Value Chain creation through Digital Innovation: The Ebb and Flow of Communality and Connectivity in a Networked Interorganizational System

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Abstract

Communality and connectivity are types of public goods offered in online spaces. As theoretical concepts, they provide design insight for the creation and understanding of interorganizational collaboration tools in multisided networks and value chains. In this paper, we present an extension of communality and connectivity that enables an examination of how organizations create value with networked organization-to-organization (O2O) systems. We use the framework as a lens for a case study involving the historical development of an online technology and its organization (MarketMaker) over 16 years that reframed the backbone of the agricultural market in the U.S. from a supply chain to a network. MarketMaker successfully interwove consumers, farmers, universities, government agencies, and states based on its innovation to connect stakeholders in novel ways around information and communication. As a central system in reconfiguring the value chain, MarketMaker provided services to the food industry not previously enabled. A number of important lessons learned about effective use of communality and connectivity are discussed.

1. Introduction

Virtual communities are one of the signal phenomena of the 21st century [1]. Online communities of all types and sizes have burgeoned, and they have been the subjects of much scholarly inquiry. An important but understudied type of virtual community is the organization-to-organization (O2O) or interorganizational community, which includes business-to-business (B2B) commerce, but may also link nonprofit or governmental organizations [2]. O2O communities perform important logistical functions for value chains, such as facilitating the efficient purchase of supplies and delivery of service. However, relatively little is known about the growth and development of O2O online systems and the factors that support or determine their success. To that effect, more than 75 percent of B2B marketplaces go out of business within a few years of founding [3].

In order to understand the distinct ways in which O2O communities and systems develop, we explore two dimensions within O2O technology during its innovation – communality and connectivity. Additionally, we explore the contextual environment supporting the development of an O2O community. MarketMaker (MM) is an O2O community that developed gradually from needs identified in the field since the late 1990s as a public good infrastructure. Distinct from the top-down databases used to theorize about communality and connectivity, MM's grounded development pushes and extends the flexibility of these concepts than previously explored. Moreover, the case tracks the ebbs and flows of communality and connectivity inherent in the developmental stages of MM.

There are two motivations for our work. First, there is significant interest in O2O communities and interorganizational collaboration systems in practice. Organizations are building relationships with each other to better deliver their services to stakeholders, both with and without the support of technologies [2, 4]. Second, although there is much literature about online communities at individual and organizational levels, there is currently a paucity of research that adopts a process-oriented, longitudinal understanding of these communities. Previous studies have provided insights into two-sided and multisided network platforms [5, 6] at cross-sectional time points, but without an evolutionary perspective.

In this paper, we describe a framework informed by the theory of information and communication technologies as public goods (PG-ICT) [4, 7, 8, 9]. The theory identified two types of public goods in interorganizational communication and information technology systems: communality and connectivity. We extend these two concepts in the theoretical framework, which were developed in the context of

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top-down databases, to online O2O communities. The PG-ICT theory provides a valuable set of process-based constructs for characterizing O2O community development.

This paper is structured as follows. First we discuss the background to the study, including communality and connectivity, networked technologies, and the ebb and flow model. Next we describe the case study research approach used in the study, and then present the case study on MarketMaker. We then present some lessons learned from the case study. Finally, we discuss implications for researchers and practitioners and conclude the paper.

2. Background

In this section, we discuss relevant literature and introduce communality and connectivity. First, we introduce the public goods-information and communication (PG-ICT) theory. Second, we discuss a more flexible application of concepts in the PG-ICT theory to extend from inter-organizational databases to current online networking technologies.

2.1. Communality and connectivity

Communality and connectivity of public goods in interactive communication systems and organizational information commons were theorized to help understand the communication-based public goods that technology systems offer [7, 8]. A *public good* is a commodity or service that is provided without profit and available to all members of society, such as a public park or playground. The PG-ICT theory was originally conceived in the mid-1990s as the U.S. was on the cusp of the dot-com bubble. At that time, the types of electronic communication systems that provided a space for interaction were online repositories or database systems, which implicitly shaped the way in which key constructs were developed and operationalized. The theory has been underutilized in research, but offers writ large potential to illuminate system development. Emerging information technologies have blossomed and changed the availability of communication and information technology systems [10] beyond the database context. Communality and connectivity are in need of extension into the domain of O2O communities to explain the newer capabilities of online systems to generate public goods. We propose concise definitions inspired by the ideas articulated in previous literature, which incorporate added flexibility for new technologies.

We propose the following definition of *communality*: a public good comprised of shared information resources that are also collectively stored in a forum to which members have access. Our proposed definition of *connectivity* is a public good that provides the ability to contact other members of the collective through the system.

In PG-ICT, there are two types of connectivity in a system: physical connectivity and social connectivity. The first type of connectivity, *physical connectivity*, is the infrastructure that supports communication between members, including hardware, software, and the Internet [4]. The second type of connectivity, *social connectivity*, is the use of the physical connections to communicate, such as via email [4]. Physical connectivity is superordinate of social connectivity because infrastructure must be established first in order to offer social connectivity. Without physical connectivity to a communication system, individuals experience *involuntary exclusions*. After physical connectivity is established, the user can choose whether or not to engage socially, and exclusions at this point are generally *voluntary exclusions*.

An additional concept based on public goods theory more broadly is relevant for the current discussion. Users can *free ride*, or enjoy the benefits of a public good without contribution to its establishment or maintenance, only in physical connectivity; they cannot benefit from social connectivity without participating [4]. Aligned with the transaction-cost economics of traditional public goods theory, PG-ICT presents the "non-contributor" status of free riders with a tone of undesirability. Admonishment against the activity of free riding was sensible in the context of databases. Online public goods, however, benefit in from free riding activity, such as site traffic and ubiquity in society beyond the system itself.

The PG-ICT theory implies that a system will be optimal if it comprises both communality and connectivity, and that a system that has too much of one and not enough of the other could be detrimental. An unaddressed question is the degree to which communality and connectivity ebb and flow with one another in the development of online interorganizational technologies. As a digital innovation to revolutionize process, MM provides a context in which to explore the consequences of varying degrees of communality and connectivity for stakeholder interests.

3. Research Method

In order to understand how digital innovation supports value chain creation in O2O communities, we use a single case study research approach. Case studies are especially useful for rich descriptive analysis of organizational phenomena [11, 12]. The case study reported in this paper is revelatory because it extends communality and connectivity. The case explores the innovation of an online, networked value-chain system that reconfigured inter-organizational collaboration and trade.

Data collection involved semi-structured interviews and other archival documents, both proprietary and publicly available. The first author conducted a total of eleven interviews with key MM stakeholders, including founders and managers (3), developers (3), administrative staff (1), and state partners (4). This sample represents a cross-section of the organizational roles and a census of the central parties involved in the MM development since its earliest stages. The average length of interview was one hour. All interviews were recorded and noted. In addition to the interviews, a large corpus of historical documents about MM was collected, including items such as grant applications, website specifications, news articles, consultant business proposals, lists of partners, strategic plans and budgets, conference meeting agendas, and branded paraphernalia. The UIUC Extension hosted the MM database and computing at a uiuc.edu domain name at the time of data collection. Partner states had their own portals but were hosted on mwu.edu. In total, 815 recorded minutes of interviews, 34 single-spaced pages of interview notes, and 27 documents of 460 pages that spanned 16 years of MM history comprised the data for this case.

Case study data was analyzed using thematic content analysis to identify common vocabulary, patterns, and themes emerging from the data [13, 14]. The constant comparative technique was used to solidify themes [15].

4. Case study

4.1. Case study context

MarketMaker is an online, interactive public database and website of food industry marketing and business data across more than 19 states in the U.S. and with a growing international presence. It provides an information and communication platform for value-added agricultural producers and distributors. Through this platform, these parties are able to find and discuss available and needed specialty product in various markets. In 2013, MarketMaker hosted 660,000 profiles of food-related enterprises, including more than 8,600 agricultural producers [16]. It is highly focused on the food industry at all levels, including consumers interested in farmers' markets, but concentrates on organizations, such as specialty grocery stores and organic farms, in value-added supply chain networks.

Formed within the University of Illinois at Urbana-Champaign (UIUC) Extension, the MM system initially furthered the objective of agricultural education by teaching farmers about how to sell their value-added produce and meat at a profit in the agricultural supply chain. Value-added agricultural products include items with specialty characteristics, such as organic apples, grass-fed beef, and free-range chicken. These specialty products involve an increased cost of production for farmers, and are therefore inappropriate candidates for large-scale commodity market pricings. Farmers who offer value-added products are often unsure about how to fairly price their goods because they are less aware of their market location and demand.

Two UIUC Extension consultants stumbled onto this significant challenge to small and value-added producers in the meat sector of the U.S. agricultural supply chain in the mid-1990s. Commodity markets for lamb did not adequately reward lamb producers for either raising a higher quality meat product or for product characteristics such as halal or organic lamb even though consumers were willing to pay a premium for high-quality, differentiated lamb. It was a microcosm of a familiar dilemma echoed by Extension offices all over the country: farmers produce well, but market poorly, resulting in a small market for niche goods and the possibility of underpayment. Furthermore, perishability and time operate as active efficiency constraints to the size of the market farmers can reach.

The consultants initiated a system to address this market gap, and over several years built MM into an online platform that supplied geospatial visuals of business location data and demographic data on communities where specialty products might find market appeal. Maps became important to identify areas with high concentrations of cultural groups that tend to offer a niche market for value-added producers. For instance, Hispanic, Islamic, and Jewish neighborhoods offer a market for specialty meat products, such as sesos (beef brains), halal, and kosher beef, respectively. During the course of 16 years, MM incorporated many other tools, such as user-updated directory profiles and a buy-sell forum (to find buyers or sellers of product), and was adopted by several segments of the food industry and

other states, each of which received its own state-centered MM website.

4.2. Case study analysis

The case study analysis is organized using four developmental periods for MM based on metaphors for the system that emerged in the data: one-to-one links, repository, and network. These periods are created by the flows of two main concepts in the PG-ICT theory, communality and connectivity, evident in innovation of the technology. Also discussed are the organizational and situational requirements of the system at these time points.

4.2.1. One-to-one links. The one-to-one links metaphor refers to MM as a connector in a chain of links. One state partner highlighted MM as a natural component of the value chain: "Think of a log chain lying on the ground. Each link in that chain is connected to one on either side of it that will help move something on that chain. At the beginning, we have the producer on that food chain, and he has to sell it up the chain to get to the buyer. Very little food is sold directly from the producer to the buyer" (Interview 9, paragraph 25).

MM began as a middleman resource of phone calls from consultants between the meat packing yards of Chicago and nearby grocery store retailers. In the one-to-one chain of links, MM was positioned as an intermediary. The consultants acquired a state-funded research grant to help lamb producers brand and market their products, collecting business data that identified grocery store locations and marketing data to help farmers target specific consumers quickly. By 1997, they became brokers on a steady stream of telephone calls and in-person visits between a growing number of lamb producers and retail outlets. This rudimentary telephone operation began the gestation of what would become MM.

The MM system began with minimal requirements in its first generation. Complexity would be added in the coming years. In the one-to-one links period, where the consultants managed users, these were the requirements of the system:

- Management: Two UIUC Extension Consultants
- Funding: Illinois Council of Food and Agricultural Research (C-FAR) grant
- System: Phones
- Tools: Illinois business and marketing data
- Users: Illinois meat producers and distributors in Chicago

The one-to-one link system was not web-based and the consultants inserted themselves into the traditional supply chain like telephone operators to connect the right parties. They comprised and negotiated the system's social connectivity via the physical connectivity of phone lines. The service they offered was conceived of as a marketing resource. Data was stockpiled and created the basis for communality in the system. As the consultants alone had direct access to the communality, other users settled for indirect access to the data about other value chain players and markets. Free riding was not an option in the system, as only participants in the telephone calls benefitted. The system, mediated by the consultants in their role as Extension Agents, offered connections and resources not previously extended to the value chain.

4.2.2. Repository. Even with only 12 livestock producers to manage at first, the increasing number of accounts soon wore on the consultants. Within a year, they sought to stem the communality requests by posting to an "electronic medium… that would be a source of strategic food marketing data and a forum for connecting food supply chain partners for value-added food marketing ventures" (Document 12, paragraph 4). As a storage site of information, MM shifted to a repository for archiving current market information. With support from the Illinois Department of Agriculture, they brought on UIUC programmers from the College of Agriculture, Consumer, and Environmental Sciences (ACES). In 1998, the online MM website launched on campus software with static information to help livestock producers identify market opportunities.

In 2000, the consultants became aware of geographic information system (GIS) technology and began to look at web-based mapping platforms. One consultant commented, "It seemed that the logical next step was to allow the farmers and the markets to access the information democratically. We wanted to build a tool to outlast us… we spent years developing what the tool would look like" (Interview 3, paragraph 3). Census data and grocery store locations were graphed in map displays with the assistance of a demographics professor at UIUC (see Figure 1). Wealthy neighborhoods with independent grocery stores that advertised higher quality meat products and Hispanic markets in Chicago were initially targeted. The consultants also began to locate meat-processing facilities, adding another step of the supply chain into the MM system. The integration of demographic and business market data into interactive mapping, though not searchable, became the central tool around which MM developed.

In its second generation, MM moved online and no longer fit within the communality and connectivity characteristic of the one-to-one links metaphor. Instead, many users could access its communality at once, and the requirements of the system changed:

- Management: Two UIUC Extension Consultants
- Funding: Illinois Department of Agriculture
- Programming: Demographics professor, ACES programmers
- System: Static website
- Tools: Maps of Illinois business and marketing data
- Users: Illinois meat producers and distributors in Chicago

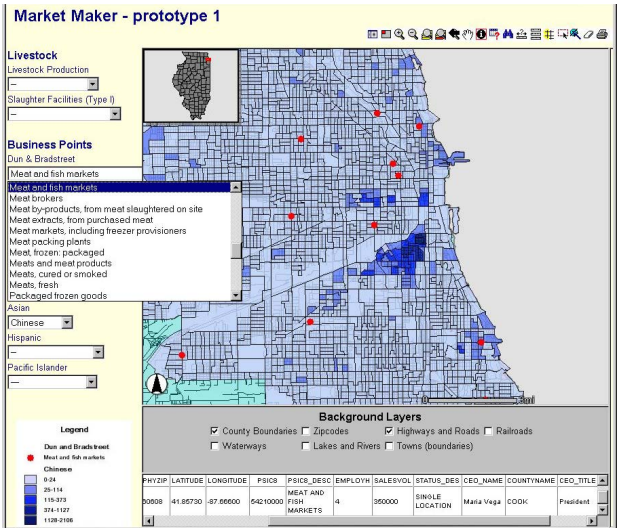

Figure 1. Static MarketMaker site, c. 1998

The underlying identity of the MM system took shape as a store of agricultural business and market demographic information. The publicly accessible online maps provided a direct source of communality to users. The system empowered users to find information for themselves without needing to depend on the consultants. Additionally, users were not encouraged or asked to make contributions to the site, essentially establishing free riding as a norm. However, connectivity changed dramatically in this move to the online space when the consultants transitioned from intermediaries to website managers. Except for data requests to the consultants, social connectivity was essentially pushed to mediums outside the online MM system. Additionally, the site depended on users having their own means of access to the appropriate physical connectivity (e.g., computers and Internet) to take advantage of the system in the late 1990s. At the time, some users were likely involuntary excluded from using the system.

Despite the technological advances, data requests for maps or directory information still consumed the consultants' time and spurred the search for alternative ways to manage and communicate market information. Under the auspices of Extension, MM organized and partnered with a private company that offered mapping software. For three years in development with the company, the consultants crafted the foundations of the system as a networked resource tool.

4.2.3. National Network. The network metaphor refers to MM as a bridge-builder or intermediary in a web of relationships between multiple organization types. In 2003, an Assistant Dean of UIUC Extension joined MM management and added legitimacy to the developing technology, bringing opportunities for funding, staffing, server space and intellectual property guidance. UIUC's Office of Technology Management (OTM) services were made accessible, including intellectual property protection, licensing, market assessment, and business plan development. Increased status and capacity allowed for fast growth, and the system's purpose broadened with federal funding from the United States Department of Agriculture (USDA). As the technology was increasingly supported, the market opportunities for MM expanded quickly. One of the consultants commented, "We migrated from farmers accessing markets to markets accessing farmers, and we went from livestock to all kinds of producers selling food all across Illinois with USDA" (Interview 3, paragraph 5). A more structured organization began to develop around the technology to support its development with resources beyond the purview of the Extension consultants [17].

MM became a two-sided market platform between producers and distributors. A *two-sided model* is an economic platform with two distinct user groups that provide benefits to each other through common affiliation in a network [5, 18]. Interview participants mentioned the importance of attaining a critical mass of farmers and a critical mass of businesses so that each side was sufficient to keep the other side involved. The system began to transform relationships, and grew organizationally into a complex group of ties of multiple stakeholders in the United States. One developer described MM as an online dating site for agriculture, despite its lack of algorithmic matching:

> The easiest way to describe it is the eHarmony® of value-added agriculture: a dating site for farmers and producers. Farmers go in to register

and select the products they offer. When a restaurant registers, they can say this is what I do and these are the things I'm looking for. There's no suggestion function for farmers that they might consider, or distributors they might think of, but we do enable the search function. That sort of matching is a lot of searching for users (Interview 6, paragraph 12).

A site tool was added for farmers to list their available produce in a Craigslist®-style buy and sell forum. In the buy and sell forum on MM, the profiles became user-enabled individual pages for producers to create, maintain and update, rather than data dumped from other directories. Ads in the buy-sell forum were highlighted in a monthly electronic newsletter sent to all registered users.

The beta version of MM debuted at a national value-added agriculture conference in 2004. Enticed by the capabilities of a centralized and communal information database, two neighboring land-grant states joined MM as state partners in 2006. MM comprised two levels: a national portal, which connected all states, and various state portals that accessed state-specific databases. By 2008, MM had nine state partners (Iowa, Nebraska, Kentucky, New York, Georgia, Mississippi, Michigan, Ohio, and Indiana). The amount of market information in the MM system increased greatly as the geographic territory expanded both in terms of the mapping capabilities and the directory listings (Figure 2).

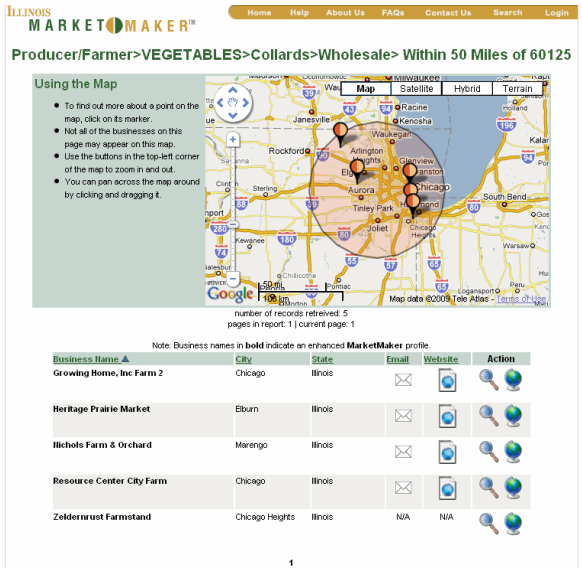

Figure 2. MarketMaker with proprietary content management, c. 2007

State partners brought quality control and multi-platform ideas to MM's development. To reinforce accurate profiles, state partners requested the implementation of certification logos, such as Good Agriculture Practices (GAP) (USDA, 2013). State partners integrated new stakeholders, such as product groups (e.g., wineries) and participants of food trends other than value-added. MM grew from a two-sided market network between producers and distributors to a multisided platform with the addition of average consumers and even tourists [19, 6]. MM evolved further by capitalizing on several food trends, such as farm to fork in schools, food justice, local food movement, organic, grass-fed, and artisanal food. No longer about value-added agriculture exclusively, the purpose changed to "develop quality driven food supply chains" (Document 9, paragraph 1). The influence and interests of state partners aligned with the redesign of MM as a network of ties between various potential matches.

In the national network, the requirements of the system pushed MM beyond the communality inherent in either the one-to-one or repository metaphors. The digital technology supported new forms of service innovation as it expanded to transparently involve all parties in the value chain of the food industry.

- Management: Extension Consultants, UIUC Extension staff, UIUC OTM, and 9 state partners
- Funding: USDA funding
- Programming: Private GIS company
- System: Multisided platform, desktop only
- Tools: Buy and sell forum, online mapping tool for business and marketing data for 10 states
- Users: Meat producers, farmers, distributors, consumers

State partnerships dramatically increased the amount of communality provided to users through MM, although website designers and programmers struggled to organize the information. Without effective search optimization, the full benefit of the increasing communality was obscured by obtrusive navigation. The site redoubled its communality and transformed into several state portals, though connectivity was relegated outside the system. Physical connectivity was assumed of users by the late 2000s. As in its repository incarnation, communality dominated the purpose of the site. Free riding was viewed positively as evidence of users' efforts to educate themselves. MM was viewed as an information resource for farmers to both find markets through the GIS-mapping and find buyers through the buy-sell forum. However, any transactions and contacts that occurred outside of the system found basic customer service was unavailable, nor support for messaging via email or instant chat within the

system itself. Without a method to message each other within MM, social connectivity was not supported for users and occurred, if at all, outside of the MM system. MM maintained its position as an additional resource for the agricultural sector rather than the central source of communicative and economic activity because of its connective limitations.

4.2.4. Boundless Network. The network metaphor became boundless as MM shifted to consider international stakeholders. Before it could shift, however, management issues caused by MM's rapid growth began to surface in 2008. Specifically, the proprietary mapping software technology could not scale further. Separately, the expected improvements and new features for partners were slowed by existing UIUC contract bidding policies, and the contractor's fees were draining resources. State partners began to question the MM system's effectiveness for constituent needs. Blogs highlighted innovation of the MM system (Document 13), while the state partners began pressuring the MM organization for analytics on the site's usage and its direct impacts on farmers. States grew even more weary when a 2011 journal article on MM showed annual sales for participating agricultural producers had increased by a mere $121 as a result of involvement (Document 18). The reports in 2008 and 2011 pointed to deficiencies in the MM system according to various stakeholder values and goals, despite its improved technologies.

To maintain its credibility and improve its financial stability, MM transitioned its technology from the private GIS company to the National Center for Supercomputing Applications (NCSA), housed internally at UIUC. One participant commented, "The geo-spatial products and interface were cumbersome…so we moved into NCSA and into open-source so that the IP has been developed by the university and allows for more flexibility" (Interview 1, paragraph 19). NCSA engineers had regular access to supercomputing resources on the UIUC campus and chose to use open-source coding for the redesign. The transition to NCSA helped speed development and lower costs with better technology. By 2012, the number of state partners doubled to total 19.

MM took on a federated IT organizational structure, where UIUC functioned as headquarters and state partners became chapters with independent lines of business. The central MM organization incorporated the two consultants and Assistant Dean as managers, NCSA and MM programmers, and administrative staff at UIUC Extension, and chapters were the larger group of state partners, usually two people for each state. The state partners functioned as the managers of the MM system in the land grant university Extensions of their home states, allowing state partners to make requests for changes to the MM system through UIUC. Depending on priority level and available funding, those requests became projects for the MM and NCSA programmers after approval by the MM managers. The MM managers met with state partners twice a year at its own semi-annual conference in Chicago, and also informally at various agricultural conferences throughout the year.

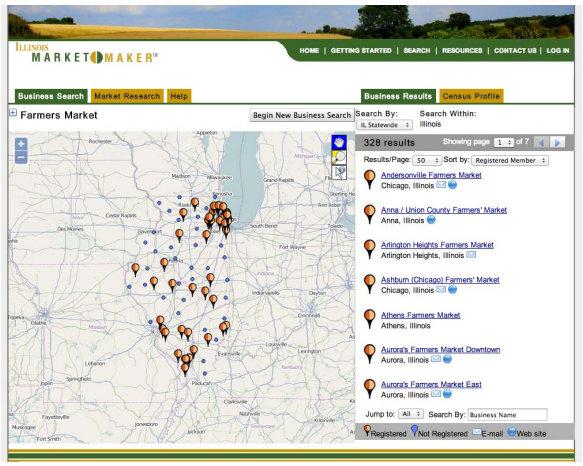

Figure 3. Open source MarketMaker, c. 2012

The improved organizational structure, which was built to sustain and advance the MM technology, enabled the implementation of additional features to the site (see Figure 3). Streamlined maps with an integrated search of the businesses and markets in the GIS system were released together in 2010. The searchable map included several sectors of the agricultural market along with business profiles that differentiated a variety of agricultural sector roles, including faith-based buyers, farmers markets, oilseed milling processors, agritourism, and wineries. Once funded, state partners' requests for profile bookmarking and a mobile application targeted to consumers were answered. MM publicly offered a document library, instructions for use, a list of related websites, recipes, a regularly updated list of upcoming events and in-season, a blog and newsletters. Users could use any of these resources without logging into the website. MM continued to provide a local, ground-up focus on the value chain that intertwined its own organization and others with technology. However the boundless network was growing beyond the national borders that were the latest focus of MM. By 2012, the MM organization had initiated a search for international partners to license its system. In its transformed state, the MarketMaker system was an online website and a

public good targeted to serve businesses and consumers in the agricultural sector by "connecting willing markets and quality sources of food from farm and fisheries to fork." Requirements of the system:

- Management: MM federated IT organization and 19 state partners
- Funding: USDA funding
- Programming: NCSA
- System: Multisided open-source platform, desktop and mobile
- Tools: Advanced search, buy and sell forum, online mapping
- Users: Any participant in the supply chain from producers to consumers for all food types

With almost half of the United States pouring their market and business data into MM, the communality reached a point at which the technology needed to adapt. Novel tools, namely the GIS searching and a mobile application, were added to support effective user access to the site's communality. Social connectivity was indirectly enhanced with the added feature of profile bookmarking, but MM users were unable to make direct connections. One state partner commented, "A lot of connections are being made through MM but people are going outside [of the system]" (Interview 11, paragraph 42). Direct messaging was specifically left out because UIUC Extension, which housed MM, wanted to avoid potential legal issues for any transactional agreements made through the system. Another information tool related to commercial transactions, price discovery, was also an essential function that value-added producers claimed to want, but MM was prohibited from any economic engagement as part of Extension at a land-grant university. MM sought international franchising with India and Costa Rica as a possible next step in expanding the reach of its public goods.

5. Discussion

In this section we discuss four lessons learned from the MarketMaker case study, and implications.

5.1. Lessons learned

The ebb and flow of communality and connectivity changed in the various metaphors used to envision the MM system. The system provided strong communal and partial public goods for users throughout development as an agricultural resource.

5.1.1. Constraints offer learning opportunities for system development. O2O technologies have finite growth potential when housed within a context that constrains the ability to support connectivity. MM outgrew the capacity of the support and protection originally offered by its land-grant institution. Without enough financial or legal sustainability, and built on a network of university Extension offices, MM management chose to reside within the restrictive confines of university policy. Though this disabled its ability to support connectivity due to restrictions against economic activity, MM's O2O community was arguably successful in its expansion across the U.S.

In the current example, constraints are emphasized, but those very constraints offered learning opportunities about needed functionalities. The two UIUC management consultants realized that the institutional structure could not support connectivity. These constraints, in turn, helped to identify the limitations of the system and presented learning opportunities. The consultants were able to lay an invisible groundwork via an interface metaphor, the boundless network, and positioned the system for rapid advance if the connectivity constraints were removed. As an epilogue beyond the scope of this study, MM was indeed moved beyond university walls to a private non-profit to manage its growth. Institutional constraints may inhibit the development of communality and connectivity, but the groundwork for success can still develop within these constraints.

5.1.2. The metaphor for a system is dynamic, often exhibiting radical change; it serves as a critical force of system development for designers and users. Much of the literature on visions and interface metaphors has emphasized their enduring imprint on the development team [20, 21, 22]. The initial metaphor that the O2O system uses in a particular medium imbues later development, though the notion of metaphors changing is not novel [20].

Three metaphors – one-to-one links, repository, and network – arose in the case. Although the repository metaphor infused the core of MM services, it was supplanted by additional metaphors, adding complexity to the system's development in two ways. First, multiple metaphors superimpose in a system's architecture. The network metaphor contested the vision of MM as a storage facility and pushed for dynamism in additional features. Innovation occurred in conjunction with the reframing that new metaphors allowed. Second, in a community-based system, different stakeholders may perceive alternate metaphors for disparate time periods. Users may be operating multiple metaphors on the system at once, as the state partners did with their own versions of

MM. Convergence around one metaphor becomes difficult and complicates system design and use.

5.1.3. The meaning of communality and connectivity will change over time as a system and its community develops. The social connectivity initially offered via phone calls in the one-to-one links metaphor disappeared as MM moved online. In its repository format, MM expanded its reserve of data, but as it morphed to a network and physical connectivity became a basic assumption, the system and organization saw renewed demand for social connectivity for transactional purposes. Whereas previously users interpreted social connectivity as relational, in the network stages, users re-interpreted social connectivity as a transactional resource, and unfortunately, not one that MM could support in its institutional context. This evolving definition of social connectivity highlights one of the possible tensions that O2O systems developed bottom-up may experience from user-driven requests. An O2O's place in the value chain may change because of meanings users impart to the underlying concepts of communality and connectivity. Management practices, software design, and organizational processes involved in an O2O need to have an adaptive orientation with its community to survive.

5.1.4. Changes in the architecture and technology play a key role in driving changes in conceptualizations of communality and connectivity. Communality changes in its presentation style to users as the technology endures rounds of updates. In the three metaphors, MM transitioned from a static page of maps, to multiple platforms for individual state databases, and finally to a streamlined searchable GIS mapping system across all states. In terms of connectivity, physical connectivity was initially supported via phone systems, and then changed to become Internet-based. The MM website was a resource hosted by the system's servers and accessed by the users individually through their own computing systems. Though initially supported in a limited way, social connectivity sustained the roughest transformation in the MM system development. Organizations planning alterations in the design of O2O networked systems may consider supporting the incorporation of equivalent communality and connectivity tools throughout phases to streamline user experience.

5.2. Implications for researchers

Considering communality and connectivity in dynamic, processual terms provides researchers with a theoretically-based identification of how changes in technological capacities deliver process, product and service innovation to multisided value chains. Previous studies [4, 8] examined communality and connectivity in databases accessed by a limited number of organizations, usually with a B2B perspective and the assumption that communality and connectivity changed in a continuous, progressive manner, rather than undergoing radical and disruptive changes, as this case illustrates. The MM study examines multiple stakeholder perspectives that range from individuals to groups to organizations and change discontinuously.

Communality and connectivity provide case study researchers with a useful lens for conducting empirical data collection and analysis about digital innovation for organizations. Longitudinal case study research of the balance between these two terms will enable deeper understanding of the applicability of the concepts and their interrelationships in identifying online or technological public goods.

5.3. Implications for practitioners

The concepts of communality and connectivity provide practitioners with a systematic means of thinking about the capacities supported by interorganizational systems, and how they might be used to enhance value and market advantage. These concepts provide organizations with a means to understand opportunities inherent in the systems in which they are participatory members.

The PG-ICT theory implies that a balance between communality and connectivity is ideal, but MM demonstrates that this ideal is not always reality. Practitioners should monitor the balance between communality and connectivity as a critical factor to maintaining a healthy O2O community.

The MM case also underscores the need to consider multiple stakeholder perspectives. PG-ICT theory also suggests that connectivity and communality have stable meanings, but MM reveals that the meanings are destabilized. Practitioners should explore changes in the meanings of communality and connectivity in the user community. Determining their meaning can provide developers with important metrics for assessing effectiveness of a developing system, such as number of messages sent or pages viewed and shared frequently among members.

Despite the constraints faced, MM management learned from them and created objectives for future directions. The MM case demonstrates the impact of learning within limitations, and that constraints can be framed as opportunities to learn.

6. Conclusion

This study reveals the potential of the PG-ICT theory to illuminate system development. This paper proposes communality and connectivity as a means of understanding and explaining how capacities within digital innovations, such as O2O communities, can be designed to bring maximum value to their stakeholders. The case used communality and connectivity, concepts from the PG-ICT theory, to identify emergent metaphors in the data.

Future research could incorporate economic or mathematical models, such as game theory [23] to study specific behaviors among users within a system as it develops over time. Additional studies of longitudinal rather than cross-sectional user data in a public goods system could also examine changes in the meaning of communality and connectivity.

7. References

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