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Exploring New Approaches to Understanding Innovation Ecosystems

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Exploring New Approaches to Understanding Innovation Ecosystems

Abstract

A firm's connections into its ecosystem influences its ability to innovate. Much research on innovation ecosystems has examined high technology firms and locations and has used interview, survey, or science and technology data methods. Our study focuses on a resource-based ecosystem—agri-food in a medium-sized region—and explores the use of a novel method, media sources to identify ecosystem links. We use this method to capture the innovation ecosystem around two plant-based protein firms and a conventional food processor in Winnipeg, Canada. We extract organizational actors from the full text of business and news articles, link co-occurring actors in social networks, and use modularity partitioning to detect communities in these networks. Our results show that the focal agri-food firms vary in their ecosystem associations, with little duplication in the actor organizations across the different firms' networks. We found that the plant-based protein firm networks had a greater innovation orientation than was noticeable in the established food producer's network, particularly with industry and civic association intermediaries, government, and other agricultural companies. Insights from using the method as well as implications of the findings are discussed.

Keywords: innovation ecosystem; Canada province; agri-food

1. Introduction

An innovation ecosystem can broadly be viewed as the sum of connections of businesses, typically in a region or industry, and including key actors in supporting sectors such as academia and government, that influence innovative performance. Innovation ecosystems are also characterized by underpinning shared norms, rules and institutionalized frameworks. Much of the work on innovation ecosystems has involved high technology industries and locations (Saxenian, 1994; Owen-Smith and Powell, 2004). These works examine how linkages among organizations in the same and supporting sectors lead to innovative business development.

A challenge of this work has been identifying the relevant businesses and other organizations and the extent of linkages among them that comprise an ecosystem. Sometimes interactions are assumed because of geographic co-location. Interviews or surveys with organizations in the industry and region are useful, but difficult to scale-up and sometimes even obtain. Other studies use unobtrusive methods such as mining of scholarly publications, patents, and joint venture directories in lieu of or as a supplement to interviews. However, not all industries or regions are well represented in science and technology databases, especially traditional industries (Gök et al., 2015).

We suggest there are opportunities both for extending innovation ecosystem research into more diverse industries and regions and for developing new research methodologies. While existing interview, survey, and science and technology database methods are useful, we explore unobtrusive methods of examining innovation ecosystems using full-text media. We also focus on a less examined industry in innovation ecosystem studies, agri-food, in particular the development of plant-based (i.e., dairy and meat alternative) protein industries. We use the lens of the innovation ecosystem to understand how firms developing innovative plant-based protein products interact with regional and other resources.

Our focus on agribusiness contributes to broadening the understanding of the role of ecosystems in supporting innovations in traditional industries. Since our empirical work is in the Canadian Prairies, we note that agri-food is a large sector of the Canadian economy (6.7% of GDP versus 4.5% for information and communication technologies) that is increasingly encouraged to innovate to address sustainability challenges. Although a primary agribusiness producer of livestock and crops, the Canadian Prairies is one of the regions targeted in the Canadian government's 2017 Innovation Supercluster Initiative, created to advance innovations in selected domains in existing and startup companies through promoting connections among private companies, academia, and public sector organizations (Innovation Science and Economic Development, 2017). The Canadian government allocated CAN$ 950 million to the program further matched by the private sector. One of the five superclusters is the protein industries supercluster which is linked to Prairie region businesses. Our work does not study or evaluate the superclusters initiative, but it does provide context for our research.

Our exploratory propositions are that small and medium-sized enterprises will differ in the ways in which they link to subgroups in their innovation ecosystem, and that plant-based protein firms will more similarly engage with the ecosystem than a conventional protein firm. We examine these exploratory propositions using network analysis of text extracted from indexed newspaper articles. Our results show small and medium-sized protein firms do vary in their connections with organizations in their ecosystem, with almost no duplication in the actor organizations across the three different networks. We also found that the plant-based protein firm networks had more of an innovation orientation than was noticeable in the established food producer's network, especially with intermediary organizations such as industry associations and government as well as with other firms in the agricultural sector.

2. Background

2.1. Innovation Ecosystem Overview

The innovation ecosystem notion builds on Moore's (1993) concept of a business ecosystem in which firms develop partnerships and alliances with customers, suppliers, partners, and financiers to compete in evolving markets. Following a comprehensive and synthetic review, Granstrand and Holgersson (2020) define an innovation ecosystem as "the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors."

This understanding of innovation ecosystems, through which innovative performance is driven dynamically by an actor system and linkages embedded in institutional rules and norms, builds upon related innovation theories and concepts. Such notions are rooted in Nelson and Winter's (1982) evolutionary argument that the fittest firms develop routines to sense and respond to evolving technological changes. A related theory is that of innovation systems, where public, private, academic, and bridging actors dynamically associate in a nation or region, exchanging knowledge and learning to produce innovations (Lundvall, 1992; Freeman, 1995). Also related are industrial districts where regionally clustered firms in an industry sometimes compete and sometimes cooperate (Piore & Sabel, 1984; Markusen, 1996). Saxenian (1994) depicted industrial systems through differences in the decentralized industrial systems of Silicon Valley and the vertically integrated system in the Boston area. The Triple Helix concept also views regional actors in terms of relationships among government, industry, and universities which dynamically evolve (Etzkowitz & Leydesdorff, 2000). From the firm perspective, the global value chain represents links with international customers and suppliers (Gereffi and Fernandez-Stark, 2011; Lee et al., 2012). The innovation value chain extends the metaphor by examining forward links with customers, backward links with suppliers and service providers, horizontal

links with joint venture partners and competitors, and linkages with universities and public research institutes (Roper et al., 2008).

Several reviews of the literature on the innovation ecosystem have been conducted. For example, Audretsch and colleagues (2019) reviewed the literature on entrepreneurial, business and innovation ecosystems, observing the need for more diversity in industry, knowledge domains, and regional settings. Criticisms have been raised against the innovation ecosystem framework for its ambiguity (Oh et al., 2016; Ritala and Almpanoloulo, 2017). Nonetheless, use of innovation ecosystem concepts has grown in popularity in scholarly, management, and policy domains (Granstrand and Holgersson, 2020; Beaudry and Solar-Pelletier 2020) as an approach to understanding innovation performance in the context of regional and industry organizational relationships. However, a characteristic of studies of innovation ecosystems is that they tend to focus on high tech industries and geographic hotspots for innovation. For example, in the Boston (Massachusetts) area, Owen-Smith and Powell (2004) examine the evolution of biotechnology networks using patent, licensing and joint venture data while Panetti and colleagues' (2019) study biopharmaceutical social networks using licensing and joint venture information. In studies of innovation ecosystems elsewhere, Rocha et al. (2019) examine Industry 4.0 digital manufacturing using interviews, Lee et al. (2016) use patent citation analysis to understand smartphone ecosystems, and Cui et al. (2019) use personal interviews and archival information to investigate 3D printing ecosystems.

Studies of innovation ecosystems outside of high-technology sectors, including in mature manufacturing, food and agriculture, and other traditional industries, are less common, particularly where innovations are process-oriented or tacit rather than patented. An exception is a study of university-industry relationships in the transfer of science to the agribusiness industry (Carayannis et al., 2018). Ciarli and Rafols (2019) use rice research publications and grower and end user demand for rice as represented in national account data. Chapple and colleagues (2010) survey California companies in

traditional versus green sectors. Doloreux (2004) surveyed 53 small firms in the Ottawa area, finding that they used regional R&D resources, but had more links to customers and suppliers outside of Canada.

We seek to contribute to knowledge about innovation ecosystems in three ways. First, by focusing attention on an ecosystem (in our case, agri-food) that has tended to be overlooked, even though there is innovation within this sector. Second, by situating our study in a regional location that hosts an innovation ecosystem albeit not one that is typically viewed as a leading high-technology location. Third, by exploring the development of methods to analyze innovation ecosystems in addition to interviews, surveys, and use of patents and other data from science and technology databases. In so doing, we build on streams of work using website analysis and other non-obtrusive data sources (e.g., Gök et al., 2015) to explore the use of text extracted from indexed newspaper articles to probe innovation ecosystem networks.

2.2. Winnipeg, Canada, and the Agri-food Business

Our empirical context is that of agri-food in Winnipeg, the capital of Canada's province of Manitoba, and its surrounding region in the Canadian Prairies. Winnipeg's 2019 estimated population of 763,900 comprises 90% of the metropolitan area.[1] Although metropolitan Winnipeg's growth rate is slightly higher than the Canadian average, Leo and Brown (2000) depicted Winnipeg at the turn of the 21st century as a slow growth city with an economy combining agriculture, manufacturing, and government activity giving it some protection from cyclical extremes.

[1] Economic Development Winnipeg (EDW) (2020), *Choose Winnipeg, Economic Indicators*. Retrieved from https://www.economicdevelopmentwinnipeg.com/choose-winnipeg/locate-expand-here/economic-indicators and Statistics Canada (STC) (2020 -1). *Annual Population Estimates by Census Metropolitan Area*. Retrieved from https://www150.statcan.gc.ca/n1/daily-quotidien/200213/t001a-eng.htm

The province of Manitoba is home to a large protein-based agribusiness industry. Meat exports in 2017 exceeded CAN$1 billion.[2] Manitoba also has several large pea processing facilities for making plant-based proteins including a CAN$600 million investment by France-based Roquette in 2017. This agri-food sector is undergoing significant innovation-driven change in food bioengineering including plant-based beef equivalents (Goldstein et al., 2017). Much of the literature on the development of plant-based proteins concerns growth performance and yield, digestibility and nutritional differences, and sustainability (Roell and Zurbriggen, 2020; Gorissen et al., 2018; Phillips and Williams, 2011; Tziva et al., 2019). Firm introduction of plant-based protein into the market is less examined.

This spotlight on enterprises enables us to closely ascertain ecosystem linkages. Our guiding exploratory propositions are two-fold. The first is that small and medium-sized enterprises will have different connections to different organizations in and outside of the region. The regional innovation system literature tends to assume that there is an overall consistent framework in a region. Our proposition posits that firms may make a variety of connections, consistent with Boschma's (2005) work about five kinds of connections, of which only one is regionally focused. The second proposition is that plant-based protein firms will more similarly link with the ecosystem than a conventional protein firm. We anticipate that the plant-based protein firms, because they are trying to be innovative, will connect to sources of innovation and R&D and promotion. More established conventional firms have their foundational R&D in the past and so would be more likely to link to suppliers and less to research and promotion firms.

3. Method

[2] Manitoba Agriculture. (2020) *Foresight and Analysis, Value of Agri-Food Exports by Commodity Group and Selected Subgroups*. Retrieved from https://www.gov.mb.ca/agriculture/markets-and-statistics/statistics-tables/pubs/value-agfd-exports.pdf

This research is based on network analyses from the perspective of three firms in and around Winnipeg: Merit Functional Foods, Nutri-Pea, and Naleway Foods. Two of them (Nutri-Pea and Naleway Foods) were subsequently purchased by companies outside of the region though the facilities continued their Manitoba operations. Two of the firms—Merit Functional Foods and Nutri-Pea—have plant-based protein offerings and the third—Naleway Foods—is a decades old food maker that serves as a baseline for understanding how a longstanding firm connects with the agri-food ecosystem in the region and how, by contrast, connections for novel plant-based protein firms might or might not differ.

To advance a new approach, we explore the way these firms link to the innovation ecosystem by analyzing the full text of news articles referencing any of the three firms. The assumption that this approach makes is that mentions together in news articles means being part of the same agri-food-related innovation ecosystem. We searched for the names of these firms in two global news databases: *Factiva* and *Access World News*. The searched records using the name of the company were inspected for duplicates based on the content of the full text article and those with repetitive text were removed. We also searched to exclude articles about awards and prizes that would not obviously imply connections (i.e., where an article presents a list rather than a story that connects organizations), but we found none. We ended up with 73 full text articles for the three focal firms. The resulting full text is content rich without including too many unrelated topics. Our manual reading of the articles indicated that they provided narratives about actors and relationships that were relevant from an innovation perspective. For example, many articles were announcements of partnerships or stories discussing the companies and their partners. The articles we accessed had an average word count of more than 713; 14% of the articles had 1000 or more words while only 6% had fewer than 200 words.

Our focus is on the co-occurrence of one of the three focal firms with another actor: a company, organization, academic institution, or government agency. If the actor appears in one of these articles, we assume that the firm and the actor are linked. Subjects appearing together in publications have been

shown to be related in work on co-word analysis (Callon et al., 1983). We draw on this to analyze the co-occurrence of citing of actors in articles. The number of different articles in which these actors appear along with our focal firm forms the basis of our network analysis.

Network analysis is a common way to examine innovation ecosystems. Network surveys can be used but can be time consuming to complete, requiring an hour or more (Hayter, 2016), because of the need to identify all actor influences. This is problematic given declining response rates associated with survey research (Bartholomew & Smith, 2006), especially for small firms (BarNir & Smith, 2002). None of the three firms have patents, although one has 14 trademarks.[3] No one to our knowledge has used full text analysis to represent ecosystem networks.

We imported the 73 full text news articles into VantagePoint text mining software, using its natural language processor to extract nouns and noun phrases and a thesaurus to preliminarily identify organizations. We reviewed these terms to ensure they included all organizations in the full text. The resulting terms underwent three rounds of cleaning and grouping to produce a list of all actors mentioned in the articles alongside our focal firms. An actor-to-actor matrix showing the counts of articles associated with each pair was exported into Gephi to perform the network analysis for each focal firm. We used the community detection algorithm of Blondel and colleagues (2008) to partition the actors into modularity classes. We sized the actor organization node labels in proportion to the number of articles in which they were mentioned using the PageRank statistic. We did not consider centrality measures because the networks were, by design, centered around the exploratory case firms. The network maps used the ForceAtlas2 algorithm with LinLog mode on to make the clusters denser and easier to recognize.

[3] Trademarkia.com (division of LegalForce RAPC Worldwide P.C) (2020) Nutri-Pea Limited https://www.trademarkia.com/ca/company-nutripea-limited-1148333-page-1-2

After an overview of each firm's network map, we perform a comparative examination. In addition to conventional network statistics (e.g., graph density, average degree, diameter, and modularity), we use two ecosystem measures: connectedness and depth. Connectedness is the extent to which different companies in the same region and industry are linked to the same stakeholders. From the perspective of a firm, a highly connected network would facilitate network navigation for finding links with other organizational actors. Connectedness (*C*) for a network *a* is calculated as n_{ab} / N_a where *n* = nodes in common between two networks *a* and *b*, and N_a = total number of nodes in network *a*. As an illustration, if network *a* has 66 nodes and has 7 nodes in common with network *b*, then *C* = 7/66 = 0.106. By this index, the greater values of *C* represent higher connectivity, with *C* ranging from 0 (no connectivity) to 1 (complete connectivity). Depth measures whether a network concentrates its linkages on one part of the innovation value chain (for example, the academic sector). Depth is measured through coding the network actors into different value chain categories and calculating a concentration measure from these categories. We modified an innovation chain framework (Roper et al., 2008) to code actors into innovation chain categories to obtain a standardized classification of organizational actors. The following seven value-chain categories were used: backward (e.g., suppliers), forward (e.g., customers), horizontal (e.g., other firms), public knowledge (e.g., academia, public research organizations), government, associations, and infrastructure (transportation, utilities). Depth was calculated as a Herfindahl Index by squaring the proportion of a focal firm's actor network count by value-chain category and summing. For example, if a focal firm's network of 90 actors for these seven categories is comprised by the proportions of .278, .333, .056, .089, .067, .078 and .100 respectively, then the proportions squared and summed provide a Herfindahl Index value of 0.220. The higher the Herfindahl index, the greater the depth of concentration, up to a maximum of 1 which would indicate complete concentration in only one value-chain category. We might expect a well-established firm to

report an ecosystem network that is more concentrated than a newer innovative firm which is undertaking a broader (and more dispersed) value-chain search to set up the most useful relationships.

4. Results

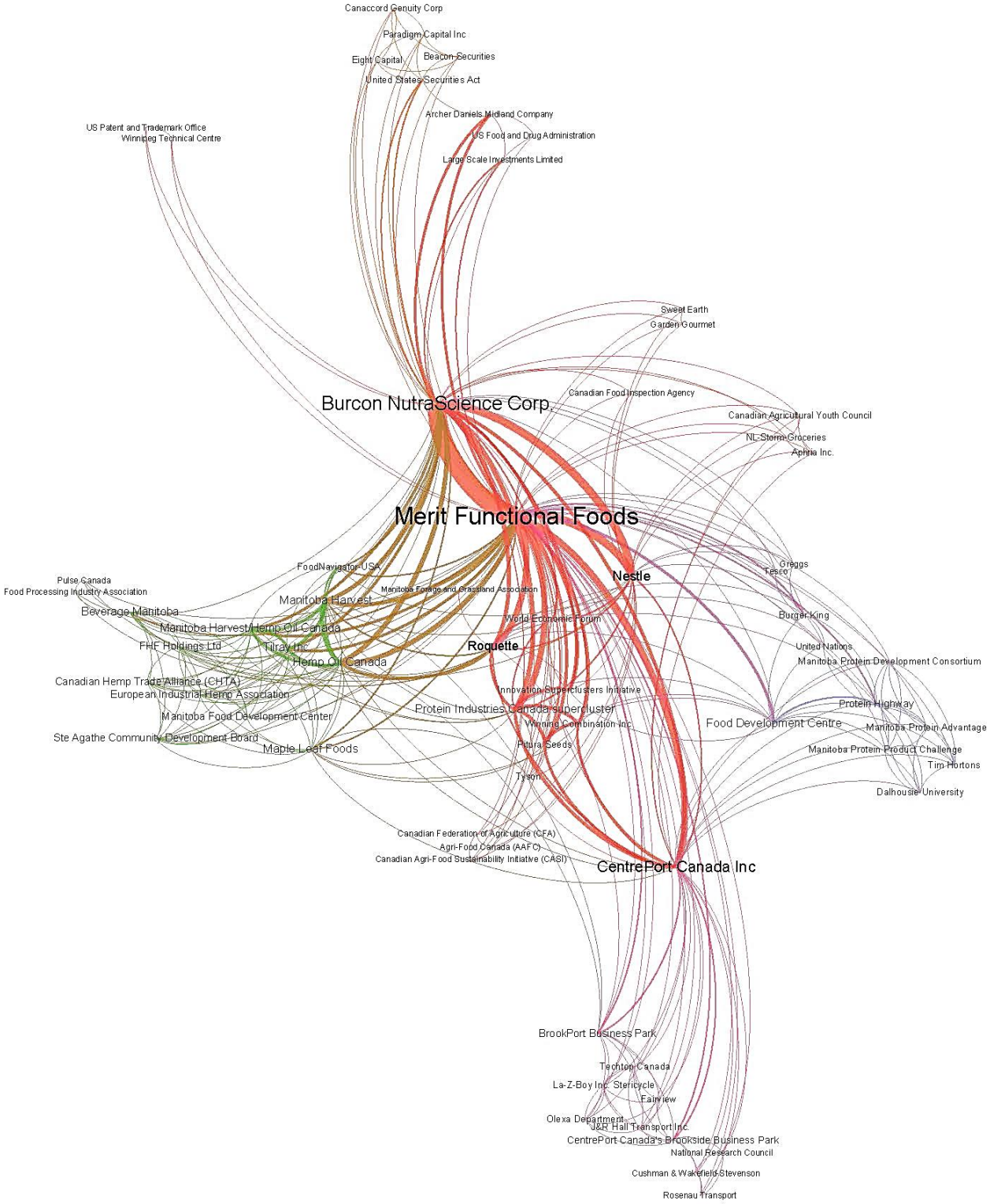
4.1. Merit Functional Foods

Merit Functional Foods is a plant-based protein producer of pea and canola proteins created in 2019. A joint development agreement between Merit Functional Foods, the Vancouver-based food-based technology research and development company Burcon Nutrascience Corporation, and Nestle Foods was signed in 2020. Merit invested in a facility in a Winnipeg suburb with five employees as of 2020. Merit received CAN$9.5 million from the Protein Industries Canada Supercluster.

Thirty-six full-text articles in the Factiva database published in 2019 and 2020 mentioned Merit Functional Foods. Sixty-six organizational actors, including Merit Functional Foods and Burcon Nutrascience, were mentioned in these articles. We charted the relationships among actor organizations appearing in the same article in a network map with organizational names proportionately labeled and colored using modularity partitioning (Figure 1).

Figure 1. Merit Functional Foods Organizational Actor Network

Source: Author analysis of 66 organizational actors associated with Merit Functional Foods, extracted from the Factiva database



The Merit Functional Foods network has six communities. At the top are finance and investment firms (e.g., Beacon Securities, Canaccord Genuity, Eight Capital). The upper middle comprises emerging proteins and agribusiness. This community is anchored by the Merit-Burcon Nutrascience venture relationship with Nestle and includes other plant-based protein and hemp firms (Roquette, Sweet Earth, Hemp Oil Canada) and supporting organizations and government agencies such as the Protein Industries Supercluster, and Agriculture and Agri-Food Canada (AAFC), Canada's federal Department of Agriculture.

The left side of the network comprise several agri-food and beverage associations: Food and Beverage Manitoba, Canadian Hemp Trade Alliance, and Food Processing Industry Association. The right side of the network consists of protein food chains (e.g., Tim Hortons, Burger King) and research and development centers (e.g., Food Development Centre). The lower middle of the map consists of a small community of partners with Merit Functional Foods: Pitura Seeds, Winning Combination (sports nutrition), and Tyson.

Transportation and real estate infrastructure anchor the bottom of the network map. This community represents the location of Merit's production facility and is made up of CentrePort Canada, Inc. (a large inland port), Brookport Business Park, and companies in or nearby the office park where Merit is located.

4.2. Nutri-Pea

Nutri-Pea was founded in 1997 as a pea-based protein manufacturer through a joint venture between Parrheim Foods and its parent company Parrish & Heimbecker, Ltd. and Taiwan-based Soo Properties LLC/Asian Specialty Ingredients, Inc. The Nutri-Pea facility is in Portage la Prairie Manitoba, an hour west of Winnipeg. Ontario-based mustard producer G.S. Dunn acquired the firm in 2018. Nutri-Pea

indicates 22 employees in 2021[4] and is reported to have sales of US$1.35 million.[5] Nutri-Pea was listed among the top six global providers of pea hull fibers in a Market Watch report.[6]

Eighteen full-text articles in Factiva and Access World News Database were associated with Nutri-Pea. The publication years for these articles ranged from 2005 to 2020. Fifty organizational actors were extracted from these full-text articles. Co-occurrence of actors in an article formed the basis for the network map in Figure 2, which displays proportionally sized labels from the PageRank statistic. Modularity partitioning resulted in six communities of actor organizations.

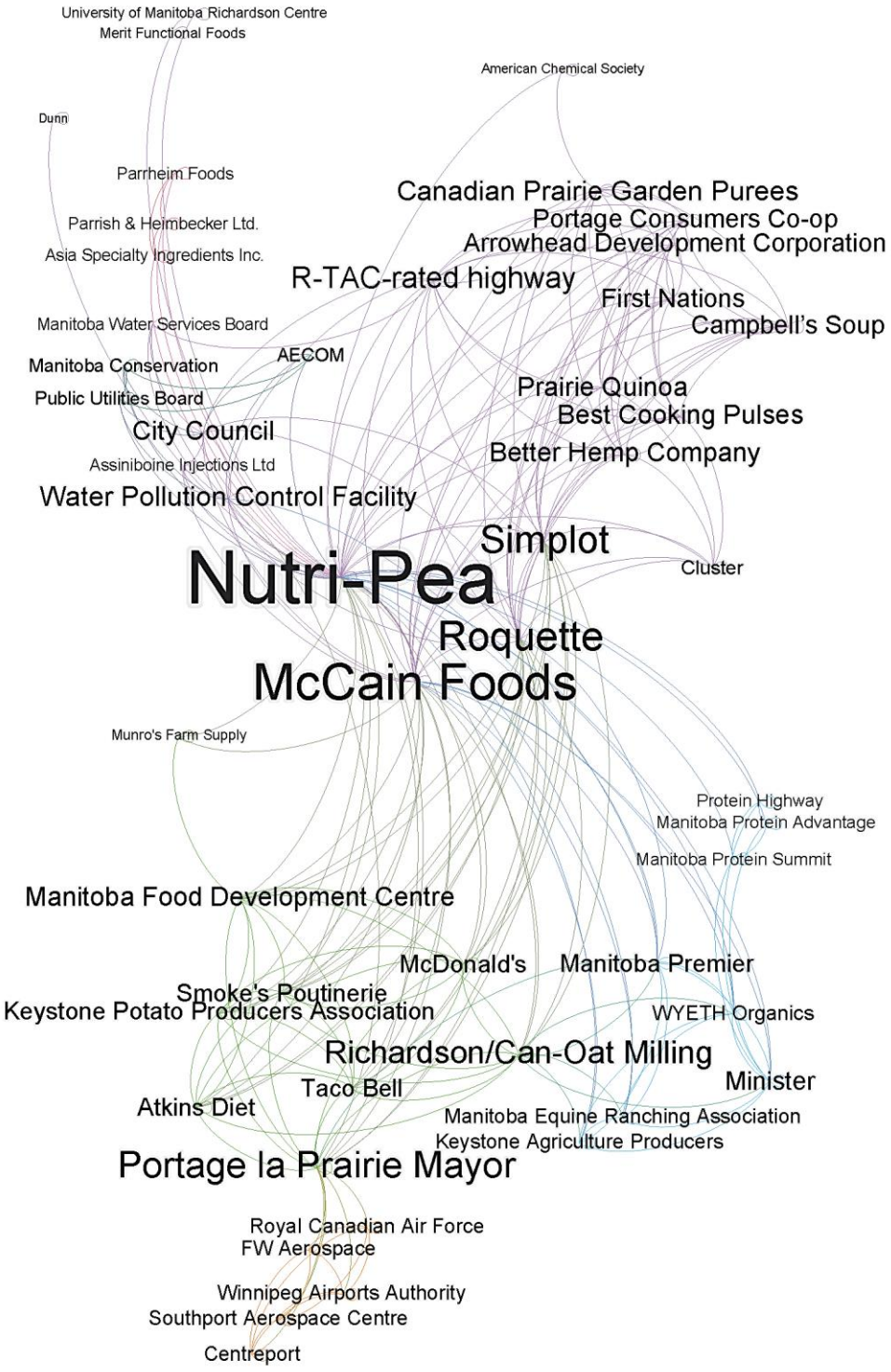
[4] https://ca.linkedin.com/company/nutri-pea

[5] https://www.dnb.com/business-directory/company-profiles.nutri-pea_lp.51dc15192355ab511579fb6b65c989ec.html

[6] Pea Hull Fiber Market Size by Industry Types and Applications 2020 – Global Industry Analysis by Share, Estimated Share, Emerging Trends, Research Includes Regional Forecast and Dynamics till 2026, https://www.marketwatch.com/press-release/pea-hull-fiber-market-size-forecast-2020-2026-by-global-industry-trends-future-growth-regional-overview-share-estimation-revenue-and-outlook-says-industry-research-biz-2020-05-12.

Figure 2. Nutri-Pea Organizational Actor Network

Source: Author Analysis of 50 organizational actors associated with NutriPea, extracted from the Factiva and Access World News databases



Nutri-Pea's founding and acquisition is represented in the upper left of the map. The map is dominated by a large protein and agri-food community at the center of the network map, similar to the Merit map. Nutri-Pea, Roquette and Merit Functional Foods anchor this community. Other food companies in this network include McCain and Simplot, Best Cooking Pulses, and Better Hemp Company. The University of Manitoba Richardson Centre in this community performs research and development. The appearance of the City Council, Manitoba Water Services Board, Water Pollution Control Facility, exemplify the need for water and other infrastructure to support these agribusiness facilities.

The network has a cluster that mixes customers and innovation. This cluster falls just below the Nutri-Pea centered community. It includes the Manitoba Food Development Centre. Other food companies include Atkins, Smoke's Poutinerie, Taco Bell, and the Keystone Potato Producers Association.

Provincial government agencies and associations appear on the right side of the map. These include the premier, an agriculture minister and an economic development minister. We also see several agriculture related associations: Keystone Agriculture Producers, Manitoba Protein Advantage, and Protein Highway. The importance of transportation is evidenced in the airport and inland port actor organizations at the bottom of the map.

4.3. Naleway

Naleway Foods is our baseline exploratory case of an established agri-food firm. Naleway Foods is a maker of frozen pierogis. The region has a cluster of pierogi makers stemming from its concentration

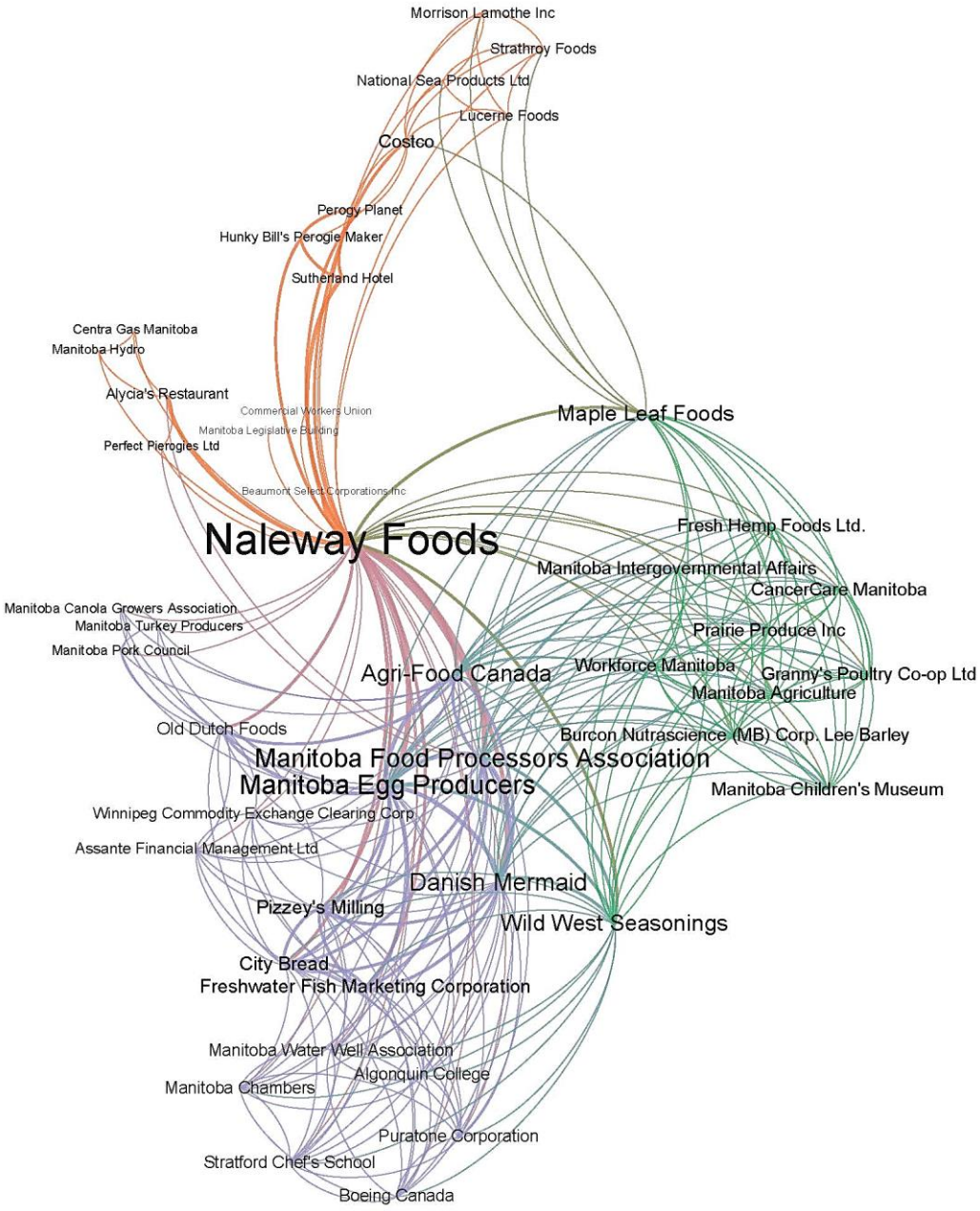
of eastern European immigrants.[7] Although Naleway Foods has its roots in a 1940s-era family restaurant, it was established as a frozen food manufacturer in the 1970s and sold in the late 1990s, although Naleway Caterers Ltd. was retained. We consider both enterprises in our network analysis by searching for the company name "Naleway." Naleway Foods has 80 employees and sales of over US$9.1 million; Naleway Caterers has 10 employees on sales of less than US$0.3 million.

We identified 19 articles that mentioned Naleway Foods or Catering from 1989 to 2016. Seven of these were published from 2011 to 2016. There were 46 actor organizations, including Naleway, mentioned in these articles. Actor organizations mentioned together in these articles are linked in the network map and proportionately labeled (Figure 3).

[7] Knight, B. (2015, September 21). Perogies on the Prairies: Manitoba's European community keeping traditions alive. Yahoo Canada News. https://ca.news.yahoo.com/perogies-on-the-prairies--manitoba-s-european-community-keeping-traditions-alive-013001910.html

Figure 3. Naleway Organizational Actor Network

Source: Author Analysis of 46 organizational actors associated with Naleway, extracted from the Factiva database



The top of the network map is comprised of actor organizations related to pierogi makers and their customers. Naleway and its corporate parent Beaumont Select Corporation are members of this community along with Alycia's, Perogy Planet, and Perfect Pierogies. Other packaged/frozen food makers in this community are Morrison Lamothe, Strathroy Foods, and Lucerne Foods.

The left side of the network map is comprised mostly of agri-food associations: Manitoba Egg Producers, Manitoba Canola Growers Association, and Manitoba Pork Council. Agriculture and Agri-Food Canada is in this community. On the right side of the map are meat and produce packing companies and suppliers (e.g., Maple Leaf Foods, Prairie Produce, Granny's Poultry) and emerging innovative food-related companies (e.g., Fresh Hemp Foods, Burcon Nutrascience). The bottom of the network is comprised of food processors (e.g., Danish Mermaid, Pizzey's Milling, Freshwater Fish).

4.4 Across the Networks

We compare these networks using conventional network measures such as node count, graph density, average degree, diameter, and modularity. We do not consider centrality measures because the networks were intentionally centered on the exploratory case firms. Most of these measures are similar across the three firm networks and reflect their low density (Table 1). Naleway Foods has a slightly higher graph density than the other two firm networks. The newest of the three firms, Merit Functional Foods, has the greatest node count in the shortest period. Merit Functional Foods was associated with 66 organizational actors, compared with 50 for Nutri-Pea, and 46 for Naleway. New entrants may have greater searching needs for connections with ecosystem actors who can support their ventures.

Table 1. Cross Network Analysis

Cross Network Measures	Merit Functional Foods	Nutri-Pea	Naleway
Network Statistics			
Number of Nodes	66	50	46
Network Graph Density	0.189	0.239	0.278
Average Degree	11.273	11.72	12.522
Diameter	2	3	2
Partitions	6	6	4
Modularity	0.261	0.283	0.302
Connectedness			
Share of overlapping actors: Merit & Naleway (2 actors)	0.030		0.043
Share of overlapping actors: Merit & Nutri-Pea (7 actors)	0.106	0.140	
Share of international actors	0.273	0.160	0.043
Share of Canadian actors	0.727	0.840	0.957
Share of Canadian actors in Manitoba	0.348	0.640	0.674
Share of Canadian actors elsewhere in Canada	0.379	0.200	0.200
Depth			
Backward (suppliers, consultants, finance, real estate)	16.7%	8.0%	4.3%
Forward (customers)	10.6%	10.0%	8.7%
Horizontal (competitors, joint venture, acquirers, other agriculture)	19.7%	32.0%	41.3%
Public knowledge sources (academia)	6.1%	4.0%	4.3%
Government	19.7%	16.0%	4.3%
Associations	16.7%	12.0%	30.4%
Infrastructure (transportation, utilities)	10.6%	18.0%	6.5%
	100.0%	100.0%	100.0%
Herfindahl Index	0.159	0.193	0.280

Source: Author analysis of 162 organizational actors; framework adapted from Roper et al., (2008)

To learn more about the relative differences across these networks, we apply the two additional ecosystem measures of connectedness and depth (as defined in Section 3).

4.4.1. Connectedness

Each network appears to represent a different way of accessing the Manitoba innovation ecosystem from the perspective of the three companies we investigated. The networks of the three exploratory case firms included 162 organizational actors of which only nine were duplicated in another firm's network. Naleway Foods and Merit Functional Foods each were referenced alongside Agriculture and Agri-Food Canada. Naleway Foods and Merit Functional Foods were referenced alongside Maple Leaf Foods. Nutri-Pea and Merit Functional Foods had seven of the same mentions: Burcon Nutrascience, Merit Functional Foods, CentrePort, the Manitoba Food Development Centre, Manitoba Protein Advantage, Protein Highway, and the French pea protein maker Roquette. There were no common nodes between Naleway Foods and Nutri-Pea. The shares of overlapping nodes are higher between Nutri-Pea and Merit Functional Foods at 14% and 11% respectively than between Naleway Foods and Merit Functional Foods (3% and 4% respectively). The way the two plant-based proteins networks were organized was broadly similar. Both were linked in articles to emerging proteins and agribusiness industries, current or potential customers, and transportation, although the specific organizational actors differed. Still, the low degree of node overlap between Nutri-Pea and Merit Functional Foods suggest only modest connectedness even though the two are in the same market segment.

The 153 organizational actors with duplicates between the networks removed are primarily Canadian actor organizations. Only 17% (28 actors) are international. Nearly all (26 of the 28) are in the two plant-based protein actor networks. Additionally, 14 of the 26 international actors in the plant-based protein networks are end use customers such as McDonald's or Tesco. Merit Functional Foods has

more connections to domestic actors elsewhere in Canada, while Nutri-Pea and Naleway Foods have more with Manitoba actors. Most of the actors outside of Manitoba are in Ontario, home to the capital and many Canadian firm headquarters. As a new venture, Merit Functional Foods may have a greater need for actors in the capital or headquarters locations. The main point is that the innovation ecosystem for plant-based protein firms is largely rooted in and dependent on Canadian companies, industry associations, government agencies and initiatives, and research centers, although some international connections, particularly with end use customers, may be important.

4.4.2. Concentration Depth

We analyze the depth of these networks by mapping the elements of the innovation chain framework (Roper at al., 2008): forward links with customers; backward links with suppliers and service providers; horizontal links with joint venture partners, competitors, and others in the sector; and linkages with universities and research institutes. We add to this framework formal government programs, agencies, and elected officials; industry and civic associations; and infrastructure such as the inland port, roads, and airports. We seek to understand how deeply concentrated a network is in a particular innovation chain sector.

The Merit Functional Foods network is relatively evenly spread across government and horizontal nodes (at 20% each), followed by associations and suppliers (at 17% each) and customers and infrastructure (at 11% each). Nutri-Pea's network nodes are somewhat more concentrated, with nearly one-third falling in the horizontal category, and the remainder split between infrastructure (18%), government (16%), associations (12%), and customers (10%). Naleway Foods' nodes are concentrated in the horizontal group (41%) and associations (30%). The academic and public research group accounted for the smallest number of nodes (6% for Merit Functional Foods and 4% each for Nutri-Pea and Naleway Foods).

The overall depth of concentration in these sectors is low based on the Herfindahl Index. It is higher for the established firm, Naleway Foods, at .28 than for the two plant-based protein firms (.16 for Merit Functional Foods and .19 for Nutri-Pea). This difference suggests that the firms in the new plant-based protein subindustry are reaching out to a greater variety of innovation ecosystem actors rather than going for sectoral depth.

5. Discussion and Conclusion

5.1 Discussion

Returning to our guiding exploratory propositions, we found that small and medium-sized enterprises do vary in the ways they associate with organizations in their ecosystem. Each case study firm had distinctive networks, with little duplication (i.e., connectedness) in actor organizations even though all three have operations in or near Winnipeg. Each firm appears situated in its own network in accessing available regional assets.

The second proposition is that plant-based protein firms will more similarly engage with the ecosystem than the established food firm. We found broad similarities between the organizational networks of the two plant-based protein firms. The two plant-based protein firms had more actor organizations than the traditional food firm. These newer entrants may have to engage with others more explicitly to gain visibility and recognition. The two plant-protein networks had more innovation-oriented actors than did the established food producer's network including other plant-based protein firms (e.g., hemp producers) and ingredient providers, industry associations and government initiatives, transportation and other infrastructure, and customers including some international food customers.

The networks show considerable engagement with intermediaries. Agriculture and civic associations serve as important intermediaries by building relationships, transferring knowledge, and lobbying on behalf of their members. We also found many connections to government intermediaries such as Merit Functional Foods with the Protein Industries Supercluster and Nutri-Pea and Merit Functional Foods with Manitoba Protein Advantage. Universities and research centers are infrequently mentioned even though they are prominent in the theories that connect with the innovation ecosystem literature such as the Triple Helix Model.

5.2 Validation

To validate the results of the analysis, we invited four Canadian industry experts from agri-food associations or consulting firms with at least five years' experience in the sector and current or former executives from two of the three case study firms to provide reviews of these results. The reviewers were obtained through protein industry supercluster contacts using purposive selection and direct contacts. All but one of the reviewers had a strong connection to the Prairies and Winnipeg. Each was asked whether they would be willing to review the results of the study and provided comments on both the methods and the results. Following interviews with industry experts in July 2020 to review early results, the validation interviews using the final maps were conducted in June 2021.

All experts agreed that the analyses provided useful information and represented meaningful snap shots, although they diverged in their assessment of the completeness of the maps. One reviewer suggested that if asked to prepare lists of relevant ecosystem actors under the headings provided, results would be similar. The second and third reviewers also agreed about the usefulness of the ecosystem maps. Several asked if maps could be produced for other companies in other regions, indicating that they saw value in the method. Two reviewers said the maps were useful but the reliance on publicly available news articles may have understated the roles of universities and public research

institutions as these linkages are not always publicized. Although the text-based analysis uncovered some university actors, these reviewers suggested that food companies' efforts to protect competitive advantages and concerns about being perceived as requiring the assistance of external parties might lead to underreporting. Company executives also suggested nondisclosure agreements were a reason for underrepresentation of universities and foreign organizations. As one reviewer put it: "No public players are missed … none that we can talk about". A few reviewers pointed out that the size of the networks may be missing some organizational actors not named in the press, such as universities, but validated the basic structure of the networks.

The industry expert reviewer confirmed the findings that the food ecosystem in the Winnipeg region is highly segmented and not sufficiently connected to international actors, although it was noted that companies' international activities would not necessarily be reflected in local news coverage. Industry experts commented on the narrowness of the segments in the three different food company networks, as identified in our analysis and discussion. The company executives did not raise this as an issue, instead pointing to a few marginal players that were mentioned more as a function of the type of press coverage, e.g. articles about locations or the career paths of individuals associated with a company.

These industry experts further highlighted that they would expect the observed differences between the plant-based protein companies and the traditional company in terms of positioning within the food chain. The company reviewers also noted that the plant-based protein companies are operating in substantially different competitive "spaces". Merit Functional Foods has been founded only recently, whereas Naleway and Nutri-Pea are established companies. Merit Functional Foods and Nutri-Pea are developing and producing the protein that a company like Naleway may potentially use in the future. While the sector may be viewed as relatively low innovation when compared with other high

technology categories, each company executive highlighted the importance of innovation to their competitive positioning, referencing their early adoption or development of processing technologies.

Overall, the assessments of the results of our approach by the industry experts and company executives were consistent and generally positive. Respondents in both groups could recall the actual press releases in the moment of seeing the maps and considered the maps to broadly reflect the record of company activities and linkages. They also highlighted areas that would be systematically underreported in press releases, notably confidential business relationships with universities or corporate partners. Despite these shortcomings, both industry and company experts saw value in, as well as further applications for, the method, particularly for companies that met certain criteria (e.g., of a size or geographic focus that would attract coverage), and for mapping the entire sector regionally, nationally or internationally.

5.3. Conclusions

This study makes contributions to innovation ecosystem theory by showing how it applies to a region that while not known as a high technology hotspot nonetheless has a dynamic set of actors engaged in varieties of innovation. It also contributes to the innovation ecosystem field by focusing on an industry and set of actors in the agribusiness domain that are not a conventional subject of innovation ecosystem studies. The study demonstrates the importance of disaggregated examinations. Each company must build its own ecosystem which is going to be unique to that company. This work has highlighted the importance of understanding the networking strategies of the companies which vary according to whether the company is in an emerging innovative versus a mature stage.

This study also makes a methodological contribution in that it presents an alternative methodology based on text mining of full-text business and news articles to measure co-occurrences of organizational actors. This methodology, which assumes organizations mentioned in the media together

are part of the same ecosystem, is less obtrusive than approaches based on lengthy survey and interview instruments and can address issues of data availability (e.g., on joint ventures or intellectual property) not being readily available for studying the agribusiness sector (and other mature or traditional industries).

The study's approach centered on text analysis of business and news articles does have limitations, the first of which relates to the lack of ability to interpret these networks in a causal framework. The actors were mentioned together in articles, so we do not always know how these actors were related to one another and which actor influenced other actors. Survey and interview-based methods can provide more information about the direction of influence among organizational actors.

The method emphasizes formal linkages, particularly linkages that companies acknowledge in press releases and news articles. In this analysis, norms and rules are assumed to be embodied in network nodes and links. We acknowledge that this assumption may not fully account for all the effects of norms and rules. We further recognize that co-mentioning of organizations in a news article does not necessarily mean there is a connection, although our screening for possible non-related connections and manual reading indicates that the articles identified in this specific study did have something to say about actors and their relationships that could inform innovation ecosystem analysis. It is important, in future studies, to continue to review content for relevance and validity and, especially if larger samples are anticipated than can readily be reviewed manually, to apply text-analysis methods that can analyze content (as well as map linkages).

We further acknowledge that linkages that are confidential, informal, or occur among ordinary employees outside top managers' purview may be underrepresented in our method of analysis. Survey and interview-based methods not only may generate evidence of the effect of one organizational actor on another, they may also enable greater completeness of lists of organizational actors to the extent

that these data collection methods can introduce prompts to encourage respondents to add more actors. Yet, interviews and surveys may also not produce more complete lists of organizational actors either because of their reliance on subjects' memories or disclosure restrictions. Hence, it may be best not to view text mining and survey or interview approaches as competitor methodologies. Rather, it is a method to be used alongside other methods. As an exploratory way to view the ecosystem around small firms, our text-mining approach can be a useful complementary step prior to subsequent interviewing by suggesting pathways and gaps in the networks as well as network community memberships from modularity partitioning that can be explored in survey and interview protocols. The Canadian expert reviewers agreed that news article text mining can serve as a valuable complement to other resources for understanding innovation ecosystems. Future research can test the usefulness of text mining in advance of social network interviews for improving the understanding of innovation ecosystems.

Our study suggests that plant-based protein firms are embedded into their local ecosystem in regions outside of recognized science and technology hotspots. Industry associations and government agency initiatives can play a role in informing and connecting these firms to other private sector, industry association, government initiatives, and research and education actors that could benefit their business and innovation trajectory. Careful monitoring of the text of news in a new way from the point of view of the business ecosystem can serve as a new source of information for bridging associations and government agency actors. This information can also help these intermediary actors in considering how to improve ecosystem connections and to strengthen links to other key regional, national and global innovators and innovation ecosystems.

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