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THE ROLE OF MATURE FIRMS IN AN ENTREPRENEURIAL ECOSYSTEM

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The Role of Mature Firms in an Entrepreneurial Ecosystem

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Abstract

Entrepreneurial ecosystems are geographically situated collections of organisations that support the cultivation of entrepreneurial talent. Entrepreneurial ecosystems include several major homogeneous constituent groups. One of these constituent groups are mature firms (i.e. technology companies, large corporations, enterprise, big business). Little has been written about mature firms' interactions with the ecosystem, and start-ups in particular. Mature firms (non-innovating or non-growth oriented firms) benefit the entrepreneurial ecosystem in three ways. Their presence lures talent, develops deep expertise in functional and process areas, provides employees for potential spinoffs, and talent for hire for high-growth young firms. Mature companies also act as investors and acquirers for start-ups. Lastly, mature firms benefit entrepreneurial ecosystems by engaging with start-ups and growth-oriented firms in myriad other ways which is the focus of this research. The goal of the study is to investigate the amount of engagement by mature firms and start-ups as well as what they do, and how they do it. A mixed-method approach using quantitative network theory finds less-than-optimum mature firm-start-up interaction in a sample population. A qualitative investigation presents some data and highlights 18 different ways for mature firms to engage with start-ups. The author begins to develop theory about the role of mature firms in an entrepreneurial ecosystem from an inductive standpoint. This work responds to mature firm practitioners who question how they can participate in an entrepreneurial ecosystem, and to policy makers who want to learn how to improve entrepreneurial activity in a jurisdiction.

Keywords: Mature firm, Entrepreneurial ecosystem, Cluster of innovation, Entrepreneur, Start-up, Social network, Network theory, Enterprise, Corporation, Big business

1 Introduction

Social networks are important to entrepreneurial accomplishment and firm performance. Extant research indicates that firm networks are positive indicators of entrepreneurial firm performance (Lechner and Dowling, 2003). Entrepreneurs who use their network to access resources facilitate their ability to acquire finance (Fornoni, Arribas et al. 2012) and taking advantage of strong ties (where interpersonal ties are more similar in various ways and therefore more likely to be friends (Granovetter, 1973)) is linked to

sales performance (Collins and Clark, 2003). Entrepreneurs capitalize on confidence, experience, and their relation to others in social networks facilitating access to information and knowledge. Thus, entrepreneurs with greater networks and social capital influence the financial performance of their firms (Semrau and Sigmund 2012) through sales and the acquisition of finance.

Entrepreneurs compensate for their lack of resources for finance, markets and information by drawing on their social networks which provide them with access to information without having to pay for it. Indeed, start-ups often begin with little more than the social networks of their founders. In locales where many entrepreneurs are situated, the notion of entrepreneurial ecosystems (EE) describes the network of ties and support systems that connect entrepreneurs to finance, information, support and technology in the ecosystem. Born out of the concept of clusters, EE and clusters of innovation (COI) describe relations established amongst various constituents in an entrepreneurial environment where many young firms are situated, entrepreneurial processes are applied, and the specific requirements of start-ups are cultivated (Saxenian 1994, p 287). EE importance is magnified because they have become recognized as highly viable economic development opportunities and sources of regional advantage (Audretsch, Belitski et al. 2015).

An EE or COI starts as a geographic cluster of start-ups attempting to survive and succeed. A collection of other constituents with which start-ups engage include venture capital, professional support, universities and research institutions, and mature technology firms in the case of Silicon Valley (Ferrary and Granovetter, 2009), and government interactions as in Israel (2014). Recent empirical work indicates that accelerators and incubators often play a major role in EE as well (Farrell and Dennison, 2015). Ecosystems expands in the current environment of instant personal communications where an email address or a cell phone permits information and interaction acquisition from around the world. By so doing, actors from distant geographic locations are brought into the orbit of a local EE.

Much has been written about various constituents within EE or COI. The importance of universities, and venture capital dominate this literature. The objective of this paper is to assess the contribution of the mature firm constituents to the EE or COI. This work is novel in its theoretical and practical contributions. Though the roles played by mature firms within the domain of an EE or COI have been described in ethnographic and historical accounts (Saxenian, 1994), and summarized in accounts of EE (Mason and Brown, 2014), their actions have not been previously isolated for research (except Freeman and Engel, 2007). The actions of mature firms, enterprise and anchor firms are known to be important for

the development of employees who sometimes leave as spinoffs, and as acquirers of start-up firms. The roles that mature firms perform over and above these characteristics is not so well known.
The research question asks how mature firms engage with start-ups in an EE. The study therefore seeks to identify the quantity of interactions amongst start-ups and mature firms, and it also attempts to clarify what the engagements exist between the large and small players and illustrate how those engagements are executed.

2. Structure of the paper

The research objective of this study is to investigate the amount of mature firm (MF) interaction in an EE, what they do to interact with the entrepreneurial firms and start-ups (SU), and how MF engage with SU. The remaining structure of this paper begins by tracking the contributions of mature firms in an EE in Section 3. This is conducted by using the main constructs that identify a COI as outlined by Engel and del-Palacio (2009; Engel and del-Palacio, 2011). Section 4 outlines the mixed methods, sequential methodology employing network theory to assess the amount of MF-SU interaction, and a qualitative investigation to explore what MF are contributing to SU and how they are doing it. Section 5 presents the results of the quantitative network theory and qualitative investigation to scrutinize a conceptual framework for the types of specific actions mature firms may adopt in interacting within an EE or COI and the possible motivations for each. A conceptual framework and theory development for the contribution of MF to an EE are presented in Section 6. The conclusion notes both the work's limitations and future research opportunities for the Academy.

The terms of COI and EE are used interchangeably in this research to describe EE and COI. Mature firms (MF) may be small, medium or large firms, but they are corporations that are no longer growing rapidly, nor innovating. Entrepreneurial firms and start-ups (SU) are variously referred to also as young firms, founders' firms, and growth companies.

3. Extant research regarding MF role in EE

In this section, extant research is used to examine what is currently known about the role of mature firms as they interact amongst EE constituents. Knowingly, or unknowingly, do mature firms contribute to network ties and how. How they catalyse the mobility of resources and hasten testing and developing commercialising processes? Do they promote start-up know-how and business practices and what do they

offer by way of capital and finance; how do they support the innovation process and do their larger ranks promote the frequent flow of people; and lastly how collaboration is enhanced by the presence of the mature firms.

High mobility of people and talent between and among ventures

Successful COI tolerate -- indeed encourage -- the rapid recycling of talent, and the movement of people between and amongst firms, large and small. This mobility of human capital facilitates the transfer of tacit knowledge, intellectual collaboration and rapid validation and success or rapid failure.

Mature firms participate in seeding this cycle with an abundance of deep talent who may harbour pre-entrepreneurial intentions. Rapidly growing entrepreneurs often turn to mature firms for talent when completing the management team. As the firm grows, the likelihood of the founder being replaced is also exacerbated. And the more successful and faster the firm grows, the sooner the entrepreneurs will be called upon to look to mature firms for openings in their own management teams, and replacements for themselves (Freeman and Engel, 2007).

Age, attitude and income are influencers in entrepreneurial populations. Entrepreneurial attitude and age have an inverted U shape, albeit more pronounced in aggregate over a population, that implies an optimum entrepreneurial activity in mid-career (Lévesque and Minniti, 2011). Similarly, populations who are more advanced in age, start firms that have greater longevity. Entrepreneurs with higher previous incomes and who have greater access to resources, are motivated by income targets, and start-firms that grow faster (Cressy, 1996). Pre-entrepreneurs migrating out of MF have apparent prosperity and maturity to be more successful and resourceful during mid-life.

Employers have the ability to encourage such activity out of their firms. They might support their employees who harbour entrepreneurial intentions and who plan to leave the traditional employer workforce. This notion might even be extended to high-performing employees who are valuable to the MF, but who have a disposition to leave to pursue entrepreneurial intentions which may be competitive to their employer. Similarly, while the mature firm may not go as far as to encourage the defection of a valuable employee, they may not act to impede the intended defector either. Such was the case of Hoffman LaRoche in Switzerland when it watched four of its key cardiac researchers leave the giant pharmaceutical firm, following the disillusionment and defection of their team leader, Thomas Widdmann. Hoffman LaRoche did not impede the group either, by not enforcing the non-compete clauses for any of the individuals involved. Using licensed IP they had developed while at Hoffman

LaRoche, Widdman and his party went on to create Actilion which grew to hundreds of employees and sold in, 2017 to Johnson and Johnson for $36 billion.

Downsizing firms also contribute to recycling of talent in an ecosystem. A mature firm down-sizing strategy may seek to support the subsequent entrepreneurial intentions of downsized employees when mature firms reduce workforce numbers. Entrepreneurs founding a firm under the circumstances of adverse events occurring to the parent firm will have previous organisational experience (Curran, O'Gorman et al., 2016). Similarly, but earlier in the downsizing process, a mature firm engaged in an adverse event may look to identify personnel willing to leave for entrepreneurial motives (Mishra, Spreitzer et al., 1998). Supporting downsized employees with entrepreneurial education, means, contacts and counselling prepares previously unsuspecting founders for potentially unforeseen opportunities.

Start-up know-how and business practices

MF develop skills in employees that enhance start-up skills and business practices for currently employed pre-founders with an innovation to launch. Likewise, MF cultivate deep knowledge in specific areas that founders acquire during their careers of which they can take advantage. However, Klepper's (2001) summary of the literature on spinoff founders found that the nature of a spinoffs' products and services derives primarily from their founders' backgrounds and contributions rather than from the parent firms' principle products or technologies.

Moreover, speculations indicate the more previous-parent-experience that founders have with their co-founders improves ventures' performances as a result of their shared experiences, knowledge and familiarity (Cooper and Gimeno-Gascon, 1992) of each other and business practices. Dyck (1997) also used the parental dynamic to suggest that employers that were supportive of the defecting spinoffs, helped give greater lift to the start-ups' performance than those start-up founders who leave the mature firm without "parental" backing and encouragement.

There are other skills and business practices that start-ups learn *in situ* rather than from the MF from which they departed. Founders need to be fluid and adaptive to the evolving needs of the firm (Freeman and Engel, 2007), and new founders' abilities to validate, sell, finance, create control systems, market, design, code, hire and build are facilitated by having few organisational charts, or job roles. This may be unfamiliar territory for the talent departing from MF. Being able to respond opportunistically to customer feedback or unexpected developments, and having the personal nature and know-how to reorient their

plans in mid-start-up is a characteristic of successful entrepreneurs (Bhide, 2000) which may also be unlikely for employees from MF.

Deployment and acquisition of capital and finance

Founders whose creations have the potential to grow quickly have to secure a sufficient and ongoing source of cash flow to secure a growth trajectory where revenues lag behind spending. The search for capital is vital and the amount of time spent conducting such activities is not disproportionate to its importance. The ongoing discussions, board meetings, control systems, reporting and network development will predominantly occupy the activities of at least one of the team members. This is a perverse event since much finance is accompanied with issuing equity and is thus dilutive to the founders. The paradox of spending inordinate amounts of time for outcomes that will dilute ownership is not lost on founders who often struggle to avoid dilutive finance wherever possible. Mature firms' roles relative to the deployment of capital in an EE or COI includes acquiring young firms outright, investing in these firms to gain an insight or an edge on a developing technology or innovation of interest to the mature firm, gain an eye to the start-ups' intellectual property. This is discussed further in Section 6.

Rapid experimentation, testing and innovation

During early-stages entrepreneurial development, many new venture teams focus on the product instead of the business and the business model. Rapid testing and validation foster the develop-pivot-redevelop learning process (Engel and Forster, 2014) that accelerates entrepreneurs' understanding of success or failure and movement to commercialisation. In Saxenian's (1994) seminal ethnographic examination of Silicon Valley, Jeffrey Kalb of MasPar mused that "… time is everything. Time-to-market is right behind cash in your priorities as a start-up" (p. x). Established firms and enterprise accelerate SU validation process by testing prototypes, providing access to resources, hiring (or firing) talent, prescribing the necessary logistics of selling into specific markets, cultivating an understanding of document control procedures in larger firms, evaluation and insights.

Validating the business case in advance prevents wasting resources on unnecessary product development (Mitra and Euchner, 2016). Mature firms contribute to creation of the business case and the value proposition without every writing a line of code particularly in B2B situations. MF facilitate the creation and testing of minimum viable products by giving rapid feedback to start-ups. Developing and testing a prototype by a willing MF accelerates rapid re-testing because customer feedback is incorporated. Concepts of iteration, stimulating the imagination, and consulting with customers is a staple of both

design thinking and lean methods of entrepreneurship. Alternatively, selling the prototype to the MF provides the SU with its first revenues.

Collaboration enhanced by mobility

The prevalence of an abundance of skills diffused throughout an ecosystem is influenced by the presence of MF and the potential spinoffs they represent. It is speculated that the greater stock of industry-informed employees in a specific locale enhances the stock of management available for start-up opportunities (Garvin, 1983). Likewise, earlier theories noted that locales or regions that housed considerable specific industrial or commercial interests (i.e. many suppliers, vendors, and employees with specific industry acumen) were inclined to have more spinoffs of employees leaving parent firms to create start-ups. The easy movement of employees from MF to SU intensifies the relationships amongst individuals and companies creating heightened affinity for alliances, cooperation and partnerships.

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3. Research Methodology

A mixed-methods, sequential study using quantitative and qualitative methods was adopted for this work. In attempting to address the research question, the needs if the study to quantity the amount of MF-SU activity was best addressed by a survey-based quantitative approach. But finding out what activities MF engage in and how they were being executed required a qualitative approach. The data relative the frequency and importance of MF interactions would not prescribe specific actions taken, nor would the quantitative approach alone have been enriched by context and examples helping to inform theory development. Both research types were equivalent in importance (Molina-Azorín, López-Gamero et al., 2012).

3.1 Quantitative - network theory

Studying EEs with more quantitative approaches has been encouraged in order to contribute a different lens (Engel, 2015; Overholm, 2015) to the highly insightful and significant qualitative observations already conducted and reported earlier. A mixed methods approach was adopted to take advantage of the features of both paradigms using equal emphasis on each (Molina-Azorín, López-Gamero et al., 2012). A sequential two-phase design used quantitative network theory to identify how much mature firm activity was in the ecosystem, followed by a qualitative assessment of the different types of interactions and how mature firms were engaging with entrepreneurial types.

The construct measured in the study were knowledge seeking behaviours used by members of the ecosystem to search for information to enhance their entrepreneurial-decision making. To effectively analyse the ecosystem's knowledge-seeking behaviours quantitatively, network theory was employed which permits viewing connectivity, density and diversity of the network. Information about the knowledge-seeking activities included the importance and frequency of the ecosystem's participants' activities. For more information about the population sampling, measure, data collection and descriptives, visit (Farrell, 2017 at http://www.smu.ca/academics/sobey/working-papers-series.html).

3.2 Qualitative Analysis

To explore the nature and manner of entrepreneurial-mature firm interactions, case analysis was employed to learn situations and examples using: literature searches, regional media searches, and situations known to the authors. Situations where MF and SU engaged with one another were documented. General examples were sought initially, however, specific attention was devoted to finding examples of MF-SU in the Atlantic Region of Canada. The data collection methods included interviews, observations, and reviewing literature and news stories

Table 1 - Mature Firms' Interactions with Entrepreneurs

Mature Firm	Location	Description of Action	Entrepreneurs Engaged	Details	S
Beckman Instruments	Silicon Valley	Provided finance to establish new firm	New firm Shockley Semiconductor spawned with finance	Deep resources of mature firms are insignificant to large firms, but are vital and instrumental to entrepreneurial firms	(
Fairchild Camera and Instruments	Silicon Valley	Mature firm in non-financial industry provided finance for establishment of new firm	Ent – Fairchild Semiconductor created and later Intel and Kleiner Perkins Caufield & Byers created, Philips , AMD	Many other companies were spawned from the original eight who left the firm Typifies rapid reemployment and movement between firms	(
F. Hoffmann - La Roche Ltd	Switzerland	Waived non-competition clauses Later closed cardiovascular research division and put IP up for licensing.	Former employees, now entrepreneurs – Co-founders Jean_Paul Clozel, Martine Clozel, Walter Fischli, led by Thomas Widmann	1997, Large pharmaceutical firm chose not to support further testing for a new hear drug innovation; Former employees raised US46 million in two rounds of VC; Spawned Actilion; Then to highly successful IPO $146 million US.; Billion dollar market valuation now; sold to Johnson & Johnson $36 billion; One founder went on to lead Vinci Fund & Herperion	(
McCain Foods	Atlantic Canada	Mature firm collaborated with ent'l firm when requested; Provided data to ent'l firm in order to identify an important problem to solve for the mature firm	"The only thing Baxter and Shawn Carver knew was that they wanted to work with McCain on a project involving advanced analytics. The exact nature of the project would be determined by interviewing McCain employees and discovering what component of the international food business would benefit from advanced analytics."	FiddleHead went on to achieve seed round of $1.8 million from Build Ventures and NBIF "co-creation — the partnering of a start-up and a large company to attack a corporate problem. "	(
Verifin robotics and financial security firm	Atlantic Canada	Created a work space	Incubator and Entrepreneurs benefitted Startups associated with an accelerator, Genesis, received all the old furniture from Verafin;s new 200-person office move; Metrics Flow, Mysa Smart Home Thermostats, and Vish Salon Tech, along with exciting graduates Agile Sensors, HeyOrca, Solace Power, and Whitecap Scientific all accepted some furniture	Recycling furniture and equipment to growth start-ups in the locale	I i
SAP	MNC	Created HANA, a platform	Entrepreneurs to build their businesses & products, a bit of a recruiting tool for SAP	Cultivate relationships by holding contests and offering scholarships to entrepreneurs	(

DMGT Group	UK	Worked with One Million by One Million	Britain's largest media group wanted entrepreneurs to participate in developing their innovation agenda	Used commercial acceleration and incubation group One Million by One Million to get entrepreneurs to help with their businesses	(Mitra and Euchner 2016)
NSPower	Atlantic Canada	Wanted to identify ways to contribute to economic prosperity via interactions with entrepreneurs	Ultimately entrepreneurs via University	Could be used to sponsor prizes and funding for emerging start-ups, but may likely go into the construction of a building on campus and the entrepreneurs may see little obvious comingling with the MF	Personal knowledge of author
Elmsdale Lumber & Ecan Lumber	Atlantic Canada	Entrepreneurs needed help in understand dynamics of timber industry in Canada & US	Entrepreneurs used the contacts of a University professor to gain access to long-term significant players in the Canada/US cross border lumber industry. Four hours with two different participants in the industry benefitted entrepreneurs	Traditional Timber was launched with early success.	Traditional Timber Personal knowledge of author
Louisbourg Seafoods	Atlantic Canada	Created an open innovation competition Sea++; Rapid Business Competition with Dragon Den style Sunday night session	Innovators, entrepreneurs, existing small businesses were asked to solve seafood and fishing business problems; $5k and $1k prizes; designed to tap into local tech community to solve local fishery problems	Competition open to anyone to help solve one of five problems: contest entrants were asked to look at improving ore or more problems -- mobile and fixed fishing gear, to solve an issue in aquaculture, to improve sales and marketing, or to solve an issue in the management of a fishing enterprise; Adam Mudgridge	(Moreira 2016) http://entrevestor.com/ac/blog/louisbourg-seafoods-launches-sea http://www.cbc.ca/news/canada/nova-scotia/cape-breton-louisbourg-seasfood-tech-sector-sea-plus-plus-1.3530797
Cisco	Atlantic Canada	Cisco Innovation Grand Challenge, a global competition that helps Cisco	Fredericton entrepreneurial firm, Eigen Innovations, won third place spot with Cisco	Eigen Innovations of Fredericton placed third; build relationships with innovators; "Many are "too young to have real-world experience to completely understand problems that businesses encounter, so they never get the ideas that lead to killer applications. For that reason, some early-stage companies are based on weak ideas."	(Moreira 2015) http://entrevestor.com/ac/blog/closing-the-startup-corporate-gap
Mariner Partners	Atlantic Canada	Established a division, East Valley Ventures, to invest in specialized IT applications	Created a division for making investments into innovating entrepreneurs with synergistic properties for Mariner and the Region	Providing mentorship, advice, entrepreneurial financing, and vision to mover young firms further along their growth trajectory	http://marinerpartners.com/

4. Results

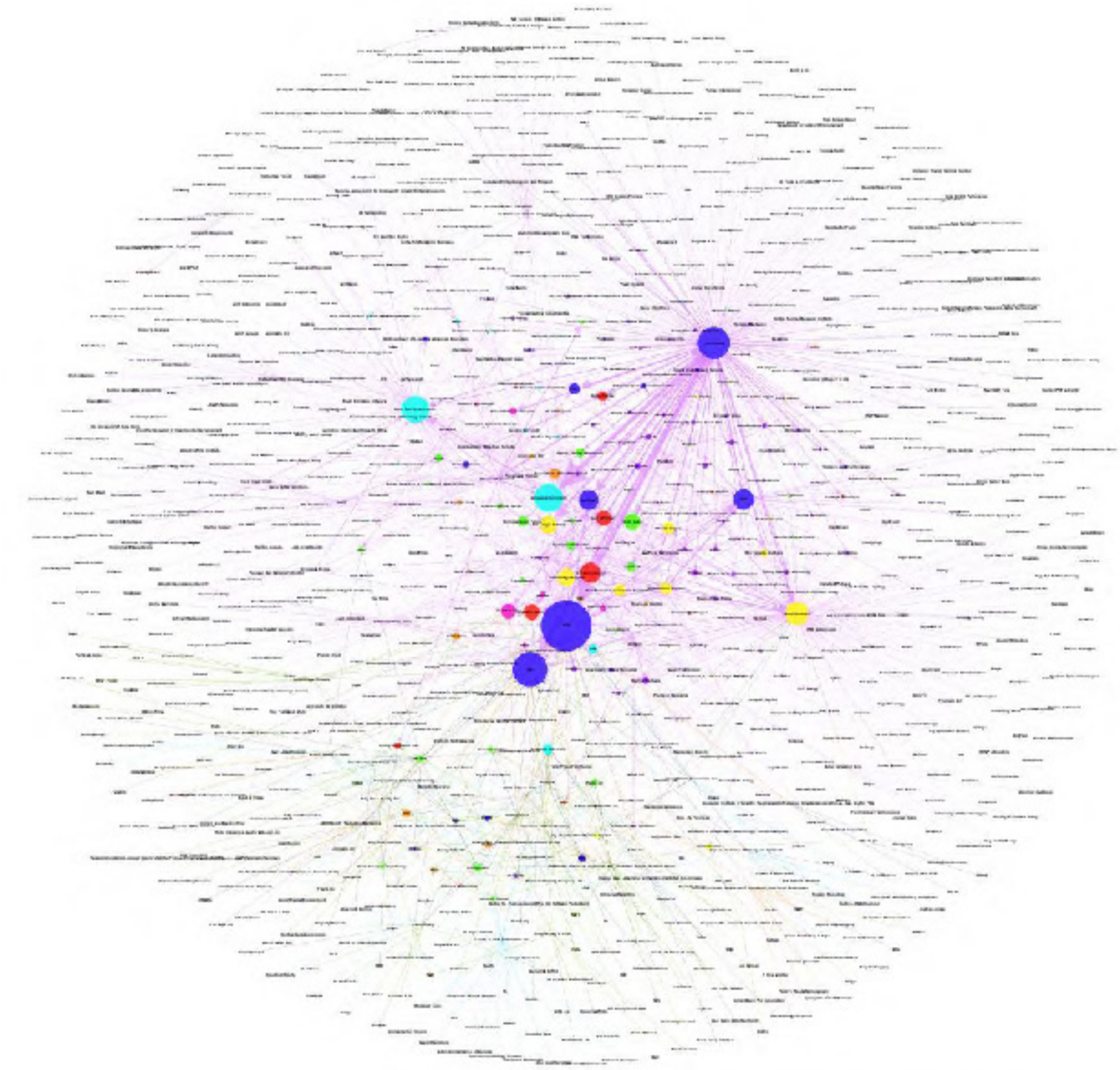
The results of the quantitative and qualitative approaches are discussed below. The quantitative analysis of egos in the entire ecosystem measures inbound and outbound requests of knowledge are presented first. The findings of the qualitative exploration of how MF engage with the entrepreneurial ecosystem and what they do follows.

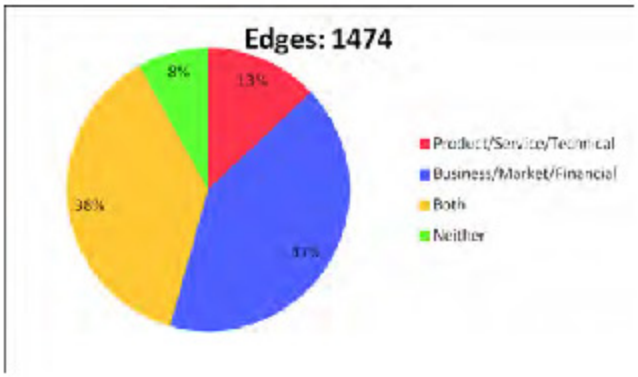
Quantitative analysis

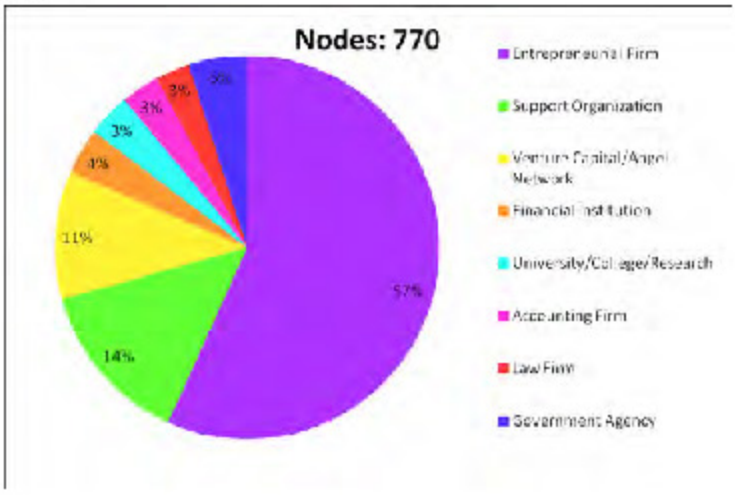
The targeted sample for the AEE began with a base list of 148 qualified potential respondents and grew as other entrepreneurial locales were noted by respondents. This quantitative analysis employed the egocentric method of network theory (as opposed to whole network method) because the total population of entrepreneurial firms is unknown. Rather than trying to capture the whole network, we seek detail information about the personal networks of each of a sample of individuals (nodes or egos) relieving the requirement for strict onerous response rates onerous (Grosser and Borgatti, 2013) which are impossible to accurately achieve know when populations are not known.

The composition and nature of the related nodes and the type of information sought and indicates the respondents' networks when actively searching for information about their entrepreneurial endeavours are shown in Figure 1. The knowledge-seeking activities of the entire AEE are very complex. There are 781 different organisations represented in the reported Atlantic EE and 1474 separate knowledge-seeking relationships defined. For information about how to read interpret these network graphs, please visit (Farrell, 2016 http://www.smu.ca/academics/sobey/working-papers-series.html)

Figure 1 - Atlantic Entrepreneurial Ecosystem







Using the same data but stripping out all knowledge-search behaviours that are not related to MF produces the chart shown in Figure 2. This chart has the same properties as that of Figure 1, but shows the inbound and outbound requests only as they related to MF.

Figure 2 - Ecosystem Interactions Involving Mature Firms

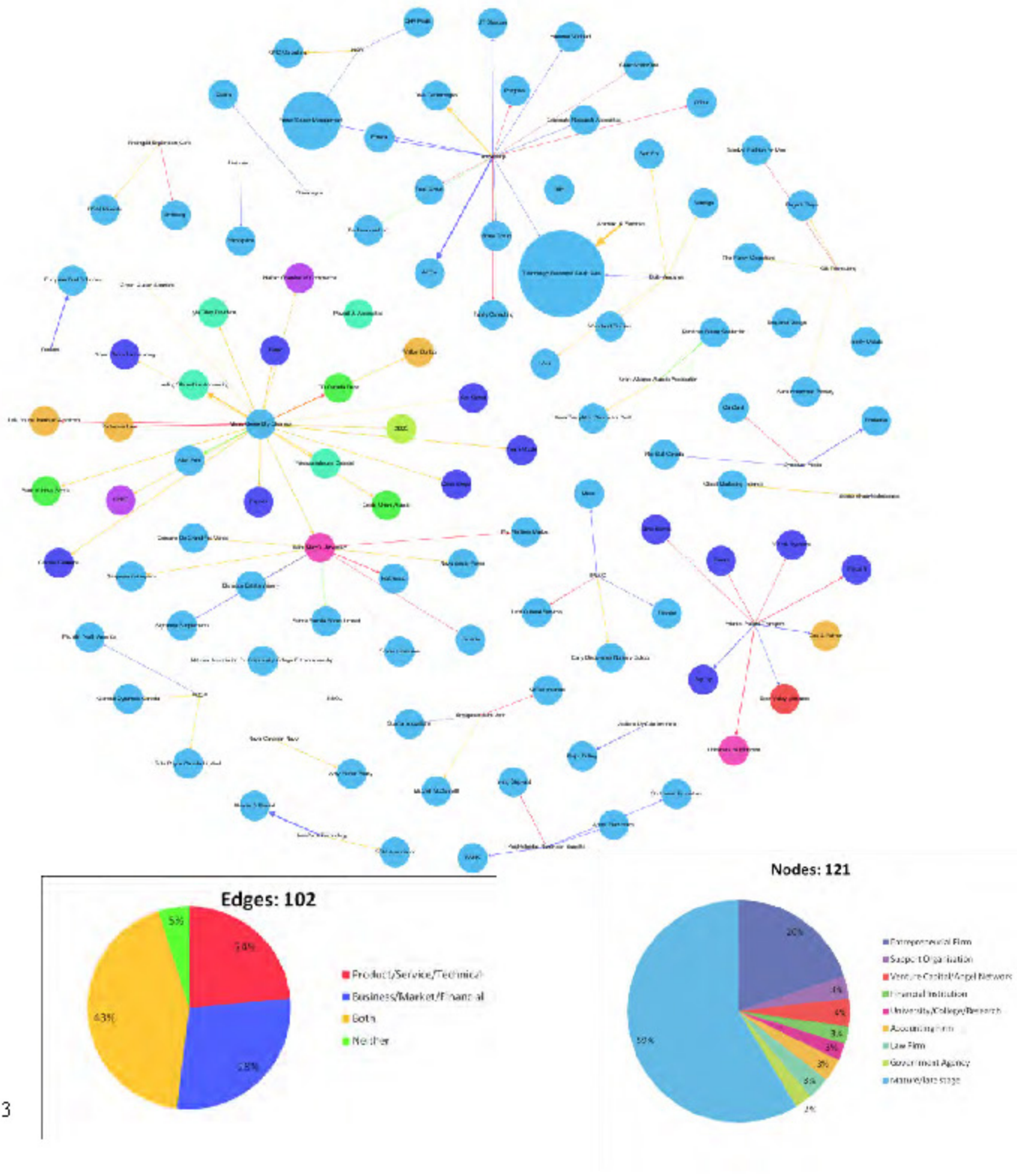


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Table 2 simplifies the constituent and direction of the requests in a table format. When MF are the target of ecosystem participants, entrepreneurial firms and venture capitalists equally dominate the requests for information. When the MF are instigating the information-search behaviours, they are principally searching for information from entrepreneurial firms. The EE respondents have a total of 1474 interactions amongst all the participants (Figure 1), but includes only 39 communications amongst entrepreneurial firms and MF (27+12). There is no extant research to compare this to, however, it appears that the proportion of MF-SU firm interaction is very light as a proportion of all interactions in the ecosystem (2.6% = 39/1474).

Table 2- Mature Firms as Target and Instigator of Ecosystem Information

Type	Mature Firm as a Target: search for information from a Mature firm by:		Mature Firm as Instigator: search for information by a Mature Firm from:	
	#	%	#	%
Venture Capital/Angel Network	27	37%	1	3%
Entrepreneurial Firm	27	37%	12	40%
Government Agency	4	5%	1	3%
Support Organisation	3	4%	2	7%
University/College/Research	11	15%	2	7%
Law Firm	0	0%	4	13%
Financial Institution	0	0%	3	10%
Accounting Firm	0	0%	4	13%
Mature Firm/Late stage	1	1%	1	3%
Total	73	100%	30	100%

Qualitative Analysis

The qualitative approach to investigating mature firms manners of supporting entrepreneurial endeavours uses a more inductive approach -- investigating actions actually executed and developing a framework to classify them (McEnany and Strutton, 2015). In some cases it was difficult to identify whether the founder or the MF initiated the engagement. A short table of those interactions appeared in the

Qualitative Analysis sub-section of the Methodology, Section 3. Collecting all the various different situations produced the following table, Table 3, which enumerates various combinations of connections. For the sake of shining a spotlight on the collaborations, efforts were to elaborate as many different items rather than trying to consolidate them. Hopefully, this list will be useful to entrepreneurs, as well as executives and managers in MF.

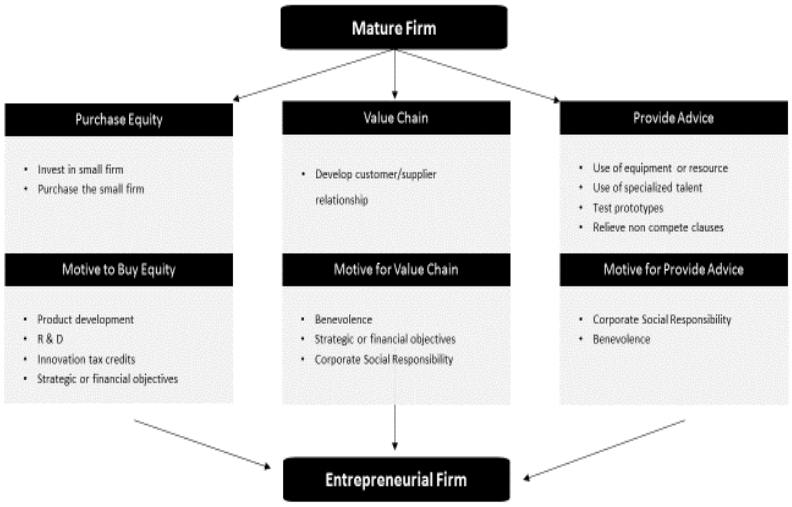
Table 3 - Nature and Types of Interactions Between Mature Firms and Entrepreneurial Firms

1.	Conduct R&D by posing problems for solution by entrepreneurial firms such as open innovation invitations, competitions, or hackathons
2.	Test prototypes developed by entrepreneurial firms
3.	Lend engineering talent and other operational and process capabilities
4.	Lend administrative or logistic support such as boardrooms, offices, equipment, photocopiers
5.	Government policy to provide in-kind support of contributions by mature firms
6..	Lend equipment and resources that are difficult or expensive to acquire or purchase
7.	Donate materials, furniture old equipment to accelerators or start-ups
8	MNC provide high paying jobs and stability and potential new entrepreneurs (Samsung, McCains, Emera, Louisburg Seafood)
9.	Accelerate commercialisation
10.	Introduce entrepreneurs to network of suppliers and customers
11.	Provide introductions to network of industry associates
12.	Government spending/support into privately held firms contains a proviso to find ways to support the venture and entrepreneurial community
13.	Assist in rapid testing to accelerate validation leading to product market fit
14.	Customer trials
15.	Assist with field trials
16.	Help in the identification and development of key qualities start-ups need for mission critical situations (i.e, document control procedures, pretests, site visits)
17.	Investing alongside start-ups
18.	Outright purchases of start-up firms (for products, services, knowledge, or acqui-hires)

5 MF interactions with SU: Discussion and theory development

Both the first and second approaches of MF contributions to SU in entrepreneurial ecosystems further MF strategic or financial objectives – first by incorporating entrepreneurial firms into MF value chain by selling to, or buying from them, or second by investing in, or acquiring, entrepreneurial firms. The third alternative manner of supporting EE or COI start-ups are not necessarily centred on the needs of the MF, but rather with the needs of the EE. The third major category are those tactics adopted by MF that are neither investment-, nor acquisition-, nor value chain- or channel of distribution-based. These MF contributions are expressed as contributions of advice, services, equipment, logistics, contacts, intellectual property, open innovation opportunities, or talent for the founders. The remaining discussion relates to the latter option, alternative engagements.

Figure 3 - Types of Support and Related Motivations by Mature Firms for Entrepreneurs



Alternative contributions by mature firms

These alternative involvements make use of capabilities and resources that are resident in MF, yet needed by small firms and very expensive them to acquire. MF efforts to reach out to growing entrepreneurs are virtually costless to a large firm, but priceless to a start-up. By representing small costs to MF, with little

ostensible benefit, they could be said to be responding to social responsibility norms or objectives, or altruism. Altruism is recognized as a promising approach for entrepreneurial environments as outward-looking mature firms attempt to develop ties with non-competing (and sometimes even competing firms) to cooperate and collaborate in open innovation contexts (Formica, 2017).

The third manner of supporting EE or COI start-ups have a more altruistic nature. The third major category are those strategies adopted by mature firms that are neither investment-, nor acquisition-, nor value chain- or channel of distribution-based. These MF contributions are expressed as contributions of advice, services, equipment, logistics, contacts, intellectual property, and talent for the founders. These involvements are capabilities and resources that are resident in MF, yet needed by the small firm. MF efforts to reach out to growing entrepreneurs are virtually costless to the large firm, but priceless to the start-up. By representing small costs to MF, with little ostensible benefit, they could be said to be responding to social responsibility norms or objectives.

MF may experience difficulties in implementing actions to integrate themselves into the start-up EE because long hierarchical organisational relationships do not lend themselves to engaging a MF embedded employee with a SU. An engineer in a mission critical area of a large organisations may a) not have the authorisation to act outside of her role, or b) does not see participation in the EE as part of her job description, or c) perceives that this is not an action that will result in an improved performance evaluation.

Mature firm social networks are created over long periods of time with internal nodes (employees interacting amongst one another) and external nodes (suppliers, customers, stakeholders, other members of the value chain) participating with one another through various levels of the organisation (Mizruchi and Stearns, 2001). Mature firm networks are composed of strong and weak ties which individuals search for advice and knowledge from peers and colleagues about transactions and deals. They deploy their networks to acquire approvals (a natural part of the hierarchy of large firms) uses resources to enhance "personal expected returns" (Lin, 2000). However, in some very hierarchical, very well-established firms, conditions of uncertainty incline employees to cling to networks that are built of strong (close and familiar) ties, rather than weak (broader less friendly, but more informative) ties. This situation creates a paradox because weak ties are more closely linked with success (than strong ties) by gathering diverse and wider range of information (Granovetter, 1973). "Not only does this illustrate the simultaneous weakness of strong ties and strength of weak ties, but it also shows how our social instincts can run counter to our best interests" (Mizruchi and Stearns, 2001, p. 667). From the mature firm perspective,

building networks that develop relationships with entrepreneurs, start-ups, co-founders, or new venture teams may not seem like the most successful strategy for enhancing one's own career.

Entrepreneurial firms, on the other hand, may be busy building networks that do not complement the types of relationships required for successful early stage venture development. Entrepreneurs build their networks starting with principally the original co-founders' networks and build them out over time and with ensuing addition of colleagues and their networks. When start-ups' many interconnections include linkages with MF ('leaders'), the benefits reinforce one another. Founders and start-ups gain the experience and support of MF, while at the same time, the combination can urge entrepreneurs to situate in these locales providing the essential elements for the genesis of innovation ecosystems (Dedehayir, Mäkinen et al., 2016).

The types of ecosystem development activities that MF are engaging with SU are rich, and resourceful. The engagements occur in both directions though there does not appear to be enough of them. Also, it is yet unknown, for example, whether the relative paucity of MF-SU activity outlined in the quantitative results is a result of SU failing to reach out to MF, or whether MF are unresponsive when approached. There are clearly very divergent power and resources at play in such requests which can hamper future relations (Mayoux, 2001; Woolcock, 2001). In one instance, an offer of an open innovation collaboration made at a community meeting seemed to fall on deaf ears, thought the MF executive who made the offer. Others perceived the audience's silence to be deference, awaiting more information and instruction.

6. Conclusion

This study investigated the interactions between entrepreneurial start-ups and mature firms in an EE. Specifically, it explored what MF do to support SU, how they do it, and how much activity exists between the two. The results from the quantitative analysis indicate that the network connections between MF and SU need development. The linkages within the study population showed fewer interactions than would be expected given the importance of MF in the extant literature. The qualitative analysis produced a rich tapestry of alternative mechanisms for MF to collaborate with SU (Section 4). In addition to the more well-known MF contributions of investing, acquiring or incorporating SU into their value chain, the results inventory surprising opportunities for SU and MF.

This work has important theoretical and practical implications. The roles played by MF within the domain of an EE or COI have been rarely isolated for research and contributions to theory. Extant

research shows the potential importance of roles played by MF (or enterprise, or anchor firms) as they consider community and social responsibility objectives and commitments to the locales in which they work. Practically, regions implementing growth strategies for economic development purposes (Ivany, d'Entremont et al., 2014; Saillant, 2014) look to entrepreneurship and the creation of EE to influence regional prosperity (Audretsch, 2015). This work outlines features that policy makers may consider to enhance regional prosperity. Lastly, there are specific practical actions that MF can contribute to a COI are listed and discussed for the executive, or senior management group, of large or mature companies. SU are advised to develop their networks and to extend that reach to (weak tie) associations with MF.

The qualitative study identified dozens of cases of successful MF-SU interactions; a crude typology of possible interactions was created. The direction of the initiative is central. On the one hand, SU cannot wait to be invited to collaborate or supported; MF need to be approached (appropriately) for most SU to have even a remote probability of successful interaction. Yet, on the other hand, the incidents noted here span a variety of different ecosystems and countries including US, UK, Switzerland, and our specific area of interest, Atlantic Canada. In Atlantic Canada two MF were recorded as having made overtures to open innovation collaborations at a community level. Future work could usefully identify the genesis of the open innovation invitation initiative within the MF, as well as the manner of its disseminations and reception by the local EE. These are practical issues about which more should be known.

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Mapping Knowledge Seeking in the St. John's and Corner Brook Entrepreneurial Ecosystems

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Executive Summary

This is the final report for the Harris Centre Applied Research Fund project: Entrepreneurial Ecosystems: Mapping the Extent, Roles, and Effects in St. John's and Corner Brook. The research mapped the knowledge-seeking activity of actors at the micro-level in both regions using proven network theory and analysis methodology. The entrepreneurial journey can, in part, be summarized as a process of discovering and exploiting opportunities with knowledge seeking critical to this process. While work has examined firm-level knowledge seeking, little has been done to map ecosystems based on entrepreneurial knowledge seeking. Moreover, an examination of this kind had not been conducted in either region and was particularly important in light of recent ecosystems enhancement efforts. This study was, then, the first attempt to address this gap in our understanding of these ecosystems.

The research methodology and approach used can be divided into two main phases, data collection and data analysis. A survey was used to collect data, between October 2016 and June 2017, from 156 respondents (51 in Corner Brook and 105 in St. John's). Data from these enable us to quantitatively map the knowledge-seeking behaviours of participants in the two ecosystems. In particular, data was gathered on four elements of the respondent's knowledge-seeking: who they contacted; the importance of the interaction to the survey participant; how often interactions occurred (frequency); and the type of information being sought (business/ market/ financial information or product/ scientific/ technical information). The frequency of communication (i.e. phone, face-to-face, and electronic) was based on the previous 12 months activities, while importance was ranked using a seven-point Likert scale. Respondents described who they were seeking knowledge from based on given categories of ecosystem actors (i.e. entrepreneurial firm, support organization, venture capital/angel network, financial institution, university/college/research, accounting firm, law firm, government agency).

The data revealed six main points. Firstly, encouragingly, overall both regions have, arguably, many of the organizations and people needed for a thriving entrepreneurial ecosystem. Each region has entrepreneurial firms, support organizations, venture capital/angel network presence, financial institutions, higher education facilities, accounting and law firms, and government agencies, all of which appear to be playing, generally, a positive role. Secondly, most troubling is what appeared to be a lack of interaction among entrepreneurial firms in both regions. The data showed roughly four times more knowledge seeking from government and support organizations than peer to peer knowledge seeking. Thirdly, overall the responses showed significantly higher knowledge seeking behavior related to business/market/financial rather than product/service/ technical knowledge. The lack of product/service/technical knowledge seeking might reduce innovation in entrepreneurial firms. Fourthly, the amount of entrepreneurial firm-to-mature firm knowledge seeking was limited. Arguably, entrepreneurial firms should be leveraging mature firm knowledge. Fifthly, in addition to government, the maps show that entrepreneurial firms were also seeking knowledge from university/colleges and support organizations. This is a positive role in the ecosystems, though the issue of these relationships crowding out entrepreneurial firm peer

relationships should be further examined. Finally, and also somewhat troubling, is that both ecosystems lack external connections beyond their regions. Survey respondents seldom referenced connections in Atlantic Canada and even fewer referenced any beyond Atlantic Canada to the rest of the world.

Reflecting on our findings we would make the following recommendations to actors in both ecosystems.

- Entrepreneurial firms in each region should consider doing more among themselves to enhance their ecosystem by taking a greater role in communicating, interacting, and supporting each other and their local entrepreneurial organizations. At the same time, they should maintain their knowledge seeking relationship with support organizations and others in the ecosystem.

- Support organizations and government agencies should consider funding and/or strengthening entrepreneurial networking (e.g. in addition to providing information themselves they should direct knowledge-seeking entrepreneurial firms to other entrepreneurial firms).

- Support organizations might also try to react to entrepreneurial firms rather than be as proactive as they have been (e.g. waiting for them to request knowledge rather than trying to anticipate their needs and, in effect, running the risk of shaping, inadvertently, knowledge seeking activities by their actions).

- Support organizations and universities/colleges could organize events that bring mature firms and venture capital firms in regular contact with entrepreneurial firms and their ecosystem. These could include hosting hackathons and inviting the firms, hosting networking events for entrepreneurial, venture capital and mature firms.

- Mature firms could make more effort to interact/mentor entrepreneurial firms in their regions. Examples of how they could help include: supporting startups through including them in their R&D efforts, hosting hackathons; providing office hours whereby entrepreneurial firms could speak to mature firms, lending resources and/or expertise to entrepreneurial firms, buying products from them, introducing entrepreneurial firms to suppliers, customers, and industry partners, and assisting with the testing of prototypes.

- All ecosystem actors should look to expand extra-local knowledge seeking, e.g. new international linkages could be shared with other ecosystem participants to forge new regional links to extra-local places, combining resources to attend trade missions and trade shows.

Glossary and Acronyms

ACOA - Atlantic Canada Opportunities Agency

NL - Newfoundland and Labrador

Introduction

This is the final report for the Harris Centre Applied Research Fund project: Entrepreneurial Ecosystems: Mapping the Extent, Roles, and Effects in St. John's and Corner Brook. The result of this project was to map both ecosystems based on the knowledge-seeking behavior of regional actors using proven network theory and analysis methodology (Borgatti, Everett, & Johnson, 2018). The project's data provided details of the knowledge seeking by ecosystem members leading to a deeper understanding of the nature and extent of this activity in St. John's and Corner Brook. This kind of examination had not been done in either place and was particularly important in light of recent efforts at ecosystem enhancement (e.g. the establishment of Common Ground Coworking, government funding for various industry groups, the creation of Memorial's Centre for Entrepreneurship, and the ongoing work of Navigate on Memorial's Grenfell campus). The fundamental reason for examining entrepreneurial firms, and here they are defined broadly and inclusively as any firm which had started within the previous five years, in Newfoundland and Labrador (NL) is that it is a crucial aspect of economic development. Entrepreneurs have created the small and medium sized firms which provide approximately 92% of non-government employment and, depending on how it is measured 20-40% of provincial GDP (Government of Canada Small Business Statistics, 2016). From this perspective, entrepreneurship development should be, and is, an important element in NL's economic development efforts. In examining knowledge seeking in these two ecosystems this project contributes by offering insights into an important never examined aspect of their operation.

Generally, many argue that facilitating entrepreneurship is a key to generating strong economic performance (Audretsch, 2015; Ribeiro-Soriano, 2017). There has been a heightened interest in studying entrepreneurial ecosystems over the past number of years in an attempt to understand and even emulate the entrepreneurial successes of the better known ecosystems (see for example: Acs, Stam, Audretsch, & O'Connor, 2017; Malecki, 2018). An entrepreneurial ecosystem is a unique, complex, self-sustaining environment that supports entrepreneurial activity (Feld, 2012; Malecki, 2018; Spigel, 2017). Ahmad & Hoffman (2008) suggest that it is a combination of three factors: opportunities, skilled people, and resources, while Isenberg (2010) proposes that ecosystems encompass six domains: policy, finance, culture, supports, human capital, and markets. Generally, the study of ecosystems has focused on more qualitative approaches using cases, ethnographic, and historical methods (see for example, Korsgaard, Ferguson, Gaddefors, 2015). Some of the more popular or grey literature asserts that entrepreneurial firms must play a key role in organizing and defining their ecosystem (Feld, 2012; Isenberg, 2010; Napier & Hansen, 2011). This includes frequent local activities (e.g., mentoring sessions, startup activities, coffee clubs, etc.) and communication among entrepreneurial firms and other ecosystem participants. According to this view, governments, universities and other organizations play important supporting, funding and/or 'feeder' roles. While building and maintaining the ecosystem must be led by entrepreneurs (Feld, 2012; Isenberg, 2010). While this body of ecosystem research has been growing over the past decade, the quantitative mapping of ecosystems, as done here, is in its infancy.

This project was organized, using the same approach, in collaboration with St. Mary's University (overall project lead), Memorial University of Newfoundland, Cape Breton University, the University of Prince Edward Island, and Université de Moncton. Our method was to undertake a quantitative approach using network theory (Farrell & Dennison, 2015; Motoyama & Knowlton, 2014). Combining entrepreneurial ecosystems research with network analysis, as demonstrated by Dr. Farrell's work in Nova Scotia, offers a new and important perspective and has shown promise as a means to enhance our knowledge of ecosystems. Previous work by Lam et al. (2013) and Vodden, Tucker, Gibson, & Holley (2011) on this province's West Coast and Northern Peninsula have shown the contribution network analysis can make to better understanding Newfoundland and Labrador's (NL) regional development dynamics. This study will build on the previous use of network analysis in regional development studies and broaden its use to mapping entrepreneurial firm knowledge seeking activity in the two regions.

The report is divided into three main sections, the first provides the project's background, rationale, objectives, and research methodology. The second discusses the data and presents findings, while recommendations are outlined in the final main section.

Project Background

The entrepreneurial ecosystems literature provides a useful background for our work. Ecosystems study is a developing area of scholarship and there are still limitations with the approach. Generally, Spigel (2017) has argued that the emerging focus on entrepreneurial ecosystems has been undertheorized and lacks evidenced-based research. More particularly, much of the ecosystems work, while very good at mapping ecosystem participants, has failed to examine the relationships between participants at the micro or granular level (Motoyama & Knowlton, 2016). Knowledge seeking between ecosystem participants and outside ecosystem boundaries is, arguably, a key activity especially for knowledge-based innovation driven startups. Research in a variety of areas clearly shows that knowledge, networks, and social capital are important in the startup process (see for example: Aldrich & Zimmer, 1986; Stuart & Sorenson 2005).

The use of the ecosystem metaphor is meant to invoke the idea that "entrepreneurship takes place in an interdependent community of actors" (Stam, 2015: p. 2). This represents a shift from typical research on entrepreneurship, distinguishing between on the one hand; research on entrepreneurs themselves and, on the other, studies of the broader contexts in which entrepreneurs operate (e.g. Autio et al, 2014). It is increasingly recognized that there is a need to think of entrepreneurship and economic development at the system level (Acs, Autio, & Szerb, 2012). The ecosystems approach is similar to cluster and learning regions, innovation systems, triple/quadruple helix, and creative class theories in that it focuses on the spatial environment and the interaction of key actors in the region (Stam 2017; Spigel 2017). According to the ecosystems view, many of the resources needed for entrepreneurial success exist at the regional level versus within the firm itself (Spigel, 2017). However, ecosystem models differ from these models in their

clear focus on the entrepreneurial firm/entrepreneur instead of on the relationships or interactions among the constituent actors (e.g., firms, governments and universities) (Stam, 2015). These resources include knowledge held by local and non-local supports including suppliers, universities, lawyers and accountants, government officials, and other entrepreneurs. Consequently, the ecosystem model offers a fuller analysis of entrepreneurship and its impact (Audretsch, 2015; Motoyama & Knowlton, 2014). Examining entrepreneurial firms using an ecosystems lens, therefore, offers a multifaceted and important developing perspective.

Aspects of the ecosystems literature relevant to this project relate to policy, stage of development, and university involvement. The focus of ecosystem policy is the subject of some debate. For example, Isenberg (2011), and Mason and Brown (2013a & b) suggest the entrepreneurial ecosystem policy should be focused on high-growth entrepreneurs since their impacts on innovation, employment and economic growth are dramatic. Stam (2015, see also Stam et al, 2012) argues that entrepreneurial employees and innovative startups can also have economic benefit and should be included in the ecosystem approach. Researchers have recognized that ecosystems can move through a life cycle. Brown and Mason (2017) distinguish between embryonic and scale-up ecosystems, while Cukier, Kon and Krueger (2015) have developed a four stage model of startup ecosystems including; nascent, evolving, mature, and self-sustainable. The point here is that not all ecosystems are alike, that sustainability is based on constant renewal via new startups (Malecki, 2018), and that development depends on the actions of a range of actors, with entrepreneurs and their firms in the lead (Autio et al., 2014; Feld 2012). Interestingly, universities are often invoked as hubs and central actors of successful entrepreneurial ecosystems, with only entrepreneurs considered more critical to ecosystem success (Bramwell & Wolfe, 2008; Malecki, 2018; Motoyama & Knowlton, 2017). The success of university involvement in usually based on intermediaries including technology transfer offices, incubators, research centres, and makerspaces that support the local ecosystem(s). Of course, universities and colleges also provide highly qualified personnel who play important roles in entrepreneurial ecosystems (Bramwell & Wolfe, 2008).

The key focus of this study is the knowledge seeking behaviour of ecosystem participants. Knowledge seeking activities has attracted considerable research interest over the past few decades, and the capacity to search, find, and exploit opportunities is seen as critical to innovation in a knowledge-based economy (Wu & Wang, 2017). The entrepreneurial journey has been summarized as a process of discovering and exploiting opportunities, and in this way, using firm knowledge seeking capacity to rapidly find and exploit economic opportunities is critical to gaining economic benefit (Alvarez & Barney, 2007).

The Schumpeterian view of entrepreneurship places significant emphasis on the individual entrepreneur and internal knowledge capacity of the entrepreneurial firm, including research and development through the firm's own resources (Schumpeter, 1934). Though more recent research suggests that firms interacting with universities, research and governments agencies, suppliers, and customers produces more valuable

innovation outcomes than insular intra-firm R&D efforts alone (Hall, Walsh, Vodden, & Greenwood, 2014; Tappeiner, Hauser, & Walde, 2008). The growth of complexity in innovation also reduces the adequacy of internal firm knowledge, causing firms to involve more partners and sources of knowledge in their innovation processes (Wu & Wang, 2017). Generally, research on firm knowledge seeking has highlighted the importance of external knowledge to firms (Chiang & Hung 2010). The literature also posits that a firm's ability to seek and recognize value in external knowledge is based on the firms' internal knowledge. In order to use it, the new knowledge needs to be assimilated with what the firm already knows (Cohen & Levinthal, 1990). This view raises the critical importance of a firm's capacity to understand and guide their knowledge seeking (Cohen, & Levinthal, 1990; Grimpe & Sofka, 2009).

Other work suggests the need within the entrepreneurial firm for broadly based wide ranging knowledge seeking strategies. These strategies include, 'how to search' or breadth and depth of searches (Laursen and Salter 2006). Wider breadth searches implies multiple sources, while depth alludes to fewer sources and a more intensive search. Research has noted that firms with wider breadth search strategies tend to be more innovative, but that there are decreasing returns (Ferreras-méndez, Newell, Fernández-mesa, & Alegre, 2015; Laursen & Salter, 2006;). Search strategies also comprise 'where to search' or the importance of local versus non-local knowledge search (Bathelt, Malmberg & Maskell, 2004). Knowledge spillovers in clusters reveals the importance of local buzz and local knowledge is important, while the concept of global pipelines stresses exchanges with external actors (Rodrıguez-Pose, 2010). Other research shows that regionally located technological laggards spend more effort learning from local sources of information than non-local sources (Giuliani & Bell, 2005; Wang, 2015). Accessing non-local knowledge, then, seems to indicate greater firm innovation. A third difference in search strategies distinguishes between relatedness/ unrelatedness in innovation, or the overlap between external knowledge searches and the firm's existing knowledge. Wu and Wang (2017) found that related knowledge search helps low-tech firms while unrelated knowledge search supports product innovation in high-tech firms.

While the literature on ecosystems and firm-level knowledge search in informative and the literature strongly suggests the importance of knowledge for entrepreneurial firm creation and development, little research has been done specifically on the knowledge seeking activities of entrepreneurial firms. This work addresses this gap in our understanding.

Project Rationale

The evolving St. John's and Corner Brook ecosystems had not been mapped so this project promised useful insights into their functioning. Further, as this work will, in the future, be compared with other studies being conducted by our project partners across the Atlantic region, there was the distinct possibility of learning from other similar regions. As such, this project will be valuable to ecosystem members and supporters, policy

makers, academics, and other stakeholders. Moreover, the work will have practical implications for how these ecosystems can be understood, their strengths and weaknesses, and what can be done to improve them, especially as it relates to their knowledge seeking activities.

Project Objectives

This work's objective was to map the knowledge seeking activity in the St. John's and Corner Brook entrepreneurial ecosystems, using social network methodology. In particular, we identified a number of the participants in each ecosystem, mapped their knowledge seeking activity and analyzed these to better understand their dynamics with a view to recommending improvements to ecosystem participants and other stakeholders. Before discussing the details of our methodology it is important to note that we were not attempting to map the entire ecosystem, but rather we gathered a representative sample of the entrepreneurial firms in each ecosystem and mapped their relationships (for more details on this sampling method and its rigour, see: Grosser & Borgatti, 2013).

Research Methodology

The research methodology used in this work can be divided into two main phases, data collection and data analysis. Data collection was based on a quantitative survey instrument developed by Dr. Farrell at St. Mary's University and adapted for the St. John's and Corner Brook regions (see Appendix 1 for copies of each instrument). The surveys were designed to provide data that would enable us to map the knowledge-seeking behaviours of participants in the two ecosystems. The surveys collected data on four elements of the respondent's knowledge-seeking: who they contacted; the importance of the interaction; how often interactions occurred (frequency); and the type of information being sought (i.e. business/market/financial information or product/scientific/technical information). The frequency of communication (i.e. phone, face-to-face, and electronic) was based on the previous year's activities, while importance was ranked using a seven-point Likert scale. Respondents described who they were seeking knowledge from based on given categories of ecosystem actors (i.e. entrepreneurial firm, support organization, venture capital/angel network, financial institution, university/college/research, accounting firm, law firm, and government agency).

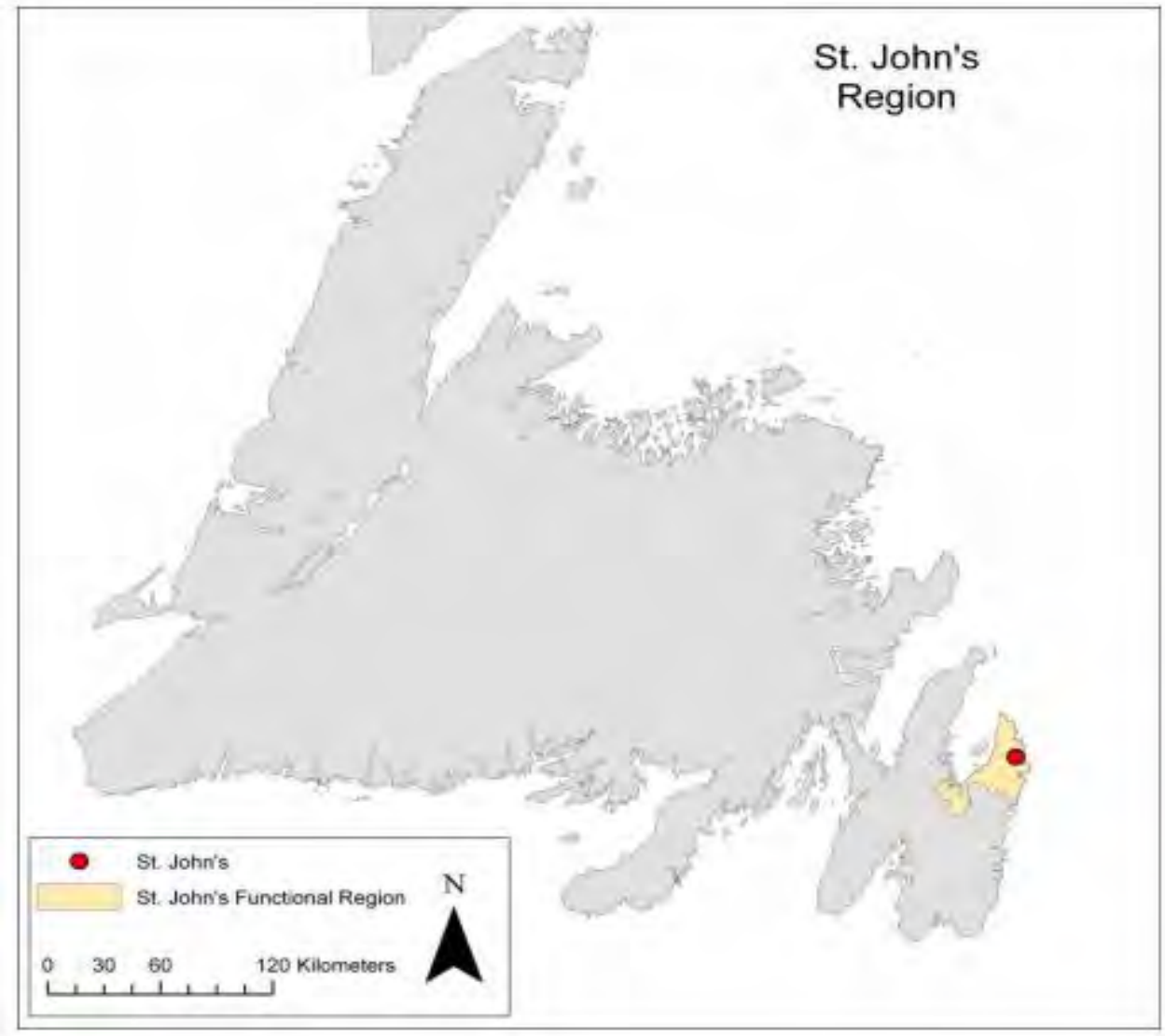
This study was focused on two urban regions, Corner Brook and St. John's, on the island portion of the province of Newfoundland and Labrador. These regions are based on the Functional Economic Regions, defined by Freshwater, Simms, & Ward (2014) as an area delineated by the commuting patterns of people working/living in the locality. The St. John's functional region is the largest urban centre in the province, and includes all of the Northeast Avalon. Both, though quite different, are examples of regions within the province capable of sustaining entrepreneurial ecosystems. St. John's is one of Atlantic Canada's 11 urban centres and Corner Brook is one of 29 Atlantic Canadian small cities

and regional towns (Freshwater, Simms, & Ward, 2014). The regions were selected based on the premise that the research could provide recommendations for strengthening each and that they likely had good comparability to other similarly sized regions in Atlantic Canada.

St. John's is located on the Avalon Peninsula at the province's eastern end (see Map 1 for details). In 2011 the St. John's region (Northeast Avalon) population was 203,325. The population increased 8.0% between 2006 and 2011 (Community Accounts, 2018). The median age in 2011 was 40 compared to 44 for the province. The region's income per capita in 2013 was $39,800, the province average was $34,500 (Community Accounts, 2018). Key occupations include sales and service, business, finance and administration, education, law, and government services.

Corner Brook is a regional centre on the island's west coast (see Map 1 for details). In 2011 its population was 41,125, which represents an increase of 0.4% since 2006 (up from 40,970). Over the same period, the entire province experienced a population increase of 1.8% (Community Accounts, 2018). The median age in the region was 46 and average income per capita was $31,600 for 2013 (provincial average $34,500) (Community Accounts, 2018). Occupations with the highest employment included sales and service, trades, transport and equipment operators, education, law, and government services.

Map 1: St. John's and Corner Brook Regions



Source: Office of Public Engagement

The surveys were sent in two rounds, in a modified snowball sampling process, and completed between October 2016 and June 2017. There was no single readily accessible list of ecosystem actors, so choosing potential survey respondents was based on researcher and key informants expertise. Initially respondents were drawn from the local entrepreneurial community and then further respondents were drawn from government officials, entrepreneurial support organizations, and universities/colleges. A drawback of this approach was the possibility of missing key ecosystem participants, though it is likely that most of those missed were named in the first round and contacted in the second survey round. As when initial survey participants named new actors they were then sent a survey in the second round (only, though, after their contact details were obtained through public sources). Originally surveys were sent as a fillable PDF document, however, some difficulties were discovered in participants' ability to complete the survey using this format, so a web-based survey was developed and used by most respondents (see Table 1 for details). Ultimately 156 surveys were completed by 51 respondents in

Corner Brook and 105 in St. John's (Table 1 summarizes the survey responses from both regions).

Table 1: Completed Surveys (Web and PDF based)

Corner Brook Web	35
Corner Brook PDF	16
Corner Brook **Total**	**51**
St. John's Web	67
St. John's PDF	38
St. John's **Total**	**105**
Overall Total	**156**

All survey emails were addressed to respondents under the principal investigator's (Blair Winsor) name/email for the St. John's portion of the study and the co-investigator (Ken Carter) for Corner Brook in order to take advantage of their relationships in the respective ecosystems and to add credibility to the survey invitation. Both the PDF surveys and the web-based surveys were exported to a CSV file. The data was then cleaned by the researchers/research assistants and coded.

In the second phase of the research methodology the data was analyzed using Gephi software employing proven and generally accepted social network analysis techniques (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008; Borgatti, Everett & Johnson, 2018; Lambiotte, Delvenne, Barahona, 2015). The software created edges (or lines) for each transaction/response in the dataset showing connections between any two nodes (i.e. actors in the ecosystem: entrepreneurial firm, support organization, venture capital/angel network, financial institution, university/college/research, accounting firm, law firm, and government agency). The nodes named by different respondents were consolidated in a map where size and centrality reflects the node's importance and frequency to knowledge seekers within the ecosystem. Each actor type was coded with a unique colour. The resulting maps (see Appendix 2 for examples) show the region's knowledge flows and highlight the central players in these knowledge flows.

Clearances

The project was initially vetted and approved through Memorial University's Interdisciplinary Committee on Ethics in Human Research on March 3, 2016. In accordance with requirements, this approval was extended by the same body annually for the project's duration.

Project Findings

Turning to the findings, as noted above, we received 156 survey responses with respondents naming 393 different entities or nodes (see Table 2). A total of 1021 knowledge-seeking transactions - edges - were listed by respondents, 329 in the Corner Brook responses and the remaining 692 in the St. John's responses. The survey asked respondents the number of times people connected (frequency) and the significance they attached to this knowledge seeking (importance). The average degree is the arithmetic mean for the number of degrees which each node possesses. The degree value is simply the sum of edges (in either direction i.e. both inbound and outbound) for any given node. These values ranged from 1 all the way to 85 (for the Atlantic Canada Opportunities Agency (ACOA) – see Appendix 2), with the average being 5.24. The average weighted degree is calculated by multiplying every nodes degree value by their respective weights. Every edge contains two different values for weight, "importance" and "frequency", these are both numbers from 1-7. For weighted degrees by importance the range in the data is 1 to 489, and when weighted by frequency it is 1 to 228.

Table 2 – Ecosystem Statistics Network Descriptives

	CB	**SJ**	**All**
Nodes	178	264	393
Edges	345	692	1029
Average Degree	3.876	5.242	5.24
Average Weighted Degree (Importance)	10.433	14.208	14.16
Average Weighted Degree (Frequency)	5.944	7.644	7.73

The nature of the respondents' profession was also captured (See Table 3 for details). Respondents self-identified on this topic and could include more than one category. Most of the respondents were entrepreneurial firms (54.9% Corner Brook and 49.5% in St. John's). The next largest group was government (25.5% in Corner Brook and 19.0% in St. John's).

Table 3 - Self Identification of Profession (More Than One Category Possible)

	Corner Brook		St. John's		Total	
	Number	Percent	Number	Percent	Number	Percent
Entrepreneur	28	54.9	52	49.5	80	51.3
Social Entrepreneur	8	15.7	12	11.4	20	12.8
Aboriginal	8	15.7	1	1.0	9	5.8
Venture Capitalist	0	0	6	5.7	6	3.8
Private Individual	3	5.9	5	4.8	8	5.1
Business angel network	3	5.9	2	1.9	5	3.2
Lawyer	1	2.0	3	2.9	4	2.6
Accountant	3	5.9	5	4.8	8	5.1

Government representative	13	25.5	20	19.0	33	2.1
Consultant	2	3.9	16	15.0	18	11.5
Journalist	2	3.9	1	1.0	3	1.9
Professor	6	11.8	6	5.7	12	7.7
Employee in a mature company	3	5.9	9	8.6	12	7.7
Research laboratory employee	1	2.0	2	1.9	3	1.9
Banker	0	0	0	0	0	0
Other (please specify below)	9	17.6	14	13.3	23	14.8

Respondents reported high education levels with all but two having had some form of post- secondary education (Table 4 outlines the respondent's educational profiles). Combined, nearly a quarter of all respondents had a master's degree, while more than half had a bachelors' degree. Ecosystem participants in both regions are then highly educated.

Table 4 – Respondent Educational Profile

	Corner Brook Percent	St. John's Percent	Total Percent
High School or Equivalent	24	15	18
Some College	12	5	7
Vocational/Technical School (2 years)	14	7	9
Bachelor's Degree	45	56	53
Master's Degree	24	26	24

Note: Percentages will not add to 100% due to more than one response from individual respondents.

Much of the data is usefully presented on network maps (or graphs) (see Appendix 2). These maps show all the nodes named by respondents and the type and direction of their knowledge seeking. In these maps centrality and node size represent frequency and importance. An examination of these maps reveals that university/college and research, government agencies and support organizations are very important in both ecosystems (see Table 5 and Appendix 2). Most have large node size and are located in the central portions of the maps with multiple edges going in both directions. Financial institutions are well represented. Venture capital/angel firms, law firms, and accounting firms are more prominently seen in St. John's (see Appendix 2 maps. Also noteworthy was the very small number of nodes outside the region and beyond, evidence of the insularity or narrowness of much of the knowledge seeking in both regions. A striking feature on both regional maps (see Appendix 2 and Table 5) is the often peripheral location of

entrepreneurial firms, many are located on the outer portions of the maps and have few edges with their entrepreneurial firm peers.

Table 5 - Node Type and Importance of Inward/Outward/Combined Knowledge Seeking

Node Type	Weighted (importance) In Degree	Weighted (importance) Out Degree	Weighted (importance) Combined
University/College/Research	27.81	45.81	73.63
Government Agency	26.13	16.00	42.13
Support Organization	16.71	19.75	36.47
Financial Institution	27.75	0.63	28.38
Venture Capital/ Angel Network	24.29	2.29	26.59
Entrepreneurial Firm	6.26	13.42	19.68
Accounting / law firm	13.74	3.98	17.72

Given our focus on the knowledge seeking of entrepreneurial firms it is important to delve into this aspect of the data. In particular, the kinds of information being sought by entrepreneurial firms. The survey asked respondents to distinguish between business/ market/financial versus product/service/technical or a combination of both, and whether they were seeking knowledge from entrepreneurial firms or others in the ecosystem (see Tables 6.0 and 6.1). Especially noteworthy here was how little knowledge seeking occurred between entrepreneurial firms. They sought knowledge 441 times and of these only 104 (less than 25%) were from other entrepreneurial firms (see Table 6.0). Also interesting was the split between types of knowledge sought, entrepreneurial firms were seeking business/market/financial knowledge about three times more often than product/ service/technical knowledge whether the inquiry was directed at other entrepreneurial firms or any other entity (see Table 6.0 & 6.1).

Table 6.0 – Total Knowledge Seeking by Entrepreneurial Firms

	Business/ Market/ Financial	Product/ Service/ Technical	Both	Neither	Total
SJ All KS	210 (55%)	50 (13%)	96 (25%)	25 (7%)	**381**
CB All KS	31 (52%)	6 (10%)	8 (13%)	15 (25%)	**60**
Total KS	241 (55%)	56 (13%)	104 (24%)	40 (9%)	**441**

Note: CB = Corner Brook; KS = Knowledge Seeking; SJ = St. John's

Table 6.1 – Entrepreneurial Firm to Entrepreneurial Firm Knowledge Seeking

	Business/ Market/ Financial	Product/ Service/ Technical	Both	Neither	Total
SJ E To E KS	38 (44%)	10 (12%)	36 (42%)	2 (2%)	86
CB E to E KS	5 (28%)	4 (22%)	3 (17%)	6 (33%)	18
Combined KS	43 (41%)	14 (13%)	39 (38%)	8 (8%)	104

Note: CB = Corner Brook; E = Entrepreneurial Firm; KS = Knowledge Seeking; SJ = St. John's

This data was thought provoking and raised a number of intriguing points which are discussed in the next section.

Discussion

Examining and reflecting on the findings reveals a number of points. Firstly, encouragingly, overall both regions have, arguably, many of the organizations and people needed for a thriving entrepreneurial ecosystem (Malecki, 2018; Spigel, 2017; Stam, 2015). Each region has evidence of entrepreneurial firms, support organizations, venture capital/angel network presence, financial institutions, venture capital/angel investors, higher education facilities, accounting and law firms, and government agencies, all of which appear to be playing, generally, a positive role. Using Cukier et al's (2015) four stage schema, our preliminary sense of the two ecosystems suggests both are currently in the evolving stage, with St. John's a little further developed as evidenced by the stronger roles of venture capital and support organizations in that region.

Not unexpectedly the data does not indicate great differences between the two ecosystems and therefore we are combining the data for both in this section. However, there are a few notable differences. Corner Brook has a substantially higher self-identification of aboriginal background compared to St. John's. This is not surprising given the number of residents of the region who were members of the Qalipu First Nation. Another difference is that Corner Brook lacks venture capitalists compared to St. John's which is likely a function of the region's smaller size. However, more respondents in Corner Brook identified as part of a business angel network which would likely compensate somewhat for the lack of venture capital funding availability in the ecosystem. There were also more respondents in St. John's who identified as consultants.

Secondly, most troubling is what appears to be a lack of interaction among entrepreneurial firms in both regions. There are good examples of entrepreneurial firm driven networking organizations in both regions, including Startup NL and Common Ground in St. John's as well as Humber Valley Entrepreneurs in Corner Brook. However, our data does not show entrepreneurial firms seeking knowledge from their peers as

much as from support organizations, with less than 25% of knowledge seeking by entrepreneurial firms directed to other entrepreneurial firms (see Tables 6.0 & 6.1). This low level of peer to peer knowledge seeking is contrary to the emphasis in the available literature that suggests entrepreneurial firms are crucial in helping other entrepreneurial firms both build their businesses and the ecosystem (Feld, 2012; Napier and Hansen 2011; Isenberg, 2010).

Thirdly, the responses (See Table 6) had significantly higher knowledge seeking behavior related to business/market/financial knowledge (55%) rather than product/service/ technical (13%), though a number of respondents referenced both (25%). This raises a number of questions. By not seeking product/service/technical knowledge as much as business/market/financial, is the data suggesting that our entrepreneurial firms are not as innovative focused as they could be or do not have the internal knowledge needed to recognize the value of this external knowledge? After all innovation, arguably, requires product/ service/technical knowledge (Cohen & Levinthal, 1990; Grimpe & Sofka, 2009; Laursen & Salter, 2006; Wang, 2011). Do these findings of lower technical knowledge seeking, added to the substantial presence of government in each ecosystem, suggest that the ecosystems are too dependent on government business/market/financial support? Is the government presence also related to our entrepreneurial firms pursuing government funding and, if so, does this point to an immaturity in the island's ecosystems when compared to regions in the world that attract large amounts of venture capital or is this normal for peripheral regions? More work is needed to address these questions.

Fourthly, the level of entrepreneurial firm-to-mature firm interaction was lower than expected based on information from established ecosystems (Saxenian, 1996). The maps of the two ecosystems show few connections between newer entrepreneurial firms and mature firms. The issue here may be the complexities of power relations (Mayoux, 2001; Wang, 2011) where smaller startups may feel intimidated by large successful firms. Arguably, each region's mature firms have significant expertise and capacity to help their region's entrepreneurial firms (Alvarez & Barney, 2001). This suggests that more needs to be done to include the expertise of mature firms in ecosystem activities. Similarly, there was also limited connections to venture capital, with venture capitalists outside the centre in both the St. John's or Corner Brook maps. This may change as the ecosystems mature and deal flow increases.

Fifthly, in addition to government, the maps show that entrepreneurial firms were also seeking knowledge from university/colleges and support organizations. Entrepreneurial respondents referenced the College of the North Atlantic, Memorial's St. John's and Grenfell Campuses, as well as support organizations such as NLOWE, Futurpreneur and the Community Business Development Corporations. The degree of centrality for these institutions as well as node size reflect the frequency and importance of these connections for ecosystem participants (see maps Appendix 2). In addition to government, other support organizations are also important sources of capital for entrepreneurial firms which may tend to skew the knowledge seeking to business/market/ financial rather than product/service /technical. Overall, these results tend to show these organizations expected ecosystem role.

Finally, also troubling was that both ecosystems lack many external connections beyond their regions. Survey respondents seldom referenced connections across Atlantic Canada and even fewer referenced any beyond Atlantic Canada to the rest of the world. There was some evidence of actors reaching outside the ecosystem to the broader Atlantic region and beyond (e.g. MARS, Build Ventures). However, there was not as much of this as might be expected in a healthy ecosystem. This suggests weak connections between the two ecosystems to Atlantic Canada, North America, and the rest of the world. Within the province, Corner Brook and St John's appeared to be well connected but both ecosystems connections are island centric. There were a few notable exceptions, both of very well connected individuals and to particular places (e.g. evidence of links to the Caribbean in St. John's likely stemming from a project driven by the Newfoundland Environmental Industry Association). Interestingly, this finding of limited connections beyond a region is consistent with the finding from the recent Halifax ecosystem mapping project (Farrell & Dennison, 2015). The literature on innovation systems notes the importance of external connections to new ideas circulating into the ecosystem, and with limited connections beyond the province we are not likely to be participating fully in global innovation processes (Bathelt, Malmberg & Maskell, 2004; Rodrıguez-Pose, 2010).

Knowledge Mobilization

This project was part of a broader Atlantic Canadian partnership that includes St. Mary's University, Memorial University of Newfoundland, Cape Breton University, University of Prince Edward Island and Universite de Moncton. The cooperating universities have held workshops in Halifax, Charlottetown, and Corner Brook. The Corner Brook workshop took place in April 2017 and included 50 participants from the local ecosystem. An additional session is planned for St. John's in partnership with the Memorial University's Harris Centre. As data becomes available across Atlantic Canada more sessions comparing and sharing research are planned. Findings for Atlantic Canada, including St. John's and Corner Brook, were shared at the Global Consortium of Entrepreneurial Centers in Halifax in the fall of 2017.

Recommendations

The literature on ecosystems and knowledge seeking by firms highlights key elements of successful regions and innovative firms. Based on this literature, there were several expectations formed at the beginning of this study. The first of these was that there would be considerable university/college knowledge search by entrepreneurial firms. This was confirmed through the interviews, with Memorial University's, St. John's and Grenfell Campuses, and College of the North Atlantic, all prominent players in knowledge seeking by entrepreneurs. Second, we expected to find considerable entrepreneurial firm-to-entrepreneurial firm knowledge seeking, however we found much less than anticipated. Third, we expected to find good knowledge seeking beyond the local ecosystems and

into Atlantic Canada, North America and beyond. Again, less of this was found than anticipated.

Reflecting on our findings we would make the following recommendations to actors in both ecosystems.

- Entrepreneurial firms in each region should consider doing more among themselves to enhance their ecosystem by taking a greater role in communicating, interacting, and supporting each other and their local entrepreneurial organizations. At the same time, they should maintain their knowledge seeking relationship with support organizations and others in the ecosystem.

- Support organizations and should consider funding and/or strengthening entrepreneurial networking (e.g. in addition to providing information themselves they should direct knowledge-seeking entrepreneurial firms to other entrepreneurial firms).

- Support organizations might also try to react to entrepreneurial firms rather than be as proactive as they have been (e.g. waiting for them to request knowledge rather than trying to anticipate their needs and, in effect, running the risk of shaping, inadvertently, knowledge seeking activities by their actions).

- Support organizations and universities/colleges could organize events that bring mature firms and venture capital firms in regular contact with entrepreneurial firms and their ecosystem. These could include hosting hackathons and inviting the firms, hosting networking events for entrepreneurial, venture capital and mature firms.

- Mature firms could make more effort to interact/mentor entrepreneurial firms in their regions. Examples of how they could help include: supporting startups through including them in their R&D efforts, hosting hackathons; providing office hours whereby entrepreneurial firms could speak to mature firms, lending resources and/or expertise to entrepreneurial firms, buying products from them, introducing entrepreneurial firms to suppliers, customers, and industry partners, and assisting with the testing of prototypes.

- All ecosystem actors should look to expand extra-local knowledge seeking, e.g. new international linkages could be shared with other ecosystem participants to forge new regional links to extra-local places, combining resources to attend trade missions and trade shows.

Conclusions

This work has led to the first micro-level quantitative understanding of the nature and extent of knowledge seeking in the evolving St. John's and Corner Brook entrepreneurial

ecosystems. Key data from over 150 respondents representing a variety of ecosystem actors has be presented. The data was analysed, based on social network analysis, and recommendations were made based on this analysis.

In terms of future work, with this preliminary underlying data set gathered for the St. John's and Corner Brook ecosystems, new opportunities arise for further research. This will include further comparisons geographically with work being undertaken across Atlantic Canada. Similar studies are taking place in PEI, Cape Breton and New Brunswick and a study based in Halifax has been completed. As all these studies are completed, comparisons of these data sets will be a priority. More work needs to be done comparing rural results to urban centres across the region. The data also will allow data mining based on gender, age, stage of growth and industry sector. Taken together this represents an ambitious research program that can give significant insights into the current state of entrepreneurship in Atlantic Canada. There is also the possibility to redo the work after a period of years to determine what changes have occurred in the ecosystems.

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Appendix 1: Survey Instruments

Appendix 2: Ecosystem Maps

Quantitative Analysis of the Atlantic Entrepreneurial Ecosystem's Innovation Activities

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Abstract

In nature, ecosystems occur when organisms network and interact resulting in value creation, and the total of the value generated exceeds the sum of its parts. Business ecosystems define economic communities participating to create opportunities that exceed those of any one of the organizations alone. Overholm (In press) points out that there is a lack of ecosystem research regarding start-ups role(s) (as opposed to established industries) within ecosystems and a lack of research regarding new ecosystem formation. This study addresses the young firms in the Atlantic entrepreneurial ecosystems using novel network theory. Data was collected from the ecosystem about innovation-driven knowledge-seeking behaviours. The work's contribution is significant in that it applies highly quantitative methods to develop highly visual and easily interpreted results. It adds to the qualitative contributions of the world's leading scholars in regional comparative advantage. Policy makers and ecosystem constituents can readily observe the nature of the patterns within the ecosystem allowing important interpretations.

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Introduction

Interest in entrepreneurial ecosystems has intensified with the acceleration of the importance of entrepreneurship and with the success attributed to specific locations such as Israel, Silicon Valley, Route 128 in Massachusetts, as examples. The discussion has principally focussed on historical ethnographic account of the interactions of personalities, events, the actions of various companies, the recycling of talent, and the composition of a variety of different types of actors and groups in the ecosystem. The research outlined in this report responds to the need to study the dynamics of differing entrepreneurial ecosystems and the investigation of their context and institutional characteristics (Autio, Kenney et al. 2014). We measure the knowledge-seeking behaviours of participants in an ecosystem and chart them using network theory. Stripping away various elements of the ecosystem shows the relative importance of the remaining actors. The results demonstrate that the ecosystem performs better when all of the components are contributing; network average degree weightings decline when any of the supportive constituents is missing. The work contributes to understanding the relative relationships in this ecosystem and suggests implications for comparison work with other regions.

The paper proceeds as follows. First we discuss the study's purpose and the call for quantitative measures based on the historic contributions to regional advantage and entrepreneurial ecosystems. The previous research is a bridge to a description of the emergence of the Atlantic entrepreneurial ecosystem (AEE) and its acceleration over the past decade. The methodology for studying the ecosystem follows; sub-sections outline the type of study, the sampling methodology, the survey protocol and type of analysis. The descriptives of the respondents are included there. This is followed by the results, including network charts and tables of measures. The paper concludes with a discussion of the implications, limitations and opportunities of this methodology.

Study Purpose

Entrepreneurial ecosystems encompass numerous variables including a combination of community, success, concentrations of university talent, growing pools of venture capital funding, and adept abilities to adopt new paradigms (Saxenian 1994). Other than the ethnographic, historical accounts and case studies noted earlier, some of the work highlighted models illustrating the flow of activities amongst the groups (i.e. Bahrami and Evans 1995; Ferrary and Granovetter 2009), and economic models using expenditure and investment data (McCann 1997). In studying ecosystems, Autio, Kenney et al. (2014) created a framework for investigating entrepreneurial ecosystems within the context of the industry, technology, social policy and organizational context, and related

policy concerns, and also including temporal and global, national and regional innovation systems. Some ecosystem research is based on survey data of measurements such as location decisions (Galbraith, Rodriguez et al. 2008), and interpretive analysis resulting in theoretically constructed propositions (Honig and Black 2007). A longitudinal analysis of inventor networks highlighted the emergence of clusters and networks in specific industrial classifications (Ter Wal 2013).

The purpose of this study is to investigate the relationships amongst various groups of actors within an entrepreneurial ecosystem in a more structured manner by using network theory. This shows the distribution of information-seeking activities as well as quantitative measurements amongst the constituents. This study heeds recent calls to introduce context by avoiding focus on the firm or the entrepreneur (Autio, Kenney et al. 2014). We conduct this study using an entrepreneurial ecosystem located on the east coast of Canada where the foci are a number of small provinces that are sparsely populated. This is in sharp contrast to the extant methodologies studying the context of entrepreneurial ecosystems.

Regional Advantage

Entrepreneurial innovation is thought to be a competitive advantage of a nation (Baumol, 2002). Yet nations can be large, and smaller regions have come to dominate success in entrepreneurial innovation. Concentrated systems of entrepreneurial innovation in specific regions has spawned the terminology of entrepreneurial ecosystems. The term goes back beyond 1995 (Bahrami and Evans 1995) where the most famous entrepreneurial ecosystem in the world, Silicon Valley, was characterized by "fleeting opportunities, shifting customer preferences, cascades of technological innovations, brutally short product life cycles, and furious global competition" (p. 62).

In the 20 intervening years, entrepreneurial ecosystems have evolved to represent "networks of actors contributing to joint value creation" and that had "undertaken some degree of co-innovation or adaptation" (Overholm In press). Now, the study of networks based on social constructs are far more prevalent (Pentland 2014) and knowledge-exchange systems that are defined by cooperation need not be spatially proximal or have a local context. This work adopts a general term of entrepreneurial ecosystem to describe a system that has elements of co-location and clustering, but that can also have the far reaching element of networks and innovation systems.

While there is a tendency to place successful ecosystems within their current day context, most of the former, and currently successful, systems have roots well back into the 1940's and 50's and for some, beyond that. The success of regionally-based entrepreneurship undertakings focussed attention on locations such as Silicon Valley, Route 128 in Massachusetts, Start-up Nation Israel, Silicon Glen in Scotland and Sophia-Antipolis in France are just a few. Some attention has been paid on less-than-successful locales (Honig and Black 2007) as well.

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The contributions made by innovation and entrepreneurship to these highly successful regions is of interest to other regional economies that are attempting to facilitate similar commercial outcomes. However, the results of imitators have been inconsistent at best (Engel 2015) which has perpetuated an interest in entrepreneurial ecosystems. In nature ecosystems occur when organisms network and interact resulting in value creation, and the total of the value generated exceeds the sum of its parts. Business ecosystems define economic communities participating to create opportunities that exceed those of any one of the organizations alone. Overholm (In press) points out that there is a lack of ecosystem research regarding start-ups role(s) (as opposed to established industries) within ecosystems and a lack of research regarding new ecosystem formation.

The methods of these works have principally focussed on historical ethnographic accounts of the interactions of personalities, events, the actions of various companies, the recycling of talent, and the composition of a variety of different types of actors and groups in the ecosystem. More quantitative approaches have been encouraged in order to contribute a different lens to the highly insightful and subtle qualitative observations made by significant scholars in the area (Engel 2015; Overholm In press).

Atlantic Entrepreneurial Ecosystem

The AEE is on the east coast of Canada with a hub in Halifax Nova Scotia and another in Fredericton, New Brunswick, two small sparsely populated provinces. The provinces of Prince Edward Island and Newfoundland and Labrador round out what is referred to as Atlantic Canada. With approximately three percent of the nation's population, the region suffers difficulties. The most populous province, Nova Scotia (population of 943,000 (2014)) has a declining birth rate as well as a declining population. The number of births in the Province dropped by 6 percent between 2010-2014.

Traditionally focussed on fishing, forestry, and some large industrial pulp and paper and tire manufacturing plants, the sources of these higher paid skilled labour positions are diminishing. One large pulp and paper manufacturer is closed and another faces a precarious future with odour levels that are challenging to correct. One of Michelin's major tire plants has announced it closure. The current trend sees many families supported by Nova Scotians working in oil fields in western Canada and commuting between Alberta and Nova Scotia on a three- to six-week schedules. More recently, the declining price of oil raises concern about even this form of employment. In February, 2015 Alberta lost 14,000 jobs (Babad 2015), many of them expected to be migrating workers from Nova Scotia but the outpouring of youth to western Canada is expected to continue with an improvement in the oil and gas industry (Babad 2015).

Proportionately less is spent on R&D expenditures in Nova Scotia than the Canadian averages. Nova Scotia's private sector R&D expenditures ($505 million) are well below the Canadian average (2014). Canada-wide, private business R&D expenditures contribute 50 percent of the total on average. In Nova Scotia only 16 percent is contributed to R&D expenditures by private business (2014). This point is further

emphasised when the Province's gross expenditure on research & development is expressed as a percentage of gross domestic product. This percentage is only 1.3% for Nova Scotia as compared to 1.8% for Canada.

Yet the Province is very well suited to see significant growth in its GDP by transitioning towards a knowledge based economy. In recent years the foundation for this has been facilitated by the urbanization of the population, as well as the Province's high levels of post-secondary education. With 10 universities, and 13 community college campuses, Nova Scotia produces more post-secondary graduates per capita than any other Canadian province. All three levels of Canadian government have begun to devote resources to encourage growth in the local innovation ecosystem.

Halifax, Nova Scotia's capital city, is the largest population centre in Atlantic Canada and is home to 43 percent of the Province's residents (2014). The city has been recently experiencing a growth in university enrolments that are twice the national average. This strong academic presence contributes significantly to the R&D expenditures in the region, accounting for 74 percent of the total (2014).

With some of Canada's oldest and top rated universities, Halifax is turning a focus towards entrepreneurship, and the knowledge transfer from academia to the private sector. There has long been a foundation of support organizations, from the private sector such as Entrepreneurs Forum (founded 1992), from the federal government such as Atlantic Canada Opportunities Agency (formed 1987), and from the Provincial government with Innovacorp (formed 1994), in the city. By 2000, there were a number of government (Innovacorp, NSBI, Investment New Brunswick) and private venture capital (ACF) options in the region, and more were to come. Entrevestor, an online news service, was founded with the help of local governments, and it follows the developing entrepreneurial ecosystem, with an explicit focus on technology-enabled high growth firms.

The emerging ecosystem saw tremendous growth in the aftermath of a $350 million exit and $640 million exit (reputed) of two entrepreneurial firms in the Region, in New Brunswick. Radian 6 and Q1Labs had similar founders, investors and were both ICT firms. Respectively, they were sold to Salesforce.com and IBM. In 2012, Halifax-based firm, GoInstant, also sold to Salesforce.com. These and the earlier sale of CanStockPhoto and later, Compilr, developed a flow of capital into the region, and some of the founders and early investors recycled their new wealth into the founding of incubators (Volta Labs), accelerators (Launch 36), university support systems (Pond Deshpond Centre) and innumerable programs and pitch contests to encourage entrepreneurship.

The longstanding entrepreneurship program at Saint Mary's University, a major business school in the country, was then supported by Dalhousie University's Starting Lean course and a new Masters in Technology Entrepreneurship and Innovation at the Sobey School of Business.

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Methodology

The methodology to effectively measure and map an ecosystem quantitatively is best undertaken with a field study of the knowledge-seeking behaviours of constituents of an entrepreneurial ecosystem. Knowledge-seeking is the measure of innovative behaviour. Using a snowball sampling method, a survey investigated the knowledge-seeking behaviours of constituents of the ecosystem as well as the importance and frequency of the ecosystem's participants' knowledge-seeking activities. The data was analysed using network theory. A more detailed description follows.

Measures

Alavrez and Barnery (2007, p 126) noted that the central measure used in the opportunity literature were "actions that entrepreneurs take to form and exploit opportunities," but not all entrepreneurial actions are innovative (Bosma, 2009). So where performance is driven by entrepreneurial innovation which is a function of entrepreneurial behaviour (Autio, Kenney et al. 2014) knowledge-seeking behaviours were used as the best indicator for entrepreneurial innovation.

In this study, knowledge-seeking behaviours were defined as actions taken by phone, in person or by email/text where a constituent of the ecosystem reached out to another individual in an effort to find information to make a decision related to an entrepreneurial firm. Three dimensions were investigated regarding each knowledge-seeking activity: importance, frequency and type of information sought. The number of times an ecosystem member reached out to someone else was measured, and the importance of the information to the seeker was measured with a seven-point Likert scale. The types of information sought were assessed as either business/market/financial information or product/scientific/technical information.

The survey protocol was executed by means of a "fillable form" survey. Returned surveys implicated other companies which were then sent a survey regardless of their physical proximity to the respondent. This type of survey distribution was adopted to avoid services such as Survey Monkey to ensure that the process of exporting data from the surveys occurred on servers owned, and operated, by Saint Mary's University, as opposed to an independent third party. By ensuring that this data was only retained by the University we were able to better ensure the confidentiality of all personal information collected.

Sample Selection

The sample began with a list of qualified potential respondents drawn from media sources within the entrepreneurial community of Atlantic Canada. The technique of using snowball samples, or respondent-driven sampling, is appropriate for network analysis (Biernacki, 1981). With respondent-driven sampling, respondents indicate

persons from whom they sought advice/information/knowledge about entrepreneurial ventures. The individuals noted by each respondent become the source for enlarging the sample and developing new potential respondents.

There is no list *per se* of all entrepreneurs and all firms and all agencies providing services to entrepreneurs so the boundaries are estimated by the participants of the snowball sample. Using this method, it is possible to access hidden agents participating within the Entrepreneurial Ecosystem. It is also recognized some influencers will not be part of the sample.

To develop a targeted distribution list for the AEE survey a base list of 75 qualified respondents was compiled. These included individuals in organizations that composed the various constituent groups in the ecosystem such as entrepreneurs, venture capitalists, incubators, governments agencies, supportive organizations and others. The list of qualified respondents was generated by carefully evaluating personal contacts of the lead researcher, Entrevestor (an entrepreneurship news service), AllNovaScotia.com (a business news service), and the online networking site, LinkedIn.ca. Those identified by these sources were the initial recipients of the survey. This distribution grew from the initial group of recipients, to 450 recipients in the first week, and snowballing to, and concluding with, 886 recipients after the final (fourth) week of distribution. A large proportion of the final group were not in any physical proximity to the Atlantic region.

Data Collection

All emails were addressed to respondents under the principal author's email to take advantage of her name recognition and to add academic credibility to the requests. Most data was obtained in pdf fillable forms and was exported to a csv file. Therefore, information provided by emailing the fillable form populated the database automatically. Cleaning and coding the data was took place. The data are analysed using the complex network theory program, Gephi (Cherven 2013).

Network theory creates *arcs* for each knowledge-seeking behaviour between two *nodes* which are the seeker and the responder. Duplicate nodes are consolidated to produce a network graph which introduces the concept of centrality in network theory. The type of information sought was also recorded. Because the entrepreneurial network data is from various types of constituents (venture capitalists, entrepreneurs, universities, accountants), research assistants manually coded organizational types.

Survey Descriptives

Table1 describes the response and network descriptive. The survey instrument was responded to by 95 individuals (some of whom declined to participate for specific reasons). The survey was completed by 79 respondents. The total number of different firms to which the respondents referred was 781. A total number of 1477 knowledge-seeking transactions were engaged in by the ecosystem.

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Table 1 - Respondent Descriptives

Respondent Descriptives	Count
Individuals responding to survey request (#)	95
Completed Surveys by Individuals (#)	79
Number of firms reported overall	781
Male/Female (%)	75/25

The nature of the respondents' capacities within the ecosystem is outlined in Table 2. Respondents were permitted to self-identify into more than one category. Most of the respondents were entrepreneurs (46.8%) and a class of individuals who reported themselves as consultants (36.7%). As a collection, the next largest group were the venture capitalists (15.2%), the private individual investors (10.1%) and a member of an angel network (1.3%). Professors from the local universities and colleges represented 12.7 percent of the respondents' professions.

Table 2 - Self Identification of Profession (More Than One Category Possible)

Self Identified as	Percent (%)
Entrepreneur	46.8
Venture capitalist	15.2
Private Individual Investor	10.1
Member of Angel Network	1.3
Lawyer	1.3
Government Representative	3.8
Consultant	36.7
Professor	12.7
Employee at a large firm	1.3
Bank Representative	1.3
Mentor	3.8

Professors aside, the level of education amongst the ecosystem is very high. Respondents were highly educated with all but two having had some form of post- secondary education. Combined, more than half of the respondents had a masters' level or a doctorate and 27.1 percent of the group had a bachelors' degree. Fourteen percent of the respondents had a professional designation. Table 3 outlines the educational profiles of the respondents involved.

Table 3 - Level of Education

Level of Education	Percent
High School/Equivalent	2.9
Vocational/Technical School	2.9
Professional Designation	14.3
Bachelor Degree	27.1
Master Degree	42.9
Doctoral Degree	10.0

Results

Three elements of the AEE are dissected in this analysis. The AEE as a whole is assessed along with the functioning of the system when specific groups are removed. That is followed by an analysis of the activities of the entrepreneurs, venture capitalists and universities – three qualities that are always recognized in successful entrepreneurial ecosystems.

Assessment of Entire Atlantic Entrepreneurial Ecosystem

The knowledge-seeking activities of the AEE are numerous and complex. There are 780 different organizations implicated in the reported AEE and 1477 separate knowledge-seeking relationships activities by the 79 respondents. The image of the AEE is displayed in Figure 1. The various types of organizations identified by their colour and a legend displays the number of nodes. Fifty-seven percent of the nodes are represented by entrepreneurial firms. Support organizations, venture capital firms, universities, Federal and Provincial governments, and professional firms represent the bulk of the named organizations that were sought after for some type of knowledge. The size of the node represents the number and importance of the knowledge-seeking behaviours which others sought of the named node. The centrality of a node is an indication of its interconnectedness amongst many different information seekers.

Two key types of information were suggested as the basis for reporting respondents' behaviours. *Product or Service Technical* information indicates science-related, product, programming, equipment, or technical information. Thirteen percent of information requests were of this nature. The legend in Figure 1 displays the types of information sought. Forty-one percent of the requests were for *Business Market or Financial* information which relates to markets, administrations, funds seeking and business operations. Thirty-eight percent of the respondents were looking for both kinds of information from their knowledge-seeking activities and the remaining eight percent indicated they were looking for information other than these two key categories. Careful examination of the arcs reveals numerous other bits of information such as the direction of the information-seeking activity. The small pointed end, terminating on the periphery of a node means the information was *sought from* that organization. Avive Naturals for example has many arcs emanating from theirs. They sought information from Perennia, NSBI, Canada Business Reference Library, Halifax Port Authority, NRC-

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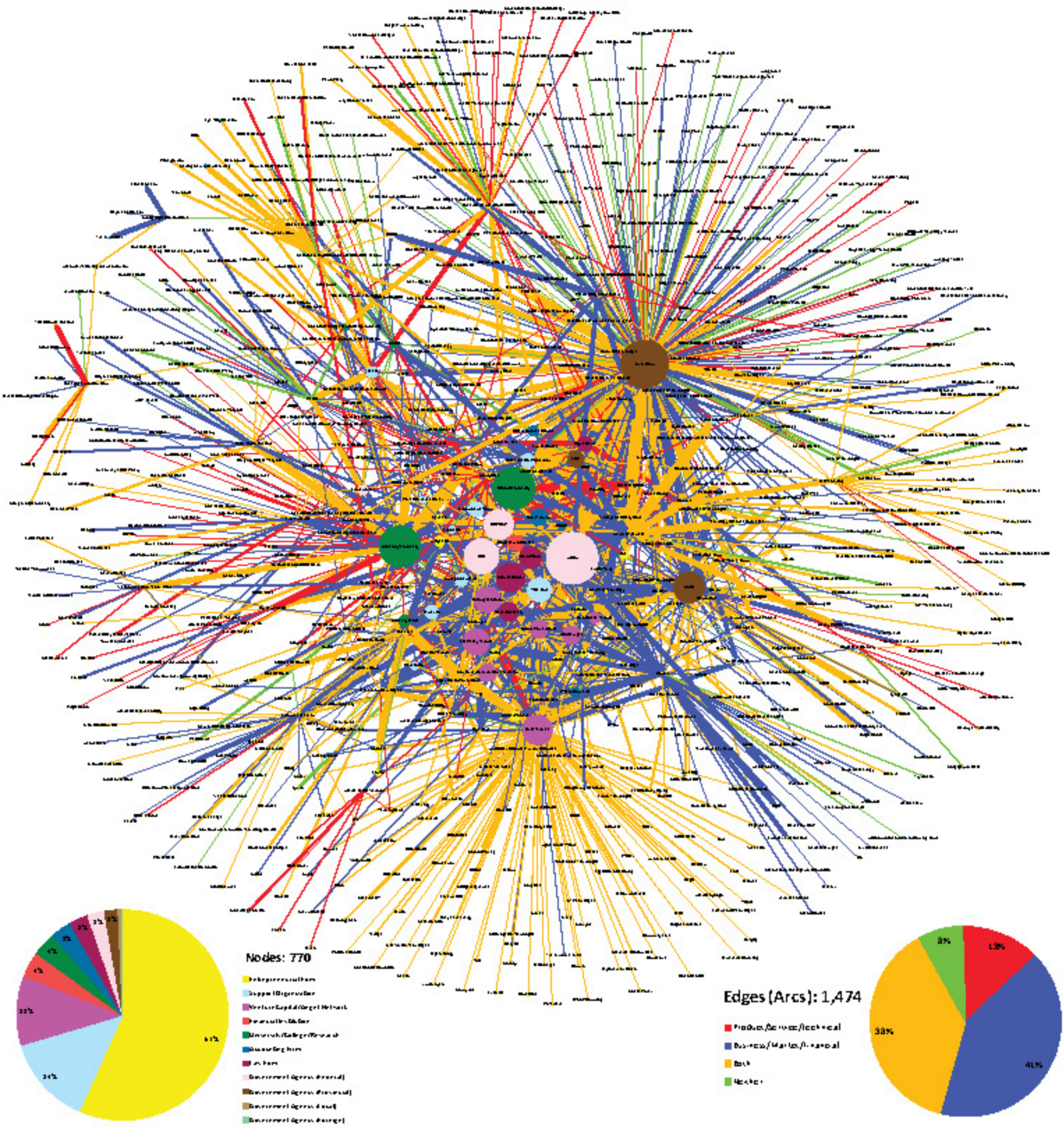
IRAP, Export Canada and Port Mexico to name just a few. They, on the other hand, are a very small node because they have not been sought to provide information to others in the AEE.

The major financial institutions, universities, support groups and federal and provincial agencies are very important to the ecosystem. They are more sought-after for information and more connected which drives their nodes it to the centre of the chart. Some entrepreneurial firms that are frequently linked to these organizations are also in the centre of the chart. Many of the firms on the periphery of the chart are those from which information was sought but that have no other knowledge-seeking associations with any other company in the AEE.

A considerable proportion of the knowledge-seeking behaviours of the AEE is not proximal to the Atlantic Canada location. Approximately 75 percent of the nodes are situated in the Atlantic region. Encouragingly, 15 percent of the nodes are from the rest of Canada, nine percent are from the U.S., and one percent are from abroad. This suggests a global group reaching out for information from companies and groups around the world. If these global-facing nodes are connected to entrepreneurs it suggests an inoculation to dis-entrepreneurship as defined by Honig and Black (2007). Dis-entrepreneurship occurs when the community adopts an inward facing orientation rather than an outward orientation in a globalizing world. "Entrepreneurs finding themselves in communities characterized by strong client-patron relations would do well by appealing to broader regional institutions that frequently trump local oligopolies" (Honig and Black 2007. p 286).

Figure 1 – Knowledge- Seeking Activities of the Entire Atlantic Entrepreneurial Ecosystem



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Another way of measuring the importance of individual groups of constituents is the proportion of relationships between the edges or arcs (the lines running from node to node) and the number of different constituents (number of nodes). This is called the Average Degree statistic. A larger Average Degree statistic (Arcs/Nodes) indicates that more knowledge-seeking behaviours are taking place per member of the ecosystem.

Table 4: Ecosystem Statistics With and Without Various Ecosystem Groups

	Entire Ecosystem (EE)	EE Minus Federal Participation	EE Minus Provincial Participation	EE Minus Support Orgs	EE Minus University Participation	EE Minus Venture Capital
NODES	770	752	571	633	692	584
EDGES	1474	1359	1059	1145	1282	1045
AVERAGE DEGREE	1.914	1.807	1.855	1.809	1.853	1.789
AVG WEIGHTED DEGREE	12.481	11.669	10.737	12.104	12.172	11.844

Table 4 shows the AEE without various groups of constituents as comparators. The average knowledge-seeking activity decreases when any group is removed from the ecosystem. For example, when the Federal Government's participation is removed from the AEE, the AEE's average degree declines from that of the average degree of the whole ecosystem; the entire ecosystem's knowledge-seeking activity level improves when Federal participation is included. Federal Government constituents punch above their weight in the AEE because the ecosystems' arcs per node declines when the Federal Government is absent. The AEE is most hampered if the Province is withdrawn likely because of the contribution of government-sponsored venture capital in Innovacorp, NSBI and Build Ventures.

A similar situation occurs when considering all of the other major groups noted in Table 4. Removing any one of them causes the average degree of knowledge-seeking behaviours to decline. The AEE is more knowledge-seeking when all the major groups of constituents are in place.

The average weighted degree takes into account the combined importance weights indicated by the respondents to the survey – the *value* of the information sought by the seeker. A higher value indicates more importance. In Table 4, the Weighted Average Degree of the AEE is 12.481 when everyone is participating. However, the AEE's average weighted degree declines the most, to 10.737 when the Provincial governments' contributions are removed (two early-stage venture capital funds).

Knowledge-Seeking Activities of Universities, Venture Capital and Entrepreneurs

The stories of Silicon Valley and Route 128 were both dominated by the active participation of universities and personalities within those institutions (Saxenian 1994) and the contribution of available finance and venture capital were considered very valuable (Ferrary and Granovetter 2009). This analysis considers these three components of the system as a group.

The chart showing the interactions amongst the universities, venture capital firms and the entrepreneurs is composed of 369 firms, the vast majority of them being entrepreneurial firms is shown in Figure 2. There are 1.8 edges per node and the importance of the transactions is high, a weighted average degree of 11. 6. This represents about half of the nodes and a third of the edges in the entire AEE. Again, the universities and the venture capital firms are driven to the centre of the chart highlighting their interconnectedness and thereby their importance to the structure of the ecosystem.

An examination of the entrepreneurial firms shows little interaction with other larger firms which has been an approach used in other ecosystems. The mixing and recycling of talent amongst large and smaller firms produces knowledge spinoffs that benefit both parties. Modest encouragement by larger companies in the Province can provide exceptional opportunities developing founders, and very early-stage ventures benefit from close proximity to, and mentorship by, successful high growth firms. Established innovating businesses can mentor aspiring technology oriented entrepreneurs to absorb business models, mentorship, technology, management practices, and the culture of fast-growing businesses.

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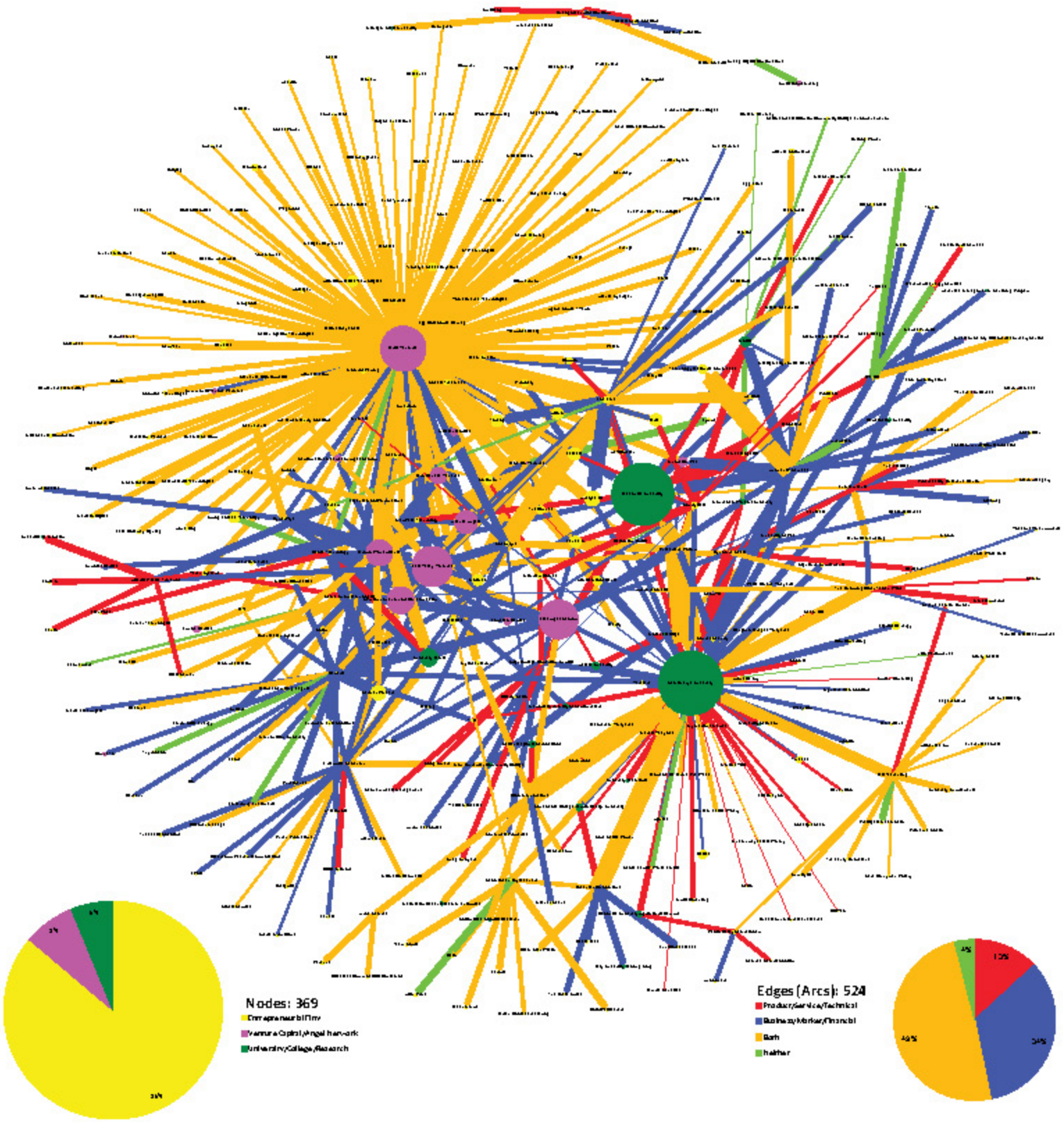
Figure 2: Knowledge-Seeking Activities of Entrepreneurs, Universities and Venture Capitalists



There is little independent private venture capital in the AEE. Most of the firms are government-sponsored venture capital attempting to fill financing gaps. The larger ones are those which fulfill a government, or quasi-government mandate. For some of them, their mandate has expanded to provide a supportive and mentoring capacity in the ecosystem as well as incubating opportunities.

The universities are sources of both business and technical information for entrepreneurs and founders. This is demonstrated in the different colour arcs emanating from the universities. It is promising to see the role that the universities play in the previous iteration of the ecosystem, but in particular with this iteration, of the entrepreneurial firms. This chart's high average importance rating indicates its value. Clearly, the efforts that are being spent on entrepreneurship education inside the Universities are resulting in considerable involvement. The high levels of education of the AEE's constituents is no doubt related to this observation.

Implications & Opportunities for Future Research

This research calls attention to the multiple parties needed to stimulate entrepreneurial ecosystems (Van de Ven 1993), and addresses a more recent call for investigations into regional and contextual influences on entrepreneurial innovation (Autio, Kenney et al. 2014). This work expands the knowledge of entrepreneurship by focussing on the context of an entrepreneurial ecosystem's knowledge-seeking behaviours. It does so with an information-dense and revealing visual and quantitative examination of entrepreneurial ecosystems' knowledge-seeking behaviours.

Knowledge-seeking behaviours as a measure of innovation necessary for successful entrepreneurship and the use of network theory is a unique contribution to the entrepreneurial literature as well as the network theory literature. Together they endeavour to tease out specifics regarding the nature of the ecosystem's functioning.

Networking is an active way to create entrepreneurial opportunities for high-tech innovation, and high-tech founders exploit existing opportunities and deploy their networks to form new contacts and relationships that form new opportunities (Moensted 2010). Knowledge-seeking networks amongst an ecosystem expose founders to complementary competencies and resources to gain access to new knowledge and people.

The interconnectedness of the constituents in the AEE is amply highlighted in the charts. The AEE has an outward-facing orientation; many of the organizations implicated by the respondents were outside of the Atlantic Region although only one percent were globally based. More research is needed to examine whether the founders specifically had a global orientation, or whether it is other constituents who are reaching out to the world.

Entrepreneurs' overwhelming search for business, market and financial information rather than technical/scientific/product information is a surprising finding. A number of

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reasons may explain it. If entrepreneurs are competent in their design, science and production of their products, their needs may be largely related to the development of markets, delivery of product, sales techniques and methods of building a firm. That would be reassuring. In an area of challenged resources and financial capabilities, the search for business acumen and finance may be expected. However, if the entrepreneurs are spending most of their time on business-building activities with little or no product innovations or design improvements, difficulties related to immature innovations may prevail.

Moreover, the metrics associated with the analyses specifically demonstrate the dwindling effectiveness of the AEE's knowledge-seeking behaviours when any one of the major constituents is withdrawn. The incremental value that each group of actors contributes to the ecosystem signifies the synergy present in the combined group of entrepreneurs, governments, support groups, professionals and venture capitalists. Removing any one of the various groups of actors causes the average degree of knowledge-seeking behaviours to decline. On average, the AEE is more knowledge-seeking when all the major constituents are in place. This is corroborated by extant research. It is recognized that governments cannot establish, or mandate, an entrepreneurial ecosystem (Soto-Rodríguez 2014). Only the value creation contributions of many actors working in concert through their interconnectedness (Cohen 2006) results in a functioning and sustainable ecosystem.

Further research opportunities abound using this method. Other research may answer questions about the mix of qualities that are necessary for successful ecosystems and provides opportunities for comparison. Is there more or less focus on university, or professional support, or venture capital funding, or incubators or accelerators in the winning regions compared to those less successful ones? Does success have more to do with the social order, or social capital? Is it influence, contacts, and networks that drive successful ecosystems, or is it capability of a number of key players that lubricate them? Is there a critical mass of venture capital required to grease an entrepreneurial ecosystem? Is there a critical mass of people working in a similar area that drives a cluster to become an innovation network? And if so, what is that critical mass? Future research may seek to investigate these areas.

Are there circumstances that cause dis-entrepreneurship. Dis-entrepreneurship occur if policies or actions cause ecosystems to fail to grow i.e. weak local investment, failure to take advantage of policy opportunities, or poor infrastructure (Honig and Black 2007). Much potential research is possible if similar analyses of other ecosystems' contexts are compared and contrasted.

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