THEORY/CONCEPTUAL

Frontline knowledge networks in open collaboration models for service innovations

Ozlem Ozkok[1] · Simon J. Bell[1] · Jagdip Singh[2] · Kwanghui Lim[3]

Abstract
Service organizations often view customer-facing or frontline employees (FLEs) as sources of inimitable knowledge valuable for innovation. This is due to the experiential nature of service and subtle qualities of engaging customer interactions. Yet, organizations face significant challenges while leveraging the knowledge of their FLEs to develop service innovations. Drawing upon the open innovation and social network literatures, we theorize the role of FLE networks, and the degree to which these networks enable the flow of distinct content for realizing effective service innovation. Specifically, we conceptualize a taxonomy of network *domains*—connecting customer- and internal-facing employees, and resource *flows*—new knowledge and self-governance activities, to provide a framework for FLE roles in knowledge networks for service-innovation. Our taxonomy expands opportunities for theorizing the mechanisms of frontline knowledge networks in service innovation as well as identifying a "dark side" that undermines potential innovation gains if left unchecked. Future directions and implications for theory and practice are discussed.

Keywords Services marketing · Frontline knowledge · Open innovation · Social network · Service employee

The academic and practitioner literatures are consistent in emphasizing two central themes in service innovations: (a) service is a knowledge-based activity, and superior knowledge is key to innovative ideas (Grant 1996; Galunic and Rodan 1998; Hargadon and Sutton 1997), and (b) service innovation emerges from collaboration or co-creation with customers (Magnusson et al. 2003; Stock and Zacharias 2011). In co-creation, research shows that frontline employees (FLEs) are critical nodes in knowledge networks that permit organizations to open boundaries to collaborate with customers. The FLEs are also reliable filters and enablers of new knowledge creation that motivates service innovation (Allen 1977; Lages

✉ Ozlem Ozkok
ozlem.ozkok@unimelb.edu.au

Simon J. Bell
simonb@unimelb.edu.au

Jagdip Singh
jagdip.singh@case.edu

Kwanghui Lim
k.lim@mbs.edu

[1] Department of Management and Marketing, Faculty of Business & Economics, University of Melbourne, Level 9, 198 Berkeley Street, Carlton, Victoria 3010, Australia

[2] Weatherhead School of Management, Case Western Reserve University, Peter B. Lewis Building 221, 10900 Euclid Avenue, Cleveland, OH 44106-7235, USA

[3] Melbourne Business School, University of Melbourne, 200 Leicester Street, Carlton, Victoria 3053, Australia

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and Piercy 2012; Melton and Hartline 2010). A 2015 Accenture survey found that 91% of enterprises identified customers as "valuable" sources of innovation ideas,[1] while a recent Boston Consulting Group survey of senior executives revealed that customer insight teams are crucial for innovation[2] and most likely to drive business growth.[3] The crucial role of customers in generating new knowledge for service innovations has elevated the significance of customer-facing frontline employees. Thus, this study aims to: (a) review the relevant organizational frontlines and open innovation literatures, (b) conceptualize a taxonomy of network *domains* and resource *flows* to provide a framework for the FLE role in service-innovation, and (c) identify taxonomy-based theory building directions for future research on the study of service innovation from the frontlines.

Leveraging customer-facing resources and customer interactions for effective service innovation is neither trivial nor spontaneous. The field of Organizational Frontlines[4] research has shown that customer interfaces in service organizations are inherently paradoxical as they require juxtaposing openness and complexity to generate competitive advantage (Singh et al. 2017). Studies on FLEs as conduits of customer knowledge for service innovation and organizational performance have both improved our understanding while also revealing several anomalies (Chen et al. 2013; Hult et al. 2011). For example, Ordanini and Parasuraman (2011) demonstrate that FLEs are fundamental in shaping the volume and radicalness of service innovation. By contrast, other researchers narrow FLEs role to "service marketability" and to *delivering* service innovations rather than *developing* new knowledge for meaningful service innovation (Melton and Hartline 2013, p. 77; Karlsson and Skålén 2015). Further, Melton and Hartline (2013) note that cross-functional teams could be more effective than FLEs in new service launch and sales performance. These anomalies do not necessarily diminish the role of FLEs as much as they suggest that an exclusive focus by scholars on customer-facing employees may yield incomplete or inaccurate insights. A broader perspective is needed to examine how frontline employees embrace collaborative

relationships with external customers as well as how they network internally with other employees (both customer- and internal-facing employees) to provide a deeper understanding of their potential contributions to service innovation.

A defining feature of the open innovation literature is a focus on how external and internal participants improve/hinder organizational performance. Open innovation is defined as "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model" (Chesbrough and Bogers 2014, p.17). While relatively few studies have examined open innovation in a services context (for an exception see Mina et al. 2014), the perspective it offers is useful due to its focus on the interaction between the firm and its customers as a source of innovation and for analyzing external and internal knowledge flows (Chesbrough and Bogers 2014; West and Bogers 2017). We use the internal-external nexus as a starting point for understanding the role of human, rather than firm-level, mechanisms in knowledge flows. Specifically, we focus on frontline employees' interactions with customers and internal employees. Thus, we draw on social network theory to understand how service innovation results from relationships among (a) customers, (b) FLEs as customer-facing employees, and (c) internal-facing employees (IFEs).

We propose a taxonomy of network *domains* (i.e., networks defined by distinct members or agents) and resource *flows* (i.e., the content of exchange among network members) to provide a foundation for subsequent theorizing about FLE-centered service innovation. In terms of network domains, we consider (1) FLE-IFE networks – networks comprising FLEs and IFEs with limited customer contact – and (2) FLE-customer networks – networks comprising FLEs connected to varying degrees with both their fellow FLEs and customers. The former is a cross-pollination network which enables mutual learning via non-redundant information exchange. The latter network is a source of new service ideas facilitated by active idea sharing during service delivery and troubleshooting processes. In terms of network flows, we consider (1) knowledge exchange – the sharing of new ideas about service delivery among organizational employees, and (2) self-governance activities – the mutually negotiated distribution of self-organizing responsibilities among network members. Knowledge flows enable novel service ideas to be shared, sorted and sieved for effective development and deployment while governance activity flows ensure that action can be taken based on new insights.

Three aspects of our study are noteworthy. First, we advance understanding of organizational frontlines research by exploring the contribution FLEs make to service innovations, and the specific mechanisms through which frontline knowledge has an impact. We do this by locating them within networks of both customers and internal-facing employees. Our research, thus, extends beyond the dyadic studies of FLE-

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[4] Organizational Frontlines research in Marketing has been defined as "the study of interactions and interfaces at the point of contact between an organization and its customers that promote, facilitate, or enable value creation and exchange" (Singh et al. 2017, p. 2). FLEs feature prominently in the frontline activities of service organizations.

customer or FLE-manager relationships and their contribution to learning and innovating (Bell and Menguc 2002; Selnes and Sallis 2003; Liao and Chuang 2004; Homburg et al. 2009). By exploring the broader intra-organizational networks, we offer a more nuanced account of the mechanisms and pathways through which new knowledge motivates service innovation within the firm and the key role played by FLEs in the proposed mechanisms.

Second, we extend the literature on open innovation to the services context. While open product innovation research offers many lessons for a service context, some unique aspects of the services context have implications for the advancement of open innovation theory. Further, we consider the specific case of FLEs as a dominant vector that enables processing of market knowledge to achieve innovation outcomes. The potential contribution of FLEs in open innovation has gone largely unnoticed as researchers have focused on the engineers and developers and on open communities of similar experts. Key features of FLE-customer interactions – continuity of contact, real-time interactions and solution generation, among others – are not apparent in these more frequently studied boundary-spanning roles.

Third, we extend social network theory by advancing the view that internal-external network interactions involving FLEs have the potential to contribute significantly to firm performance. Social network research involving FLEs is relatively scarce (Provan et al. 2007), with extant work focusing largely on the outcomes of a given network configuration (e.g., Balkundi et al. 2009; Mehra et al. 2006). Our theory accommodates intra-organizational interactions between networks where the peculiarities of one network structure might undermine (or enhance) the performance of another. We also extend social network theory by proposing the idea of self-governance as a flow within a network. While knowledge flows within networks have been explored in past research, the exchange of a mutually negotiated understanding about how individuals within a network might act on, or respond to, new knowledge represents an extension.

We organize our paper as follows. The next section reviews the prior literature on organizational frontlines and service/open innovation literatures. We then conceptualize a taxonomy of network *domains* and resource *flows* to provide a framework for the FLE role in service innovation. Finally, we provide new directions for theoretical and empirical research in the study of service innovation from the frontlines.

Literature review

Service innovation is generally defined as the creation of new or improved service offerings (Menor et al. 2002). Services are usually knowledge- and skill-intensive such that service innovation often involves the continuous generation of new knowledge and its use in improving service offerings (Ordanini and

Parasuraman 2011). The role of FLEs –boundary spanners located at an organization's external interface with customers—in generating new knowledge for service innovation is well recognized. For instance, Sørensen et al. (2013) suggest a unique status to "innovation that develops from ideas, knowledge, or practices derived…from frontline service employees' meetings with users in the service delivery process." Likewise, Bell (1981) notes that service encounters are the single greatest opportunity for potential innovations.

Our literature review centers on the FLE role in service innovation. However, to sharpen our focus, we review past studies that approach the FLE role from open innovation and social network perspectives. Below, we first discuss the distinctive features of the FLE role that make it well-suited for service innovation, and thereafter draw insights from the relevant literature to guide our theoretical contribution.

Frontline employees and service innovation Direct interactions with customers privilege FLEs with a distinct perspective on what might contribute to service innovation. Customer interactions offer an insight into, and an early signal of, changing needs, motivations, and preferences. For most service organizations, insights and early signals from customer interactions are a critical and potent source of new knowledge that can help generate innovative solutions and reconfigure existing ones (Grönroos 2007; Alam 2002). The FLEs provide a key, and sometimes the *only*, contact with this source (Woisetschläger et al. 2016; Zeithaml et al. 2008). Moreover, FLEs as boundary spanners are connected to both a heterogeneous network of customers, as well as to internal employees and other stakeholders who may not have customer-facing roles but are involved in service production, delivery and support. Thus, the boundary function of FLEs endows them access to diverse and divergent sources of knowledge that can drive service innovation if effectively mobilized.

Open innovation literature has examined the effectiveness of knowledge *flows*, both inward and outward, that yield innovation opportunities at points of contact between an organization and external sources (Chesbrough 2011). Relatedly, social network studies examine the structural properties of the formal and informal networks that make for effective connections between an actor and other actors and resources, both internal and external to the organization (Borgatti and Halgin 2011). Often, the effectiveness implications of network properties to seed innovations are examined at the level of the individual actor (e.g., FLE) and/or the level of an entity such as a business unit (Bell et al. 2010; Schepers et al. 2016; Santos-Vijande et al. 2016). The open innovation and social network streams of research are complementary —*networks* enable and lubricate *flows* — and weaving them together provides a more realistic and holistic understanding of the focal phenomenon.
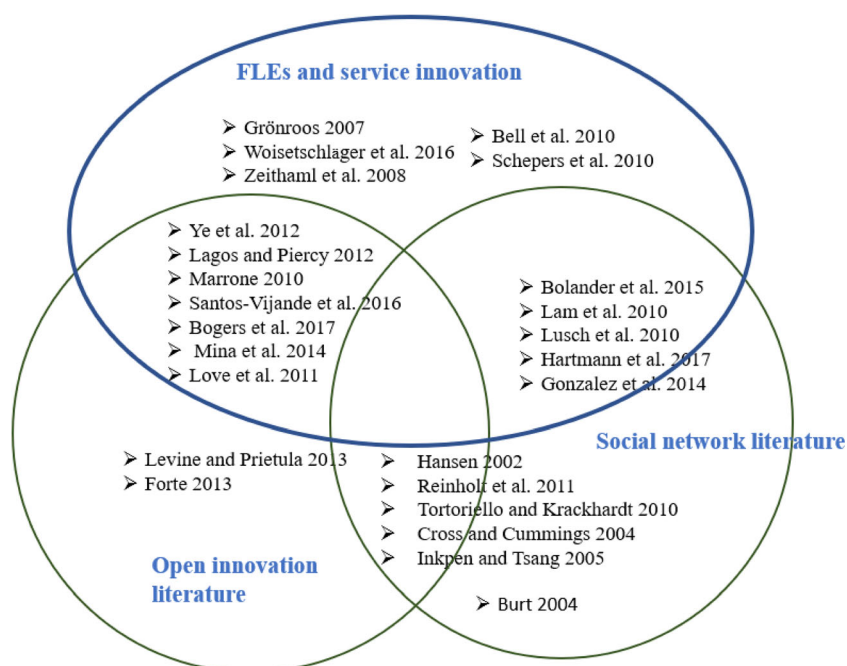
To facilitate this weaving, the Appendix summarizes a review of the literature on open innovation and social network studies with a focus on FLEs, while Fig. 1 displays the overlaps among these literatures that we subsequently develop in detail. Our objective for the literature review is to circumscribe the overlaps in the open innovation and social network literatures that have in common an emphasis on FLE and service innovation. Thus, the FLE perspective is shown in Fig. 1 as a common criterion for selecting articles from both literatures for inclusion in our review. The Appendix summarizes the key theoretical and empirical contributions of each article, as well as the key gaps identified in each study. Next, we discuss the key insights from the overlaps we identify and develop a framework for examining the FLE role in service innovation as a starting point for our theorizing.

An open collaboration approach to innovation The concept of *open collaboration* is seen as pivotal in "distributed innovation models" where knowledge flows purposefully across organizational boundaries (Chesbrough and Bogers 2014). Open collaboration is defined as "a system of innovation or production that relies on goal-oriented yet loosely coordinated participants who interact to create value and make [knowledge] available to contributors and non-contributors alike" (Levine and Prietula 2013, p. 1415). Thus, FLEs in an open collaborative model (a) create or co-create value in customer interactions, and (b) interact across different departments/units to successfully innovate customer services. To illustrate, Chez Panisse, a Californian restaurant that started sustainable local food innovation, has an open kitchen concept where staff

connectedness and customer collaboration are encouraged (Chesbrough et al. 2014). The Chez Panisse cooks create a new dish almost every day inspired by the fresh food markets and enhance their menu by listening to customers.

In open collaborative settings, participants may be either firm employees or individual contributors who are motivated by mechanisms other than formal rewards, such as the desire to be recognized as an expert or active contributor, and/or a sense of achievement. Social norms, reciprocity and diversity are important enablers of open collaboration (Reinholt et al. 2011; Forte and Lampe 2013; Levine and Prietula 2013). These collaborative actions generate new knowledge that is potentially shared and/or consumed widely. The service context and the role of the FLE share a number of similarities with this more general open collaboration idea. High-quality service innovations, for example, can emerge from the insights that FLEs gather during customer interactions (e.g., knowledge gained during customer problem solving/feedback) and the testing of these insights with peers, managers, and/or internal-facing employees (as internal knowledge flows). Customer knowledge is often tacit, and its value realized only by conscious attempts to interrogate its relevance and impact. Interactions with other firm employees that encourage the exchange of knowledge (e.g., seeking help or advice from a colleague about how to resolve a customer issue) help filter and refine the new knowledge through multiple lenses. Thus, newly generated (tacit) knowledge from customer interactions often needs to be filtered and refined, and subsequently combined and recombined with current knowledge to develop opportunities for new service offerings (Santos-Vijande et al. 2016).

Fig. 1 Figurative representation of broad research streams relevant for our study

FLEs and service innovation
- Grönroos 2007
- Woisetschläger et al. 2016
- Zeithaml et al. 2008
- Bell et al. 2010
- Schepers et al. 2010

- Ye et al. 2012
- Lagos and Piercy 2012
- Marrone 2010
- Santos-Vijande et al. 2016
- Bogers et al. 2017
- Mina et al. 2014
- Love et al. 2011

- Bolander et al. 2015
- Lam et al. 2010
- Lusch et al. 2010
- Hartmann et al. 2017
- Gonzalez et al. 2014

Social network literature

- Levine and Prietula 2013
- Forte 2013

- Hansen 2002
- Reinholt et al. 2011
- Tortoriello and Krackhardt 2010
- Cross and Cummings 2004
- Inkpen and Tsang 2005
- Burt 2004

Open innovation literature

A social network theory approach to innovation Social network studies predict that the connectedness of network actors enhances innovation, and that different actors are unequal in their impact upon knowledge flows (Subramanian et al. 2013). Exploring frontline contributions to innovations along with their connections to customers and internal-facing employees fits well with a social network perspective. Prior research on frontline innovation often focuses on employee (i.e., individual), dyadic (employee-customer), or team/organizational phenomena which obscures potential insights from taking a whole network perspective. Research has demonstrated that knowledge capture, circulation, and codification play a crucial role in enhancing market intelligence and co-creation (Ballantyne 2000, 2003). Knowledge exchanged within internal networks, in particular, legitimizes FLE tacit knowledge, enables its translation into explicit knowledge, as well as improves its value-in-use (Ballantyne 2003; Ballantyne and Varey 2006). We seek to extend this literature by exploring the role of the bottom-up employee-management networks (including FLE-IFE networks), which have provided the focus for much of the literature, while also training our focus on horizontal networks (i.e., FLE-IFE and customer networks) where significant market insight can be fruitfully cultivated.

Circumscribing the overlaps between open innovation and social network literatures reveals several gaps that guide advances in weaving these bodies of related literature (shown in the right-most column of the Appendix), and permits understanding the nuances of FLE roles for service innovation. At a broad level, these gaps include the need to account for knowledge flows, adopt a whole-network perspective, and account for effects of hierarchy, self-governance, and network characteristics especially across boundaries.

Gaps in FLE-service innovation research Based on the preceding review, in Table 1 we distill implications of frontline employee roles from open innovation and social network studies, which in turn form the building blocks for our theorizing. We organize the insights of Table 1 based on two distinct features of frontline employee roles: (a) customer interaction, which focuses on dealing with customers to serve their needs, and (b) service innovation, which focuses on employee generation of new ideas within the organization. Both features are intertwined yet distinct, and are a motivation for integrating open innovation and social network perspectives. While there are overlapping aspects of social networks and open innovation studies, Fig. 1 shows that each research stream has variously examined network characteristics (social networks), external and internal knowledge flows (open innovation), and service employees for knowledge-intensive work. Our study intersects these three research streams and advances theorizing of frontline roles in service innovation.

Service innovations are effective when new knowledge stems from FLEs performing their work at the frontline and gleaning insights into non-obvious market preferences. This customer network is essential to enhance FLEs' knowledge about how services can be improved or modified to fit changing customer demands. As a result, frontline employees are key enablers of new service development or service innovation (Ordanini and Parasuraman 2011). Consistent with this, we identify several drivers of creativity and speed essential for service innovations including: *live* customer-interactions, *fast* decision-making requirements as per customer conversations, *continuous* internal coordination for problem-solving, *frequent* exposure to unveiling roots of customer service problems, and *prompt* customer feedback about service performances (see Table 1).

In addition to customer interactions and service innovations roles, we also identify four sources of tension as a consequence of the interplay of these two roles (Table 1, "Tensions" column). As Fahey and Prusak (1998, p. 267) suggest, knowledge is meaningful when a "knower" knows it and is influenced by external social interactions and the knower's own needs. Further, when personalized (tacit/unobservable) knowledge is not shared through communication, it is harder to utilize (Alavi and Leidner 2001). This generates our first type of tension: the lack of social mechanisms in intra- and inter-organizational networks to extract FLE tacit knowledge could hurt FLE idea generation processes for the organization. Second, as problem-solvers, FLEs may inherently develop creative ideas at work, but continuous effort in resolving conflicts and troubleshooting may impede FLE innovation by imposing a heavy burden on their cognitive resources and available time. Third, as FLEs examine and resolve the underlying roots of service problems for a particular customer, the improvised solution deployed for that specific customer may remain as a solution at the dyadic-level but fail to generalize into an innovation for the organization as a whole. Finally, FLEs when acting as change agents may have difficulty promoting top-down enforced service solutions, thus organizations could see failures or diminished gains in new service deployment and commercialization phases of a project.

Toward a taxonomy of frontline network domains and flows

A taxonomy facilitates theory building by developing a classification schema that provides a mutually exclusive and collectively exhaustive description of the phenomenon (Hunt 1991). A classification schema, in turn, facilitates theory building by directing attention to different configurations or combinations represented in the schema that are differentially effective for a given outcome such that "ideal types" may be theoretically conceptualized and empirically tested

Table 1 FLE roles, service innovation and potential tensions

FLE customer-facing roles	Representative studies	FLE roles and their inherent relations to service innovation	Tensions identified due to interplay between FLE roles and service innovation
Co-creation with customers as customer interactions are often *frequent*, fragile, dynamic, and intimate.	Ye et al. 2012; Ordanini and Parasuraman 2011; Vargo and Lusch 2004, 2008	Access to diverse and non-obvious knowledge about a) customer preferences and priorities b) dynamic market conditions and demands.	Complex organizational frontline interface that intertwines with diverse and distinct networks for knowledge exchange. Tacit FLE knowledge is difficult to articulate, may not be in an easily useable or stored form for organization.
Real-time problem-solving for hetero-geneous customer problems.	Bowen and Lawler 2006; Van der Heijden et al. 2013; Singh et al. 2017	Inherently help develop creative service solutions – e.g., with fast decision making, and continuous internal coordination processes.	Improvised solution may not be mobilized as an effective solution for the whole organization. Cross-level and multi-level knowledge and task flows influence the nature of good-quality service innovations.
On-the-job learning from a diverse array of customer needs, wants, and responses.	Bell et al. 2010; Ye et al. 2012; Schepers et al. 2016; Choudhury 2017	Learn underlying causes of customer problems contributes to organization learning and innovativeness. Get prompt customer feedback while learning occurs to facilitate new idea developments.	Knowledge acquired may not be relayed easily to organization entities or forms – i.e., may not be stored in a database, repository, and library or relayed to another employee/manager. Service as a knowledge-intensive and intangible activity requires frontline employee creativity and skill development to advance innovation quality.
Acting as *change agents*-i.e., promotes and delivers new services to customers.	Melton and Hartline 2010, 2013	Improve how new services are implemented and mobilized in service ecosystem.	Innovation implementation from top-down to bottom often requires FLE buy-in. Top-down and bottom-up governance are not sufficient - self-governance of social networks play an important role when emergent customer service is inherently and frequently present in knowledge- and skill-intensive service innovation work.

(Cornelissen 2017). For instance, in the strategy field, Miles and colleagues (Miles et al. 1978) identified three "ideal" organizational forms—Prospector, Analyzer, and Defender—that relate differentially to firm outcomes. Classifying organizational strategies into mutually exclusive and collective exhaustive categories permits theorizing about the mechanisms that explain how different organizational forms foster and cultivate different pathways to innovation and performance (Doty et al. 1993).

Taxonomy of frontline networks A meaningful taxonomy requires well-defined and clearly demarcated constructs as its building blocks. Consistent with our objective of linking frontline networks and the open collaboration literature, we conceptualize frontline network *domains* and *flows* as the distinct constructs. *Domains* indicate the distinct and substantively meaningful category of agents or stakeholders that are connected to frontline employees; for our study, we propose two disparate domains: (a) customers and (b) internal-facing employees (within the same organization). Other domains could be considered such as suppliers or outside-employees (in other organizations) but we leave them for future work, as they are less proximal to the service innovation process. Contrary to domains, *flows* indicate the distinct content that network connections carry; for our study, we propose two disparate forms of content (a) knowledge and (b) self-governance activities (Table 2).

We first identify and focus on employees (FLEs and IFEs) and customers as domains of interest. We also attend to knowledge and self-governance as flows of interest in our initial taxonomical development. Both are prompted by our literature review of FLE roles in service innovations (Appendix and Table 1) that highlights gaps and tensions in FLEs connectedness to customer and intra-organizational networks and their innovation-related flows. Other flows are feasible including influence (power) and social (belongingness), but we leave them for future extensions in order to focus initially on the two primary content types.

Taxonomy-based theory building directions

We develop our taxonomy-based theory building in three steps: (1) We explain the characteristics of domains and flows (2) We intersect flow-domain networks to predict each quadrant's distinct effect on service innovations (3) We explicate network-level mechanisms for each domain-flow network by utilizing their characteristics and functions. We conclude by examining the dark-side of frontline networks by theorizing countervailing knowledge and self-governance mechanisms that can diminish service innovations.

In terms of defining the domain and flow networks' characteristics, in Table 3, we delve into a deeper level of detail to characterize the taxonomy outlined in Table 2. Table 3

Table 2 Taxonomy of frontline networks

	NETWORK FLOWS	
	Knowledge exchange in network Definition: Sharing, acquiring, or seeking customer service knowledge between (frontline and internal-facing) employees and customers form this network flow.	Self-governance activities in network Definition: Employee self-organization activities (i.e., evaluate, decide, select, assign tasks) regarding customer services form this network flow.
DOMAIN NETWORKS		
FLE-customer networks Definition: Frontline Employees' (FLEs') connectedness in customer idea sharing processes form this network.	Customer-connected knowledge networks (Quadrant 1)	Customer-connected governance networks (Quadrant 3)
FLE-IFE networks Definition: Frontline Employees' connectedness in other employees' (IFEs) work-related communications form this network.	Internally-connected knowledge networks (Quadrant 2)	Internally-connected governance networks (Quadrant 4)

FLE: Frontline employee, IFE: Internal-facing employee

Table 3 Theory building directions for taxonomy of frontline networks

	NETWORK FLOWS	
	Knowledge Exchange (KE) in network	Self-Governance (SG) activities in network
DOMAIN NETWORKS	Definition: Sharing, acquiring, or seeking customer service knowledge between (frontline and internal-facing) employees and customers form this network flow. Dimension: KE for customer services. Attributes: Flow: Expertise, guidance, help, and advice around customer services. Actions: Seek, exchange, acquire, and/or integrate knowledge.	Definition: Employee self-organization activities (i.e., evaluate, decide, select, assign tasks) regarding customer services form this SG network flow. Dimension: SG activities for customer services. Attributes: Flow: Emergent tasks or alternatives for customer services. Actions: Assign, evaluate, and/or execute emergent tasks or alternative courses of action.
Customer-FLE Networks Definition: Frontline Employees' (FLEs') connectedness in customer idea sharing processes form this network. Dimension: FLE-customer interactions (Definition: the extent of FLE-customer conversations) Attributes: Closeness to customers (distance), Number of connections.	Quadrant 1 Definition of network activities: FLEs and customers interact for seeking help regarding customer services and exchanging service solution knowledge. Functions of networks: Uncovers root causes of customer service problems; improves FLE knowledge by customer feedback; helps extract testable new service ideas. Expected effects on service innovation: Generates and improves *creative* knowledge shared between organization and customers, enables *real-time* search for and testing of newly conceptualized ideas for service modifications and improvements.	Quadrant 3 Definition of network activities: FLEs and customers interact for decision-making activities regarding emergent customer service processes. Functions of networks: Self-organizes for efficient service idea implementation; allocates and executes emergent customer service tasks; evaluates alternative customer service solutions. Expected effects on service innovation: Facilitates *rapid filtering of best-quality* ideas as candidates for organization knowledge.
FLE-IFE Networks Definition: Frontline Employees' connectedness in other employees' (IFEs) work-related communications form this network. Dimension: FLE and other employee interactions. (Definition: IFE networks are identified by their extent of cross-functional FLE employee communications) Attributes: Closeness amongst employees (e.g., with proximity, departmental functions), Number of connections (e.g., meetings, conversations, serendipitous collisions)	Quadrant 2 Definition of network activities: Knowledge exchange and integration activities amongst internal networks. Functions of networks: Establishes creative communication for customer services across departments. Expected effects on service innovation: Engenders informal knowledge *validation* regarding *feasibility* of new customer service ideas; creates synergies through cross-sectional employee conversations.	Quadrant 4 Definition of network activities: Decision-making activities amongst internal networks. Functions of networks: Establishes fast idea validation through peers; inherently develops FLE organizational awareness and active bottom-up sense-making for better decisions. Expected effects on SI: Enables *timely* and *effective* execution of emergent customer service tasks.

substantiates and specifies our choice of domains and flows by including for each case a definition, its dimension and key attributes. Domain networks involve FLE-customer or FLE-IFE interactions. The frequency and extent of interactions may be spontaneous/uncertain, or planned/predictable, or both. Further, the attributes of the domain networks are the *closeness* and *number* of connections (i.e., ties) at each node, which we collectively refer to as connectedness. For network flows, defined as the knowledge or governance activity content carried over networks, the relevant dimension is the *level* of content that passes through the network. For knowledge exchange network flow, the flow attributes are expertise-related, reflected in providing guidance, help and advice to others, while for self-governance networks, the flow attributes are task-related and reflected in negotiated responsibility for assigning and executing tasks. The attributes of network flow differ depending on whether the content of ties are knowledge or self-governance activities.

Intersecting frontline network domains and network flows yields different combinations that reflect distinct ways of characterizing innovation in service organizations. Specifically, a range of "ideal" or prototypical combinations may be conceptualized using the domains and flows that constitute the proposed taxonomy. Some combinations are especially noteworthy. For instance, "more is better" combinations intuitively characterize service organizations that are "high" on all or most features including customer and inside-facing connectedness, as well as knowledge and self-governance activity flows. Other combinations may characterize service organizations that optimize by selectively combining features *across* domains and flows rather than *within*. For instance, a "customer-connected knowledge network" (Table 3) combination may refer to a service organization that selectively optimizes frontline networks by emphasizing customer connectedness and knowledge flows, while paying less attention to inside-facing connectedness and governance activities flows. Conversely, an "internally-connected governance network" (Table 3) combination may optimize selectively by giving priority to inside-facing connectedness and flows of governance activities. Finally, some service organizations may optimize frontline employee networks by combining features *within* domain or *within* network flow, missing the gains from optimizing *across* domains and flows. For instance, a connectedness combination may emphasize connectedness in both customer and inside-facing networks but pay less attention to the flows enabled on these networks. Likewise, a flow combination may give priority to flows of knowledge and governance activities but may pay less attention to the connectedness in frontline employee networks.

Our key argument is that the proposed domains and flows features of the taxonomy permit a comprehensive representation of a wide diversity of service innovations; these may differ substantively in terms of the frontline networks an organization fosters and supports. More importantly, the proposed taxonomy identifies major features that distinguish these service organizations and guides theory-building by directing researchers to hypothesize the influence of the distinguishing feature(s) on service innovation.

Our taxonomy provides the building blocks for better understanding service innovation. Each network domain and flow component reveal a portion of the overall picture of a firm's capacity to innovate. It is beyond the scope of this study to explicate a grand theory of FLE-led service innovation that integrates all the components of our taxonomy; however, we see value in demonstrating the mechanisms that contribute to service innovation outcomes. Thus, in the following section, we explore the implications of the four combinations of network domain and flow (shown in Table 3) for two of the most commonly studied aspects of innovation, (1) creativity, and (2) speed to market. Creativity in the context of service innovation affects the extent to which the service differs from competing alternatives in a way that is meaningful to customers (Dewar and Dutton 1986), while speed to market refers to the time elapsed between the initial idea stage of the service innovation process and its actual implementation (Fang 2008). As we explore each quadrant in Table 3, we illustrate elements of our taxonomy in practice. We explicate general network-level mechanisms for each domain-flow network and show these mechanisms at work within an exemplar company. These are summarized in Table 4.

FLE-customer networks and knowledge exchange Turning to the intersection between FLE-customer networks and knowledge exchange (Quadrant 1 in Table 3), a high level of connectedness is likely to have a positive impact on service innovation creativity. High connectedness leads to increased velocity of knowledge shared (i.e., higher frequency of conversations, shorter pathways between customers and FLEs and fellow FLEs) which enables real-time search for, and testing of, new ideas for service modifications and improvements. Social resources such as trust and cooperation, forged within close ties, are positively related to new knowledge creation (Collins and Smith 2006). A lack of connectedness, by contrast, suggests infrequent contact between FLEs and customers, meaning that ideas and new approaches invented at the frontline are not easily 'road tested' with customers and other frontline colleagues. Further, higher connectedness, and the trust between FLEs and customers that this implies, allows the suggestion and trial of more radical and risky ideas. Customers, for example, demonstrate greater patience with service providers with which they have strong relationships (Lengnick-Hall et al. 2000; Tax et al. 1998).

As an example, consider the approach to service innovation at online retailer Zappos, where customer relationships are built not "through the website," but as "a result of how people are treated" in frontline interactions (Solomon 2017, p. 1). At

Zappos, customer interactions are not measured by the number of customer calls, but the average duration of the call – *the longer the call the better*. Having "in-depth" conversations with customers generate intriguing stories with exciting – and often highly improvised – customer service solutions. The firm's encouragement of FLEs to pursue deeper, more meaningful interactions with customers unearths novel and varied ways of serving customers.

FLE-IFE networks and knowledge exchange As FLE-IFE knowledge exchange networks (Quadrant 2 in Table 3) increase in connectedness, we are likely to observe increases in service innovation creativity as new ideas are interrogated by a wider range of employees from different backgrounds and with different skill sets. Increased connectedness across departments allows informal knowledge validation which helps refine organization-wide thinking about new service processes. Cross-unit knowledge exchange in organizations is prone to synergies (Hansen 1999, 2002; Szulanski 1996), which enable the creation of new knowledge (Tsai and Ghoshal 1998). Further, the influence on service innovation increases as emergent ideas that flow are seen as practical and realizable within the firm. Internet firm Google, for example, actively tries to span department boundaries where possible to bring the full weight of the organization's competencies to the innovation process. Google's COO describes the firm's efforts to "have as many channels for expression as we can… different people, and different ideas, will percolate up in different ways" (He 2013, para.4). Thus, a cross-connected service organization network is a positive lever for service innovation creativity. Finally, Fujitsu, which is well-known for open innovation activities, prioritizes the support of employee initiative both within and outside the firm (see Table 4 for details) (Edmondson and Harvey 2016).

FLE-customer networks and self-governance Turning to FLE-customer self-governance networks (Quadrant 3, Table 3), we anticipate that a high level of connectedness will be associated with more efficient implementation of new ideas. FLEs with a strong sense of autonomy are likely to be more proactive in filtering and discarding ideas that are unlikely to be candidates for implementation when shared widely within the organization. The FLE-customer self-governance network, thus, performs a 'triage' function to ensure that only the better ideas for implementation are considered by other departments and senior management. Consider, for example, the autonomous nature of self-organized networks at Netflix. Their company culture references employee judgement as one of their important values. They empower and encourage employees to pursue and implement new ideas within minimal consultation or process constraints (Netflix Culture 2018). Software developer Adobe takes a similar decentralized approach, funding creativity and testing upfront, by providing employees with a prepaid credit card to spend developing and testing ideas. This allows fast, and relatively inexpensive, testing of an idea in its early stages without time consuming cycles of formal approvals (Burkus 2015a). In the fashion industry, Zara exhibits customer-connected governance networks (Table 4, Quadrant 3). Customers interact with "Regional Commercials" (FLEs responsible for understanding dynamic customer demand). Further, "commercials" are autonomous and can execute innovative ideas. For example, they can change clothing designs or manufacturing orders to match local demand (Ringel et al. 2016; Doiron 2015).

FLE-IFE networks and self-governance A high level of connectedness in the FLE-IFE self-governance network (Quadrant 4, Table 3) leads to greater speed to market for emergent ideas but for different reasons than the FLE-customer network. The FLE-IFE network brings two important benefits to the innovation process: (1) idea validation through peer input, and (2) collective awareness and sense-making. The process of active sense-making has a positive effect on decision making effectiveness (Van Riel et al. 2003), although a bottom-up sense-making approach is likely to be more valuable for service innovation. For instance, healthcare provider Kaiser Permanente's utilization of collaborative communities "requires people to think beyond their own jobs to how their roles fit within others" (Adler et al. 2011, p. 99). Thus, a self-organizing, connected employee network helps implement, in a timely and effective manner, new service ideas that are in the best interests of the organization.

In terms of self-organizing internal networks, the music streaming company Spotify is an example of Quadrant 4 (Table 4). The company has "squads" – i.e., working groups – that oversee the development of new services and are autonomous in building their task networks. Members of squads can easily cross-over back and forth to other squads to solve problems or implement ideas jointly (Mankins and Garton 2017; Vroom and Sastre 2016).

In proposing our taxonomy for FLE networks, we recognize that FLE roles may vary significantly both *within* and *across* service categories. For example, in the hotel industry, a firm such as Red Roof Inn – an economy chain hotel – is less likely to have complex FLE roles due to its emphasis on efficiency during customer interactions. Luxury hotel chain, Ritz Carlton, in contrast, is more likely to nurture and support the connectedness between FLEs and customers to develop more engaged and intimate relationships. FLE roles, and the relative importance of network domains and flows, is likely to vary also *across* service categories. For example, frontline roles in the grocery industry are likely to be faced with markedly different challenges relative to frontline employees in professional services.

Service contexts may be differentiated along different dimensions, but the relative emphasis on intangibility and

Table 4 Taxonomy of open collaborative networks and network-level mechanisms in practice

DOMAIN NETWORKS	NETWORK FLOWS	
	Knowledge Exchange (KE)	Self-Governance (SG) Activities
Customer-FLE Networks	Customer-connected knowledge networks (Quadrant 1)	Customer-connected governance networks (Quadrant 3)
	General network-level mechanisms:	General network-level mechanisms:
	• Knowledge exchange between customers and FLEs seeds new service ideas.	• Cross-functional employee teams (comprising IFEs and FLEs) accelerate decision-making with new customer knowledge.
	• Knowledge exchange enables better fit of existing service to customer needs and wants.	• Cross-functional teams filter new ideas for quality and relevance for service innovation.
	• Knowledge accumulated by FLEs is codified to enable sharing across the whole organization.	• Frontline teams operate with autonomy to implement service modifications.
	Examples of mechanisms in Zappos:	Examples of mechanisms in Zara:
	• Zappos do not impose time limits on FLE interactions with customers, with longer duration) leading to new ideas for services.	• Customers interact with "Commercials" (i.e., employees charged with understanding customer preferences by geography).
	• Unscripted customer interactions allow greater breadth of customer knowledge generated.	• Regional "Commercials" work with Design "Commercials" (i.e., product managers & designers) to modify product lines.
	• Zappos creates an annual culture book of customer service stories from which Zapponians (Zappos employees) learn.	• "Commercials" have the authority to set designs, order supplies, change manufacturing details for the greatest local impact.
	See: Solomon (2017), Burkus (2015b), Zappos Insights (2018)[a]	See: Ringel et al. (2016), Doiron (2015)
FLE-IFE Networks	Internally-connected knowledge networks (Quadrant 2)	Internally-connected governance networks (Quadrant 4)
	General network-level mechanisms:	General network-level mechanisms:
	• Open communication between FLEs and IFEs is encouraged.	• Cross-departmental groups interact formally and informally to test new ideas.
	• Well-established infrastructure for transparent knowledge exchange.	• New service and product design changes are implemented quickly through joint, decentralized decision making.
	Examples of mechanisms in Fujitsu:	Examples of mechanisms in Spotify:
	• Cross-functional teams operate jointly to support a culture of creativity and innovation.	• Spotify's agile culture allows fast reaction time to environmental changes through collaboration between working groups called "squads".
	• Use of network-based modes of collaboration to combine employees.	• Squads have autonomous leaders and members can switch seamlessly between squads.
	• Support for engagement between employees who interact with outside firms and internally facing employees helps change implementation programs.	• Squads have the latitude to oversee development of new services and knowledge networks
	See: Edmondson and Harvey (2016)	See: Mankins and Garton (2017), Vroom and Sastre (2016)

a https://www.zapposinsights.com/culture-book/digital-version

personalization are particularly useful to assess the degree to which FLEs play a central or peripheral role in customer's service experience (Lovelock 1983; Cunningham et al. 2004). We expect that service experiences that involve greater levels of intangibility and personalization are more likely to engage FLEs as central players in creating such experiences (e.g., "cast members" at Disney). FLE networks in these contexts are likely to be more relevant in supporting service innovation. However, this should not be taken to imply that the yield for service innovation from FLE networks will be minimal in service contexts that do not emphasize intangibility and/or personalization. As we note in Table 4, service contexts with moderate-to-low levels of intangibility and personalization, such as Zara, may nevertheless benefit from FLE networks because customer-facing employees are the frontlines in observing changing market (fashion) trends across the diversity of customer interactions. Where agility in reading changing and dynamic customer or market trends is prized, FLE networks may play a central role in service innovation.

Theorizing a dark side Our taxonomy also permits theorizing about mechanisms of a dark side. Highly-connected, knowledge-rich, self-governing networks will, for the most part, have positive impacts on creativity of service innovations and their speed to market. In certain circumstances, these effects may be constrained, or even become unwound. Specifically, we consider how our main effects arguments might be affected by, (1) problems with identity, and (2) the salience of divergent goals. Each of these factors, we argue, might conspire against universal positive influences of connected knowledge and self-governance networks.

One of the advantages of increasing connectedness between organizational members from varied departments, backgrounds, and skill sets is a higher diversity of insight and feedback given to new ideas. Equally, it enables faster implementation of innovations due to greater decision-making potential in self-governing networks. A complicating factor, however, as members from more and varied backgrounds within the organization connect is potential conflicts in social identity (Tajfel and Turner 1979). As diversity increases, there is potential for a "hunkering down" effect (Putnam 2007) as the diversity creates uncertainty and, ultimately, reduces both between- and within-group social capital. A reduction in social capital is likely to undermine the decision-making benefits of a strong mutual perception of self-governance potential. The implication is that there is likely to be an optimum level of connectedness, especially as it intensifies identity differences.

Increased connectedness between groups will also bring into focus the (often) disparate nature of organizational goals. Customer-facing employees, for example, are often driven by customer-focused metrics, while those in operations or finance are motivated by a cost-containment calculus. These goal differences are as much a function of professional norms as management driven metrics. Members of a group tend to engage in collective behavior that maintains the internal cohesiveness of the group's goals (Sandefur and Laumann 2000). As different groups develop ties with each other, goal differences become more salient, leading to competition and a throttling of knowledge sharing and joint decision-making. The extent to which organizational members collaborate across groups is thus curtailed. Inefficiencies enter the process of service innovation as lengthy negotiations between individuals occur as they compete to capture the gains from innovation.

Discussion

Taxonomies are core conceptual contributions that systematically organize the nature and scope of a phenomenon of interest, and provide a foundation for building theory that develops a nomological net around the phenomenon of interest (Doty and Glick 1994; Cornelissen 2017). Theoretically grounded nomological nets connect the phenomenon of interest to other (related) bodies of literature to theorize mechanisms that advance our understanding of the phenomenon, and identify its key antecedents, processes (e.g., mediators and moderators) and outcomes. These aspirations for future theoretical work, motivated by our proposed taxonomy, guide our discussion. Specifically, we discuss theoretical connections between our taxonomy of frontline knowledge networks and several research areas, including open collaboration, social networks and organizational frontlines, that can be exploited in future research. We also discuss implications of our proposed taxonomy for service practice and innovation in organizations keeping in mind the caveat that detailed managerial prescriptions must await empirical testing. We close with a brief conclusion.

Frontline knowledge networks and open collaboration research

Open collaboration research recognizes the importance of networks (e.g., ego-networks within an organization) and gives attention primarily to technical boundary spanners (e.g., R&D scientists) to focus on product/process innovations. However, service firms have unique qualities distinct from manufacturing firms (Chesbrough 2010; Mina et al. 2014). Most do not invest heavily in R&D facilities, and scaling innovations often requires gains in knowledge accumulated by FLEs and customers.

Further, FLEs as boundary spanners present distinct qualities relative to R&D engineers or open source developers, who span different organizational boundaries. For instance, customer-facing employees are often engaged in improvising or constructing *real-time,* solutions to customer problems that

enhance the service experience and generate novel knowledge. During a product innovation or project development stage, boundary-spanners often interact with customers with a "best-fit" solution that is well-articulated prior to facing customers. Therefore, while limited time for troubleshooting may germinate an abundance of new ideas, it may also act as a stressor for FLEs, thus diminishing their subsequent knowledge-sharing behaviors. This has implications for the use of dynamic controls to encourage idea generation while reducing stressors, and thus overcoming barriers to knowledge sharing. In short, we underscore the case for taking a micro-foundational approach to understanding open collaboration and service innovation, beginning with the FLE – with their unique boundary spanning qualities (Table 1) – as the basic building block.

Our paper focuses on the role of frontline employees as sources of service innovation. However, we acknowledge that service innovations may emerge in other ways. For instance, some companies utilize dedicated innovation teams to promote a top management imperative on innovation processes (e.g., Apple). Other companies benefit from unexpected market conditions or regulatory changes to discover service innovations (e.g., 3M's post-it innovation). In open innovation research, user-led, R&D and market-research are also often key sources of innovation. As a result, further research may investigate how different sources of innovations can interact within FLE networks to influence service innovation.

Frontline knowledge networks and social network research

Our study aims to extend social network theory by defining four network constructs (including domains and flows) and demonstrating their combined effects on service innovation. Connectedness as a construct and its relationship to innovation has demonstrated intriguing yet mixed results. Our approach of delineating sub-networks within organizations oriented around pivotal FLEs, while also isolating knowledge and self-governance flows is an attempt to reconcile these findings. Further, network theory has predominantly explored the effects of network variables (e.g., density, clustering, closeness) on non-network dependent variables (e.g., individual performance, organizational performance) (See Borgatti and Halgin 2011 for a review of network theory-building). By contrast, we consider the potential for *interactions* between network variables across both network domain and network flows, before exploring the implications of these for organizational performance.

Additionally, studies taking a whole-of-network approach rather than an ego-centric view of organizational performance are few and far between (Burt 1992; Uzzi 1997; Ahuja 2000; Uzzi and Spiro 2005). Inter-organizational whole-network research has demonstrated the value of understanding the structure of whole-networks for its impact on business performance (Provan, Fish, and Sydow 2007). We extend this idea by exploring the impact of both intra- and inter-organizational whole-network structure for service innovation.

Finally, we add to the literature on tie *content* which has received less attention than more commonly explored concepts in network theory such as tie strength (Burt 1992; Levin and Cross 2004) and nodal properties (e.g., network position and proximity studies; Burt 2004). Prior research on tie content has focused mainly on the exchange of resources such as kinship, support, advice, and assistance (Hansen 2002; Collins and Smith 2006; Gittelman 2007). While useful in an organization setting, these resources present few insights about the decision-making processes that are essential for getting work done, especially by employees empowered to do so. By advancing the notion of self-governance flow (e.g., negotiating, evaluating, and jointly confirming new solutions) we enable a better understanding of how social networks support the performative aspects of organizations as a whole.

Frontline knowledge networks and organizational frontlines research

An emergent field of organizational frontlines is taking hold that conceives "frontlines" more broadly than frontline employees (Singh et al. 2017). Specifically, organizational frontlines research conceives "frontlines" as the site of contact between the organization and customer, regardless of whether the contact is human-to-human (e.g., employee-customer), machine-to-machine (e.g., remote monitoring of a customer device such as a car or some combination thereof (e.g., machine-to-human; self-help technology). Our proposed typology of frontline knowledge networks conceives a central role for frontline employees, and does not explicitly consider the wide range of technological or augmented (human+machine) interfaces that are increasingly observable in frontline interactions between firms and their customers. However, our proposed taxonomy is compatible with the conceptions anticipated by organizational frontlines research and can be further developed and advanced to incorporate frontline knowledge networks that are infused with technological interfaces. To motivate this development and advancement, we consider the contribution of our proposed taxonomy in the context of the increasing relevance of artificial intelligence (AI) and automation in frontline technologies (Huang and Rust 2018).

AI is a key enabler for emergent frontline technologies, with technologies such as chatbots helping to shift the emphasis in FLE roles from the repetitive and the mundane, to the more intricate, social interactions (Huang and Rust 2018). While it is uncertain that AI technologies will autonomously execute complex frontline roles requiring a high level of

intuition, tacit knowledge and emotional labor, frontline *employees* are likely to remain essential to many service contexts that require empathetic, customized, and agile solutions for both internal and external customers. This suggests a growing separation between service contexts where frontline technologies may substitute for frontline employees (making human aspects less salient) and those where frontline employees assume greater salience. In the latter contexts, our proposed taxonomy can be a starting point for extending the network and self-governance features to incorporate the role of feelings/emotions and response agility in designing and accelerating innovative service experiences.

In service contexts where frontline technologies may substitute for human participation in service delivery, the challenges for adapting our proposed taxonomy are more significant but not less interesting. Substitution of human function in organizational frontlines is unlikely to diminish the relevance of knowledge and governance challenges in service innovation. Instead understanding the nature and scope of knowledge flows enabled by frontline technologies is likely to require expanding the proposed taxonomy to account for different *types* of knowledge and different *kinds* of knowledge flows that disparate frontline technologies enable. Likewise, the nature and scope of governance protocols for designing interfaces with frontline technologies goes beyond computational efficiency if the objective function is effectiveness in service innovation. Much interesting work remains in building on our proposed taxonomy to account for a phenomenon that substitutes frontline technology for human participation in frontline roles.

In addition to enabling AI-based interfaces capable of autonomous agency, digital technologies are also improving capabilities of business analytics that can augment and supplement frontline employees' capacities for processing knowledge and managing governance challenges. Likewise, there is increasing democratization of access to customer intelligence throughout the organization. Where once customer research and insight were the purview of the marketing department, now all parts of the organization have ready and convenient access to customer data. Yet democratized access does not guarantee coherent interpretations of the meaning of new knowledge across groups. Indeed, democratization may unleash multiple and competing interpretations that are tainted by internal territorial and power conflicts. This, we suggest, underscores the importance of connectedness *between* networks to help dissolve inter-group differences. In the context of our framework, connectedness between FLE and IFE networks is likely to help reconcile variance in service-related knowledge interpretation and transformation. Connectedness between groups will enable more complete sense-checking and validation of interpretations which may reduce errors in implementation of innovations deriving from this knowledge. In short, greater levels of FLE-IFE connectedness is likely to clarify knowledge flows and enhance their positive impact for service innovations.

Finally, our conception accepts parallels between frontline employees and field salespeople; both are key customer facing roles and likely to be instrumental in the flow of customer/market knowledge and self-governance activities over their external and internal networks. For example, Kraft Foods in China turned its money-losing business into a profitable one by forming a frontline team to gain customer insight (Furr and Dyer 2014), which led to the production of locally appealing Oreo cookie flavors (e.g., peanut butter and green tea ice cream), shapes, and layers. Other product-oriented companies also deploy customer-facing employees as technical consultants, technical product sales, and problem solvers. To illustrate, Cisco Systems offers both products (e.g. network switches/routers) and services (e.g., networking management/security) and expects customer-facing employees (e.g., network engineers, marketing) and internal facing employees (e.g., R&D, finance) to collaborate and coordinate for effective customer experiences (Gulati and Puranam 2009). Similarly, in many companies that engage in open innovation, R&D employees and scientists work with customers and across departments to explore and test new ideas (e.g., new and patentable innovations). Thus, our model, which highlights domain networks and network flows, is sufficiently general and can be applied to a wide range of settings.

Frontline knowledge networks and service practice

Our framework suggests a more nuanced, but, at the same time, more comprehensive approach to the generation, refining, and implementation of service innovations. Our ideas reflect recent observations by consulting firm, McKinsey & Company, that service innovations are no longer the exclusive domain of in-house R&D units and managers, but rather a function of collaboration with suppliers, customers and specifically FLEs who occupy a crucial nexus connecting the firm and its customers (Jong et al. 2015). Thus, we recommend firms explore all possible sources of inspiration for new ideas and, in particular, consider ways in which FLEs can be brought more fully into the innovation process. We advocate moving beyond "suggestion boxes" or "idea tournaments", which tend to reflect scattergun approaches to idea generation. Devolving some responsibility for innovation to the frontline is a first place to start. FLEs are not only natural sources of inspiration but are also great 'filterers' of ideas. Increasing FLEs' ability to self-govern will mean that only the best ideas will percolate through the organization for more cost effective and speedier implementation.

Managers might also track the progress of ideas as they flow through the organization. This would require a deeper understanding of the nature of intra-firm relationships. Exploring such relationships has become more feasible in

recent years given the availability of Social Network Analysis Tools (e.g., UCINET, Gephi). Recent research suggests mapping employee interactions can help managers to identify which type(s) of employees stay isolated and those that are more connected than others (Yamkovenko and Tavares 2017). That study mapped the firm into three types of networks: (1) decision-making (2) idea-sharing and (3) emotional networks. We suggest a similar approach to mapping the service organization to allow a better understanding of sub-network interactions which might uncover root causes of knowledge flow failures or idea generation scarcity. Our model emphasizes connectivity of FLE-customer and FLE-IFE networks that could also be useful to managers for understanding service performance, customer satisfaction and service innovation.

Conclusion

Our theorizing focuses on frontline employees (FLEs) and their open collaborative networks. The study aims to understand how FLE networks can help organizations to leverage ideas from open innovation to advance service innovations with a bottom-up and horizontal comprehensive and realistic view rather than a formal and top-down management driven approach. Our study obtains conceptual support from exploring informal (social) networks that form alongside the organization's formal structures, yet remain invisible and complex. Recognizing that the social network layer of these collaborative employee relationships intertwine with customer networks facilitates our understanding of how market- and intra-organizational knowledge might be integrated by FLEs. Our theory can be extended by investigating when and why these multi-layered networks contribute to various dimensions of service innovations. Added granularity for boundary conditions could enable FLE networks theory to further advance and help practitioners utilize key decision-making and knowledge network conditions effectively.

Appendix - Literature review - FLEs in open innovation and social networks research

Authors	Broad research stream	Key theoretical contribution	Key empirical contributions	Key gaps identified
Hansen 2002	Social (Knowledge) Networks	Theorizes a knowledge network model to explain how the nature (connectedness) and degree (related/unrelated knowledge) of lateral inter-unit relations influence effective knowledge sharing and project completion.	Shorter network connections to units with related knowledge (joint effects) increase knowledge acquisition (.37/.06, p<.01). The net effect of outdegree and non-codified knowledge has a negative effect on project completion time.	More inclusive knowledge network models that go beyond lateral relationships are needed to understand how network connectedness and knowledge *flow*s (codified/uncodified) interact to influence knowledge and project outcomes.
Burt 2004	Social Networks	Conceptualizes structural holes (information holes between densely connected groups) as an antecedent to generating new ideas and employee job performance and promotions.	Brokerage (0.939, p<.001) and idea length (.0013, p<.05) have a significant impact on idea discussion. Further, managers with networks who do not span structural holes had low idea value (.694, p<.001, high dismissal of ideas (.972; p<.001), and have fewer ideas (2.356, p<.001).	Ideas were generated as different social groups were integrated but the idea spread was an issue as whole networks stayed disparate in organizations. The need to investigate how whole networks (i.e., small worlds) work to diffuse ideas for innovations remains a fertile research area.
Cross and Cummings 2004	Social Networks	Theorizes that individuals spanning social boundaries will observe higher performance ratings in knowledge-intensive work due to access to diverse knowledge, and knowledge absorption in solving complex problems.	Consultants with ties to internal-facing employees outside and inside the organization (p<.01), high betweenness centrality (awareness network position) (p<.05), and high flow betweenness (information network position) (p<.05) had high performance ratings.	Network characteristics and boundary spanning ties and positions are relevant factors in knowledge intensive networks. The need to adopt a whole network perspective to study organizational innovativeness requires further attention.
Inkpen and Tsang 2005	Social Networks	Theorizes a network typology of horizontal and vertical networks	N/A	Inter-organizational network types that permit knowledge spillovers

		that span from a structured to unstructured dimension. Inter-organizational networks are conceptualized as having structural, cognitive, and relational dimensions that facilitate knowledge transfer.		and transfers may be impacted by different conditions and mechanisms such as shared goals in an intra-corporate network vs. goal clarity in a strategic alliance.
Lam, Kraus, and Ahearne 2010	Social Networks	Theorizes top-down frontline learning by positing that individual-level market orientation (IMO) diffuses to frontline-level through formal channels (mid-managers) and informal channels (social learning through expert peers). Additionally, sales district network size could hinder IMO diffusion from top-level managers and experts to frontlines.	Sales directors' IMO has a positive effect on sales managers' IMO (.16, p=.01) and expert peers' IMO (.11, p < .05). In turn, expert peers' and managers' IMO have a positive effect on sales representatives' IMO respectively (35. p<.01; .17, p<.01). When size of a sales network district size is larger, the effect of expert peers' IMO on sales representatives' IMO diminishes (-.05, p<.01).	Formal top-down learning in organizations is extensively researched; informal market-driven learning from expert peers to frontline require further attention. Social learning within groups are key for frontline learning. Dynamic and informal networks and their characteristics can complicate theorizing about FLE networks.
Lusch, Vargo, and Tanniru 2010	Social Networks (S-D Logic view and Value Networks Perspective)	Theorizes supply chains as service ecosystems that employ value networks. These networks are tied through information technology and business relations. Thus, value is co-created by customer in networks by knowledge exchange and governance of supply chain (service) activities which improves learning to serve in a value network.	N/A	Market and hierarchical *governance* have been researched extensively, however little is known about the governance of networks. A governance approach to better understand how social norms, network positions and characteristics predict learning requires further investigation.
Marrone 2010	Open Innovation	Theorizes about (1) team boundary spanning (a) antecedents include leadership, team characteristics and structure, (b) contextual antecedents such as environmental certainty and team resources (c) outcomes including team innovativeness; (2) network-level boundary spanning which is defined by having inter-team and external unit boundary spanning activities that could help innovation and performance outcomes triggered by leadership influence.	N/A	Conceptual and empirical research are scarce in a) mediating mechanisms of (*whole*) network-level boundary spanning activities and innovation area (b) team-level boundary spanning activities and moderating variables.
Tortoriello and Krackhardt 2010	Social Networks	Boundary spanners' bridging ties are conceptualized to have different micro-structures that generate individual innovativeness. Specifically, Simmelian ties are embedded in cliques and improve innovativeness via agreement creating forces, stability and increased cooperation.	Individual innovativeness is negatively associated with high number of Simmelian ties due to accessing redundant information which impedes creativity. However bridging Simmelian ties increases innovativeness (p < .01). Strong or weak bridging ties have positive but non-significant associations with innovativeness.	Mixed findings in strong and weak ties research call for further examination of networks' structural characteristics which may have a confounding effect on network structure and innovation relationship.
Reinholt, Pedersen, and Foss 2011	Social (Knowledge) Networks	Theorizes a motivation-opportunity-ability framework to explain why open (egocentric) networks may overcome its limitations of diffused trust and dispersed reciprocity to enhance knowledge sharing and acquisition.	Significant effects of 3-way interaction among between autonomous motivation, network centrality and knowledge sharing ability on knowledge acquisition (.1, p<.001). Moreover, motivation to share knowledge positively moderates the association between knowledge acquisition and network centrality (0.9, p < 05).	Individual difference variables explain variation in the degree to which knowledge is shared and transferred, but issues of the quality of knowledge shared and the learning it entails are not examined.

Lages and Piercy 2012	Open Innovation	Theorizes about drivers of employee generation of ideas for service improvement (GISI). Key antecedents including employee perceived organizational support, reading of customer needs, job satisfaction and employee affective organization commitment directly influence GISI.	Reading customer needs (.54, p<.01), affective organizational commitment (.16, p<.05), and job satisfaction (.26, p<.01) facilitate idea generation for frontlines.	As FLEs are embedded in customer networks, it is important to note what amplifies and impedes knowledge flows, Customers and FLEs as *domains of knowledge flows* represent rich opportunities for future research.
Ye, Marinova, and Singh 2012	Open Innovation	Frontline knowledge is key to organization learning because it is developed from or created during customer interactions and is rich with insights for navigating productivity-quality tradeoffs but remains untapped. Theorizes a frontline knowledge mechanism for extracting value to improve service efficiency and customer satisfaction.	Frontline knowledge articulation fully mediates the relationship between knowledge generation and knowledge updating. When frontline knowledge mechanism is functional, it significantly increases service efficiency (.13), customer satisfaction (.12), and revenue (.03) (all p < .01).	Harnessing frontline knowledge for organizational outcomes requires mobilization of frontline networks for effective articulation.
Forte 2013	Open Innovation (Open Collaboration)	Theorizes about Open Collaboration (OC) characteristics: 1) Participants work towards a goal 2) Self-organizing communities such as Open Source Software projects or peer production platforms represent good examples of OC 3) Social relations are persistent and permit negotiation of social norms.	Findings from varied literature are present, but a key and common finding is: Diverse motivations and social mechanisms exist for voluntary knowledge flows.	Different *domains* of human activity present for OC. The need to discover dynamic social mechanisms that lead to producing new knowledge requires further investigation.
Levine and Prietula 2013	Open Innovation	Theorizes the nature of "open collaboration" organization as (a) goal-focused (create value), (b) open access (contribute/consume), (c) networked (interaction/exchange) and (d) loosely coupled (coordination/control). Also theorizes performance benefits of open collaboration organizations.	Simulations of a random population with (a) 13% cooperators, (b) 63% reciprocators, (c) 20% free riders, and (d) 4% inconsistent participants show open collaboration improves performance, but this improvement occurs at a decreasing rate with increasing "cooperators."	Reciprocity and diversity are key mechanisms that require further development in open collaboration networks.
Love, Roper, and Bryson 2011	Open Innovation	Theorizes about innovation value chain in three phases – knowledge sourcing, transforming, and exploiting. Furthermore, the linkages throughout the value chain are formed by exploratory, encoding, and exploitative linkages to external knowledge sources.	As for exploratory linkages, firms use of customers (27.935, p <.01) and internal networks with multi-functional teams (.223, p<.01) impact firms' knowledge sourcing activities. As for encoding linkages, public and private research organizations facilitate knowledge transformation from external sources (29.287, p < .01).	Firm external environments and knowledge activities play a key role in translating resources into business value, however, more longitudinal research is needed to understand causal linkages of knowledge processes in open collaborative networks.
Gonzalez, Claro, and Palmatier 2014	Social Networks	Theorizes about how Relationship Managers' formal and informal networks impact RM's performance. Social capital sources (structures and relations) are posited to improve social capital benefits including information access and cooperation. Cross-level networks (informal and formal) can enhance RM's performance – defined as "cross-level" network synergy.	Density of formal and informal networks have positive effects on performance (.24, p<.05; .37, p<.01). Moderating effects are found for brokerage of 1) informal networks and density of formal networks (.24, p<.05), 2) formal network overlap (.38, p<.05), and 3) informal network density and network overlap (.56, p<.01)	Social capital derived from intertwined networks can be crucial for frontline performance. Studies that test whole-network level effects, specifically different networks such as advice or mentorship where different knowledge flows may impact FLEs require further attention.
Mina, Bascavusoglu-	Open Innovation	Theorizes differentiating features of service and manufacturing firms in open service innovation. Service	For manufacturing and service firms, firm size (.008, p<.1) and R&D expenditure (.02, p<.01) are	Open services innovation has been neglected by open innovation research stream. An in-depth

Moreau, and Hughes 2014		firms are posited to rely heavily on external knowledge and non-R&D sources. They also co-create with customers more frequently. Drivers of open innovation in business services firms are often informal governance choices such as mutual trust, relationships, and/or less contractual solutions.	related to engagement with open innovation activities. Service firms utilize informal knowledge exchange activities more than formal (.2, p<.01) as they engage with open innovation activities.	understanding of open innovation behaviors of the service firms helps discover how open innovation enables organization outcomes and performance.
Bolander, Satornino. Hughes, and Ferris 2015	Social Networks	Theorizes that network positions of sales employees lead to knowledge flows. In fact, network centrality differs when a salesperson possesses power through *reputational* resources derived from access to powerful others versus *informational* resources derived from access to unique information.	Salesperson network characteristics (i.e., relational centrality and positional centrality) improve salesperson performance (.262, p = .000; .209, p = .000, respectively).	While political skills may drive relational centrality, it is not quite clear what drives positional centrality in networks. Further investigation for antecedents of network characteristics that impact *flows* would be useful.
Bogers, Foss, and Lyngsie 2018	Open Innovation	Theorizes about micro-foundations of open innovation such that employee roles and characteristics play an important role in how and to what extent firms utilize external knowledge.	Innovative leadership of employees is associated with firm-level openness (.05, p<.001). Educational Diversity of employees positively affects firm-level openness (.19, p<.05). Interaction effect of educational diversity and work history on openness (.18, p < .05).	Study looks at two types of employee diversity as micro-foundations of open innovation to understand how knowledge heterogeneity employs firm openness to external knowledge use. The mechanisms and performance of open innovation remain unobserved.
Hartmann, Wieland, and Vargo 2017	Social Networks (Service Ecosystem Perspective)	Theorizes salespeople in a service ecosystem and defines selling actors as people who dynamically interact and exchange resources through service-for-service exchange. Actors in the ecosystem form ties and relationships which facilitate flow of information. As a result, they co-create value through the institutional arrangements via crossing points and service ecosystem interactions. Often systematic interactions adopt and change collectively for institutionalized innovations.	N/A	As a research priority, the authors suggest a social network lens to understand what service ecosystem tasks for emergent decision activities, and what technologies will evolve and develop as the number of crossing points for multiple actors increase.
Santos-Vijande, Lopez-Sanch-ez, and Rudd 2016	Open Innovation	FLE co-creation involves collaboration with internal R&D teams to launch and market new service developments (NSDs). FLE co-creation enhances NSD market performance through FLE and customer outcomes as well as NSD speed and quality.	Some key findings for FLEs and customers: FLE co-creation directly affects FLE outcomes (2.074, p<.05) but does not significantly impact customer outcomes. FLE outcomes improve customer outcomes (4.355, p<.01) and in turn that positively affects NSD Market Performance (2.297, p<.05).	Co-creation which involves purposeful knowledge flows from *internal- and external-facing*, employees, holds complex and inherent challenges. The area research is scarce and could benefit from further research.

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