessibility is important, too, as it assesses the potential reach of firms' content to stakeholders by addressing their potential lack of access (Scott and Lane, 2000; Slatin, 2006). It is key to the widespread adoption in a social network, and many social networks have failed or at least not met their true potential due to a lack of reach. For instance, poor individuals without access to information or the technology to access that information about microfinance innovations miss out on

potential benefits (Hudon and Sandberg, 2013). Similarly, stakeholders cannot simply be included in content diffusion because they are disconnected from the rest of the network (Porter, 2009). Firms can influence this accessibility dimension depending on their support and platforms (i.e., the nature of the network) they use to reach out to their stakeholders (Rowley, 1997). In social media, individuals receive digital content from a variety of digital devices (e.g., computer, mobile phone, tablets) or different digital media platforms (e.g., Twitter, YouTube, Facebook, WeChat, TikTok) (Hollebeek et al., 2014), so SNE is partly contingent on reaching the largest possible stakeholder network. To enable accessibility, firms can transmit their content in ways that are readable on common digital devices and platforms where their stakeholders are likely to be.

Interactivity describes the extent to which the content compels stakeholders to pass on or exchange content or co-create new content with the firm or the rest of the network (Neville and Menguc, 2006). From a network perspective, the interaction between stakeholders within the network is as important as their interaction with the focal firm (Rowley, 1997). However, such interaction might still be the result of the firm's strategy to generate engagement within its network (Pajunen, 2006). Unlike diffusion, interactivity focuses on the stakeholders' intent to actively contribute by reacting to or spreading a message, and therefore, contributing to the message themselves. Interactivity's contribution to SNE depends on well-connected individuals that are willing to react to and pass on messages (Prell et al., 2009). If individuals only passively observe a message, this stops the message from spreading to other individuals and also does not contribute to the network's interactivity. However, if network participants actively (or are encouraged to) contribute by forwarding or commenting on a message or even by creating and sharing new content, they add to the potential

network value through interactive co-creation (Roosens, Dens and Lievens, 2019; Grönroos and Voima, 2013; Parent et al., 2011). Digital platforms have various levels of interactivity potential, as they differ in how they enable individuals to communicate and share content in different ways, thus either encouraging or limiting interaction and co-creation (Pitt et al., 2011). Therefore, to inspire interaction with a stakeholder network, firms must not only actively participate with stakeholders and their content, but also create content that encourages and enables this interaction. Thus, an increase of network interactivity will lead to an increase of SNE.

Influence reflects the ability of the firm (or individual stakeholders) to successfully persuade others to pass on, distribute or interact with their content and its message (Froome, 1999). This dimension is important in two ways: First, the centrality of the firm within the network is determined by its influence on the flow of information (Rowley, 1997). Second, this influence can provide the firm (or individual stakeholders) with additional network resources, such as access to opinion leaders, that enable not only the consumption of firm's messages, but also network support and approval (Daudigeos et al., 2018; Phillips, 2010). Thus, it is important that the firm leads the stakeholder network's dialogue to enable positive co-creation (Brodie et al. 2011), as without this leadership, the stakeholder network may be hijacked by powerful stakeholders (Daudigeos et al., 2018; Okazaki et al., 2019), and this can lead to negative outcomes for the firm. High levels of SNE are partly due to a firm's level of influence within its stakeholder network.

Those four dimensions—diffusion, accessibility, interactivity, and influence—paint a picture of the different strategies of network engagement firms may have. We

expect firms from different industries to use strategies that focus on different dimensions. Some industries require communication to a broad set of stakeholders. While other industries require firms to communicate mostly with an important, narrower set of salient stakeholders (Laplume et al., 2008; Neville and Menguc, 2006). The use of these four dimensions also depends on the nature of the stakeholder groups—while some groups might be scattered aggregations of individual actors, others might be represented by unique target individuals or groups. Situations in which there are cascades of information (Entman, 2012; Daudigeos et al., 2018)—especially when selected stakeholders have the power to influence others—may require more influence and interactivity. For example, in the retailing context where customers are generally scattered and unorganised, stakeholder engagement would require high accessibility and diffusion. In contrast, in the reinsurance context where insurance firm representatives cooperate and socialise with each other, stakeholder engagement would require high interactivity and influence.

Measuring Stakeholder Network Engagement

In this section, we first define a mathematical representation of the different dimensions of SNE, and second illustrate the SNE index with Twitter data.

Mathematical Representation of the SNE Index

We suggest four network metrics, to empirically measure the SNE dimensions—average path length, density, clustering coefficient, and PageRank—that when combined assess the level of stakeholder engagement present in a network (see Figure 1).¹

¹ Network theory leverages graph theory, which is based on the analysis of graphs. A graph G has two

main components: vertices or nodes (v) and edges (e). An edge connects two vertices, for example e_{ij} connects v_i and v_j .

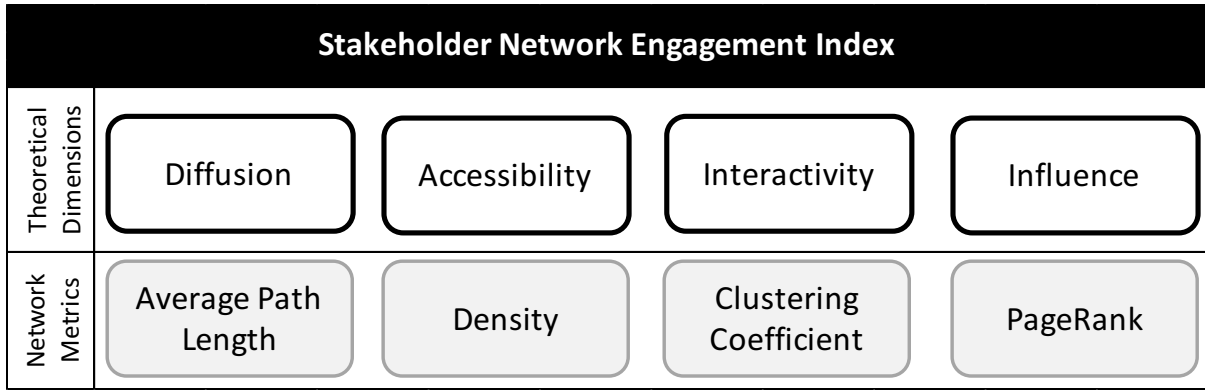


Figure 1: Conceptualisation of the SNE Index

Diffusion. A good measure of message diffusion in a network is average path length, $l(G)$, which assesses how far a message can spread in a network, or more formally, the distance, d , between the starting vertex (i.e., individual or node), v_i , and the ending vertex, v_j . In studies of viral propagation of messages in small world networks (e.g., Kiss and Bichlet, 2008), the average path length is commonly used to describe the topology of the message network between two nodes. This distance defines the path (i.e., route) between starting and ending vertices, and path length is the number of edges (i.e., connections between vertices) involved. Considering the number of vertices, $|V|$, the average path length, $l(G)$, can be calculated using this formula:

$$l(G) = \frac{1}{|V|(|V| - 1)} \sum_{v_i, v_j} d(v_i, v_j)$$

Accessibility. A common accessibility metric is density, $den(G)$, which shows how many individuals are engaged in interactions with other individuals. More formally, density assesses the number of edges, E , or bilateral interactions between two vertices (i.e., individuals) over the total possible number of interactions. Density, $den(G)$, can be mathematically described as:

$$den(G) = \frac{2|E|}{|V|(|V| - 1)}$$

Interactivity. Interactivity in a network can be measured by examining the

segmentation of a dialogue using the Clustering Coefficient, $CC(G)$, which breaks down the network into a series of triangles. In a network, a triangle is defined by three vertices (v_i, v_j, v_h) and the connections between them (a_{ij}, a_{ih}, a_{jh}). $CC(G)$ is calculated using the observed number of triangles divided by the total possible number of triangles in a network. Formally, the $CC(G)$ can be mathematically described as:

$$CC(G) = \frac{1}{|V|} \sum_{v_i \in G} \left(\frac{2}{k_i(k_i - 1)} \sum_{j, h} a_{jh} a_{ij} a_{ih} \right)$$

Influence. To formalise influence in our model, we use PageRank statistics, which are iterative algorithms that calculate the relevance of each node in the network considering the distribution of inbound links ($L(v_j)$) of individual nodes. These statistics are used by Google, and are the genius behind their algorithm, by evaluating content links based on their behavioural influence (i.e., how many users click on the link). For the purposes of SNE, we use two PageRank statistics: (1) the most influential node, PR_{max} , and (2) the firm's node, PR_{firm} . The firm may well be the most influential node, but by dividing PR_{firm} by PR_{max} , we can ascertain how influential the firm is in the network and discount the contribution of the influence dimension if the firm is not leading the dialogue. The PageRank metric also uses a damping factor (d) to balances between the influence of the node inside the network, just by belonging to it, and their influence

during the communication with other users. This factor is normally set to 0.85 (Baeza-Yates and Ribeiro-Neto, 1999). Considering V as the set of vertices whose cardinality is $|V|$, and $M(v_i)$ the set of vertices connected to v_i , PageRank, $PR(G)$, is mathematically represented as:

$$PR(G) = \max_{v_i \in G} \left\{ \frac{1-d}{|V|} + d \sum_{v_j \in M(v_i)} \frac{PR(v_j)}{L(v_j)} \right\}$$

Now that we have defined and proposed the metrics to evaluate the four dimensions of SNE, we can calculate the SNE index, $SNEI(G)$. We propose a formula that combines the above network metrics—average path length, density, clustering coefficient, and PageRank—into a meaningful index value:

$$SNEI(G) = 100 * \frac{PR_{firm}(G)/PR_{max}(G) + den(G)}{3 \cdot l(G)}$$

This index is sensitive to network size, as the combined effect of PageRank, density, and clustering coefficient is reduced by the average path length, which is our indicator of diffusion. While high diffusion partly indicates higher SNE, the other dimensions must increase as well in order to preserve the level of engagement. The SNE index also aims to optimise the impacts of density, clustering coefficient and the firm's PageRank, PR_{firm} . The index has a maximum value of 100 for a totally connected network (i.e., full network engagement) and a minimum value of 0 where all individuals are isolated (i.e., no network engagement). To better illustrate how this index performs under different conditions, we provide a mathematical simulation with various network dynamics in Appendix A.

Empirical Application of the SNE Index with Twitter Data

This section empirically illustrates how the SNE index works in practice. To this end, using a scraping algorithm, we extracted tweets that are either from the firm's CSR Twitter messages or tweets that mention or directly reply to these tweets.² By analysing how tweets are responded to and shared, we can calculate the relational ties among stakeholders and also between the stakeholders and the firm (Neville and Menguc, 2006). These relational data produce small-world networks that record how a firm and its stakeholders behave in that network.

We extracted over 428,000 tweets from stakeholder networks of eight different companies in four industries over six months. We selected two pharmaceutical (Merck and Pfizer), two financial (Barclays and Citibank), two prepared food (Nestle and Danone), and two cosmetics (L'Oréal and Nivea) firms. These firms have been selected according to the following criteria: (1) these four industries represent more than 50% of world GDP (Investopedia, 2015), and (2) the chosen firms are considered the most active in Twitter activities and CSR with social media according to available leading industry reports (Brandlogic, 2012; Salterbaxter MSL, 2015).

Before conducting our SNE analyses, we pre-process the tweets to generate a clean dataset that reduces outliers and noise in the data, as well as identifies the networks that surround each firm's CSR Twitter activity. This pre-processing stage involves text-mining techniques. Our main goal is to distinguish tweets that correspond to the CSR dialogues. To guarantee the quality of the analysis, we performed well-known,

² Tweets extracted contained any of these CSR-related keywords: economic (financial aid, financial support, foreign aid, microfinance, credit, microcredit, entrepreneurship, monetary aid, donation, charity, scholarship, etc.); ethical (sustainability, responsibility, socially responsible, fair trade, transparency, government, corruption,

prevention, human rights, ethics, etc.); social (philanthropy, working conditions, health, safety, customer voice, consumer protection, labour standard, volunteering, collaboration, solidarity, social exclusion, equality, discrimination, education, community, cultural projects, food security, sponsorship, foundations, poverty, elderly, children, etc.).

standard methods of text mining that provide a robust text cleaning solution for the clustering algorithm (Baeza-Yates and Ribeiro-Neto, 1999). This phase consists of *standardisation* (tweets are decomposed into simpler words and the capitalization of the words is set to lower case), *cleaning* (removal of special characters and punctuation symbols), *non-context text removal* (removal common stop words collected in the SMART information retrieval system (Salton, 1971), URLs, and numerical numbers), *stemming* (only the lexemes of the words are retained), *TF-IDF matrix generation* (a term-document matrix), and *sparse terms removal* (infrequent terms are removed). After these pre-processing steps are complete, we can extract clusters of tweets that form the small-world networks that emerge between

stakeholders and firms, as well as among stakeholders. These networks connect in three ways: via retweets, via replies to messages, or by the similarity of messages, provided by the clustering analysis. The pre-processing results indicate that a hierarchical clustering algorithm best suits the emergent stakeholder networks in all cases. Appendix B offers additional details related to the clustering analysis.

Now that we have identified the various stakeholder networks surrounding the Twitter accounts, we can proceed with the SNE analyses by calculating the four network metrics that make up the index. Using these network metrics, we can calculate the SNE index (see Table 1) and analyse what factors significantly influence this index (Table 2, Figure 2).

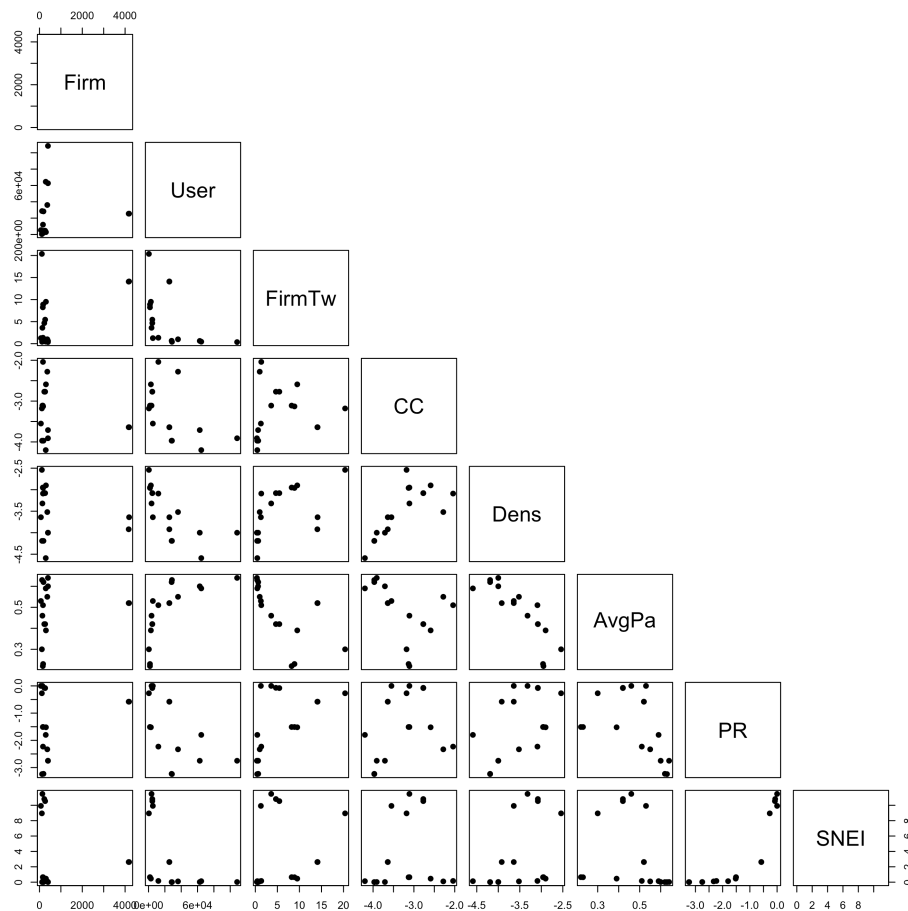
Table 1: Network Statistics and SNE Index Results

	Cluster	Firm Tweets	User Tweets	Firm % of Tweets	CC (log)	Density (log)	Avg. Path Length (log)	PR _{firm} /PR _{max.} (log)	SNE Index	Firm's SNE Index Average	Industry's SNE Index Average
Consumer Finance											
Barclays	1	122	28641	0.42	-3.97	-4.19	0.63	-3.24	0.01	0.01	1.31
	2	187	28240	0.66	-3.97	-4.19	0.62	-3.23	0.01		
	1	4168	25451	14.07	-3.64	-3.92	0.52	-0.58	2.62	2.62	
	2	4187	25471	14.12	-3.64	-3.64	0.52	-0.58	2.62		
Packaged Foods											
Danone	1	137	3668	3.60	-3.11	-3.32	0.46	-	11.48	10.22	7.62
	2	112	438	20.36	-3.18	-2.54	0.30	-0.27	8.95		
Nestle	1	67	5269	1.26	-3.55	-3.64	0.53	-	9.92	5.03	
	2	293	64534	0.45	-4.20	-4.59	0.59	-1.80	0.13		
Cosmetics											
L'Oréal	1	397	62701	0.63	-3.71	-4.00	0.60	-2.75	0.02	0.02	3.64
	2	396	108416	0.36	-3.91	-4.00	0.64	-2.75	0.02		
Nivea	1	265	4597	5.45	-2.77	-3.08	0.42	-0.08	10.54	7.27	
	2	225	4597	4.67	-2.77	-3.08	0.42	-0.07	10.81		
	3	302	2875	9.51	-2.59	-2.90	0.39	-1.52	0.46		
Pharmaceuticals											
Pfizer	1	156	1737	8.24	-3.11	-2.95	0.22	-1.51	0.65	0.65	0.39
	2	170	1744	8.88	-3.13	-2.96	0.23	-1.51	0.64		
Merck	1	164	12003	1.35	-2.04	-3.09	0.51	-2.23	0.16	0.13	
	2	365	36073	1.00	-2.28	-3.52	0.55	-2.33	0.10		

Table 2: Pearson's and Spearman's correlations

Metric	Mean	Standard Deviation	1		2		3		4		5		6		7	
			r_p	r_s	r_p	r_s	r_p	r_s	r_p	r_s	r_p	r_s	r_p	r_s	r_p	r_s
(1) Firm Tweets	689	1317														
(2) User Tweets	24497	29692	0.07	0.52												
(3) Firm % of Tweets	0.06	0.06	0.51	0.02	-0.45	-										
(4) CC (log)	-3.27	0.63	-0.22	-	-0.53	0.12	0.11	0.43								
(5) Density (log)	-3.51	0.58	-0.20	-	-0.71	-	0.55	0.73	0.73	0.77						
(6) Avg. Path Length (log)	0.48	0.13	0.14	0.28	0.69	0.93	-0.61	-	-	-0.64	-0.85	-	1.00			
(7) PR_{firm}/PR_{max} (log)	-1.61	1.12	0.24	0.26	-0.58	-	0.54	0.61	0.25	0.38	0.52	-	-0.49	-		
(8) SNE Index	3.48	4.66	-0.10	-	-0.50	-	0.23	0.63	0.20	0.45	0.42	0.57	-0.27	-	0.85	0.99
				0.23		0.65								0.66		

Notes: Figures headed by r_p indicate Pearson's correlations and r_s indicate Spearman's correlations. The bolded correlation figures are significant at least at $p = 0.05$ or lower

**Figure 2: Scatter Plot related to the Correlations of Table 2.**

Moving on to the theoretical dimensions, network diffusion (i.e., average path length) was the least variable dimension with (log) average path length ($\mu = .48$; $s.d. = .13$) indicating that it was not a significant contributing factor in variations in SNE ($r = -.27$, $p = .29$) in the studied CSR networks. Firm influence in the

network proved to be the most variable dimension in studied CSR networks with (log) PR_{firm}/PR_{max} ($\mu = -1.61$; $s.d. = 1.12$) having a large positive influence with SNE ($r = .85$, $p < .01$). Network accessibility, measured by density ($\mu = -3.51$; $s.d. = .58$), did not significantly contribute to the variation in the SNE ($r = .42$, $p = .09$) in the

CSR networks studied. Similarly, network interaction, indicated by the clustering coefficient ($\mu = -3.27$; $s.d. = .63$), was not a significant contributor to SNE ($r = .20$, $p = .45$) in the CSR networks studied.

On average, the SNE Index ($\mu = 3.48$; $s.d. = 4.66$) reached a height of 10.22 in both Danone CSR network clusters and a low of 0.01 in both Barclays CSR network clusters. From the eight firms in the four industries studied, industry exhibits marginally significant impacts on the SNE index [$F(3,16) = 2.58$, $p < .10$], while firm does not [$F(7,16) = 2.42$, $p = .11$]. Even though we realise the oversimplification due to our limited sample, we would like to point out some patterns in the four industries studied. For example, the SNE index of packaged foods seems notably higher than those of the other industries. This may reflect that an increasing number of customers are willing to pay for more products and services offered by sustainable firms (Nielsen, 2015). Because healthy and sustainable food choices are among the concerns of most stakeholders, the greater SNE index scores may have been achieved. In contrast, both pharmaceutical and financial industries are highly regulated by government, thus customers have less control, leading to the lower scores of the SNE index. Somewhere in between is the cosmetics industry.

In the CSR Twitter networks studied, the firm's tweeting effort in comparison to the total tweets in the network ($\mu = 5.59\%$; $s.d. = 6.06$) is significantly correlated with network density ($r_p = .55$, $p = .02$; $r_s = .73$, $p < .001$), average path length ($r_p = -.61$, $p = .01$; $r_s = -.80$, $p = .00$), and $PR_{\text{firm}}/PR_{\text{max}}$ ($r_p = .54$, $p = .03$; $r_s = .61$, $p = .01$), suggesting that a firm's tweeting activity promotes a denser network that reduces path length but increases the firm's influence in the network. However, this firm effort is not clearly correlated with the SNE index as the different correlation measures provide opposite results ($r_p = .23$, $p = .38$; $r_s = 0.63$, $p = .01$) in the CSR networks studied, so

this indicates that while the firm's effort in a CSR network contributes to aspects of the stakeholder network, it might not directly significantly impact the SNE index. Also, the number of users' (i.e., stakeholders') tweets is significantly negatively correlated with the SNE index ($r_p = -.50$, $p = .04$; $r_s = -.65$, $p < .001$), which might indicate that the SNE index is measuring the quality of the firm's impact on the network rather than just the quantity of its effort.

Discussion and Conclusions

This article establishes a theoretical framework to understand, capture, and measure SNE. Building on insights from marketing, management and communication literatures, we define four dimensions of SNE, propose a SNE index and empirically apply the index to the CSR communication context. The SNE index's theoretical dimensions—diffusion, accessibility, interactivity, and influence—hold the key to objectively measuring SNE beyond counting metrics or self-reported attitudinal or behavioural scales, thus helping address the limitations of existing metrics and approaches. The role of stakeholder communication investments is to engage stakeholders, both inside and outside the firm, in order to co-create additional value for the firm and stakeholders alike. It is through the measurement and benchmarking of SNE over time, that managers can assess the success of their communication and judge the relative value of stakeholder communication as they relate it to other outcomes such as firm performance. Social media platforms aid the measurement of SNE as firm communication to stakeholders, and also communication among stakeholders, is digitally transmitted and therefore can be easily captured and analysed. Yet, the literature provides little insight into the evaluation of firm–stakeholder communication on social media. Thus, our conceptualisation of SNE along with its index can start filling this gap and advance our understanding of how

firms can successfully engage with their stakeholder network and communicate their CSR activities.

Theoretical Contributions and Implications

This article provides several implications for scholarly research that help researchers to further explore stakeholder communication on social media, measure stakeholder engagement, and clarify how firm initiatives (e.g., CSR activities) can effectively reach out stakeholders. While stakeholder networks (Frooman, 1999; Rowley, 1997) and their engagement (Dawkins, 2015; Husted and Allen, 2011; Strand and Freeman, 2015) have often been examined separately, we further conceptualise of SNE (Korschun and Du, 2013; Svendsen and Laberge, 2005) by expanding on the customer engagement literature (Brodie et al., 2011; Hollebeek et al., 2019). Stakeholders' perceptions of the firm are intertwined (Shymko and Roulet, 2016) and understanding how stakeholders are connected (Alexander et al., 2017) is a first step to analyse how firms can trigger positive stakeholder evaluation of their activities.

To flesh out the concept of SNE, we extend the network approach to stakeholder theory to define four dimensions: diffusion, accessibility, interactivity, and influence. Thus, we contribute to stakeholder theory by exploring the multidimensionality of engagement (Brodie et al., 2013) and expanding it to the stakeholder network. Building on our rich conceptualization, we provide an actionable tool that could be used to design instrumental perspectives on how firms should engage with their stakeholders. Because the stakeholders' perception of the firm's CSR activities is so crucial for those activities to pay off (Aguinis and Glavas, 2012), our conceptualisation and operationalisation of SNE can be helpful in deriving concrete takeaways with regards to stakeholder communication and management. The SNE index can enable future researchers to dynamically capture the reactions to

communication initiatives in the effort to improve their effectiveness by observing and quantifying stakeholders' outcomes.

We expect to find different norms of engaging with stakeholder networks in different industries, firm sizes or other contexts that might translate into different firm opportunities, benefits or risks. For example, a package goods firm might expect an entirely different SNE than a petroleum firm, as these firms have very different stakeholders and stakeholder expectations, as well as regulatory environments.

Adding to existing measures of assessing engagement (e.g., counting metrics, self-reported scales), the SNE index objectively measures SNE by observing four network metrics that indicate the four conceptual SNE dimensions. For example, based on counting metrics, Barclays seems like it is in a good position, with both clusters generating more than 28,000 stakeholder tweets. Yet, using our proposed method, Barclays's SNE performs poorly (SNE = .01 out of a possible 100), as their networks are characterised by a higher average path length, a low network density with very low network interactions, and low firm influencers within the network. Therefore, Barclays's CSR stakeholder communication inspired less stakeholder engagement on Twitter than other studied firms, such as Danone or Nivea. The proposed SNE index provides a more objective and comprehensive assessment of stakeholder engagement on social media. A careful monitoring of the SNE index will also allow researchers and managers to dynamically assess the effectiveness of different stakeholder communication strategies.

As we pointed out, the SNE index is very useful for researchers examining the link between a firm's CSR activities and its performance via stakeholder engagement (El Akremi et al., 2015). The SNE index provides a summary metric that can be potentially linked to other measurable

forms of firm performance. Moreover, this index provides a tool for researchers to further develop and empirically test stakeholder theory (Margolis and Walsh, 2003). Stakeholder theorists tend to focus around studying the relationships that firms build with stakeholders, how those relationships interact and impact each other, and how stakeholder networks actually determine corporate social performance (Frooman, 1999; Gambetti et al., 2017; Rowley, 1997; Shymko and Roulet, 2017). The SNE index is a tool that could contribute to the ongoing debate regarding the link between CSR and firm performance by capturing a finer grained, more objective measure of stakeholder engagement with the firms' social and environmental activities.

Managerial Implications

The SNE index has a number of practical implications. First, the index offers a simple number from 0 to 100 that can be used to assess the level of stakeholder engagement inspired by a firm's communication activities on a social network. This index provides a useful cross-sectional benchmark for managers to assess both current and future investments in social media-based stakeholder communication, and the effectiveness of their stakeholder engagement strategy. For example, a firm that has an SNE index score of 15 could then use the SNE index in the future to assess if additional social media communication efforts were fruitful, or if the current method of social media communication is becoming tired and in need of refreshment.

Second, stakeholder engagement is key for CSR activities to be translated into corporate performance (Aguinis and Glavas 2012; Oh et al., 2016), and this index provides a way to measure this engagement. Firms need to not only be socially responsible, but also to communicate their activities and initiatives to engage stakeholders to enjoy positive benefits, such as an improved corporate reputation,

more positive stakeholders' perceptions of the firm, and increased firm value, among others. The SNE index provides managers with an assessment tool that can give numerical feedback on the performance of their social media communication efforts, which could be used to calculate, for example, return on investment (ROI). This ROI analysis can be used to argue for the maintenance or even an increase in the budgeted funds allocated to social media stakeholder communication. Our SNE index can be captured over time, thus looking at how different messages and stakeholder strategies translate into better engagement, potentially leading to a more positive attitude from stakeholders, and ultimately improving firm performance.

Third, the SNE index can also help firms co-create value with their stakeholders by providing a quantitative stakeholder engagement evaluation. So, whether it is through actionable stakeholder feedback on CSR policy design, requests for volunteer participation or donations, or generating potential CSR ideas, CSR co-creation has the potential to increase the reputational and associated financial benefits of CSR, which would be indicated by high levels of stakeholder engagement (Bhattacharya and Sen, 2003).

Limitations and Future Research Directions

Some important limitations should be recognised to make our contributions more objective. First, our study should be considered as an initial steppingstone, as there is room for refinement of our metrics but also our conceptualisation of SNE. Although we examined the most theoretically relevant dimensions and indicators of SNE, a number of other network characteristics (e.g., conversation sentiment, topic trends, post frequency or length, rich media contributions) or other associated attributes (e.g., customer satisfaction, stock market valuations, firm reputation perceptions) may also be useful in uncovering other aspects of stakeholder

engagement. Moreover, other artificial intelligence (AI) analysis methods that employ natural language processing may be useful in better understanding the more nuanced aspects of stakeholder engagement (Pitt et al. 2020). In this regard, our SNE index should be considered as a sophisticated proxy, rather than a direct measure of engagement. Future research should test different types of metrics to compare findings and identify the most appropriate composite.

Second, while we explore the notion of SNE in the context of CSR communication, we did not examine if SNE varies according to the type of CSR activities, that is, if SNE differs when firms engage in CSR associated with environmental (e.g., protection of natural resources), social (e.g., community relations, education support, and charitable contributions), or economic (e.g., support for poverty, charitable contributions) purposes. Moreover, our research did not consider the source of the CSR communication, for example, if it was driven from an internal network of stakeholders or an external network of stakeholders. Such contextual factors should be examined in future studies.

Third, while our application of the metric for eight global firms does provide useful insights into the current level of SNE, other industries need to be explored and patterns of network formation could be analysed and compared at the industry level. Future research could also entail a wide-ranging benchmark study to ascertain the level of SNE over time and across industries, which might bring insights into how to successfully implement stakeholder engagement strategies. Moreover, these studies might show further insight into the differential nature of stakeholder engagement dependent on attributes of the brand or the industry, as some might naturally evoke more engagement than others. For example, CSR communications from luxury cosmetics brands may inspire a deeper level of SNE compared to the mass-

market cosmetic brands we tested above. Furthermore, we would expect that the nature of SNE to be different in business-to-business markets that might inspire more intimate professional relationships compared to the largely business-to-consumer brands we studied.

Fourth, while we would expect our index and its dimensions to be generalizable to other contexts, the nature of the CSR communication could have implications for our conceptualization and simulation. In particular, accessibility would be affected depending on whether the effort to reach out is on the side of the firm or on the side of its stakeholder. The importance and boundaries of our four dimensions could be adapted depending on the type of messages being transmitted. Future research should test the index with non-CSR communication networks, which will help to improve its calibration.

Considering the assumed relation between stakeholder engagement and financial performance (Husted and Allen, 2011; Margolis and Walsh, 2003), these important questions would benefit from further investigation: Would SNE be ultimately related to a firm's value and other strategic outcomes? What other relevant drivers moderate the relationships between SNE and a firm's performance outcomes? Considering the temporally changing nature of networks, firms can be expected to adapt their engagement with stakeholders and the resulting network as their situation or strategy evolves. In addition, firms are also structured internally as a network, and internal actors might represent different bridges towards the external network of stakeholders. Consequently, future research could capture the dynamic aspects of SNE by looking at how network structure changes, at what pace and under what conditions, as well as the link between internal and external networks of stakeholders. By assessing SNE, firms have the potential to maximize their investments in CSR activities in terms of producing more

positive stakeholders' evaluations and behaviours towards the firm.

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Appendix A. Mathematical Simulation of the SNE Index

Past research has confirmed that a small-world network is formed across many “weak ties” that will accelerate the spread of a social behaviour farther and more quickly than a network with strong ties (Centola 2010). Weak ties are those connecting “acquaintances who interact less frequently, are less invested in the relationship, and are less readily influenced by one another,” and strong ties are those connecting “close friends or kin whose interactions are frequent, affectively charged, and highly salient to each other” (Centola and Macy 2007, p. 703). In small-world networks, the weak ties tend to be long, and considerably few long ties enable rapid diffusion of information. Small-world networks can be found in many self-organising systems, including social media such as Twitter (Ch’ng 2015). The purpose of this simulation is, therefore, to apply the SNE index to various network conditions so that we can observe how the score varies when it runs under small-world network conditions. Such simulation would help managers take appropriate actions when some of the index components fail to stimulate SNE.

We tested the SNE index on small-world networks using the Watts and Strogatz (1998) algorithm. This algorithm starts by simulating a *regular network* solution (i.e., no random interactions or $\text{prob} = 0$) and progressively allows for randomisation of interactions until the simulation reports the *random network* (i.e., all interactions are random or $\text{prob} = 1$). Small-world networks fall in between regular and random networks and feature relatively high clustering coefficients with good interactions between individuals (i.e., they have low average path length and several dense areas or subgraphs; Watts and Strogatz, 1998).

To test how the SNE index performs under various network conditions, we perform a mathematical simulation using the R-Project’s iGraph package that shows

how the index varies as three dimensions change: diffusion (average path length), accessibility (density), and interactivity (clustering coefficient). Due to of the Watts and Strogatz (1998) algorithm, influence (PageRank) is distributed uniformly, as it needs PageRank to be uniform to find the regular network solution, and this uniformity continues as the likelihood of random connections increases. Also, we hold network size (nodes = 1000; edges = 5000) constant to simplify the simulations.

We can observe how the SNE index dynamically changes as it passes through the three theoretical types of networks, as well as variations in density and random interaction probability (i.e., a combination of average path length and clustering coefficient; see Figure A1). When density is very low, the SNE index is also very low. However, when density is relatively high, the SNE index is very close to 100 due to the constant uniform PageRank statistic, which differs from observed social media networks. However, these results confirm the mathematical validity of the SNE index as a stable metric ranging from 0 to 100 that measures the engagement between stakeholders and also between stakeholders and the firm. Our mathematical simulation enables us to objectively examine the SNE index by modifying its key variables. This leads us to the next question as to how the SNE index actually behaves when it is tested in an empirical application based on industry data.

The most relevant conclusion of the simulation is the stability of the index under different network structures. As we show, it keeps its growing patterns from regular to random networks passing through small-world ones. We also see that it is growing with the density of the network as we expected. Although our index was initially designed considering small-world network properties, it can extrapolate to other types of networks.

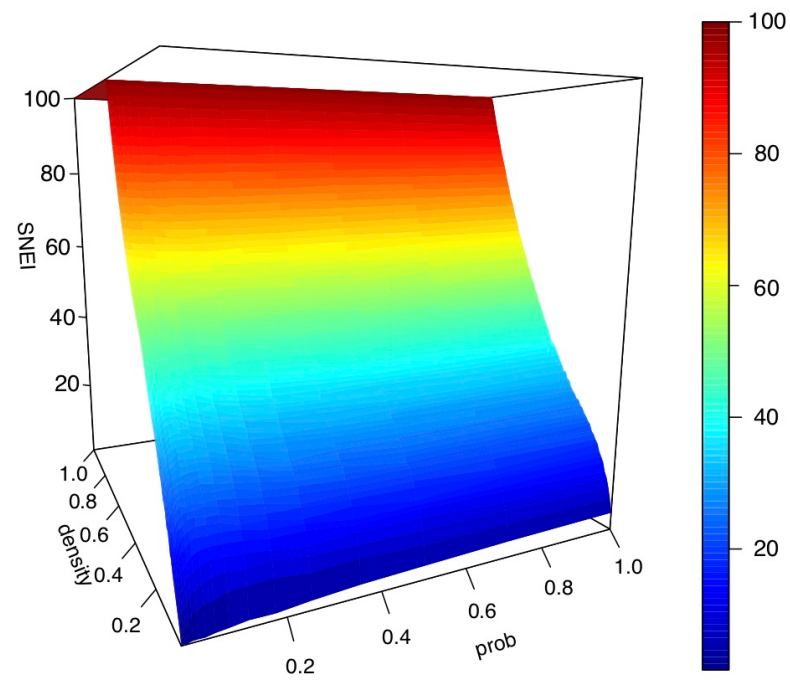


Figure A1: SNE Index Simulated Solution

Appendix B. Clustering Procedure

In order to extract relevant patterns which can provide important insights into the relationships between users' and companies' dialogues, we applied four different clustering algorithms—hierarchical, K-means, Partition Around Medoids (PAM), and Self Organising Maps (SOM)—with which we grouped the data with different clustering sizes. Once the clusters were generated, we used internal evaluation metrics to choose the best clustering discrimination. In determining the best clustering algorithm, we applied the following evaluation metrics:

- **Connectivity:** this indicator measures the dispersion of the data instances inside the cluster. It should be minimised.
- **Dunn:** this index is the ratio between the smallest distance and the observations outside the cluster.
- **Silhouette:** this indicator is used to evaluate the degree of confidence in the clustering assignment of a particular observation.

The clustering processes used, and their parameters are:

- Hierarchical clustering applies the `hclust` algorithm. The agglomerative method used is “complete linkage” which aims to link similar clusters (Defays, 1977). The TF-IDF matrix provides the distance used for the clustering.
- K-means uses the same distance matrix and a uniformly at random initialization of the centroids.
- Self-organising maps (SOM) uses a grid as the starting mapping, covering the space of the data instances. The chosen algorithm for training is the online SOM algorithm (Kohonen, 1995).
- Partition Around Medoids uses the original algorithm (Reynolds, 1992).

The implementation of these algorithms comes from the `clValid` library of the R-project.

All the clustering algorithms were executed 100 times. The main variations between the runs are:

- The order of the data, which is reshuffled in every run. This is a common practice between clustering algorithms to force the algorithms to choose different initial values. This is especially relevant for hierarchical clustering (Sebastianin and Perls, 2016).
- For K-means: the initial set of centroids.
- For PAM: Initial medoids.
- For SOM: Initial random weights.

Once we determined the best clustering solution based on the above evaluation metrics, we evaluated the information extracted by this solution and labelled each clustering according to the main dialogue topics (see Table B1).

Table B1**Clustering Results**

	Metric	Score	Method	Clusters
<i>Consumer Finance</i>				
Barclays	Connectivity	-	-	-
	Dunn	0.87	hierarchical	2
	Silhouette	0.32	hierarchical	2
Citibank	Connectivity	-	-	-
	Dunn	0.87	hierarchical	2
	Silhouette	0.32	hierarchical	2
<i>Packaged Foods</i>				
Danone	Connectivity	-	-	-
	Dunn	1.82	hierarchical	2
	Silhouette	0.50	hierarchical	2
Nestle	Connectivity	2.93	hierarchical	2
	Dunn	1.02	hierarchical	2
	Silhouette	0.28	hierarchical	2
<i>Cosmetics</i>				
L'Oreal	Connectivity	3.03	hierarchical	2
	Dunn	1.36	hierarchical	5
	Silhouette	0.59	K-means	4
Nivea	Connectivity	4.52	hierarchical	2
	Dunn	0.98	hierarchical	4
	Silhouette	0.44	hierarchical	2
<i>Pharmaceutical</i>				
Pfizer	Connectivity	3.93	hierarchical	2
	Dunn	2.31	hierarchical	2
	Silhouette	0.57	hierarchical	2
Merck	Connectivity	3.27	hierarchical	2
	Dunn	1.11	hierarchical	5
	Silhouette	0.20	K-means	2