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The role of institutional interactions on cluster health:

A qualitative and quantitative analysis of the Montreal translation cluster through the lens of its institutional environment

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Abstract

In an effort to determine the role of institutional interactions on cluster health, this research paves the way for a new cross-fertilization of cluster theory, institutional theory and network theory. By drawing on a mixed methods approach combining a network analysis of original data and an interview-enriched case study of the Montreal translation cluster, this research breaks new ground by quantifying institutions in isolation in order to determine the structural properties of an institutional network. The findings are subsequently returned in the context of cluster theory via the case study to make the findings particularly meaningful and to build on the bodies of literature. Some of the notable contributions to the literature include creating the foundation for the quantitative analysis of an institutional environment, specifying the roles and impacts of institutions and institutional interactions in the context of cluster theory, determining certain structural characteristics of institutional environments, and aligning the institutional and network theory on the subject of brokers. After testing seven (7) propositions, this research makes a number of findings relating to both institutional network structures and the characteristics of institutions. It is found that institutional networks tend to organize in hierarchical structures. Significantly, it is also shown that they are prone to redundancies, which can prove maladaptive to cluster health. On a positive note, institutions are found to be natural brokers. Small institutions in particular appear to be able to leverage their network connections in order to overcome the limitations of their size, although it remains unclear if this advantage is derived primarily due to the test network's particularly high density. Finally, it appears that cluster health requires that both intra-network and extra-network institutional knowledge flows be constructive, and that creating pipelines to the cluster fueling the technological disruptions would be particularly helpful for overall cluster health.

Key words

Cluster theory, institutional theory, network analysis, technological disruptions, absorptive capacity, brokers, institutional environment, translation

Résumé

Dans le but de définir le rôle que jouent les interactions entre les institutions sur la santé des grappes industrielles, cette recherche trace la voie vers une nouvelle intersection mutuellement enrichissante des théories des grappes, des institutions et des réseaux. L'approche méthodologique mixte sur laquelle elle est basée combine une analyse de réseaux à partir de données originales et une étude de cas, élaborée par le biais d'entretiens, portant sur la grappe de l'industrie de la traduction à Montréal. Cette recherche innove en quantifiant les institutions isolément afin de mieux déterminer quelles sont les caractéristiques structurelles de leur réseau. Les résultats qui en découlent sont à leur tour revus à travers la lentille de la théorie des grappes. La démarche, appliquée à l'étude de cas, rend ces résultats particulièrement significatifs et permet ainsi d'enrichir la littérature actuelle. Parmi les principales contributions de ce travail de recherche, notons la création de bases pour l'analyse quantitative d'un environnement institutionnel visant à, notamment, préciser les rôles et les impacts des institutions ainsi que leurs interactions entre elles à la lumière de la théorie des grappes, à établir certaines des caractéristiques structurelles de ces environnements, et à aligner les théories des institutions et des réseaux de façon à aborder le concept de courtage. Après avoir testé sept (7) propositions, cette recherche présente les différents résultats obtenus en lien avec les structures de réseaux institutionnels et les caractéristiques des institutions. Il convient de noter que, parmi les résultats, se démarque la tendance qu'ont les réseaux d'institutions à s'organiser en structures hiérarchiques. De plus, ces derniers sont fortement marqués par les redondances, ce qui peut s'avérer nuisible à la santé des grappes. Sur une note plus positive, il semblerait que les institutions sont des courtiers naturels, et que les petites institutions plus précisément sont aptes à faire jouer les relations de leur réseau pour outrepasser les limites inhérentes à leur taille. La source de cet avantage ne peut toutefois pas être attribuée sans équivoque principalement en raison de la densité spécialement élevée du réseau observé. En conclusion, cette recherche nous montre qu'il est nécessaire, pour contribuer à la santé des grappes, que les flux de connaissances institutionnelles à l'intérieur et à l'extérieur du réseau soient constructifs, et que la création de canaux vers la grappe alimentant les bouleversements technologiques seraient particulièrement bénéfique pour la santé générale des grappes.

Mots clés

Théorie des grappes, théorie des institutions, analyse des réseaux, bouleversements technologiques, capacité d'absorption, courtiers, environnement institutionnel, traduction

Acronyms

ACGL	Association des conseils en gestion linguistique
ACJT	Association Canadienne des juristes-traducteurs
AILIA	Association de l'industrie de la langue / Language Industry Association
ALCIT	Association of Legal Court Interpreters and Translators
ATA	American Translators' Association
ATIO	Association of Translators and Interpreters of Ontario
CATS	Canadian Association of Translation Studies
CIQ	Conseil interprofessionnel du Québec
CLEF	Carrefour des langagiers entrepreneurs
CTTIC	Council of Translators, Terminologists and Interpreters of Canada
EAC	Editors Association of Canada
FIT-NA	Fédération Internationale des Traducteurs / International Federation of Translators, North America
LTAC	Literary Translator's Association of Canada
NTE	Network of Translators in Education
OPQ	Office des professions du Québec
OQLF	Office québecoise de la langue française
OTTIAQ	Ordre des traducteurs, terminologues et inteprètes agréés du Québec
SQRP	Société québécoise de la rédaction professionnelle
TB	Translation Bureau (Public Services and Procurement Canada)
UdeM	Université de Montreal

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1. Preamble

The cluster literature can trace its origins to the end of the 19th century, in Alfred Marshall's theory of agglomeration economies. Michael Porter breathed new life into this literature with his conception of clusters, defined as "geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions in a particular field, linked by commonalities and complementarities." (Porter 1998, 197) Over the decades, scholars have built on this new body of literature to understand and/or promote innovation, creativity, regional entrepreneurship, overall economic health, etc., sometimes within the view of shaping regional economic policy. Despite the number of significant contributions of this literature, however, there remains an incomplete understanding of the roles of institutions in the overall cluster dynamics that yield these benefits. Although some research has drawn on existing institutional literature to augment cluster theory, the findings remain limited, and primarily conceptual in nature. Similarly, although the relatively recent relational view of clusters, which draws on network theory to better understand cluster relations, has resulted in exciting new research, it has largely ignored the institutional question and has not fully tapped into the immense potential of network analysis to determine the structural properties of clusters.

As such, this research seeks to answer the question, "What is the role of institutional interactions on cluster health?" By adopting a mixed method approach consisting of both a network analysis and a qualitative case study of the Montreal translation cluster—chosen due to the particular importance of the institutions in an industry that is 1) characterized by a high proportion of freelancers, thereby amplifying the impact of institutions to reach generalizable conclusions, and 2) undergoing disruptive changes fueled by advancements in artificial intelligence—this research uses original data to quantify institutions in isolation in order to study the structural properties of the institutional network and characteristics of institutions, and contextualize the findings within the case study. The implications will lead to a new cross-fertilization of cluster theory, institutional theory and network theory.

This thesis is divided into seven (7) sections. After these introductory remarks, Section 2 presents a literature review of different perspectives of cluster theory, incorporating traditional, institutional and relational views, as well as a more technical portion on network analysis. A case is made for a new cross-fertilization of cluster, institutional and relational theories, specifically by leveraging network analysis to study institutional interactions in isolation so as to determine their particular impact on cluster health. Section 3 presents the conceptual framework as well as research propositions bearing on the structural

properties of the institutional network and institutional interactions. Section 4 presents the methodology for testing these propositions, which relies on a mixed methods approach combining a quantitative network analysis as well as a qualitative case study, where the chosen methods are both ideally suited to mitigate the weaknesses of the other, and furthermore serve to make the results particularly meaningful. Section 5 presents the case study of the Montreal translation cluster, constructed through the lens of its institutional environment and enriched through interviews with industry representatives. It also offers preliminary observations that will be verified in the subsequent network analysis. Section 6 explains the different calculations performed on the network as part of a network analysis, and describes the findings. Section 7 provides a discussion of these findings, explains them in the context of the cluster literature, and lays out some of the practical applications for the Montreal translation cluster. Finally, Section 8 summarizes some of the principal findings and contributions of this research to all three bodies of literature, and offers some concluding remarks.

2. Literature review

2.1 Introduction

Clusters are by no means a new concept. The idea is grounded in Alfred Marshall's agglomeration economies, a product of the late 19th century, which claims that "a local pool of skilled labour, local supplier linkages and local knowledge spillovers" creates increasing returns for firms (Potter and Watts 2010, 603). Marshall's ideas in turn provided the foundation for clusters, a term and theoretical body that was introduced by Michael Porter in the 1990s.

Clusters have since aroused a great deal of interest among scholars, due to, among other things, the great potential for regional economic policy and innovation, and have contributed mightily to the literature, notably by documenting cluster evolution, the benefits derived from cluster membership, the characteristics of different cluster actors, etc. Some of the most recent and interesting research on clusters has integrated network analysis into the literature, offering new insight into cluster dynamics.

However, cluster literature has largely ignored the specific role of institutions in cluster dynamics. Although it is possible to find some answers of institutional characteristics and functions in the institutional literature (some of which has been integrated into cluster literature), and despite the fact that institutions are recognized throughout the literature as playing a vital role in cluster dynamics, there is very little focused, in-depth research on their contributions to cluster health.

The following review examines the cluster literature from three different perspectives—the traditional view of clusters, the institutional view of clusters and the relational view of clusters—and ends with an in-depth, technical overview of network analysis, whose tools will be used to shed new light on cluster institutions and help answer the research question, "What is the role of cluster interactions on cluster health?"

2.2 Clusters

2.2.1 The challenge of defining clusters

The field of clusters and cluster policies is an offshoot of agglomeration economies championed by Michael Porter (1998, 197, 226), who famously provided the following general definition of clusters:

> *"Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions in a particular field, linked by commonalities and complementarities. […] A cluster is a form of network that occurs within a geographic location, in which the proximity of firms and institutions ensures certain forms of commonality and increases the frequency and impact of interactions."*

The benefit of this definition is that it identifies the two basic, constituting units of clusters—firms and institutions (Menzel and Forhnal, 2007), as well as underscores the importance of connections cultivated by "commonalities and complementarities" and the geographic boundedness of the phenomenon. However, some argue that the definition is simply too general, and gives rise to too many questions (Martin and Sunley, 2003; Wolman and Hincapie 2014): Do geographic boundaries imply cities, states, countries or continents? What is the cut-off for including related actors and industries? How specialized does the economic activity have to be to constitute a cluster? (Martin and Sunley 2003, 10). Many authors have responded by providing their own definitions, leading to a proliferation of definitions, some which have focused more on the structural features (i.e. cluster composition):

> *"We define an innovative cluster as a large number of interconnected industrial and/or service companies having a high degree of collocation, typically through a supply chain, and operating under the same market conditions."* (Simmie and Sennet 1999, 51)
>
> *"We define regional clusters expansively to consist of firms in a region producing similar or related products, using similar processes, or engaging in similar functions (headquarters; research and development). These clusters also include related actors and entities, such as the regional suppliers and customers of these firms, pools of specialized labor (occupations) in the region employed by these firms, public and public-private programs that provide services to cluster members (e.g., customized training by community colleges) and institutions (e.g., universities, community colleges, industry and trade associations, public and private sector associations)."* (Wolman and Hincapie 2014, 135)
>
> *"Regional concentrations of large and small companies that develop creative products and services, along with specialized suppliers, service providers, universities, and associated institutions. Ideally, they bring together a critical mass of skills and talent and are characterized by a high level of interaction among entrepreneurs, researchers, and innovators."* (Wessner 2012, n.p.)

And others on the relational features (**emphasis added**):

> *"Economic clusters are not just related and supporting industries and institutions, but rather related and supporting institutions that are more competitive **by virtue of their relationships**."* (Feser 1998, 26)
>
> *"Clusters can be characterized as **networks** of producers of stronger, interdependent firms (including specialised suppliers) **linked to each other** in a value-adding production chain."* (Roelandt and den Hertag 1999, 9)
>
> *"A geographical group of economically and socially **interconnected** companies and institutions and firm ENC [**entrepreneurial networking capability**] as the capacity of firms to **orchestrate relational-based resources** towards achieving enhanced performance and building competitive advantage." (Li et al. 2015, 524)*

Although there appears to be a core understanding or overlap of the concept of cluster, one further issue emerges from these definitions: there is a clear focus on only one of the cluster's constituting elements, namely, the firm. Some definitions entirely neglect to mention institutions (Simmie and Sennet

1999; Roelandt and den Hertag 1999), whereas others at most mention them in a list, without necessarily mentioning their contribution to cluster dynamics (Porter 1998; Wolman and Hincapie 2014; Wessner 2012; Li et al. 2015), reflecting a broader trend in both traditional cluster literature as well as the more recent relational cluster literature to treat institutions and the institutional environment as a given, or in a cursory manner. This is problematic, as institutions play a critical role in shaping economic practices, and should, accordingly, be studied as an economic actor. (Bathelt and Glückler 2014)

2.2.2 Traditional view of basic cluster units

The research has a wealth of case studies focusing on cluster firms and their roles in innovation and overall economic health. Specifically, there have been studies on whether firms in strong clusters are more likely to be innovative than firms outside these clusters (Beaudry and Breschi 2003; Baptista and Swann 1998; Boix and Galletto 2009); studies on the role of clusters on regional entrepreneurship (Delgado et al. 2010; Rocha 2004); studies on the role of clusters on creativity (Bagwell 2008); and studies on the role of clusters on overall economic growth (Cooke, 2001), among other things. However, even though cluster institutions are by definition instrumental in the successes or failures recorded in the case studies, as would suggest the definitions, authors often fail to explicitly define them, assigning them a vague role or using them as a catch-all for unexplained phenomena. (Bathelt and Glückler 2014)

Generally speaking, institutions (or "institutions for collaborations" [Carpinetti and Lima 2013], or "nonmarket organizations" [McEvily and Zaheer 1999]) are described as entities that do not participate directly in the supply chain, but that are nonetheless fundamental to cluster activities by managing interactions within the cluster, such as coordinating joint actions, fostering the diffusion of knowledge inside the cluster, providing a cognitive framework to interpret knowledge (Audretsch and Lehmann, 2006; Lorenzen and Foss 2002) and mediating conflicts of interests between cluster associates. (Audretsch and Lehmann 2006; Edquist and Johnson 1997) Institutions also provide the shared infrastructure that supports the economic activity in the region. (McElivy and Zaheer 1999; Edquist and Johnson 1997) Indeed, though external economies naturally emerge from agglomerations, cluster associates may benefit from local supporting institutions whose missions are geared toward satisfying the needs of cluster stakeholders. (Porter 1998; Solvëll 2008) Cluster institutions can take many forms: private organizations, public agencies, industry associations, regional development agencies, R&D centres, etc. (Porter 1998; Sölvell 2008; McEvily and Zaheer 1999) What is important to retain is that to be considered "cluster" institutions, these institutions must be locally oriented and provide a range of support services to cluster firms. (McEvily and Zaheer, 1999) "Locally oriented" is key here, as it implies that an institution does not necessarily have to be physically located in the cluster, so long as it provides support services to that

cluster. Similarly to Nelson and Nelson (2000) and Nelson and Sampat (2001), Steiner (2006) also refers to institutions as "social technologies," insofar as they are regarded by the relevant stakeholders as standard and representing the proper way to get things done. Although this creates certain constraints on actions and behaviours, it also enables and supports other actions and behaviours, particularly when human cooperation is needed.

Clusters have both horizontal and vertical dimensions. The horizontal dimension refers to the cluster firms with a number of commonalities (e.g. technologies, clients, distribution channels, spillovers) (Turkina et al. 2019; Lorenzen and Foss 2002) and produce similar goods and services (Bathelt et al. 2004), i.e. the cluster's breadth and diversity (Turkina et al. 2019). The vertical dimension refers to the presence of the supply chain, i.e. the presence of complementary firms at different levels of the value chain that are connected through a network of suppliers, services and customers (Bathelt et al. 2004; Turkina et al. 2019), i.e. the cluster's depth (Turkina et al. 2019). It is important to note that firms can be integrated both horizontally and vertically in a cluster, but as institutions are not part of the supply chains, their relationships with other network actors can only be horizontal in nature, i.e. cooperative engagements whereby they share resources (e.g. knowledge) and have minor interactions in cluster-specific events and platforms that can lead to knowledge sharing. (Turkina et al. 2019)

2.2.3 General cluster benefits

Clusters, as bounded geographic agglomerations, are able to take advantage of benefits derived from geographic, cultural and institutional proximities and resources to cultivate healthy competition, special access, better information, powerful incentives and collaboration between and among members of the cluster. (Porter, 1998) Resources that clusters can leverage can also include linkages (i.e. channels that allow for the "efficient transfer of resources such as technology, knowledge and capital" [Lorenzen and Mudambi 2013, 503]) inside the cluster, facilitated by this colocation, and outside the cluster (Li et al. 2015). The resulting benefits in turn lead to overall cluster growth and economic output for the region, namely through "creating lower input costs for firms through agglomeration economies, and [facilitating] knowledge spillovers that produce innovation and increased productivity (Wolman and Hincapie 2014, 135); indeed, because all firm activity takes place in a given space, all firms can essentially benefit from the same production conditions. (Bathelt et al. 2004) As such, firms that belong to these clusters become more competitive, and the regions with strong clusters are more likely to experience growth. (Wolman and Hincapie 2014)

Specifically, clusters are uniquely positioned to engage in modern, innovation-focused competition, which goes above and beyond simply using sophisticated methods and advanced technologies (Porter 1998; Turkina et al. 2019); as Porter highlights, "all industries can employ advanced technologies; all industries can be knowledge intensive" (Porter 1998, 80). Rather, clusters are documented as being instrumental to innovation as they benefit from externalities such as high-quality infrastructure, a specialized and flexible labour force, and an advantageous regulatory environment. (Turkina et al. 2019; Porter 1998)

There are also benefits in terms of business formation—namely, there are lower risks for new entrants, as stakeholders can perceive gaps in products or services. (Porter 1998; Sölvell 1998) New business formations are part of a positive feedback loop, where an expanded cluster amplified all cluster benefits (increases collective pool of competitive resources, which benefits cluster members)—which underscores the importance of having policy that upgrades cluster (or business environment) as a whole. (Porter 1998)

Cluster competition is driven through a number of mechanisms. In terms of agglomeration, they increase productivity of companies based in area, they drive the direction and pace of innovation; and they stimulate formation of new businesses within cluster. (Porter 1998; Beaudry and Breschi 2003; Baptista and Swann 1998; Boix and Galletto 2009; Delgado et al. 2010; Rocha 2004) The colocation and proximities also lead to greater direct interactions between actors, leading to potentially valuable linkages that result collaboration, new knowledge and industry insight or "buzz." (Li et al. 2015; Steiner 2006; Bathelt et al. 2004; Sölvell 1998)

Clusters also benefit from synergies derived from qualitative and quantitative systemic effects. In other words, as the cluster expands, so does its influence with government and public/private institutions. (Porter 1998) This is due not only to the direct effects of the clusters' quantitative (size) and qualitative (diversity) advantages, but more significantly due to the qualitative and quantitative systemic effects, which in part explain the greater dynamic and complex relationships and processes observed in clusters. (Menzel and Forhnal 2007)

Quantitative systemic effects account for the fact that a large grouping of firms and institutions in a given area are not only able to achieve a critical mass with all the inherent beneficial linkages, but moreover able to rely on this size to possibly arrive at a collective project and yield a greater influence among high-level decision and policymakers and shape the region's economy in its image through the creation or redefinition of institutions (e.g. trade associations, universities, chambers of commerce,

professional orders) (Menzel and Forhnal 2007), who are able to lobby the government on the cluster's behalf, define university and trade school curricula to cultivate the necessary workforce, provide a discussion platform for various industry issues, compile information that benefits cluster members, etc. (Wolman and Hincapie 2014; Porter 1998). This is where the institutions' mechanisms for collective action (Nelson and Sampat 1999) become more obvious.

The qualitative effects refer to the diversity, or heterogeneity, of firms and institutions in a cluster, which translates into heterogeneity of knowledge and competencies. (Menzel and Forhnal 2007) Specialization among firms in a cluster can lead to advantageous technological synergies (Menzel and Forhnal 2007), which can lead to more patents produced by the cluster and enhanced economies of scale (Turkina et al. 2019). Overspecialization, on the other hand, may lead to a narrowing developmental path and firm lock-in, which prevents the creation of new linkages between industries, limits future options and opportunities for innovation, and makes firms more vulnerable to external shocks. (Menzel and Forhnal 2007; Turkina et al. 2019) A decrease in diversity may also lead to "shared norms, standards and rules of conduct among firms," resulting is less dynamic, creative and innovative networks. (Huggins and Johnston 2010, 460) Too much heterogeneity, on the other hand, may enable the cluster to adapt to changing environmental conditions and potentially even change developmental path, but it also makes it very difficult for firms to exploit the synergies and innovation potential between them. (Menzel and Forhnal 2007; Turkina et al. 2019).

The ability to exploit synergies relies on an organization's absorptive capacity, which is the ability to "recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990, 128) or transcode one another's technologies and methods (Lorenzen and Foss 2002) for the ultimate purpose of improving its capacity for innovation (Cohen and Levinthal 1990; Turkina et al. 2019). Absorptive capacity is particularly important in clusters with intense firm interactions and whose health depends on their ability to exploit synergies in the cluster. (Turkina et al. 2019) This ability, of course, is not innate, and must constantly be developed and honed by building on one's prior knowledge, for instance through R&D, in order to be able to recognize and interact with knowledge external to the organization, to create new associations between the old and new knowledge that can be exploited, thus leading to innovation. As this shared knowledge and expertise is critical to any communication, both within the organization and between organizations (Cohen and Levinthal 1990), it constitutes a system of language, or "coding scheme" (Cohen and Levinthal 1990, 133). When, in turn, institutions are able to spread this language and help other cluster organizations acquire and contribute new knowledge (e.g.

through training, newsletters, industry watches), the cluster benefits immensely. The concept of absorptive capacity can also be extended to clusters in general, where a cluster's absorptive capacity is its ability to "absorb, diffuse and exploit extra-cluster knowledge." (Guiliani and Bell 2005, 49) However, it must be noted that clusters do not absorb extra-cluster knowledge uniformly, but rather through actors that both play a bridging (or brokerage) role and have the necessary absorptive capacity to understand, synthesize and import this knowledge into the cluster. (Guiliani and Bell 2005)

2.2.4 Cluster life cycles

Cluster evolution can be explained through life cycles, which can in turn be explained in institutional terms. These phases, which range from birth (or emergence), growth (or evolution) and sustained (mature) phases to decline (i.e. museum stage) (Menzel and Forhnal 2007), are characterized by a distinct institutional environment and distinct institutional activity.

Cluster literature states that birth can be traced to historical circumstances; a natural factor advantage (e.g. climate, soil conditions, resources); unusual, sophisticated or stringent local demand; prior existence of supplier industries, related industries, or even related clusters; or one or two innovative companies (i.e. a "hero", Sölvell 1998) that stimulate the growth of a new industry (Porter 1998). This stage is characterized by a small number of entrants (Sölvell 2008). However, institutional theory would suggest that it would be impossible to take advantage of these elements if basic institutional elements were not in place to allow their exploitation, such as systems of routines that dictate business relations, legislation, etc. that by constraining behaviour also create potential avenues for action to be exploited (Nelson and Nelson 2002). Old world wine clusters could not emerge if there were no existing systems of trade and transportation, no matter how basic. Indeed, why would a farmer choose to go from subsistence agriculture to a specialized crop requiring specialized processing if there was no way from him to get his product to a market? Similarly, the US biotech industry would have never seen the light of day without its network of universities and university researchers. (Sölvell 2008)

The cluster literature argues that for a cluster to pass from the emergence phase to the growth phase, there must be some form of momentum that leads to the creation of an institutional environment to frame the activity. (Sölvell 2008) However, it may be more accurate to say that the institutional environment begins to respond more closely to the needs of the emergent cluster. Then, the increase in firms and business entrants leads to a critical mass, the critical mass begins to enjoy quantitative advantages. (Menzel and Forhnal 2007)

These advantages further shape the institutional environment, which allows for and explains the greater dynamic and complex relationships and processes observed in clusters. Everything works together to create a snowball effect: As the critical mass grows and is able to mold the institutional environment to its advantage, it encourages a multitude of new entrants to join, bringing with them their own sets of skills and competencies (Sölvell 2008; Menzel and Forhnal 2007; Porter 1998; Dalum et al. 2002), and reinforcing the institutional environment.

It is also important to note that the growth phase of is characterized by risk, for both the firms and the institutions (Sölvell 2008; Sampat and Nelson 1999). Indeed, in order to grow, a cluster must exhibit a high level of entrepreneurial activity with a tolerance for risk, and the ability of firm stakeholders to venture off the beaten path to explore and embrace new technologies and markets (Sölvell 2008). The same tolerance for risk exhibited by firms in this phase must also to a certain extent be present in the institutions. (Sampat and Nelson 1999) Despite the nature of institutions, which is to standardize and stabilize conditions in order to eliminate risk, this period of institutional innovation is also risky for them due to the tremendous change they are experiencing. Change is by definition a period of vulnerability for institutions, which firms can exploit to continuing to exercise an influence on the environment. Sampat and Nelson (1999) refer to this co-activity—the concurrent growth of the institutional environment with the growth of technology—as the co-evolution of physical and social technologies, the latter being defined as patterned human interaction that allows for effective coordination.[1] Indeed, the growth phase is a period of both technological and institutional innovation, and a synergy can only be achieved if the new or newly defined institutions work well with the new technologies and cope with the new conditions of demand and scarcity. (Sampat and Nelson, 1999, 44)

As clusters progress through the growth phase, they begin to specialize through firm competition, rivalry, innovation and product differentiation. (Bathelt et al. 2004) Through this, a self-reinforcing cycle promotes its growth, especially when backed by supportive local institutions that allow collaboration and collective action (e.g. trade associations, employment centres, training centres) and rigorous local competition (Porter 1998). This phase is characterized by a large number of small- and medium-enterprises (SMEs) that are increasingly specialized and increasingly linked, which injects heterogeneity

[1] Although the authors make the argument to associate the term of "institutions" with "social technologies," they nonetheless specify that not all social technologies are institutions. Rather, it is only those "that have become a standard and expected thing to do, given the objectives and the settings." (Sampat and Nelson, 1999, 40).

into the cluster and fosters knowledge circulation, which in turn leads to greater innovation.[2] (Menzel and Forhnal 2007; Turkina et al. 2019) It is also at this phase that the cluster more firmly embarks on a given development (or technological) path. (Menzel and Forhnal 2007) Clusters may eventually broaden to encompass related industries. It may take a cluster more than a decade or more to develop real competitive advantage. (Porter 1998) This is also where the vertical dimension (interconnected complementary firms) gains import, since as the cluster continues to specialize, demand for equally specialized services and supplies also grows. These complementary firms then have an incentive to move or establish themselves in the cluster—which at this point represents an important market—and by the same stroke benefit from growing economies of scale and low transaction and transportation costs, among other things. (Bathelt et al. 2004)

The sustained (or mature) phase is reached when the cluster begins to focus on taking advantage of economies of scale and its development path. At this phase, the institutional environment has stabilized. Indeed, the cluster has succeeded in creating and firmly implementing institutions to serve its purposes, and their potential for innovation is greatly decreased (Sölvell 2008), except potentially among larger players (Turkina et al. 2019) and multinational enterprises (MNEs), which may be more or less integrated in the cluster (Rugman and Verbeke 2003). There are fewer new entrants, and existing firms tend to consolidate in a smaller number of key players, both horizontally and vertically (Sölvell 2008; Turkina et al. 2019); in other words, the cluster's firm gravitate to the centre and direction of the rest of the industry (Menzel and Forhnal 2007). While the cluster's network remains somewhat open and flexible, though much less than before, firm innovation becomes occasional and incremental in nature. The cluster can remain in this phase for long periods of time, and will either exit this phase to go in decline if the cluster becomes too focused and exhausts its technological and/or development trajectory, and something (e.g. from a new hero to a substantial crisis) can alter or renew the cluster's development path and propel the cluster into another growth phase (Menzel and Forhnal 2008) (i.e. "renaissance" [Sölvell 2008]). The sustaining phase can come to an end in one of two ways: Either through new impetus launching it into a new growth phase, or a continued decrease in diversity leading to decline (Menzel and Forhnal 2007).

[2] This explains why cluster development is often particularly vibrant at the intersections of clusters, where insight, skills and technologies from various pools of competencies merge and spark innovation and new businesses (Menzel and Forhnal 2007).

Finally, clusters can lose competitive edge and "die," leaving behind only a museum (Sölvell 2008). Just as both firms and institutions are the constituting elements of clusters, both have their roles to play for this phase to unroll.

Firms in particular can become maladaptive when they fail to conduct their own basic research, which is critical if they are to acquire sufficient general background in order to rapidly detect and exploit external advancements and developments, such as technological discontinuities or disruptions and shifts in buyers' needs (Cohen and Levinthal 1990) (e.g. the Detroit automotive cluster was for a long time shielded from mounting external pressures calling for more energy efficiency technology, and therefore fell in decline when it was no longer able to keep up with the energy efficient technologies developed overseas [Porter 1998]). Without appropriate R&D and industry monitoring, firms lose touch of the common language, and fail to "stay on the technological escalator," getting potentially caught up in a "not-invented-here syndrome" where organizations begin to resist external innovations because ideas are too distant from their knowledge base to be appreciated or even assessed. (Cohen and Levinthal 1990, 147) In other words, organizations enter a negative feedback loop where they become increasingly inward-looking as they cannot cope with the advancements in the external environment.

Both firms and institutions can suffer from a number of internal rigidities that are typical of this cluster phase, such as overconsolidation, regulatory inflexibility, groupthink, etc. (Porter 1998) All these factors share one underlying cause: the local networks are "too close, too exclusive and too rigid," which ultimately harms cluster competitiveness. (Bathelt et al. 2004, 41-42) Indeed, although many benefits can be derived from dense, close relationships with suppliers and customers, including organizational, procedural, structural and trust-based efficiencies (Djelic 2004), overembedded relations are in fact a predictor of failure (Uzzi 1996, 1997, in Bathelt et al. 2004; Huggins and Johnston 2010). In fact, despite the benefits of stable networks, there is a risk that knowledge becomes too homogenous and therefore of limited use to members. (Huggins and Johnston 2010)

2.2.5 MNEs and clusters

The value of MNEs for cluster health is not intuitively clear, as they strive to maximize the benefits they derive from the cluster, while operating someone independently from cluster actors by operating within their own systems. (Lorenzen and Mudambi 2013) MNEs are often initially foreign to the region, can afford to do their own R&D (and may guard their R&D religiously) and may not participate as actively in planned cluster activities.[3] Some authors even describe them as "footloose" and inherently unable to

[3] Interview with Berlin Partner as part of the EU Campus Abroad in 2016, organized and led by Ekaterina Turkina.

entrench themselves sufficiently in a local environment to either understand or properly capitalize on the local knowledge. (Audretsch and Lehmann 2006) However, Rugman and Verbeke (2003) argue that MNEs are "knowledge generators and knowledge seekers," and there are many scenarios in which they can stimulate the knowledge activity in a cluster, and even shape the institutional framework governing the cluster's activities.

Indeed, though MNEs are generally pressured into adapting to the local environment (whether in terms of regulatory requirements, to ensure national responsiveness [Ragman and Verbeke 2003], and simply to understand the local context so as to be able to interpret and use the local knowledge and competencies [Cowan et al. 2004; Bathelt et al. 2004; Audretsch and Lehmann 2006) a strong MNE presence in a cluster can also lead to interesting and significant efforts on behalf of the latter to institutionalize some of its routines across the cluster (e.g. to avoid vertically integrating certain activities and rather encourage the cluster to perform those activities, leading to technological and knowledge spillovers for the cluster at large) as part of its proactive cluster management behaviours.

2.2.6 Types of clusters

Different authors present different cluster types, such as "regional innovation clusters" (Wessner 2012), "regional innovation systems" (Lorenzen and Foss 2002), "technological districts or knowledge clusters (Turkina et al. 2019) and "industrial districts" (Markusen 1996; Boschma and Ter Wal 2007). Gordon and McCann (1999), however, have created an interesting core typology, the three "ideal-typical" models, namely, the pure agglomeration model, which largely consists in cluster actors benefitting from the naturally occurring externalities produced by colocation and cooperation being limited to actions that advance their individual interests in a competitive environment; the industrial-complex model, which in addition to benefitting from externalities is characterized by identifiable and stable relationships (especially trading links) between cluster actors; and the social-network model, which is characterized by an institutionalization of trust and embeddedness, whereby relationships between organizations allow the cluster to as a whole to work towards mutually beneficial goals and achieve greater levels of innovation.

However, the first two types are problematic, as their competitive advantage is mostly explained by the efficiency gains and flexibility afforded by the concentration of externalities (e.g. pools of specialized labour, increased input sharing and supplier specialization), and are not particularly innovative, nor do they require a great deal of cooperation or conscious effort to share knowledge (Sölvell 2008; Wolman and Hincapie 2014; Steiner 2006). In fact, Sölvell (2008) claims that to be considered a cluster, there must

be innovation potential; otherwise, the body is a mere agglomeration. And indeed, only the latter cluster type identified above engages in meaningful, complex and dynamic relations that lead to the knowledge spillovers that are key to innovation, the cultivation of trust environments, and the presence of institutions that play relatively strong brokerage and facilitation roles for information, knowledge and relationships. (Steiner 2006; Wolman and Hincapie 2014; Carpinetti and Lima 2013)

2.3 Institutional view of clusters

2.3.1 The roles played by institutions in recent cluster literature

A number of authors have already drawn on institutional literature to respond to the limitations in traditional cluster theory, and have greatly contributed to our understanding of the role of institutions in cluster dynamics. (Turkina et al. 2019; McEvily and Zaheer 1999; Carpinetti and Lima 2013; Wolman and Hincapie 2014; Steiner 2006; Sölvell , 2008; Bathelt and Glückler 2014; Markusen 1996) Broadly speaking, institutions are viewed as facilitators, coordinators and sources of collective support services (Bathelt and Glückler 2014; Carpinetti and Lima, 2013; McEvily and Zaheer 1999; Lorenzen and Foss 2002) and a source of external knowledge to be tapped into for firm innovation (Turkina et al. 2019; McEvily and Zaheer 1999; Huggins and Johnston 2010). More specifically, their functions fall under two categories: 1) functions that relate to upholding, channeling or improving the global external economics that are derived from agglomeration (Sölvell , 2008; McEvily and Zaheer 1999); and 2) functions that relate to promoting and fostering knowledge exchange, creation and spillovers as well as innovation (Steiner 2006; Wolman and Hincapie 2014; Bathelt and Glückler 2014; Edquist and Johnson 1997).

Indeed, institutions have the power to elevate clusters from being a “mere” agglomeration of colocated firms (Porter 2000; Carpinetti and Lima 2013) to a “comprehensive local innovation system that aims to improve local competitiveness through joint actions and network formations” (Carpinetti and Lima 2013, 16). Specifically, action is required for clusters to fulfill their potential (Porter 2000), and institutions can play an impactful role in terms of fostering knowledge diffusion and technological spillovers by serving important coordinating, sense-giving, trust-generating and knowledge-creation functions. (Audretsch and Lehmann 2006; Asheim and Coenen 2006; Steiner 2006; Turkina et al. 2019) The role of institutions becomes particularly important as the economy becomes increasingly knowledge based, characterized by the hyper-mobility of information and knowledge (Steiner, 2006); as such, competitive advantage lies not so much in margins and economies of scale, but rather in the cultivation and exploitation of unique competencies and resources. In this context, the role of formal organizations and local institutions is to help coordinate activities, facilitate or manage cluster transactions (Asheim and Coenen, 2006), and

contribute to R&D, thereby improving the cluster's absorptive capacity and reducing the cost of acquiring external knowledge (Turkina et al. 2019).

2.3.2 The specific role of institutions in technological advances and economic health

Even though institutions are recognized, at least fluidly, for their importance, researchers continue to struggle to make concrete connections between the quality of the institutions and that of innovation. In other words, researchers have difficulty incorporating institutions into models of economic growth (Tebaldi and Elmslie 2008) and innovation (Edquist and Johnson 1997). At a basic level, institutions are known to be critical to innovation and economic health as they create the basic conditions for "information and knowledge exchange." (Bathelt and Glückler 2014, 347) It is also argued that as institutions, as rules or organization, govern the interactions between people and other organizations, and that innovation is essentially an interactive learning process, institutions are key to innovation. (Edquist and Johnson 1997) However, as uncertainty is part and parcel of innovation, and institutions are designed to reduce uncertainty, a balance can be difficult to achieve—but this balance, which translates into strong institutional support of technological advancements, is critical. (Edquist and Johnson 1997)

This call for a balance highlights the importance of a proper alignment between institutions and technology. Tebaldi and Elmslie (2008) present a framework that underscores the importance of a co-evolution of institutional quality and technology, "so that technological change will only take place in an economy that has an institutional structure suitable to its level of technological development." (40) In their framework, it follows that "[p]oor institutions or institutional barriers that prevent or restrict the adoption of newly invented technologies decrease the share of human capital employed in the R&D sector, which hinders innovation" (2008, 41) and that "[i]nstitutional barriers to adopt newly invented technologies decrease the short-run growth rate of output." (2008, 41) Nelson and Nelson (2000) propose something to a similar effect, namely, that economic growth results from a co-evolution of physical technologies and social technologies (patterned human interaction [Nelson and Sampat, 2001], or institutions). They also make it clear that though institutions, or social technologies, can serve to encourage physical technological advances, the institutions themselves will be called on to change only after these technological advances are in play. In other words, technological change precedes institutional change. However, the long-term success and existence of physical technologies need institutions. Physical technological innovations, no matter how crucial or superior, can simply not take hold without the proper supports in place (e.g. despite the superior quality of Betamax, VHS technology was eventually adopted). This suggests an institutional rather than a functional explanation of technological change, where the innovation process must be aligned with existing institutions in order to increase the chances of the

innovation's initial acceptance and legitimization (Bathelt and Glückler 2014; Markard et al. 2016; Edquist and Johnson 1997).

However, just as adaptive institutions can facilitate technological innovation and promote economic growth, maladaptive institutions can have the opposite effect (Bathelt and Glückler 2014; Nelson and Sampat 2001; Tebaldi and Elmslie 2008), particularly if in their attempts to reduce uncertainty (Edquist and Johnson 1997), they create conditions that create lock-in for actors by limiting their perceptions and opportunities, ruling out innovative technological solutions, and supporting ineffective technologies and maladaptive hierarchies (Bathelt and Glückler 2014) Indeed, although it is normal for institutional change to be slower than technological change (Edquist and Johnson 1997; Nelson and Nelson 2000), if it is too slow, institutions will hinder innovation and economic health. (Edquist and Johnson 1997; Bathelt and Glückler 2014; Nelson and Nelson 2000) Maladaptive institutions and institutional conditions can also lead to "institutional hysteresis," where institutions persist in time, even though the conditions that led to the creation have long since disappeared. (Bathelt and Glückler 2014, 348)

In other words, even though institutions are sometimes overlooked, there does appear to be a consensus in the existing research that institutions have the potential to both support and hinder innovation and economic health (Edquist and Johnson 1997; Bathelt and Glückler 2014; Nelson and Nelson 2000; Tebaldi and Elmslie 2008.

But what, exactly, are institutions, and what do they say about the broader institutional environment?

2.3.3 Institutions as a reflection of the institutional environment

The concept of "institutions" is a malleable one. Definitions abound because different authors, depending broadly on their fields (social sciences, political sciences, sociology, economics, etc.) and more specifically on their individual subjects of analysis, bend the concept to suit their purposes (Nelson and Sampat, 2001; Nelson and Nelson, 2000; Bathelt and Glückler 2014; Edquist and Johnson 1997), or simply use the concept or phenomena of institutions as a catch-all for any unexplained phenomena. (Bathelt and Glückler 2014) This lack of consensus may initially be viewed as a heavy challenge (Bathelt and Glückler 2014)—where does one even begin when faced with such a plethora of starting points? However, the very malleability and cross-disciplinary potential of the term also provides an opportunity to ascertain common threads between the different bodies of literature (institutional theory, cluster theory, network theory) studied in this research.

Nonetheless, some narrowing down remains necessary, as the range of possible definitions runs quite large, from denoting strictly non-physical social structures or frameworks of rules and regulations, like marriage and money (Commons 1934, 69, in Hodgson 2006; Edquist and Johnson 1997), to denoting physical organizations, such as government, unions and universities (North 1991; Edquist and Johnson 1997), or being outright synonymous with all public organizations (Porter 1998; Solvëll 2008; Edquist and Johnson 1997), to social mechanisms that stabilize mutual expectations and correlated interaction between economic agents (Bathelt and Glückler 2014). Are these definitions mutually exclusive, or is it possible to reconcile these different facets into a broader understanding?

Geoffrey M. Hodgson (2006, 2015) offers such a possibility with the following definition:

Systems of established and embedded social rules that structure social interactions. (2006, 2015)

By the author's own admission, this definition is meant to be "all-encompassing," so that it can include systems such as language, money, and firms. However, his definition is meant to provide the essence or understanding of the general nature of institutions ("the nature of the beasts" [p. 499, 2015] in order to be able to roughly demarcate it from what it is not (other social phenomena and structures such as the demographic or social structures of society, as they are not rule based). (2006, 2015) This leaves room for the researcher to bend certain qualities of definition for her purposes and the type of analysis employed.

In this definition, rules are considered to be inherently normative and embedded in "shared habits of thought and behaviour" (Hodgson, 2006, 6), i.e. social norms, which in turn creates a "positive feedback loop with strong self-reinforcing and self-perpetuating characteristics." (Hodgson 2006, 7) Through this positive feedback loop, habits make institutions more durable by lending their normative authority, and the institutions, through mechanisms of conformism and normative agreement, ensure that these habits are maintained and endure. (Hodgson 2006) As a result, institutions are relatively inert and stable, and not easily subject to change (Bathelt and Glückler 2014), and departures from these rules are likely to result in inefficiencies (Hodgson 2006) and be met with external sanctions and social disapproval—powerful motivators to keep players in line with the broader institutional environment. (Nelson and Sampat 2001)

These rules also lead to the creation of routines (Nelson and Nelson 2002), which lead to a limited range of alternatives and channel choices (Nelson and Nelson 2002; Bathelt and Glückler 2014) as well as create opportunities for new choices (Bathelt and Glückler 2014) These in turn pave the way for more effective action, and yielding predictable and specifiable outcomes. Routines are used not only for the

resulting efficiency, but also because deviation is risky as routines tend to be part of wider systems of routines that provide the necessary inputs (human and material resources), a shared language, etc. (Nelson and Nelson 2002; Bathelt and Glückler 2014) As such, deviations initially lead to inefficiencies while new support systems and routines are developed—a costly, time consuming behaviour. (Nelson and Nelson, 2002; Bathelt and Glückler 2014)

Finally, although Hodgson's definition clearly and conclusively takes institutions to exclusively mean a broader, non-physical system of embedded rules that shape and is shaped by human behaviour (Hodgson 2006, 2015), in keeping with the sociological school of institutional economists (Edquist and Johnson 1997), he nonetheless allows for the possibility, in his interpretation of the tradition of Douglass C. North (1991), to consider institutions to be individual actors (i.e. brick-and-mortar organizations such as universities, trade unions, associations and government bodies) when, and only when, they are subject to analytical abstraction for purposes of research and study. (Hodgson 2015) Indeed, "it is possible for organizations to be treated as actors in some circumstances and generally be regarded as institutions." (Hodgson, 2006, 10). This is especially true in light of the fact the organizations themselves are embedded within the broader institutional rule-system (Hodgson 2015), and therefore, to a certain extent, reflect this rule-system in their own organizational structures. This, to a certain extent, joins Edquist and Johnson's proposed approach to this definition of institution, which, rather than marry the two predominant schools of thought, i.e. "institutions as concrete things" (in keeping with innovation theorists) and "things that pattern behaviours" (in keeping with sociological institutional economists), they acknowledge both as separate but connected. (Edquist and Johnson 1997, 43)

Bathelt and Glückler (2014, 350) argue against conflating institutions as the broader institutional environment (macro perspective), as it diminishes micro-level agency and assigns a certain deterministic approach whereby social actions are simply the result of "functional constraints or a priori principles." However, Hodgson also warns against conflating organizations as institutions, acknowledging that whereas institutions considered more broadly provides the informal basis for all structured and durable behaviour, physical institutions or organizations-as-institutions are made up of people with conflicting objectives that may or may not align with those of the institution. As such, these people are likely to bring changes to individual institutions, that may not be in keeping with wider social tendencies. (Hodgson 2006)[4] However, it remains that the rules, habits and routines that shape institutions do stem from the

[4] Indeed, assuming corruption is considered inacceptable by a society, if a newly appointed CEO, following her individual objectives, decides to deviate from the broader institutions (break laws, cheat investors, etc.) in order to line her pockets, a corrupted culture may permeate the organization from the top down, causing the organization

broader institutional environment, which is in turn reinforced by these institutions (Hodgson 2006); the institutions are a reflection of this environment, albeit an imperfect one. Furthermore, treating organizations as single players that as a whole can be taken to reflect the wider institutional structure opens the door to quantifying these players and their interactions, which can be a rich source of new insight into institutional dynamics.

This definition was chosen for a number of reasons. For one, it was crucial that the definition referred to the wider institutional environment, a determining factor in cluster growth. However, it was equally crucial that the definition accounted for individual organizations-as-institutions, as these will serve as a unit of measure in a network analysis to study the cluster institutional environment. While remaining mindful of the limitations of this approach (i.e. individual organizations can deviate from the broader institutional environment because they are constituted by individual actors with individual objectives who exercise varying levels of influence on the directions, strategies and actions taken by individual institutions), I posit that since the same constituting rules are embedded at level of society, it is possible to make a number of observations about the wider institutional environment by studying individual organizations-as-institutions. From there, it will be possible to derive conclusions regarding the ability of an institutional environment to adapt to technological advances.

2.4 Towards a relational and institutional view of clusters

2.4.1 Relational view of clusters

A relational view of clusters studies the "roles of agents and organizations, the economic practices and relationships in which they engage, and the resulting social institutions and their dynamics at different spatial and non-spatial scales." (Bathelt and Glückler 2014, 341) In this view, economic action is not solely driven by actors acting to maximize self-interest, but rather by the embedded relationships between actors, which are in turn a reflection of individual preferences, norms, values, ethics, and objectives, among other things. (Bathelt and Glückler 2014) As such, social network analysis, which maps and measures flows between actors (Krebs 2008, n.p.), is a particularly apt methodology for building on this view.

Emerging studies have applied network methodology to develop a relational view of clusters and demonstrate the impact of connectivity on cluster health. For instance, Guiliani and Bell (2005) used relational data and inter-firm cognitive linkages to explore the different cognitive roles and absorptive

to deviate from social and market norms. Herein lies the power of individual action, and herein lies the danger of defining organizations as institutions.

capacities of firms in a Chilean wine cluster, and found that cluster innovation was driven by knowledge, rather than buzz, which circulated between core firms with advanced absorptive capacities. Turkina et al. (2019) performed a network analysis of patent citations from 26 European regional clusters to determine the impact of location on innovation, and found that cluster membership offers both benefits and constraints—namely, diminishing returns from R&D—but that connectedness to high performance firms, research institutions and universities mitigates those negative effects. Huggins and Johnston (2010), through their network analysis of knowledge-based firms, found that firms that invested in both their inter-firm networks (i.e. intra-cluster) in combination with their external knowledge networks were able to achieve higher levels of innovation, whereas an overreliance on social capital (social networks and relationships between firms and organizations, generally 'local', that are conducive to knowledge flows) hindered the ability of firms to manage the external knowledge networks necessary for innovation. Lorenzen and Mudambi (2013) used social network analysis to enrich cluster theory by finding that clusters that are linked to the global economy via decentralized network structures and pipelines (i.e. marked by broad collaboration and R&D partnerships among high-tech or high-knowledge actors) have potential for in-depth (i.e. vertical) catch-up (value creation and value capture), whereas those linked via decentralized personal relationships (i.e. marked by high-knowledge activities among individuals who share a common language, culture, experience and contacts) have potential for "in-breadth" (i.e. horizontal) catch-up.

However, similarly to the traditional cluster literature, one pervasive issue is that the primary focus of these studies is firms (interactions, knowledge flows, etc.); relegating minor roles to institutions, and treating the institutional environment as a given. Guiliani and Bell (2005) mention institutions (universities) only as a source of extra-cluster knowledge. In their discussion on global linkages, Lorenzen and Mudambi (2013) posit that social network relations are what gives value to 'hard' infrastructures, such as transportation and communication. Turkina et al. (2019) make a significant contribution by measuring the impact that being connected to research institutions has on firm innovation and by identifying the measure of closeness centrality as being most relevant to measure horizontal relationships (i.e. cooperation with institutions); however, the institutional environment is still considered as given.

There have also been calls to use social network analysis to evaluate cluster development programs and policies, specifically by measuring both their impact in the host regions as well as network positions and characteristics to determine if these are healthy and achieving program or policy objectives. (Guiliani

and Pietrobelli 2011) Once again, however, although there is a cursory mention of universities, all data collection is focused on firms. The institutional contribution is a given.

2.4.2 A new cross-fertilization of cluster theory, institutional theory and network theory

Although network analysis has been used to develop a relational view of clusters, resulting in some of the new findings described above, it is not often used to make structural assessments of clusters, and it has never been applied to map and analyze institutions and institutional-level activity in a cluster.

Regarding the former statement, the relational literature has primarily focused on analyzing clusters and pipelines on a conceptual level (Djelic 2004; Bathelt et al. 2004; Lorenzen and Mudambi 2013; Huggins and Johnston 2010). Indeed, despite network theory's robust body of literature addressing structural features (see Section 2.5), it has been insufficiently leveraged to validate the conceptual research.

Further evidence that the potential of network analysis remains untapped is that despite the plethora of evidence on institutional contributions to clusters and their above-mentioned role in building and maintaining the institutional environment, sharing knowledge, fostering growth, optimizing research, facilitating relations, among other things (see section 2.3), such benefits have been qualified as "soft" given the difficulty in measuring them (Sölvell 2008; Carpinetti and Lima 2013). In other words, there is an explicit need for quantitative evidence of institutional impacts. This need is particularly poignant given that institutional interactions and institutional structure has never been quantified in such a way as to isolate their contribution to the cluster, in particular in the context of a specific life cycle phase. However, this new cross-fertilization of institutional and relational theory and network analysis provides the foundation for measuring institutional interactions through the use of a social network analysis methodology and situating these findings in cluster literature, thereby bridging this gap. By analyzing the structural properties of institutional networks—something that has never been done in the past, despite the availability of network analysis—it becomes possible to demonstrate that these benefits and qualities are in fact concrete, and play a determining role in cluster dynamics and cluster health.

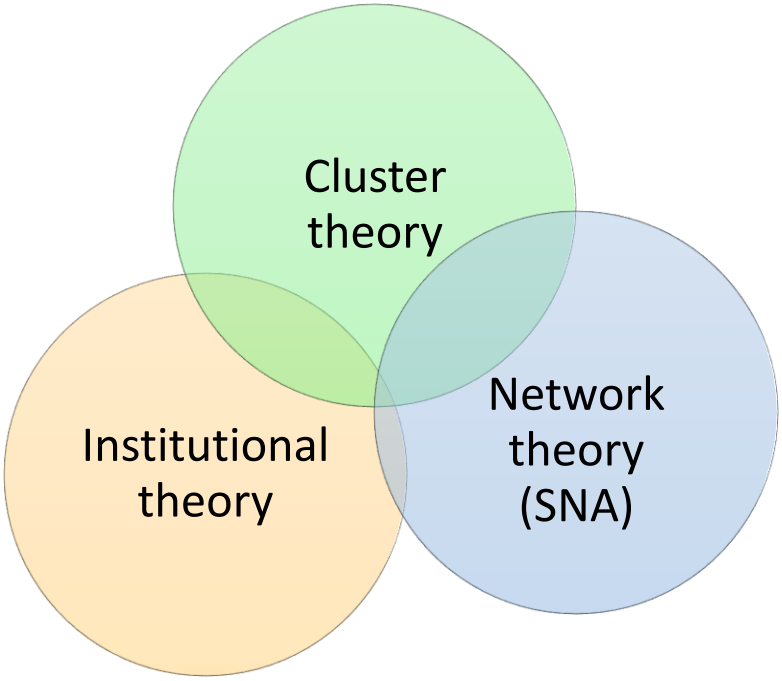


Figure 1: Cross-fertilization of cluster theory, institutional theory and network theory

This new cross-fertilization hinges simultaneously on Nelson's proposed definition of institutions, which permits an abstraction of the institutional environment for purposes of analysis, as well as network analysis, which makes it possible to create a structural network of institutions, map their channels of interaction, and isolate their contribute within the cluster. In other words, the resulting social network is analyzed as a concrete mechanism of transfer, providing both micro-level insight (knowledge transfers between specific institutions, roles in the network) and macro-level insight of the network—and therefore cluster—as a whole (Djelic 2004).

The following section examines network theory and its implications on knowledge sharing and transfer, and provides a technical overview of the tools that allow for a quantification of institutions in isolation, which will in turn allow for an analysis of the structural properties of the institutional network.

2.5 The network potential

2.5.1 Networks

Networks are "a pattern of interconnections among a set of things" (Easley and Kleinberg 2010); they are a context for action. (Burt 2004, 354) Networks can be found in every aspect of our lives (Jackson, 2008): from our very biological cell structures, to whom our friends are and what companies we do business with. These network structures in turn "play a central role in determining outcomes in many important situations" (Jackson and Rogers 2005, 617) and shed significant light on patterns of interaction

and behaviours that help to explain phenomena (Jackson 2010). Social networks, in turn, are simply a network of nodes that are connected through their relationships—an important type of network structure that in fact constitute a concrete mechanism for knowledge transfer. (Djelic 2004)

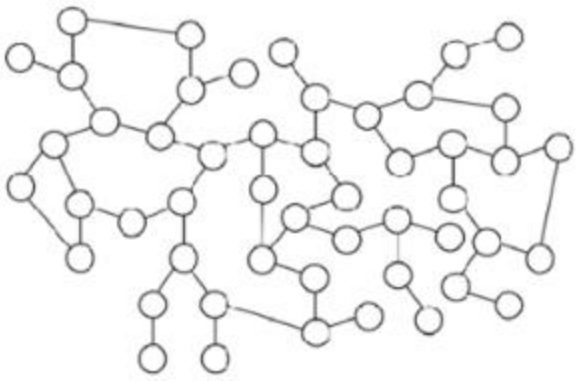
Network structures form the basis of an incredibly versatile methodology that can be used to measure interactions within and across its boundaries (Ter Wal and Boschma 2009). Specifically, this methodology, social network analysis (SNA), "is the mapping and measuring of relationships and flows between people, groups, organizations, computers, URLs, and other connected information/knowledge entities. The nodes in the network are the people and groups while the links show relationships or flows between the nodes. SNA provides both a visual and a mathematical analysis of human relationships." (Krebs 2008, 1) The relationships or linkages between these actors, in turn, are the key to explaining the nature, behaviours and outputs of actors. (Guiliani and Pietrobelli 2011)

As will be seen below, by mapping the interactions of actors, or nodes, this methodology makes it possible to determine network borders, the position of nodes in the network, the quality of interactions between nodes. This, in turn, sheds light on node characteristics (i.e. whether the institutions within the network demonstrate a high degree of similarity, which institutions are in positions of high or low influence), how the network behaves as a whole (i.e. how network relationships govern network habits), what type of knowledge is present (i.e. what type of knowledge can be introduced and diffused in this network, based on network relationships), and, given that different types of knowledge serve different functions, whether this knowledge is conducive to innovation and adaptation.

2.5.2 Network structures

Random networks

Random networks are the most basic model of network formation, namely, one whose link formations are governed by an entirely random process. (Jackson 2008) Although these networks do not generally reflect "real" social and economic networks (Jackson 2008, 31), random networks nonetheless provide a benchmark against which to compare other types of networks, i.e. to determine which social structures are based on randomness or other, more specific factors and choices. (Jackson 2008)



(A) Random network

Source: https://www.spandidos-publications.com/10.3892/ijo.2013.2114

Core-periphery networks

Core-periphery networks are hierarchical structures with densely connected and interconnected core nodes, sparsely connected peripheral nodes, and a reasonable number of connections between core nodes and peripheral nodes. (Jackson 2008; Rombach et al. 2014; Borgatti and Everett 1999; Guiliani and Pietrobelli 2011; Romback et al. 2014) Core nodes must be connected to both other core nodes and peripheral nodes (Romack et al. 2014) In this structure, core nodes are well connected both to other core nodes and to peripheral nodes, thereby ensuring relatively short paths throughout the network. (Rombach et al. 2014) Nodes can belong to the core only if they are well connected to both core nodes and peripheral nodes. (Rombach et al. 2014) Although all core actors are by definition highly central, all central actors do not necessarily form a core, as an actor's high centrality may simply be explained by its connections to other connected actors. (Borgatti and Everett 1999) Network position is particularly important in core-periphery networks: core actors tend to have "elite" status and enjoy higher absorptive capacity, whereas peripheral actors are disadvantaged insofar as they are only somewhat included in the "local knowledge-generating networks," negatively impacting learning and innovation opportunities. (Guiliani and Pietrobelli 2011, 15) This hierarchy furthermore creates a risk of creating and maintaining a divide between actors (Guiliani and Pietrobelli 2011), hampering opportunities for creativity, innovation and collaboration.

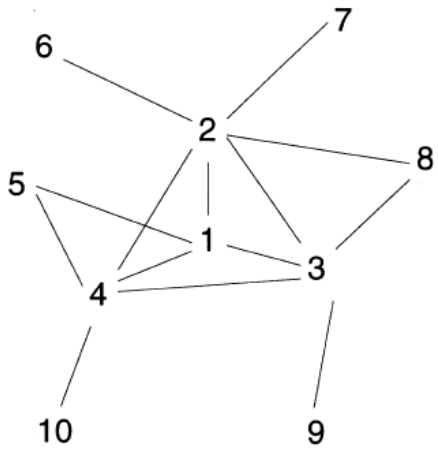
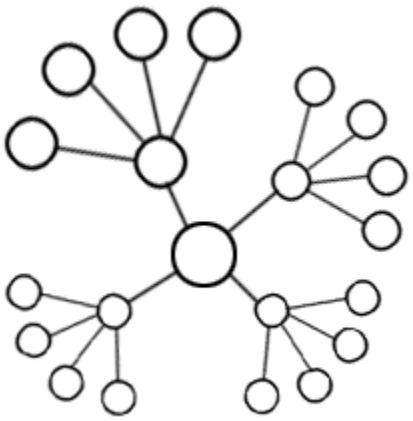


Fig. 1. A network with a core/periphery structure.

Source: Borgatti and Everett 1999

Scale-free networks

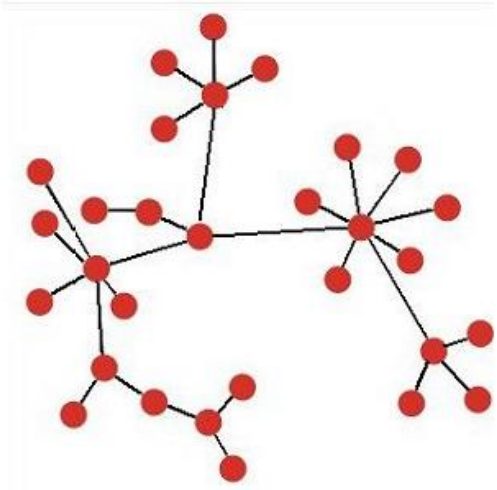
Scale-free networks are another hierarchical model that are highly reflective of real-life situations, where most nodes "have a less-than-average degree of connection and that a small fraction of hubs are many times better connected than average" as new actors tend to connect to well-connected rather than poorly-connected hubs due to a mechanism of preferential attachment (Guiliani and Pietrobelli 2011, 15). This ultimately reinforces the centrality of central hubs over time (Guiliani and Pietrobelli 2011), resulting in a situation where nodes tend to have either very small or very large degrees. (Johnson 2008) This leads to a high, uneven and even polarized concentration of resources as well as high vulnerability (Guiliani and Pietrobelli 2011); indeed, if a central node is removed, it places the entire network at risk.



Source: https://www.futurelearn.com/courses/complexity-and-uncertainty/0/steps/1855

Small-world networks

Small worlds are characterized by small diameters, average path lengths and high clustering coefficients (Jackson and Rogers 2005; Watts and Strogatz 1998). Considering that costs are higher when connected to distant (in terms of geography or differences in terms of social standing, political preferences, research interests, etc.) nodes, high clustering is the result of connecting to close or similar nodes (less costly connections), and the small diameters are the result of the "large benefit of attaching to dissimilar (distant) nodes because of the substantial indirect access they provide to other distant nodes. A limited number of such distant links emerge due to the high costs, but in concern with the high interconnection rate at the local level, these distant links substantially decrease network diameter and average path lengths." (Jackson and Rogers 2005, 619) In other words, there is higher cost to connecting to distant nodes, but there are also greater benefits (Jackson and Rogers 2005), as there are opportunities for bridging actors to reach across structural holes (Burt 2004) and capture heterogeneity through their indirect relationships (Jackson and Rogers 2005). Indeed, local cliquishness and clique-spanning ties allow network actors to be highly connected to one another, despite a small number of intermediaries. (Guiliani and Pietrobelli 2011) Note that costs are only associated with direct relationships (i.e. indirect relationships are free). (Jackson and Rogers 2005) Small world characteristics are associated with greater efficiency (Guiliani and Pietrobelli 2011), high creativity and innovation potential (Uzzi and Spiro 2005; Lee et al. 2007) and greater robustness (Kogut and Walker 2001). These structures also benefit from high local trust, a cooperative environment and limited local isolation; however, the downside is that the network's success depends on its brokers. (Guiliani and Pietrobelli 2011)



Source: http://jasss.soc.surrey.ac.uk/12/2/3.html

2.5.3 Network characteristics

Pairwise stability

A network is considered to have pairwise stable if no network actor wants to sever a link (unilateral), and no two actors want to add a link (mutual consent) (Jackson 2008; Jackson and Rogers 2005). In other words, if at least two players would benefit from the addition of a new link, the network is not stable. (Jackson 2008)

Homophily

Node homophily points to the phenomenon whereby actors are more likely to form and maintain relationships with actors with whom they share similarities (e.g. age, race, gender, relation, profession). (Jackson 2008)

Structural holes

A structural hole is, quite simply, a void, or an absence of connections, in a social structure or between groups. (Jackson 2008) They are present in the network when a focal actor is tied to other actors who are themselves not connected to one another (Zaheer and Soda 2009), who may or may not be aware of each other (Jackson 2008). Structural holes are a source of value for networks, as they permit bridging actors to tap into new sources of information and ways of doing things (Burt 2004; Jackson 2008), as "opinion and behaviour are more homogenous within than between groups." (Burt 2004, 349) The presence of structural holes prevents a network from being overly interconnected, thereby avoiding the risks of density and promoting knowledge diversity, innovation and even radical innovation, creativity and efficiencies. (Guiliani and Pietrobelli 2011)

The actors that bridge structural holes are referred to as *brokers*. Network brokers tend to have a lot of power in networks (Burt 2004; Jackson 2008); indeed, due to their network position and their ability to control knowledge flow, they have a great deal of *social capital* (i.e. social networks across firms or organization that provide a channel for knowledge [Huggins and Johnston 2010]) that they can leverage to benefit the network and/or themselves (Burt 2004; Jackson 2008). An *honest broker* (showing signs of reciprocation [Borgatti et al. 2002]) may create value for the network by 1) sharing ideas, interests and difficulties between the groups; 2) sharing best practices between groups and translating or synthesizing these practices to assist in their adoption; 3) drawing analogies about the two groups to assist with the adoption and adaptation of ideas. (Burt 2004) As such, because brokers are more highly connected to different networks, they tend to have better absorptive capacity and network centrality (Guiliani and Bell 2005; Boschma and Ter Wal 2007)

2.5.4 Network indicators

Geodesic distances

The shortest path (i.e. the number of relationships) between two nodes, and helps to indicate the speed at which knowledge will travel (Jackson 2008; Hanneman and Riddle n.d.). However, it is not guaranteed that the information will flow according to the shortest path. (Jackson, 2008)

Density and related concepts

Network density is "the proportion of possible linkages that are actually present in a graph." (Guiliani and Pietrobelli 2011, 32), i.e. "the total number of ties divided by the total number of possible ties" (Borgatti et al. 2013, n.p.). High local density refers to situations where "actors have dense connections with their neighbours" (i.e. cliques) and "few connections with other distant actors" (i.e. clique spanners). (Guiliani and Pietrobelli 2011, 14)

Four concepts that are closely tied to network density are cliques and cliquishness, clustering coefficients and diameter:

Clique: "[A] maximum completely connected subnetwork of a given network" that contains at least three nodes. These nodes, in turn, can simultaneously belong to other cliques. (Jackson 2008, 34)

Cliquishness: The number and size of cliques in a network. (Jackson 2008, 34)

Clustering coefficients: A measurement of "the frequency with which two neighbors of a given node are themselves connected." (Jackson and Rogers 2005, 618)

Diameter: "Maximum distance between any two nodes in a network, where distance between nodes is defined as the number of links in the shortest path between them." (Jackson and Rogers 2005, 617)

Cliquish, or dense, networks tend to provide actors with a highly cooperative and egalitarian environment marked by social monitoring, trust and extensive resource sharing. (Guiliani and Pietrobelli 2011) High cliquishness is said to be positive for knowledge creation and innovation, but negative for knowledge diffusion, spreading it unevenly across the network. Conversely, low cliquishness, when combined with short paths, has a positive effect on knowledge diffusion, spreading it evenly across the network, but a negative impact on knowledge creation and innovation. (Cowan and Jonard 2003) The optimal measures of cliquishness in a network depends on the industry: Indeed, some industries that rely on a high degree of innovation benefit from high cliquishness, whereas other industries that benefit more from greater homogeneity also benefit from low cliquishness. (Cowan and Jonard 2003).

Close ties tend to lead to trustful relations, as high closeness reduces uncertainty and information asymmetries. As high closeness indicates a high absorptive capacity between the two nodes, it follows that it allows for exchanging more specific or technical information, which is "more proprietary and tacit

than the information exchanged in open networks" and leads to a faster and more coordinated response to external circumstances (Guiliani and Pietrobelli 2011, 9)

Despite the benefits of closeness, there are also downsides to overly embedded local networks, such as isolation. These types of structures "breed relational inertia and obligations for reciprocity." (Guiliani and Pietrobelli 2011, 10) Although the resulting network may be stable, actors develop the habit of relying almost exclusively on existing relationships for knowledge and solutions, creating a risk for technological lock-in and weak innovation performance. (Guiliani and Pietrobelli 2011)

Network centralization

Network centralization sheds light on the network's overall structure and cohesion (Borgatti et al. 2013). Specifically, if one or a handful of nodes are very central and critical to the network, then the network is said to be highly centralized. Conversely, if no nodes, or relatively few nodes, holds positions of specific importance, then the network is said to be decentralized, which makes it very resistant to failure (Krebs 2008) or "attacks" (Jackson 2008). In other words, centralized networks have one or more highly influential hubs or brokers, and therefore have certain small-world properties and are conducive for innovation. A decentralized network, on the other hand, is associated with better information flows and knowledge sharing, is overall better for cooperation, and is more resilient to attacks. (Turkina and Postnikov 2012).

Ego network centrality

An "ego" is a node, and can represent persons, organizations, etc. The size of individual ego networks is equivalent to the number of first-degree and second-degree ties the node has, whereas ego network density is the number of ties that is divided into the number of pairs (i.e. the percentage of ties, out of all possible ties, achieved by the node, or ego). (Hanneman and Riddle n.d.)

Degree centrality

Degrees define how connected a given node is, and can furthermore be used to determine a node's position in a network, and how many direct or indirect links. (Jackson 2008; Krebs 2008) Degree centrality is the "number of direct ties an actor has with others in the network." (Guiliani and Pietrobelli 2011, 11) A high centrality results is easy access to information, knowledge and other resources, but too many connections can be inefficient and costly. (Guiliani and Pietrobelli 2011)

Bonacich centrality

Bonacich centrality is the "centrality of an actor dependent on the centrality of its direct contacts." (Guiliani and Pietrobelli 2011, 11) A node with high Bonacich centrality will have power (when other connected nodes have low centrality) and/or good access to resources (when other connected nodes have high centrality). However, as above, too many connections can be inefficient and costly. (Guiliani and Pietrobelli 2011)

Betweenness centrality

Betweenness centrality is an indication of structural holes, where the "degree to which an actor is able to connect others that will be otherwise disconnected." (Guiliani and Pietrobelli 2011, 11) It designates a node's power as an intermediary—in order for Node A to get to Node C, it must pass through Node B (Hanneman and Riddle n.d.). Nodes with high betweenness centrality derive a host of benefits as brokers (e.g. gatekeeping, influence, dependence, control), but a network with few brokers is vulnerable to disruption (i.e. in the event a broker disappears). (Guiliani and Pietrobelli 2011) However, these brokers can also make the entire network vulnerable, because if they are removed from the equation, the network loses out on a valuable source of information. (Jackson 2008; Krebs 2008).

K-cores

K-cores are "a type of subgraph defined on the basis of the actors' degree centrality [where] each node is adjacent to at least a minimum number, k, of the other nodes in the subgraph." (Guiliani and Pietrobelli 2011, 32) They are helpful for identifying clique-like structures in the network (Borgatti et al., 2002).

2.5.5 Network knowledge

Codified knowledge: Low cost, low value

Codifed knowledge is "context-free information" (Audretsch and Lehmann 2006). Specifically, due to changing institutional environments (e.g. relaxed trade regimes) and the telecommunications revolutions, information or knowledge, once codified, can be shared across great distances with little friction or cost (Bathelt et al. 2004; Audretsch and Lehmann 2006). However, despite the low cost of codified knowledge and the fact that it is easily accessible to firms regardless of location, it is not "free." Firms and institutions must invest substantial costs to identify, assess, assimilate and apply codified knowledge. What's more, despite its omnipresence, codified knowledge is only truly worthwhile when combined with "stickier" knowledge to create new, valuable knowledge. (Bathelt et al. 2004)

Tacit or "sticky" knowledge: High cost, high value

Tacit or "sticky" knowledge, as opposed to information, cannot be easily codified (Audretsch and Lehmann 2006), and is therefore quite expensive and difficult to transmit over great distances, whether geographical or cognitive (Audretsch and Lehmann 2006; Huggins and Johnston 2010).

"Buzz": In the air, or on the ground?

"Buzz" (also termed "local broadcasting" by Owen-Smith and Powell [2004]) consists in "the information and communication ecology created by face-to-face contacts, co-presence and colocation of people and firms within the same industry and place or region" and is characterized "by being frequent, broad, relatively unstructured and largely 'automatic'" (Bathelt et al. 2004, 38, 40). Buzz falls under the category of "sticky" knowledge as it is entirely specific to a given location (region, etc.).

Although Marshall famously explained that the advantages inherent to such economies were simply "in the air" of the bounded region (Marshall, 1920, in Bathelt et al., 2004), this has been completely disproved by several authors and studies (Bathelt et al. 2004; Guiliani and Bell 2005). Indeed, Bathelt et al. (2004) specify that though cluster members do not have to make any particular investments to tap into this buzz, it does not mean that they become automatic receptors of this buzz. Their participation in various cluster spheres is necessary to make it meaningful, as it is through this participation that cluster actors are able to develop a shared language and attitudes towards technologies within a given field, which reduces cognitive distances, and allows them to apply shared interpretive schemes and understanding of new knowledge and technologies. (Bathelt et al. 2004)

Knowledge pipelines

Pipelines, or global linkages between organizations (Lorenzen and Mudambi 2013), are channels created, used and maintained in distant interactions and resource flows that give cluster member access to extra-cluster (as opposed to inter-cluster) knowledge (Bathelt et al. 2004; Lorenzen and Mudambi 2013), and are necessary to promote new knowledge combinations. (Bathelt et al. 2004) These pipelines are a means for the connecting organizations to efficiently move knowledge and resources "across geographical space by creating organizational commonality at both ends of the pipeline through common ownership or strategic alliances." (Lorenzen and Mudambi 2013, 503) A cluster with multiple pipelines (i.e. where cluster actors have linkages to sources of knowledge outside the cluster) is considered to have an 'open' knowledge system. (Guiliani and Bell 2005) Although both buzz and pipelines give clusters access to tacit knowledge, pipelines are fundamentally different from buzz because of the way they are formed. Namely, because pipelines require a great deal of investment in terms of time and costs, firms and institutions must be strategic in their choice of partners, and part of this strategy involves targeting

specific knowledge. As a result, significant institutional and infrastructure support is required to develop pipelines, especially global pipelines. All resulting knowledge injected into the cluster is focused, narrow, deliberate and exclusive. (Bathelt et al. 2004) Without external pipelines, firms are at risk of becoming overly familiar with existing knowledge, thereby negatively impacting new knowledge creation and innovation and cognitive lock-in. (Huggins and Johnston 2010)

3. Conceptual framework and research propositions

After a close analysis of the literature, the following gaps and weaknesses have been identified and addressed in a conceptual framework that ensures a cross-fertilization of the three bodies of literature. This conceptual framework will in turn be leveraged to test research propositions that will ultimately serve to help determine the impact of institutional interactions on cluster health.

3.1 Conceptual framework

1) GIVEN that institutions, despite being recognized as a constituting element of clusters and a key element in the evolution of cluster life cycles and cluster health, are often treated as a *fait accompli* in both cluster literature and network literature (Sölvell 2008; Guiliani and Bell 2005; Lorenzen and Mudambi 2013; Turkina et al. 2019; Huggins and Johnston 2010; Menzel and Forhnal 2007; Porter 1998; Dalum et al. 2002; McEvily and Zaheer 1999; Nelson and Nelson 2000; Nelson and Sampat 2001), perhaps because institutions, and the institutional environment, are difficult to define (Hodgson 2006, 2015; Balthelt and Glückler 2014; Edquist and Johnson 1997);

2) GIVEN that the research that attributes a greater role to institutions in cluster or market dynamics, specifically due to their role as policymakers, facilitators and mediators, is more conceptual in nature (Carpinetti and Lima 2013; Steiner 2006; Audretsch and Lehmann, 2006; North 1991);

3) GIVEN that research has struggled to incorporate institutions in models of economic growth (Tebaldi and Elmslie 2008);

4) GIVEN the absence of quantitative analysis of the structural properties of institutional networks (i.e. institutional relationships) and the need to validate the conceptual research on institutions;

5) GIVEN that institutions have never been quantified in isolation;

6) GIVEN that institutions, because they are not part of the supply chain, can only have horizontal relationships (Turkina et al. 2019);

7) GIVEN that institutional literature allows for a treatment of individual institutions as a reflection of the broader institutional environment (Hodgson 2006, 2015), any findings relating to institutional ecosystems and interactions can be generalized, and become particularly meaningful in context;

8) GIVEN the role of embedded relationships in driving economic action (Bathelt and Glückler 2014); and

9) GIVEN that networks are a universal phenomenon (Johnson 2008; Johnson and Rogers 2005), all the indicators associated with the network structure, node positions and linkages that are applied to firms can also be applied to institutions;

THEREFORE, this research will apply a network analysis methodology to a cluster's institutional ecosystem to determine its structural properties and characterize its interactions, and the resulting findings will be contextualized within a case study and the cluster literature, thereby blending institutional and relational logics to firmly incorporate institutions in a framework of cluster health.

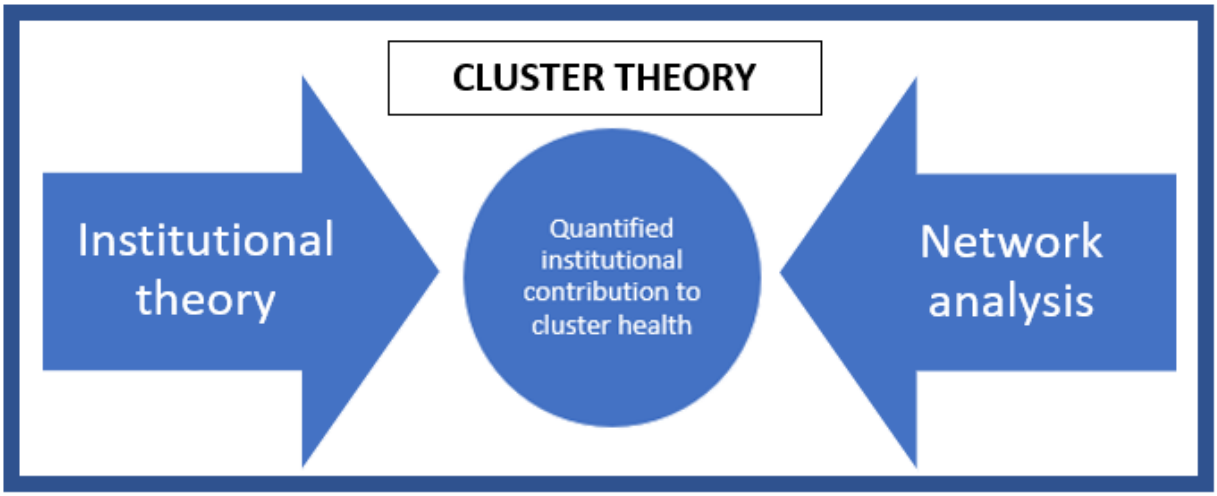


Figure 2: Conceptual framework

3.2 Propositions

In light of the above conceptual framework, seven (7) propositions—grouped under five (5) themes and bearing on the structural properties of institutional networks—will be tested.

Institutional environment

Institutions are rule-based systems that reflect the wider environment. As such, we propose that they will tend to organize in network structure with a more highly connected core. This would represent an observation that in any system, certain institutions tend to be more powerful than others, and they tend to band together. Furthermore, in keeping with institutional logic, which states that institutions are more likely to be resistant to innovation as a source of uncertainty, this type of structure is also not particularly conducive to innovation.

P1: Institutions tend to organize in hierarchical network structures.

Brokerage

Institutions are designed to serve the cluster, particularly in their functions as facilitators and mediators. As such, it follows that they are naturally inclined to be brokers, which fulfill these same roles. We expect to find a large proportion of brokers in this network.

P2.1: Institutions are naturally inclined to be brokers.

Strategic brokers are key to innovation, as they have the ability to bridge the network's structural holes and create or control knowledge flows and achieve different knowledge combinations, which can benefit the network, themselves, or both. However, we propose it is possible to have *too many* brokers. In other words, having too many cooks in the kitchen has a detrimental effect on the network, as it creates a disbalance in the network, whereby its existing potential knowledge combinations are exhausted before sufficient new knowledge can be introduced to mix things up.

P2.2: Networks with too many brokers are at risk of developing redundancies.

Horizontal relationships

As mentioned, institutions cannot develop vertical relationships because they are not part of the supply chain. (Turkina et al. 2019) The benefit of this research, however, is that it zooms in on and accentuates inter-institutional relationships in order to seize their limits. We propose that horizontal relationships do not have the same capacity for endless expansion as vertical relationships. Indeed, as institutions are more geographically bounded than firms and have limited interest in forming relationships with other institutions if they do not have similar mandates or objectives, they are at risk of focusing on their network and exhausting the possible relationships contained within it, rather than look outside of their comfort zone.

P3: Networks with an overreliance on horizontal relationships are at risk of developing redundancies.

Institution size

Given that size is a good indicator of available resources, we propose that the bigger institutions have a greater absorptive capacity for technological advancements.

P4.1: Institution size is positively correlated to absorptive capacity for technological advancements.

By the same logic, we propose that the bigger institutions have the resources to make more connections with well-connected nodes.

P4.2: Institution size is positively correlated to network centrality.

Knowledge flows

Finally, because institutions are designed to provide support to the cluster and assist economic growth, we propose that it follows that when institutional knowledge flows well through a network, and in a way that promotes innovation, the institutional network has a positive impact on cluster health. Alternately, we propose that poor knowledge flows that stifle innovation have a negative impact on cluster health.

P5: Constructive institutional knowledge flows have a positive impact on cluster health, and stagnant knowledge flows have a negative impact on cluster health.

4. Methodology

4.1 Research strategy based on mixed methods

In order to answer the research question and situate the broad and specific impacts of institutional interactions on a cluster's economic health and support the propositions made, it is necessary to incorporate institutional considerations in the relational view of clusters. This cross-fertilization will be achieved through the application of mixed methods. Specifically, a social network analysis will serve to quantify a cluster's institutions in isolation and derive generalizable findings, which will then be contextualized within the case study, resulting in applications for cluster theory, institutional theory and network theory.

As mentioned in the literature review and summarized in the conceptual framework, network analysis can be used to characterize the broader institutional environment, make generalizations regarding the impacts of institutional environments on cluster health, and determine the specific impacts of different types of institutional interactions.

Social network analysis is particularly apt for bridging the gap between the cluster, institutional and relational strands of the literature, as it makes it possible to map the institutional ecosystem and provide exact measurements regarding interactions and knowledge and resource flows. Furthermore, it provides qualitative justification to the institutional literature, which is a largely conceptual body of literature.

The case study, on the other hand, serves three purposes: 1) it addresses the exploratory nature of the research question ("What is the role of institutional interactions on cluster health"), whose goal is in part to "develop pertinent hypotheses and propositions for further inquiry" (Yin 2014, 10); 2) it addresses some of the limitations of network analysis, which will be addressed below; and 3) by investigating "a contemporary phenomenon in depth and within its real-world context," (Yin 2014, 16), it sheds light on network analysis findings, and allow these findings to become particularly meaningful.

Network analysis and a case-study approach are complementary in the sense that they are both a response to each other's weaknesses. One of the strengths of network analysis, as mentioned, allows for abstraction, which in turn makes the findings highly generalizable (Johnson 2008; Johnson and Rogers 2005). This mediates an often raised concern of case studies, being that it is difficult to generalize their findings (Yin 2014) as they arise from a particular context. This strength of network analysis, however, is also a weakness, insofar as it is important to contextualize the findings for them to find their full meaning. The case study fills this purpose.

The testing ground chosen for this research was the institutional network of the Montreal translation cluster. This cluster was deemed particularly apt for the investigation at hand, for a number of reasons: 1) the cluster has a long, established history, spanning centuries, making it possible to identify different stages in the cluster life cycle; 2) close to half of the "firms" in this industry are in fact micro-enterprises and freelancers whose principal connections are to the cluster institutions as opposed to other firms, which has the effect of amplifying the effect of the institutions and institutional interactions; 3) this "traditional" cluster is undergoing disruptive change fueled by advancements in AI; 4) a strong AI cluster has established itself in Montreal, creating the possibility for geographically-motivated bridges; and 5) given my own involvement as a participant and volunteer at OTTIAQ, it was possible to secure a greater response rate, for both the questionnaire and the interviews.

4.2 Network analysis

4.2.1 The roster-recall method

The roster-recall method will be used to measure institutional interactions (i.e. linkages) and map the institutional network. The "roster" part consists in sending each respondent a matrix-type questionnaire containing a list of all the names of other institutions in the cluster and a series of concrete questions with respect to their interactions (Ponds and Weterings 2009; Guiliani and Bell 2005; Guiliani and Pietrobelli 2011; Boschma and Ter Wal 2007). For each question, respondents were asked to check all applicable institutions, thereby measuring the existence or significance of linkages. (Guiliani and Pietrobelli 2011; Boschma and Ter Wal 2007) As it may be difficult to include all network actors on the roster, the "recall" portion consists in asking the institutions to list the applicable organizations that are not on the list. (Guiliani and Pietrobelli 2011; Boschma and Tel Wal 2007) This also serves to establish pipelines outside the cluster, where external knowledge can enter the cluster.

This methodology contains significant caveats: It only works if you know all or most of the actors in the cluster, and it requires an extremely high participation rate, which make it better suited for small networks. (Guiliani and Bell 2005; Turkina et al. 2016) This makes this methodology particularly suited for the Montreal translation cluster's institutional network, which contains only 18 actors (see Appendix B for a complete list, description and justification of network actors). Furthermore, when the roster-recall method is applied to an entire population, the relational data collected is highly effective for two reasons: 1) it makes it possible to study the entire network (Guiliani and Pietrobelli 2011), which makes findings highly generalizable; and 2) it prevents human error associated with faulty memory, insofar as all respondents can consult the entire list of network actors. (Guiliani and Pietrobelli 2011)

One limitation of the roster-recall method, which was observed during data compilation, is that it appears to unintentionally bias respondents to limit themselves to the institutions on the roster, despite the presence of the "recall" function. This will be explored in further detail below.

4.2.2 Respondents

A total of 18 institutions was eventually identified in the network. Institutions were primarily identified using my own knowledge of the network, cultivated over 10 years of active professional translation experience, and validated and augmented through online research, casual exploration interviews with industry representatives who were present at OTTIAQ's annual conference (November 19, 2016) and a discussion with OTTIAQ's president of the board of directors. Note that the roster, however, only includes 15 institutions. The last three institutions—AGCL, ACJT and CATS—were identified through the recall function, and subsequently incorporated into the network.[5]

Once the institutions were identified and included on the roster, it was necessary to select or target respondents who would have a solid overhead, multifaceted view of the institution's operations and/or partnerships (see Appendix XXX). To ensure the highest possible participation rate, I relied on my own extensive network in the industry, as well as frequent follow-up, which was conducted both through email, as well as, in the case of the LTAC and Concordia University, in person, as the survey respondent and I were all present at an industry event. For the respondents not directly inside my network (CTTIC, AILIA and SQRF), I also reached out by email, and eventually received 13 completed questionnaires.

[5] Once identified in the recall section, the questionnaire was also sent to representatives from the ACGL and ACJT. CATS, however, was only identified towards the end of data compilation, through its linkages with the university group, and was therefore incorporated during data compilation. In fact, two institutions were identified by the university respondents: the Canadian Association for Translation Studies (CATS), and the Canadian Association of Schools of Translation (CAST). However, only CATS was added to the network because 1) CAST is likely to repeat the same linkages, and therefore omitting it is unlikely to meaningfully impact the network and findings, and 2) CAST's online presence is almost inexistent (no website, no social media presence), as opposed to CATS, which has a website. Linkages between CATS and other network actors was determined using its 2018-2019 member directory (http://act-cats.ca/wp-content/uploads/2019/05/R%C3%A9pertoire-2018-2019.pdf) and as well as its Spring 2017 newsletter (http://act-cats.ca/wp-content/uploads/2014/12/Spring-Printemps-2017-CATS-ACT.pdf), which showed that 1) prominent executive and committee positions were held by faculty from Concordia University and Université de Montréal; 2) the Associate Director of the McGill University Department of Translation Studies; and 3) FIT was identified as a partner. In light of the responses provided by these respondents in their questionnaires, these linkages were qualified as "weak." (See

Table 1: Three-point scale).

4.2.3 Questionnaire

I created a questionnaire (see Appendix A) containing a matrix of the 15 actors and 10 questions to measure concrete examples of institutional. The roster-recall method requires that the questions be concrete, as opposed to vague, abstract or general. (Guiliani and Bell 2005) In other words, it is not sufficient to ask actors to self-evaluate their level of collaboration with the other actors on a scale. Rather, they must check off all the institutions that apply for the 10 different concrete scenarios described by the questions, such as "Org X attended an event organized by:" "Org X follows these organizations on social media," "The following organizations are formally qualified as Org X's partners". What's more, different questions measure different levels of collaboration: Whereas the first four questions (A, B, C and D) portray minimal interactions, the following six (E, F, G, H, I and J) convey more meaningful, integrated activities.

Finally, for each question on the matrix-type questionnaire, respondents were asked to list ("recall") other institutions and/or private firms that were not included on the roster, in order to establish external pipelines.

The choice was made to administer entirely directed questionnaires via email in order to reduce the time commitment required of respondents. To that end, the questionnaires were also designed to be very simple and streamlined (a 2-page fillable PDF where, for the most parts, respondents only had to check those that applied), and designed to take only 5 to 10 minutes to answer. Indeed, as the response rate is critical in the roster-recall method, I decided to prioritize this aspect by making the process as quick and easy as possible for respondents.

There were limitations to this approach. Although respondents were encouraged to identify both institutions and firms other than those listed on the roster in an effort to find extra-cluster linkages, I suspect that both the specific mention of the *Montreal translation cluster* in the instructions and the specified actors listed on the questionnaire acted as a form of blinders or preference for respondents, where they limited their consideration to translation-industry and geographically-bounded actors. Based on the validation interviews (see below), where respondents were explicitly encouraged to consider actors outside of the cluster, it appears that this risk, for the most part, did not materialize. However, in the case of the Translation Bureau, whose answers were principally contained to the broader translation community, it appears this bias may have had an impact; as the Translation Bureau is part of Public Services and Procurement Canada, it is difficult to believe that it would not have border-spanning linkages through the Federal government. Had I administered these questionnaires in person, it would have been

easier for respondents to ask questions or for me to provide additional specifications. However, given the importance of streamlining the process to get the highest possible response rate, this was not possible within the scope of this research.

4.2.4 Data collection phase

I initiated data collection on March 5, 2019, had hoped to complete the quantitative data collection within two weeks. However, despite follow up, it took approximately 12 weeks before I could achieve an 76% response rate (13 out of 17 respondents).[6,7] This was not entirely surprising, as many respondents had high-responsibility jobs, in addition to the volunteer positions they held at the institutions in question (see Appendix B for the list of respondents). However, give that a high response rate is critical to the roster-recall method, I extended the period of data collection as needed. I do not believe that the extended period of data collection had any discernable impact on the research results.

4.2.5 Dataset

The data was compiled in an "undirected," symmetrical matrix, where, for the purposes of this research, the relationships are assumed to be based on "mutual linkages," as opposed to a "directed" matrix, where relationships are asymmetrical (i.e. knowledge or resources may flow primarily in one direction). (Guiliani and Pietrobelli 2011, 26) Undirected networks are generally chosen when relationships are measured based on their geographical proximity or the presence of joint projects or agreements (Guiliani and Pietrobelli 2011). As this research contributes to cluster theory—which is by definition geographically bounded—and the questionnaire was designed to identify the presence of partnerships and joint initiatives, among other things, the logical choice was to build an undirected network.

The relational value of the relationship between the different nodes was measured using a 3-point scale (see Turkina and Postnikov, 2012), in keeping with Dyer and Singh's (1998) relational view. Once respondents had completed the questionnaires and reported their interactions, it was possible to assign a single value to the relationships between the institutions that represented the depth of their ties, as follows:

[6] Unfortunately, the questionnaire file from Concordia University was corrupt, and some data on this questionnaire was lost. To establish missing linkages, I relied more heavily on the reported linkages from other respondents, and filled in gaps with information found online.

[7] Note that if the 18th institution is included in this calculation, the response rate is 72%.

Table 1: Three-point scale

Points	Relationship	Characterization of interactions	Reported interactions (questionnaire)
0	None	No interactions	Did not check institution for any of the questions
0	Below threshold	Interactions constitute "noise" in the network.[8]	Checked institution for only one of the first four questions (A, B, C, D)
1	Weak	Minor interactions between network actors (Turkina and Postnikov 2012, 639)	Checked institution for at least two of the following five questions: A, B, C, D, J; **OR** Checked institution for one of the following five questions: A, B, C, D, J, **AND** one of the following five questions: E, F, G, H, I; **OR** Checked institution for only one of the following questions: E, F, G, H, I
2	Strong	"[I]ntensified interactions through joint cooperation (for instance, joint ventures or strategic alliances" (Turkina and Postnikov 2012, 639) Repeated, meaningful or diverse interactions between institutions.	Checked institution for at least two of the following five questions: A, B, C, D, J **AND** one of the following five questions: E, F, G, H, I; **OR** Checked institution for at least two of the following five questions: E, F, G, H, I

Although question J was initially grouped under "strong" relationships, upon receipt of the completed questionnaires, it appeared that not only were informal relationships quite common, but they were moreover not necessarily a gauge of strong relationships. This became particularly clear during the interview with Donald Barabé, President of OTTIAQ, who, when asked to identify partners of more secondary importance, identified those with whom, under the previous scale, would have been categorized as strong. The categorization of relationships was therefore modified to reflect this reality.

[8] As all institutions interact at some level with most of the other actors in the network, it was necessary to remove some less intensive collaboration in order to find more meaningful results or patterns. (Meeting with Ekaterina Turkina, 2016)

Another issue encountered with the methodology was related to the choice to build an undirected network. Specifically, respondents did not necessarily place the same value on their reciprocal relationships. For instance, Respondent A signaled a strong relationship with Respondent B, whereas Respondent B signaled a weak or even inexistent (or below threshold) relationship with Respondent A. Given that undirected networks must be symmetrical, it became necessary to adjust certain values. The following two rules were used to that end:

1) If Respondent A = 0 and Respondent B = 2, the average of the two was entered in the matrix.

2) If Respondent A = 1 and Respondent B = 2, greater weight was accorded to the answer of the actor that was perceived to be more outwardly "powerful" (in terms of size, influence, etc., as appropriate); it was a value judgment.

Once the relationships were measured, the values were compiled in a matrix in Excel, where red highlighted cells correspond to network actors who did not complete the questionnaire, and yellow highlighted cells correspond to instances where respondents gave divergent answers and required the application of the above rules:

Table 2: Matrix of relational data

	OTTIAQ	CLEF	ACJT	ALCIT	LTAC	NTE	SQRP	Concordia	UdeM	McGill	TB	OQLF	EAC	CTTIC	AILIA	FIT-NA	ACGL	CATS
OTTIAQ																		
CLEF	2																	
ACJT	1	1																
ALCIT	1	0	0															
LTAC	1	1	0	0														
NTE	1	2	1	0	1													
SQRP	1	1	1	0	0	1												
Concordia	2	1	1	0	2	1	0											
UdeM	2	0	1	0	2	1	0	2										
McGill	1	0	2	1	1	1	0	1	2									
TB	2	0	1	0	0	1	1	1	2	0								
OQLF	1	0	1	0	0	1	1	1	1	0	1							
EAC	1	0	0	0	1	1	1	0	0	0	1	0						
CTTIC	0	0	0	0	0	0	0	0	0	0	0	0	2					
AILIA	2	1	0	0	1	1	0	0	0	2	2	1	1	0				
FIT-NA	2	0	0	0	0	0	0	0	0	0	0	0	0	2	1			
ACGL	1	0	1	0	0	1	0	0	1	0	1	0	0	0	1	0		
CATS	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	

The matrix was then imported into UNCINET, a network analysis software that generates networks and performs the necessary mathematical and statistical operations to calculate the indicators detailed in the literature review.

4.2.6 Attributes

Attributes were also compiled to enrich the dataset and the network. These attributes, which were determined using information that was easily available on the websites of the respective institutions, were 1) size; and 2) interactions with technology.

4.2.6.1 Size

For the purposes of this research, an institution's size was taken to mean the larger of one of the following, as applicable: number of employees, members, or students. For certain institutions whose members constituted other institutions or firms, the total membership represented was taken into consideration only when the membership belonged to an institution. In other words, the employees of firms who were the members of an institution were not taken into account, but the members of institutions who were in turn members of an institution were taken into account. Note that according to this scale, 1 corresponds to the smallest institutions, and 3, the largest. (See Appendix C for justifications and sources.)

Table 3: Institutions by size

Institution	Size
OTTIAQ	2
CLEF	1
ACJT	1
ALCIT	1
LTAC	1
NTE	1
SQRP	1
Concordia	3
UdeM	3
McGill	3
TB	2
OQLF	2
EAC	2
CTTIC[9]	2
AILIA	3

[9] The CTTIC was used as the cut-off for Category 2 size. Although they represent 3500 members, the fact remains that they only have 7 members, all of which, individually, are smaller than OTTIAQ (2100 members). It also did not make sense to group them in institutions representing 80,000 members (FIT).

FIT	3
ACGL	1
CATS	1

4.2.6.2 Interactions with technology (relative absorptive capacity)

Institutions were assigned a value—on the same scale of 1 to 3 as above, where 1 corresponds to the least interactions, and 3, the most—based on their relative absorptive capacity with respect to the latest technologies. A value of 1 indicates that an institution does know have the sufficient knowledge base to understand the latest developments in AI and NMT, and this is reflected by a lack of information on their website about these disruptions, and will at most inform members or the public to approach these technologies with caution. At the other end of the scale, a value of 3 indicates that an institution has sufficient knowledge to synthesize the technological developments for their members, offering usage guidelines, information, training, etc., and perhaps even encouraging members to embrace these changes. In other words, an institution whose overall approach is to embrace technological disruptions and attempt to integrate it into the industry is valued at a 3, whereas an institution that offers information on technological disruptions while urging caution or avoidance rather than working to structure its use is valued at 2. (See Appendix D for justifications and sources).

Table 4: Institutions by their interactions with technology (relative absorptive capacity)

Institution	Interactions with technology
OTTIAQ	3
CLEF	1
ACJT	1
ALCIT	1
LTAC	1
NTE	1
SQRP	1
Concordia	3
UdeM	3
McGill	3
TB	3
OQLF	3
EAC	1
CTTIC	2
AILIA	3
FIT	3
ACGL	3
CATS	1

4.2.7 External pipelines

As mentioned, the questionnaire offered respondents the opportunity to identify actors that had not been included in the roster in order to identify external pipelines. However, few respondents added additional actors in space provided (see section 8.1 for discussion). Nonetheless, sufficient respondents volunteered other actors to shed additional light on the network structure and network dynamics.

A value was assigned to each relationship using the same 3-point scale above. Note that a number of actors who had been identified by respondents as outside the network did not meet the minimum threshold; as a result, these actors appear on the network, but are not connected to it. Some respondents also identified specific translation firms. However, all individual translation firms were grouped under the heading "Translation Firm," for two reasons: 1) given the lack of data on this respect, it would have been statistically insignificant to include relationships to disparate firms; and 2) for the purposes of this research, it is more meaningful to recognize a general connection to private sector actors, and grouping all identified firms under this broad heading accomplishes that.

Table 2 was expanded using the data on pipelines compiled on these questionnaires. This data was furthermore supplemented with the following assumptions:

All universities with a co-op program were assumed to have a weak relationship with translation firms.

All institutions whose members included translation firms were assumed to have a strong relationship with translation firms.

All universities incorporating OTTIAQ's mentorship program into their curriculum were assumed to have a strong relationship with OTTIAQ.

CTTIC was assumed to have a strong relationship with ATIO and ATIA, given that these two trade associations are members.

All universities who participate in the Translation Games were assumed to have strong relationships with the latter.

The Barreau du Québec was assumed to have the same relationships with the Conseil interprofessionnel du Québec (CIQ) and the Office des professions du Québec (OPQ) as OTTIAQ.

Finally, the data was also enriched using information collected during the interviews.

Similarly to the matrix in Table 2, this compiled data was imported into UCINET in order to produce networks and run analyses. The results are presented in Section 66: Network analysis.

Note that although the information on external pipelines is highly limited due to the issues surrounding data collection, it nonetheless served to draw limited conclusions that shed light on overall network dynamics. Naturally, however, these conclusions must be approached with care.

4.2.8 Limitations of network analysis

Although SNA is a highly robust methodology that can be used to shed valuable light relationships and knowledge and resource flows within networks, which can in turn be used to determine the actors' ability to adapt to change, it does contain a number of limitations. For one, the network produced by this research offers only a snapshot in time. It does not provide any insight on the evolution of linkages over time and past responses to environmental changes. Furthermore, the linkages between node actors represent only one type of relationship between them (Guiliani and Pietrobelli 2011); in this particular case, the linkages relate to information sharing. It does not reflect overtures made between network actors for future strategic projects that could have a structuring effect on the overall network (e.g. partnerships to work on developing international standards or certifications). Networks, in isolation, are also relatively context free. While this makes the results easily generalizable, it is also important to accompany the networks with some background information for these same findings to also become meaningful. There was also a limitation in the data-collection tool (questionnaire), insofar as even though respondents were encouraged to identify both institutions and firms other than those listed on the roster in an effort to find extra-cluster linkages, I suspect that both the specific mention of the Montreal translation cluster in the instructions and the specified actors listed on the questionnaire acted as a form of blinders for respondents, where they limited their consideration to translation-industry and geographically-bounded actors. This was particularly clear in the example of the Translation Bureau, as explained above.

The case study, and the interviews in particular, helped to mitigate the limitations of the network analysis, identified above. Indeed, as a single network depicts the relationships at a snapshot in time, it would be necessary to produce different snapshots of the network in order to measure the evolution of these relations or determine the impacts of certain events. For instance, it would have been particularly interesting to provide a longitudinal view that included the year 2016, which marked the launching of NMT by Google and the rapid expansion of the Montreal AI cluster, in order to discern any changes in the institutional interactions in response to this technological disruption. However, the interviews made it

possible for the chosen respondents to flesh out the relationships, provide context about their evolution over time, offer their projects for the future, and touch on the impacts stemming from 2016. Although this insight could not be incorporated into the network itself, it did prove quite useful for the analysis.

Additionally, the case study provided the necessary context to make the generalized findings of the network analysis more meaningful.

4.3 Case study

4.3.1 Strengths of case studies

Case studies incorporate a variety of evidence (e.g. documents, interviews, observations) to represent a real-world context in a way to better illustrate the boundaries between the phenomenon under investigation and the context from which it arises (Yin 2014). The rich context provided by a case study not only addresses the limitations of network analysis, discussed above, but it also serves to reinforce the cross-fertilization between the bodies of literature, especially since this case study was constructed through the lens of a cluster's institutional environment through the different stages of growth.

4.3.2 Evidence used for case study

This case study was constructed using the research of recognized Canadian translation industry historian, Jean Delisle, C. Tr., news articles, industry publications, my own knowledge of the cluster (based on my professional experience as a translator, high-level involvement at OTTIAQ and my participation in numerous professional conferences over the years) as well as five (5) interviews with individuals in executive positions within the institutions surveyed.

Interviews were semi-structured: they were conducted in open-ended follow-up to the questionnaires, but had a common thread of asking interviewees to provide context on the identified partnerships (i.e. attempt to trace the evolution of some of the more meaningful partnerships) and to ask their opinions about the strengths and challenges of the translation industry, including the technological disruptions. Specifically, respondents were asked to elaborate and provide context on their most and least important relationships, based on how they completed their questionnaire, discuss industry challenges, and, where appropriate, how their institution responded or planned to respond to past and current technological disruptions. Interview were designed to achieve its objectives within 15 to 20 minutes, in case the interviewees had limited time. However, as the questions were open-ended, it was possible to cover additional ground and go into greater depth on certain topics if time permitted.

The interviewees—OTTIAQ, AILIA, NTE, ACJT and FIT-NA—were chosen after analysis (whether preliminary or more advanced) showed the high level of impact they had on the network. Two respondents, OTTIAQ and AILIA, were chosen as it was suspected to be highly central actors. AILIA in particular was selected as the completed questionnaire revealed a number of potential pipelines. NTE was targeted after the network analysis showed it to be highly central in the network, despite its small size, and a deeper exploration into its practices was desired to shed greater light on network dynamics. Similarly, ACJT was chosen due to the high number of connections reported despite the small size of the institution, as well as to the particularly informed interest of its president on the issue of the translation cluster. The final respondent, FIT-NA, was also chosen post-analysis, to determine why, in context, a peripheral actor could have such a structuring effect on the entire network.

4.3.3 Limitations of a case study approach

As mentioned in the introduction, it can be difficult to generalize the findings of case studies (Yin 2014), as they are, by definition, anchored in a highly specific and individual context. However, the case study was not the primary vehicle for reaching findings; although a number a preliminary observations were made following the case study, these observations are not meant to stand alone. Rather, they serve to validate and/or reinforce, where applicable, the findings from the network analysis, and provide the foundation for the cross-fertilization of literatures. As a result, this particular limitation is largely addressed in the complementary nature of the two methodologies.

Researcher bias is also a risk in case studies,[10] and this was particularly the case given my own professional involvement in this cluster. Again, however, the fact that the case study primarily served to validate and contextualize the findings from the quantitative analysis, which is less prone to bias, significantly mediated this limitation, as did my efforts to remain critically mindful of this bias through every stage of this research.

4.4 Ethical considerations

Given that the respondents are not people deemed vulnerable within the institution due to their management or leadership roles (i.e. respondents were not considered to be at risk of losing their position), the ethical considerations were fairly minimal, and consisted in the requirement to obtain their free and informed consent.

As such, in keeping with Research Ethics Board (REB) guidelines, all respondents were sent am REB-approved consent form before completing the questionnaire/matrix and/or the interview. The consent

[10] https://www.universalclass.com/articles/business/a-case-studies-strengths-and-weaknesses.htm

form not only sought to obtain the free and informed consent of participants, but also reinforced the voluntary nature of their participation and their right to refuse any and all questions. It also provided participants with a summary of the research project and the contact information of the primary researcher and research supervisor. This way, respondents were sure to properly understand what is implied in their participation, and were equipped with the necessary information to ask questions as needed.

With respect to confidentiality, the consent form informed participants that all data collected would be kept in a secure location (password protected workstation) and would not be discussed with people outside of the research team. Participants were assured that the data collected would not be used for purposes other than then "the advancement of knowledge and the dissemination of the overall results in academic or professional forums."[11]

[11] From Appendix D: Instructions included with a questionnaire, provided by the REB Secretariat.

5 The Montreal translation cluster: A case study

5.1 Introduction

The translation industry in Montreal constitutes a cluster, falling under the Porter definition (1998, 197, 226), as follows:

> *"Clusters are geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions in a particular field, linked by commonalities and complementarities. […] A cluster is a form of network that occurs within a geographic location, in which the proximity of firms and institutions ensures certain forms of commonality and increases the frequency and impact of interactions."*

Specifically, there is a large, highly qualified workforce; three universities (McGill University, Concordia University and Université de Montréal [see Appendix B]) that offer dedicated translation programs, as well as a smattering of cegeps offering the odd practical translation course; a variety of firms—from microenterprises (freelancers), SMEs and multinationals—and dedicated vertically integrated departments (Hamilton 2010); varied business activity characterized by entrants, exits, mergers and acquisitions; a range of institutions, from a professional order (OTTIAQ) to half a dozen translation associations organized by specialization or theme (ALCIT, ACJT, ACGL, LTAC, NTE, CLEF [see Appendix B]); software developers, and conferences attracting industry people from all over the world. Significantly, there is also legislation (*Official Languages Act* [federal], *Charter of the French Language* [provincial]) as well as a particular demographic[12] that creates high demand (Hamilton 2010; Nadeau 2017). Finally, a massive federal government translation agency—the Translation Bureau—is the largest employer of translators in Canada (Hamilton 2010), a major purchaser of translation services in Canada and recognized standards bearer (AILIA 2016). Due to the long history of this industry and its legislative requirements, among other things, the Canadian translation industry is recognized around the world for quality. (Hamilton 2010; Archibald 2017)

The significance of Montreal in the translation industry, both in Canada and globally, is evident when you look at the numbers. There are estimated to be 15,000 translators and other language professionals in Canada (Hamilton 2010), and a conservative estimate from 2012 states that about 8000 of them are in Quebec. (Nadeau 2017) In 2006, Canada was also a worldwide leader in the global translating market with a domestic market representing 10% of global demand, despite only having 0.5% of the world's population (Hamilton 2010)—and the lion's share (90%) takes place in or for the province of Quebec (Cloutier 2013),

[12] One-quarter of the entire Canadian population speaks French, and they are geographically concentrated in Quebec. (Hamilton 2010)

which in turn largely takes place in Montreal. (Nadeau 2017) Furthermore, 80% of Canadian translators are trained in Quebec (Nadeau 2017), and OTTIAQ is by far the largest and most impactful institution of its kind in Canada, both in terms of numbers (OTTIAQ has over 2100 members, whereas ATIO has about 1000 members, and other translation associations with similar mandates in other provinces have 100-200 members) (interview with Ms. Cousineau) and the powers that stem from its legal mandate, as per the *Professional Code* (interview with Mr. Barabé).

However, as discussed in the literature review, clusters, including their institutional environments, are not born fully formed. Using existing literature, news articles, industry publications and interviews, this case study will look at the origins of the Montreal translation cluster and trace its evolution through history in order to inform its current status, from a technological, economic, legislative, social, and—most significantly—institutional point of view. The resulting portrait, complete with industry insights, will in turn shed light and provide context to the social network analysis of its institutions in order to make the findings particularly meaningful.

5.2 The evolution of the Montreal translation cluster life cycle

5.2.1 Centuries in the making: the emergence of a cluster

The Montreal translation cluster can trace its roots to historical accident (British and French mercantilism and colonial expansion), the imported institutions, and the resulting cultural dynamic.

Specifically, we look to the 16th century, when Jacques Cartier first sailed across the Atlantic and into the St. Lawrence. When he planted a cross in Gaspé, unknowingly baptizing coastal villages and towns throughout in his journey, and dropped anchor in Hochelaga, he was planting the seeds and implanting the institutions into what would eventually become the colony of New France. In the meanwhile, Britain was busy doing the same, colonizing the rest of North America. Both superpowers continued to expand on their respective territories for nearly two hundred years, but by the mid-18th century, territorial and maritime skirmishes gathered steam and the French and Indian War eventually led to Britain's takeover of New France.

Whereas France's policy for colonialism had always been to assimilate ("civilize") the native population, Britain's approach was more one of "indirect rule," where some aspects of government (taxes, military) were taken over by the British, but the colony was left to its own devices in terms of everyday operation (American Historical Association, n.d.).

New France, now Eastern Canada, was no exception to the British Empire's modus operandi, and a number of laws were put in place to allow the French settlers to govern themselves under British rule.

As a result of this, Quebec was never fully "assimilated" into the rest of the country, and was able to not only maintain its language, religion, legal system and other institutions, but moreover develop its own traditions (Delisle 1987). Indeed, from war arose a "great tradition of bilingualism and bijuridism" (interview with Mr. Fortier). Two groups of Eurocanadians—the representatives of historic enemies—began living side by side, with their respective languages. What arose from the colocation of these strange bedfellows was a growing level of translation both at the government and even, as demonstrated by this first example, at the grassroots level: Quebec was the site of the first publication of a bilingual gazette (the Quebec Gazette) in North America (1764); the first official translator was designated by the lieutenant-general of Quebec (1768) and an official interpreter was designated for the provincial courts (1777-1786); the Legislative Assembly of Upper Canada adopted a resolution calling for the translation of the colony's laws into French (1793); following the adoption of the British North America Act of 1840, which officially united Upper Canada and Lower Canada and made English the only official language, a bill was passed to ensure the French translation of all legislative texts (1843); Montreal, a city in French territory, was made the national capital of Canada (1844), until the French rose up and torched down the building housing the Assembly in 1849 to show their discontent, and requiring the government translators to travel between Quebec City and Toronto whenever the assembly was in session (1850 to 1866). (Delisle 1987).

5.2.2 First growth phase, followed by the sustaining phase

There have been two notable growth phases in the translation cluster. The first started at the turn of the 20th century with the change of hiring procedures for federal translators (competition based)) (Delisle 1987) and lasted to about 1940 with the creation of the Société des traducteurs de Montréal (STM), which would eventually become the Ordre des traducteurs, terminologues et intérprètes agréées du Québec (OTTIAQ) in 1994.[13] In the space of those 40 or so years, there were a number of top-down efforts to study, organize and legislate the industry. For instance, legislation was passed to increase the salary of translators (1907), force businesses in Quebec to offer bilingual services to clients (1910), and the Internal Economy for the House of Commons' Commission sent someone to Belgium and Switzerland to study the organization of services responsible for the translation of debates and laws (1910). (Delisle 1987) Federal translation services were also centralized in 1934, creating what would eventually be known as the Federal Translation Bureau, which remains the standard bearer and largest employer of translators and other language professionals in Canada today. (Delisle 1987; AILIA 2016; Hamilton 2010)

[13] https://ottiaq.org/en/about-ottiaq/mission-and-history/

Perhaps more significantly, however, was the bottom-up creation of an institutional environment (creation of language or translation associations, such as the Société du Parler français au Canada [1902], the Canadian Bible Society [1904], the Cercle des Traducteurs des Livres Bleus [1919], the Association technologique de la langue française d'Ottawa [1921], and, as mentioned, the STM in 1940 (Delisle 1987)), complete with a rich exchange fueled by the appearance of newsletters, linguistic and terminological studies and conferences (Delisle 1987). During this period, this environment was also enriched by growing involvement of academia, first by sponsoring conferences (Université Laval sponsored the First Conference on the French Language in 1912), then by beginning to offer a number of practical courses (through Ottawa University's Faculty of Arts in 1936). Various works, both academic and practical, also began appearing at this time. (Delisle 1987)

In sum, this was a period of burgeoning institutional activity, and even innovation, marked by the growing number and quality of linkages between the sector's institutions giving rise to an incredibly rich institutional environment, where dialogue, exchange of ideas and quality association shaped the sector, professionalized and demanded recognition (salary) for translators, and made the case for including translation as a discipline in its own right in academia, embarking on an increasingly clear development path that sought to professionalize and regulate translation activity.

After or around 1940, this development path was clearly laid. More institutions saw light of day, more courses were offered, and translation was increasingly recognized as a professional activity. Characteristic of the sustained phase, the cluster became increasingly focused, and innovation became incremental.

5.2.3 A second growth phase, followed by a second sustaining phase

The second major growth phase was triggered yet again by historical events, namely, the Quebec Silent Revolution in 1960 and the subsequent adoption of the federal *Official Languages Act* in 1969 by Montreal-born Prime Minister Pierre Elliot Trudeau, notably in an effort to ensure national unity and counter the growing nationalism and separatist movement taking root in Quebec (Belanger 2001).[14]

This Act, in and of itself, created the foundation for what would become the world's leading translation industry in the world; by creating a second official language and giving all Canadians—from coast to coast to coast—the right to access federal services in their language of choice (services from all federal departments, including federal courts, Crown corporations) and giving French and English the

[14] The response in Quebec was to enact the Charter of the French Language (known as Bill 101) in 1977, which enshrined French as the default language of business, government and education in Quebec. (The Canadian Encyclopedia n.d.)

same status in the workplace in all federal public services that were designated as bilingual, it created an unprecedented need for translation.

The formal deployment of the Act, however, was preceded by a flurry of activity. 1965 saw the first university-led research project on automatic translation (Université de Montréal). By 1971, the lack of qualified professionals led to the creation of a slate of university programs at both the undergraduate and graduate levels. Further indication of innovation at the academic level was that more translation departments were now autonomous, as opposed to offered through the linguistic or French- or English-studies departments. Pilot projects on automatic translation continued to gain ground, together with projects for computerized terminological databases (TERMIUM), and by the mid-1970s, the federal government had signed an agreement with Université de Montréal to develop an automatic translation system specific for meteorological bulletins, as well as acquired TERMIUM and began experimenting with subscriptions. (Delisle 1987)

By 1981, these two major innovations had begun full deployment in the federal service, and efforts had begun to determine how these technologies could be expanded and rendered more efficient. In other words, 1981 marked a return to the sustaining phase.

5.2.4 Incremental innovations and threat of decline

The decades following 1981 were marked by both incremental innovations and disruptive technologies that rocked the Montreal translation cluster. Although Montreal was an early leader in developing and determining the limitations of the first generation of machine translation (Delisle 1987), a first breakthrough technology in the field ended up being computer-assisted translation (CAT) tools (interview with Ms. Steinberg) (technology that was developed in Germany in the mid-1980s [SDL Trados n.d.]), which assists with the creation of terminological databases and draws on the translation memory (comprised of human-made translations) to populate the source text. CAT tools proved a disruptive technology for the Montreal translation cluster (interview with Ms. Steinberg; Simard 1991; Cornibert 1991; Schwab 1991; Rutledge 2013)—in other words, it produced hugely significant changes in the "basic technologies" used by an industry, which in turn altered the industrial landscape and led to the emergence of new business models (Dalum et al. 2002). The 90s and early 2000s saw a marked increase in the use of personal computers and Internet access, which slowly but surely paved the way for the more generalized use of translation software (SDL Trados n.d.; interview with Ms. Steinberg) and led to the emergence of new business models—immense multinationals with far-reaching multilingual and 'round-the-clock'

capabilities (Boers and Ørsted 2013), such as SDL, TransPerfect and Lionbridge—whose core competencies lay in project management rather than necessarily linguistic transfer.

This new business model not only took a large portion of the market share away from independent translators (who even today make up, by some estimates, close to half of translators [Industry Canada 2006; correspondence with OTTIAQ[15]]) and local translation firms (some of which were acquired by multinationals to gain a foothold on the local market [Girard 2015), but it also shifted the narrative to gains on productivity over quality, causing a downward pressure on rates (Rutledge 2013; interview with Ms. Leblanc). Having spent the better part of the century working to regulate and professionalize translation, the cluster "groupthink" was to spurn any translation process that placed the onus on quantity as opposed to quality and that modified the translation environment. There was an incredible amount of resistance. (Interview with Ms. Steinberg)

Public opinion has since grown more favourable towards CAT tools, and use has become more widespread[16], but it comes at a time where it appears that this particular technological life cycle has matured (market dynamics have stabilized, much standardization, very few new entries, acquisitions and mergers of existing firms) (Dalum et al. 2002) and fully exploited its technological and development path. What's more, new disruptive technologies have emerged to shake the industry: big data, artificial intelligence (AI) and neural machine translation (NMT).

5.3 The current portrait of the Montreal translation cluster

5.3.1 The onslaught of disruptive technologies

Big data has transformed the landscape by creating an explosion in worldwide demand for translation, in terms of new reach targets (14 languages are needed to reach 90% of the world, but websites generally support at most 6 [CSA Research 2011, in DePalma 2016) as well as the types of documents, information and products that require translation (big-data analytics, websites, multimedia, software, online customer support, social media, etc.), turning translation into a veritable growth industry (Folaron 2015).

[15] As of August 2, 2019, 1132 people out of OTTIAQ's 2144 members (i.e. more than half) were self-employed, and 1005 were employed. Although this snapshot should not be taken as an exact reflection of industry composition, it nonetheless corroborates the documentation that suggests that a large proportion of translators are self-employed.

[16] According to OTTIAQ's 2018 member survey, 86.6% of members used CAT tools in 2018, as opposed to 45.6% in 2006. (OTTIAQ 2018b)

This unprecedented demand is especially significant because it has exhausted the capability of current translators—and even future ones—to meet this demand, and organizations are scrambling to "overcome the challenges associated with volume, turnaround time, the need to deal with more target languages, and flat budgets" (DePalma 2016). In fact, there is so much demand that by some estimates, translation firms could only process 0.00000000009% of the content being created on a daily basis. (DePalma 2016)

AI, and more specifically deep learning, have led to Neural Machine Translation (NMT), which has been identified as a solution to process this massive increase in data, bringing with it even more disruptive change. Briefly, deep learning uses highly sophisticated patterns of neurons to process massive amounts of data, while striving to refine the information in the data into clear concepts, which can in turn be more quickly processed. Deep learning can then use these large amounts of clear data to train artificial neuron networks to a high level of accuracy. (Collins 2018) One application of this technology is NMT, which trains systems using millions of examples from bilingual corpuses so it can "learn" what it is that consists in a quality translation. (Trinh 2019) This advancement once again revolutionized and jolted the translation industry worldwide, especially after Google launched in NMT system in 2016 (Hu 2018), bringing vast improvements to its predecessor, Statistical Machine Translation (SMT), which would process phrases by cutting them up into series of short segments and attributing the translation with the highest probability to each segment. (Trinh, 2019) Even though NMT is far from perfect and can continue to make some of the comical errors typical of MT, the potential remains undeniable. Response has varied from rushing to incorporate NMT into their processes or cautious enthusiasm about the potential of these new tools, to wariness about such wholesale incorporation that introduces a number of ethical, security and quality risks (Pielmeier 2018), to a deep resistance and/or fear from many stakeholders due to the perceived threat NMT poses both to quality standards and the profession. (Pielmeier 2018; see "Preamble" in OTTIAQ 2015) One thing is certain: it has paved the way for newer still business models, new project management and translation processes, and has forced the profession to engage in a dialogue about what it means to be a translator. This tremendous change has raised the question of whether Montreal's translation cluster institutions are properly positioned and prepared to help the cluster adapt to these changes moving forward.

A few things, however, are different from the first technological disruption: Whereas the expertise for CAT tools was initially developed in Germany, this latest, and potentially more disruptive technology is to a certain extent home-grown. Indeed, an AI cluster has quickly found root and spread right here in

Montreal, due in part by efforts of Université of Montréal researcher Yoshua Bengio, who co-founded Element AI in 2016 and attracted the AI giants, their resources and their researchers to his city. This new circumstance offers the Montreal translation cluster institutions an incredible opportunity to create linkages, increase their absorptive capacity for this technology, control the quality narrative, and help the cluster adapt to change.

Furthermore, as mentioned by Ms. Steinberg, "the interesting thing about technology is […] that is gets adopted quicker and quicker. That they are slow to adopt certain technologies, but then once they're adopted, the next things are really fast. So I think machine translation is complementary to CAT tools, and I think the fact that CAT tools have become so widespread, and that NMT tools are being implemented right into CAT tools by a lot of CAT tool providers means that it rolls out quicker to both freelancers and companies." (Interview with Ms. Steinberg) This statement certainly reflects the reality on the ground. A few years ago, these new technologies were viewed with great caution, both on the ground in everyday discussions with language professionals and by institutions, notably OTTIAQ (see "Preamble" in OTTIAQ 2015; OTTIAQ 2019) This growing acceptance of NMT, however, is already detected by the tones adopted in industry publications and events (Pielmeier 2018; DePalma 2016; OTTIAQ 2017; OTTIAQ 2018a; Vytiskova 2019) and the incorporation of these tools in university curricula. There is not only a sense that "you [can't] put the genie back in the bottle" (interview with Ms. Steinberg), but also, among translators, a certain appreciation of the time-saving potential of machine translation (interview with Mr. Barabé). This cautious embracing of these tools is also being reflected within the institutions. For instance, although originally resistant to machine translation, not only will OTTIAQ be updating its "Caution" notice on its website, but its Executive Director, Diane Cousineau, has she stated that though machine translation is a challenge, it is important for the profession to view it as a tool as opposed to a threat: "In the right hands, it can be very productive and interesting, and if you don't see it like that, you're missing the boat." (Interview with Diane Cousineau)

However, there is a sense, as expressed by Mr. Fortier, that these tools should be "in the hands of professional translators;" otherwise, there is the risk that translation be viewed as merchandise, and translators, as livestock. (Interview with Mr. Fortier) Mr. Barabé thinks that the need goes beyond this. He says that some of the main issues with AI and machine translation stem from the fact that there are no translators and/or linguists working with the teams developing these technologies and to develop standards—neutral, impartial international standards—to evaluate machine translation. He also says that he knows, from experience, that it will be up to the language industry to go knock on their doors. "But to

do that, we also have to stop being scared of knocking. But I think we've reached a place where we are less scared. I think we're there. […] It's the next step." (Interview with Mr. Barabé)

5.3.2 Institutional environment

The institutional environment in Montreal is governed by the *Official Languages Act*, the *Charter of the French Language*, and the *Professional Code*. Whereas the first two acts govern the languages of life, education, and business, the latter has a regulating effect on the entire translation industry in Quebec (making Quebec one of only three places in the world that legislate translation [interview with Mr. Barabé], and gives OTTIAQ its mandate to protect the public.

Institutions have a special importance in the Montreal translation cluster, as a sizeable percentage of LSPs are freelance translators and microenterprises (Industry Canada 2006; correspondence with OTTIAQ) who for the most part work in isolation. These institutions represent one of very few ways they have to tap into industry developments. Indeed, since they do not have the resources to engage in their own or joint R&D projects with other businesses, they count on institutions to cultivate their absorptive capacity. Furthermore, the narrative that these institutions uphold with respect to the profession has a large, formative impact on the cluster, particularly since this narrative must be strong to compete with uninformed, out-of-cluster narratives that laud machine translation and predict the end of the profession (Marr 2018), which can increase cluster resistance to the new technologies.

There are a number of key institutions in this network:

OTTIAQ plays a strong leadership role in Quebec, and beyond. As a professional order governed by the *Professional Code*, it is in a strong position to use its mission to protect the public to strengthen the profession (the logic being that a strong profession that is upheld by professionalized workers who enjoy good working conditions is one of the best ways to provide the pubic with the highest quality of services). It strives to create strong relationships with associations who share their mission, in whole or in part, of protecting the public (Conseil interprofessionnel du Québec [CIQ], the Office des professions du Québec [OPQ] and, to a lesser extent, the Association of Translators and Interpretors of Ontario [ATIO]. It also works to create strong linkages with stakeholders who are best positioned to positively impact the health of the industry, such as universities (responsible for training and professionalizing translators), as well as AILIA and the ACGL, whose mandates are to promote the commercial interests of its members, which is a good thing for an industry but falls outside of OTTIAQ's mandate. (Interview with Mr. Barabé) Although OTTIAQ has strong ties to the Translation Bureau, the relationship is complicated as despite the

Translation Bureau's historic and positive formative role in the industry (interview with Mr. Barabé), the Translation Bureau is now criticized on a number of fronts (see below).

The Translation Bureau was constituted in 1934 to centralize the federal government's translation service. The federal government is not only the "biggest translation client in Canada, by far" (ACGL 2017) and even one of the biggest translation clients in the world (Barabé 2019), but it is also the largest employer of translators and language professionals in Canada today (Hamilton 2010). Even though their business model is geared towards profit, the fact remains that the Translation Bureau exists to serve the Canadian public and enable the Government of Canada to fulfill its obligations under the *Official Languages Act*. They have also been traditionally regarded as a standard bearer, due to role in furthering MT technology in the 1970s, their work to create and maintain a high quality, freely accessible terminological database (TERMIUM), and their development of a style guide (*Canadian Style Guide*) that is the standard for many English language professionals in Canada. In other words, all outward signs suggest that they have an immense impact on the institutional environment. However, things changed in 1995, when the Translation Bureau ceased offering its services for free to federal ministries and organizations and instead adopted a for-profit business model. Industry stakeholders claim that as a result, the Translation Bureau is failing to uphold the constitutional rights of Canadians (Barabé 2019), and has engaged in predatory pricing practices that is fragmenting the industry (ACGL 2017) and even compromising the physical, mental and financial health of professionals (interview with Mr. Fortier). However, the federal government has recently publicly committed to reinvest in the Translation Bureau, putting an end to the hiring freeze that led to a drop of one-quarter of in-house language professionals, and recommitting to hiring and training students. (Buzzetti 2017) It is also important to note that the Translation Bureau may have the highest absorptive capacity of all network actors. In continuity with its past role in advancing translation environment technology, the Translation Bureau again made headlines in 2016 when it developed and attempted to deploy its own machine translation technology within the federal government. The tool, despite developed to replace the use of Google Translate by federal employees for privacy considerations, to empower more French public servants to work in their mother tongue, and provide an additional CAT tool to its sizeable force of translators, was widely decried as an attack on quality and professionalism (Macklovitch, 2016). Although the main problem was largely one of inadequate roll-out and guidelines for use (interview with Mr. Barabé), the government was forced to reconsider the use of the tool, issue new, more restrictive instructions for its use (limiting it to internal communications), and causing the CEO, Donna Achimov, to quit her position following a petition calling

for her dismissal (started, significantly, by a translator just north of Montreal—as opposed to somewhere else in Canada). (Radio-Canada 2016)

Among the many trade associations in this network, AILIA stands apart. It is highly involved in promoting, developing, coordinating and implementing certifications and standardization efforts at both the national and international levels, and has even accepted a leadership role in the coordination and development of a new ISO/Technical Standard on Language and Terminology (ISO/TC 37).[17]

It is also worthwhile to note that despite this plethora of trade and industry associations, not one claims to speak on behalf of the interests of all translators, and their focus can range from self-employed translators, literary translators and legal translators to translation organizations and/or firms, etc. Significantly, because no one organization is all things to all people, there is a great deal of member, volunteer and administrator mobility across these organizations, and it is not uncommon for individual translators to become members of several institutions, whether simultaneously or over time. However, the lack of a clear "leader" to represent the interests of translators is viewed by some as a missed opportunity to garner sufficient influence to have a stronger impact on the industry (i.e. quantitative systemic effects), as enjoyed by other professions, such as pharmacists, who have both a professional order to protect the interests of the public, and an arguably equally influential trade association counterpart, the Association québécoise des pharmaciens propriétaires. (Interview with Mr. Barabé)

Another notable characteristic of the institutional environment is the mobility of individual and executive stakeholders. Indeed, when identifying potential respondents for the data collection phase and conducting the interviews, it became clear that executive members wore many hats. Donald Barabé, President of the Board of Directors of OTTIAQ, had been Vice-President of services at the Translation Bureau for a number of years, had taught at the Université de l'Outaouais, has chaired a translation research laboratory, and had been involved in countless collaborative issues tables. At the time of answering the questionnaire, the person responsible for professional development at the Université de Montréal was also on the board of directors of the ACGL and involved at the committee level at OTTIAQ. The presidents of at least two of the smaller, niche trade associations were also members of OTTIAQ. The respondent for Concordia University was also the undergraduate internship coordinator (requiring personal contacts with the Translation Bureau), president of CATS and sat on a committee at OTTIAQ. Diane Cousineau is both Executive Director of OTTIAQ and the Canadian representative for FIT-NA.

[17] https://www.ailia.ca/en/certifications-and-standards

Furthermore, as no organization covers all interests, it is not uncommon for language professionals to be members of or have ties with more than one organization.

5.3.3 Risk of decline, or potential for new growth?

As of 2019, the Montreal translation cluster appears to be at a crossroads. NMT is disrupting this historical cluster in a number of ways: despite its positive sides, it is redefining what it to be a translator, it is creating new business models, and it is accelerating what some say is a downward pressure on rates and a growing pressure for faster turnaround times, among other things.

The very fact that this cluster risks decline despite the presence of all the cluster building blocks—universities, qualified workforce, firm entries, rich institutional environment, incremental innovations, etc.—suggests that it has not created or maintain the proper linkages. Despite its close physical proximity to the Montreal AI cluster, there are few outward signs of the necessary cross-cluster linkages that would allow the translation cluster to adapt to the disruptive changes caused by its neighbour, and even establish partnerships including the language industry in shaping these tools.

The risks of decline are perhaps further accentuated by the fact that the Montreal translation cluster is somewhat shielded by the traditionally high demand, the long-standing recognition of the professional status of translators, and the relatively good working conditions at home. After working for over 100 years to professionalize translation and becoming the self-appointed stewards of quality, there has been a great deal of hesitance to shift the focus on increasing output by automating certain aspects of the job. These concerns are certain substantiated: as stated by Mr. Fortier, Canada has the experience and a great tradition of bilingualism, but it has been imperilled by short-term concerns of high productivity. (Interview with Mr. Fortier) However, by failing to adapt to new circumstances and creating the necessary linkages with AI, this cluster risks finding itself in a situation where "[i]ncreases in the cost of doing business begin to outrun the ability to upgrade" (Porter 1998). If the institutions lose their ability to control the quality narrative over to the multinationals and larger businesses as well as create linkages, the cluster's core competency—language transfer skills—could be replaced (as opposed to complemented) by technological ones, which risks radically transforming the cluster, to the extent where the Montreal translation cluster "dies" by becoming absorbed by the Montreal AI cluster. Appropriate linkages with this cluster would, conversely, allow it to adapt to the technological disruptions.

However, there are many outward signs of progress. In additional to the constructive tones in industry publications and events, interviewees approached the new technologies as a challenge, but one they were ready to seize (in particular Mr. Barabé [OTTIAQ], Ms. Cousineau [OTTIAQ and FIT-NA] and

Ms. Steinberg [AILIA]); Ms. Leblanc and Mr. Fortier, the presidents of two small trade associations, as well as Ms. Steinberg, spoke earnestly of the importance of partnerships, and of the need for the industry to work together. AILIA's experience with developing standards and OTTIAQ's intention to build bridges to stakeholders in the AI industry area also very encouraging.

5.4 Preliminary findings

Based on this case study, a number of observations can be made and subsequently verified in the network analysis.

At first glance, the institutional members of the Montreal translation cluster appear to derive a number of benefits from their homogeneity, long, interwoven history and proximity. They share a common language, they share preoccupations, they all uphold quality as one of their most important values. Institutions frequently sponsor or participate in one another's events, influencers go from board to board over time or are strategically involved in more than one organization at once, creating many opportunities for face-to-face interactions and having the impact of building strong, trust-based and embedded relational networks. And indeed, the ties appear to be quite strong; they are recurrent, and cultivated over the long term. (Djelic 2004) Finally, the network is arguably quite dense, as 18 institutions serve a market of approximately 8000 language professionals.

According to the literature, these agent and network characteristics suggest that the institutional network is highly interconnected, interpenetrated and complementary, and subject to co-construction and co-evolution. (Djelic 2004) In other words, they move in the same direction. Due to the density of this network and the presence of trust, it can be assumed that a number of interactions are facilitated for members. Transaction costs are low, and they have a high capability to improve the quality of delivery and performance (Djelic 2004)—which is no surprise, given the Montreal translation cluster's reputation for excellence. Information, once introduced into the group, can spread very quickly, because members share the same language and skillset.

The downside to such a network are that the shared norms and rules of conduct point to a lack of diversity (Huggins and Johnson 2010). Corroborating this is the perceived lack of bridging networks made up of weaker ties—an inward-looking tendency is evidenced by the amount of resistance that was encountered with the introduction of CAT tools. Though these types of networks do not enjoy the same level of trust and intimacy, the benefit of these kinds of networks is that they tend to cover more than one network, breaking the potential isolation of clusters. Indeed, "a risk with tight in-groups is that they limit the world of their members, causing them to wear blinkers and preventing change and adaptability"

(Djelic 2004, 346). Bridging networks are needed to cross cluster boundaries and serve as pipelines for the introduction of radically different and innovative information. (Djelic 2004) Without the presence of this type of structure in a Montreal translation cluster—specifically, one that links to the AI cluster—it is highly unlikely it can successfully and efficiently access, understand and incorporate new ideas at a cost that is not prohibitive.

6 Network analysis

6.1 Overview

The network analysis allowed us to both create a map of the institutional ecosystem of the Montreal translation cluster as well as measure a number of interactions between institutions. This section will begin by presenting the structure of the resulting network, then it will home in on nodes of interest and the relationships between nodes in order to verify the validity of propositions P1, P2.1, P2.2, P3.1 and P4. The resulting portrait, together with the analysis of external pipelines, will shed light on proposition P5.

6.2 Network structure

The Montreal translation cluster has the following institutional network structure depicted in Figure 3: Overall network structure. Note that the darker lines between nodes represents stronger relationships and more meaningful interactions (measurements of 2 on the three-point scale), and that the different colours represent the network's k-cores, which are an indication of cliquish behaviour.

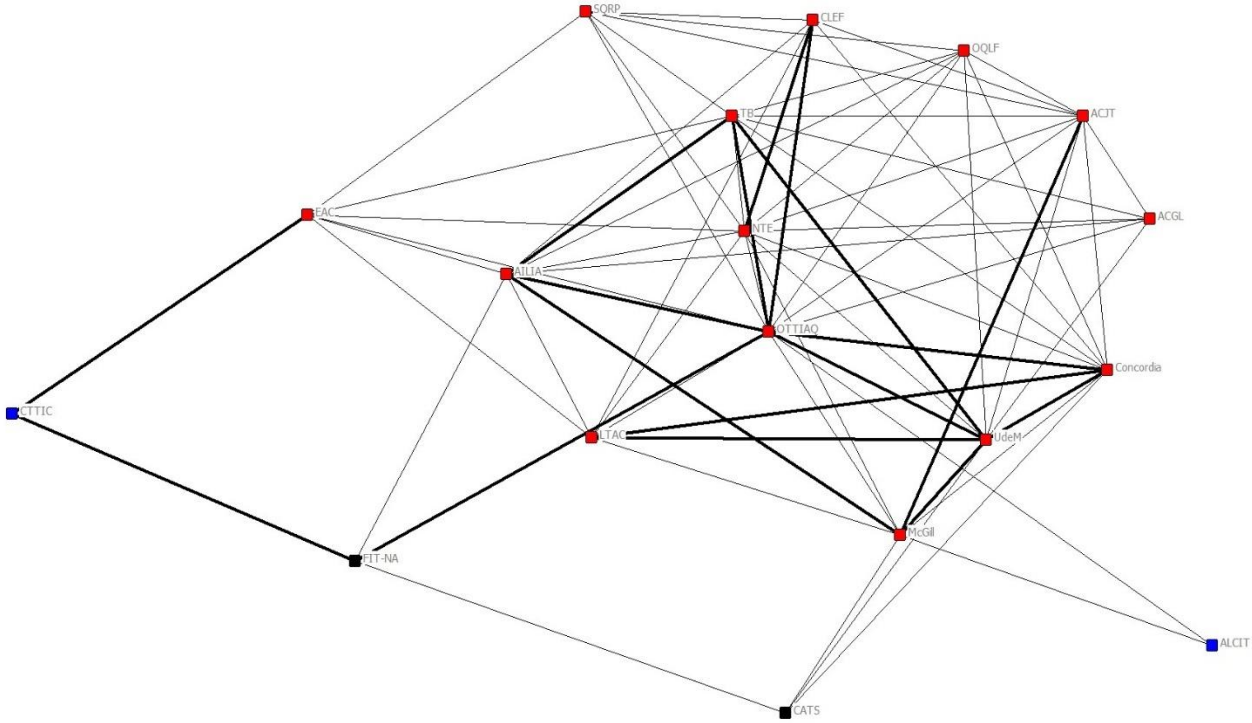


Figure 3: Overall network structure

As suspected and proposed by P1, the institutional network is organized in a core-periphery structure. The members of the core consist of OTTIAQ, ACJT, NTE, Concordia, UdeM, McGill, and Translation Bureau (7 out of the 18 actors), and the network does show that these nodes all have strong connections to both central nodes (represented by darker lines) as well as to peripheral nodes. This

structure would suggest that core actors have higher absorptive capacity; however, this is only true for 5 of the core actors (Concordia, UdeM, McGill, Translation Bureau, OTTIAQ). NTE and ACJT, in fact, demonstrate the lowest absorptive capacity. Moreover, the typical behaviours generally observed in this type of structure must be weighted by the consideration that it has a relatively low core-periphery score of 0.6404. Furthermore, although short distances are typical of core-periphery structures, they are particularly short in this network (average geodesic distances of 1.601), implying that intra-network knowledge is disseminated rapidly. This, combined with a fairly high density (average value of 0.575) and a very large majority of the nodes belonging to a single k-core, suggests that although the network is hierarchical and that most of the knowledge is concentrated at the core, the fact that the periphery is connected to the core through very short distances implies that peripheral actors nonetheless enjoy some access to the that knowledge. This information all points to a rather dense network, which is atypical for a core-periphery structure.

6.3 Core and central actors

Although all core actors are by definition central to the network, not all central actors are part of the core. The fishtail structure obtained by applying the Principal Components layout on NetDraw, which pushes the most central actors of the network to the right, and the least central actors to the left, clearly shows all the core actors at the “head” of the fish (see Figure 4: Depiction of most and least central actors). However, even though the structure pushes OQLF quite far to the right, OQLF does not belong to the core, as demonstrated by its relatively low Bonacich centrality score (see Table 6: Bonacich centrality values), indicating low access to power and resources (connections with connected nodes). This finding is corroborated by the fact that OQLF does not have strong ties (represented by darker lines) with core nodes, nor does it have many ties to peripheral nodes.

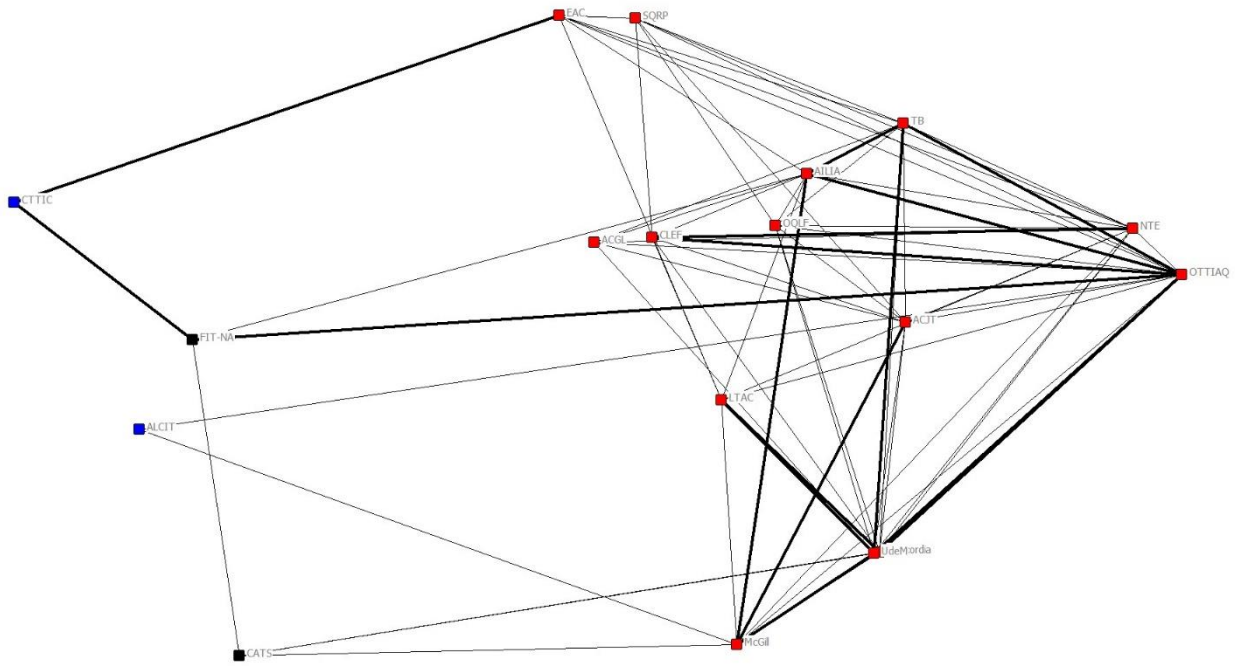


Figure 4: Depiction of most and least central actors

NTE's key position—towards the tip of the fish head, right behind OTTIAQ—also came as a surprise, particularly because it is one of the smallest ("size wise") nodes in the network. Indeed, in addition to being part of the core, NTE is also highly central to the network. As demonstrated in both Table 5: Ego network centrality and Figure 4: Depiction of most and least central actors, NTE is surpassed by OTTIAQ only in terms of total number of first- and second-degree ties.

Table 5: Ego network centrality

	Size	Density
OTTIAQ	15	0.562
NTE	**13**	**0.782**
ACJT	10	0.867
Concordia	10	0.822
UdeM	10	0.733
TB	10	0.778
AILIA	10	0.578
McGill	9	0.722
LTAC	8	1.000
OQLF	8	1.036
CLEF	7	0.857
SQRP	7	0.905

EAC	7	0.714
ACGL	6	1.200
FIT-NA	4	0.333
CATS	4	0.833
ALCIT	2	1.000
CTTIC	2	0.000

However, it is also important to note that despite NTE's core and central position, it has considerably fewer strong ties with other core actors, i.e. its relationships are more superficial. As such, despite its prominent position in the network, one could assume that between these superficial ties and its small size, it wields considerably lesser impact on the network than other core actors.

6.4 Bonacich centrality

Unsurprisingly, the core nodes in this network have the highest Bonacich centrality scores, with the exception of the ACJT, which is preceded by a peripheral actor (LTAC).[18] OTTIAQ leads the pack by a significant margin, and is followed by UdeM and Concordia, the two universities with the strongest translation programs and faculties. These are in turn followed by the Translation Bureau.

Table 6: Bonacich centrality values

	Beta Centrality	Normalized Beta Centrality
OTTIAQ	3741.581	1.740
UdeM	3091.186	1.438
Concordia	2762.828	1.285
TB	2734.230	1.272
NTE	2680.712	1.247
AILIA	2552.021	1.187
McGill	2400.658	1.116
LTAC	2231.446	1.038
ACJT	2231.241	1.038
CLEF	2024.781	0.942
OQLF	1786.415	0.831
ACGL	1435.316	0.667
SQRP	1396.853	0.650
EAC	1361.791	0.633
FIT-NA	980.232	0.456
CATS	779.035	0.362

[18] This can be explained by LTAC'S strong (level 2) connections with two 'prestigious' actors, namely, Université de Montréal and Concordia University.

ALCIT	517.484	0.241
CTTIC	397.106	0.185

6.5 Brokers and betweenness centrality

Brokers were identified using measures of betweenness centrality. As mentioned in the literature review, nodes with a high betweenness centrality are likely brokers, and insufficient brokers in a network places that network at risk of severe disruption.

Table 7: Betweenness centrality values (below) indicates who among the network actors play brokerage roles. Although once again OTTIAQ comes out on top, and by a lot, certain much less central actors are shown to have strong brokerage roles, e.g. EAC and FIT-NA. And indeed, Figure 3: Overall network structure and Figure 4: Depiction of most and least central actors both illustrate at these two nodes act as the gateway for the 4 nodes that are outside of the principal k-core of the network.

Table 7: Betweenness centrality values

	Betweenness	nBetweenness
OTTIAQ	**26.536**	**19.512**
EAC	10.883	8.002
AILIA	7.957	5.851
NTE	7.607	5.593
McGill	6.812	5.009
FIT-NA	5.717	4.203
UdeM	5.533	4.069
Concordia	5.483	4.032
TB	3.888	2.859
ACJT	3.000	2.206
LTAC	2.421	1.780
CATS	1.810	1.331
SQRP	1.469	1.080
CLEF	1.102	0.811
OQLF	1.095	0.805
CTTIC	0.400	0.294
ACGL	0.286	0.210
ALCIT	0.000	0.000

Another point of interest is the number of nodes with high brokerage potential. OTTIAQ and EAC emerge as the main brokers, but the following 6 nodes (AILIA, NTE, McGill, FIT-NA, UdeM and Concordia)

also have much greater brokerage values than those with below-mean values. This corroborates P2.1, which proposes that institutions make natural brokers.

McGill University, despite having few translation program options and weaker connections to OTTIAQ than Concordia University and Université de Montréal, emerges as a higher broker than the latter due to its connections with the ACJT and the ALCIT, i.e. connections that are motivated by a shared interest in law. Indeed, McGill University is reputed for its legal translation certificate.

The summary table below (Table 8: Network summary of betweenness centrality) sheds additional light on the brokerage role of one network actor in particular, the Translation Bureau. The Translation Bureau, both historically and currently, has played a leading and structuring role in the industry, something which is reflected in its position as both a central and core actor in this network. However, its low betweenness value suggests that that it might not be an honest broker, i.e. it benefits from its central, core position in the network, but it does not give as much as it receives.

Table 8: Network summary of betweenness centrality

	Betweenness	nBetweenness
Mean	5.111	3.758
Std Dev	6.016	4.423
Sum	92.000	67.647
Variance	36.188	19.565
Minimum	0.000	0.000
Maximum	26.536	19.512

6.6 Network resilience

As mentioned above, although insufficient brokers may make a network vulnerable to disruption, too many brokers may signal redundancies. In other words, if the removal of key brokers does not significant disrupt the network (i.e. there are sufficient alternate pathways for the knowledge to circulate), then the network has overly invested on developing ties within itself, as opposed to, alternately, developing border-crossing ties.

Table 9: Summary of attacks on network (below) represents a test that was conducted on network resiliency. The first row summarizes the data provided thus far on the current network. The following 8 rows present network measurements following the removal of strategic network actors.

Table 9: Summary of attacks on network

	Network density	Average geodesics	Mean betweenness	Maximum betweenness	Main brokers
Complete network	0.575	1.601	5.111	26.536	OTTIAQ (26.536) EAC (10.883)
No OTTIAQ	0.493	1.735	5.882	17.877	McGill (17.877) AILIA (16.198) NET (12.140)
No EAC	**0.588**	1.625	5.000	27.512	OTTIAQ (27.512) FIT-NA (15.817)
No NTE	0.544	1.647	5.176	27.783	OTTIAQ (27.783) EAC (9.617) AILIA (8.467)
No McGill	0.559	1.618	4.941	28.727	OTTIAQ (28.727) EAC (10.312)
No TB	0.551	1.625	5.000	25.703	OTTIAQ (25.703) EAC (9.452) NTE (8.081)
No AILIA	0.551	1.625	5.000	30.091	OTTIAQ (30.091) EAC (10.533)
No FIT-NA	**0.603**	1.596	4.765	18.443	OTTIAQ (18.443) EAC (15.583)
No OTTIAQ NOR AILIA	**0.467**	**1.825**	**6.188**	**16.437**	**McGill (16.437) NTE (13.756) EAC (13.250) CATS (11.333)**

There are three significant findings that emerge from this exercise:

First, despite OTTIAQ's core and central role in the network, across all measurements, removing it from the network does not in fact significantly alter its efficiency with knowledge circulation. There is a marginal, though arguable insignificant, increase in the number of average geodesics. The network density also decreases slightly, which may in fact be a positive thing for the core-periphery structure. Finally, AILIA and McGill emerge as a new strategic brokers.

Second, attacking the network by removing other core and/or central actors had, for the most part, a very limited impact on the network. Changes to the network were subtle. For instance, the range of impact on average geodesics was only 0.139 (from 0.3% decrease with the removal of FIT-NA, to 8% increase with the removal of OTTIAQ). Removing certain actors had the impact of removing the brokerage or intermediary potential from certain nodes (e.g. removing EAC left CTTIC with zero (0.000) brokerage potential; removing AILIA left the ACGL with zero (0.000) brokerage potential; removing FIT-NA left both CTTIC and CATS with zero (0.000) brokerage potential). Removing AILIA gave OTTIAQ the greatest bump

in most brokerage potential, although removing other core and/or central actors had the same impact. Only when two central/core actors were removed—OTTIAQ and AILIA—could a greater relative impact be ascertained on the network: density fell by 19%, average geodesics increased by 14%, and new brokers emerged at the top of the list (McGill and CATS). In other words, even with the removal of two key institutions, the network proves resilient, and the knowledge can still flow. This substantiates the above claim that there are a high number of brokers in this network, which in turn helps to corroborate P2.2., which states that networks with a large proportion of brokers are at risk of developing redundancies.

Third, the most significant attack on the network was the removal of FIT-NA, which by all prior measurements is neither central nor part of the core. Indeed, this action removed the brokerage potential from 2 nodes (CTTIC and CATS), and increased network density by removing a peripheral node. It also brought EAC and OTTIAQ on relatively equal ground in terms of brokerage potential. A comparison of Figure 4: Depiction of most and least central actors and Figure 5: Network structure with no FIT-NA illustrates this change.

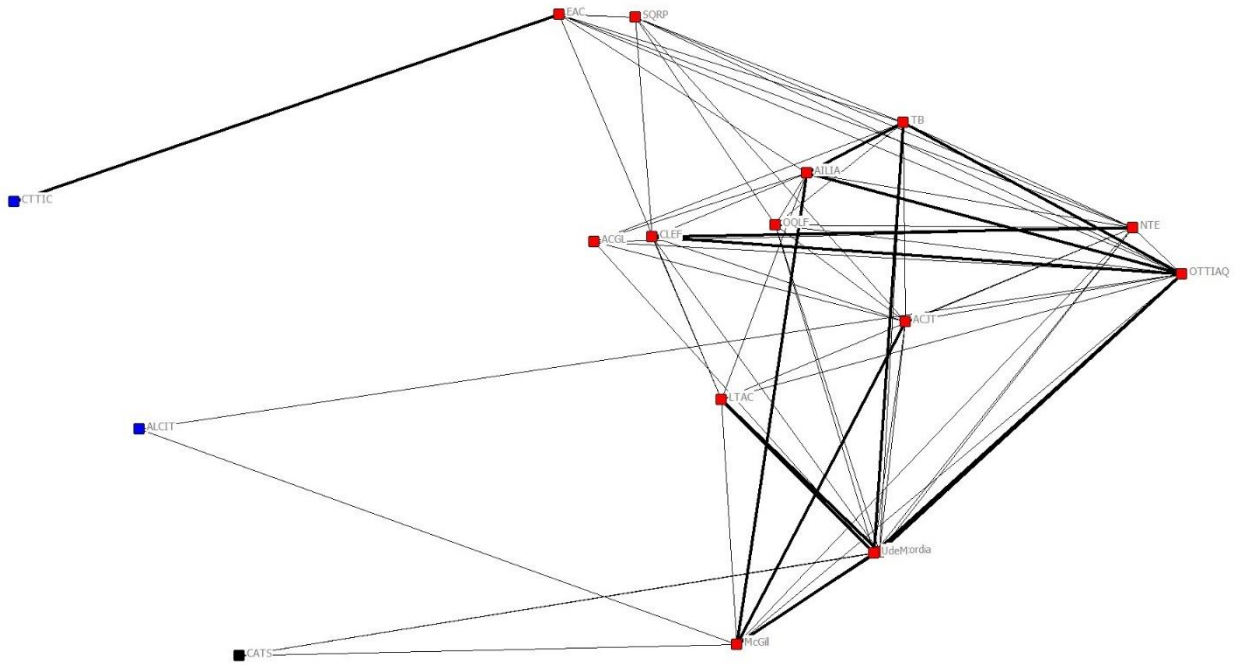


Figure 5: Network structure with no FIT-NA

6.7 Findings by attribute

As mentioned in the methodology, attributes of size and interactions with technology were also assigned to network actors, which led to a number of observations.

Figure 6: Actors grouped by size shows core actors in every size grouping, where the largest node corresponds to the largest institution. The colours are used to indicate interactions with technology,

where black = greatest absorptive capacity, blue = medium absorptive capacity, and purple = least absorptive capacity. Figure 3 makes it possible to reach two key conclusions:

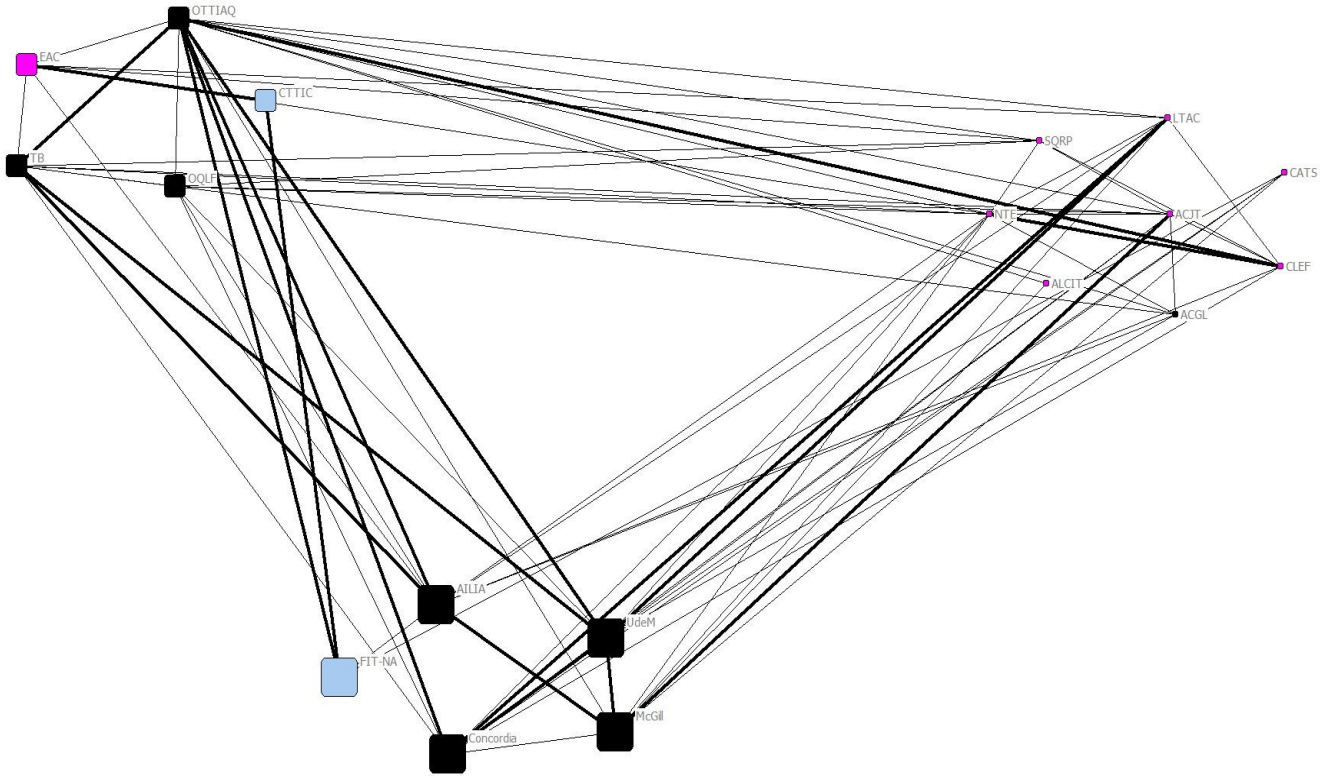


Figure 6: Actors grouped by size

First, given that core actors are spread out across all three size categories, it appears that in terms of influence and access to resources, it is possible to overcome the limitations of size if a node has key partnerships and relationships with powerful nodes. Indeed, NTE, despite counting only 84 members, is able to leverage its connections, in particular with OTTIAQ and universities, in order to position itself at the core of the network. That said, of the 7 core actors, 4 are located in the category 3 (largest) size, suggesting that size nonetheless provides a clear advantage. However, as demonstrated by the peripheral nature of FIT-NA, size is also not enough to lend core status.

Second, as suggested by P4.1, size has a very strong positive correlation with absorptive capacity. Four of out the 5 size-3 actors also have the greatest absorptive capacity, and only 1 (ACGL) of the size-1 actors have high absorptive capacity, which can be explained by its particular mandate to serve translation firms.

Figure 6, on the other hand, which re-applies the Principal Components layout to emphasize the most central actors, does not make it possible to conclusively prove P4.2.

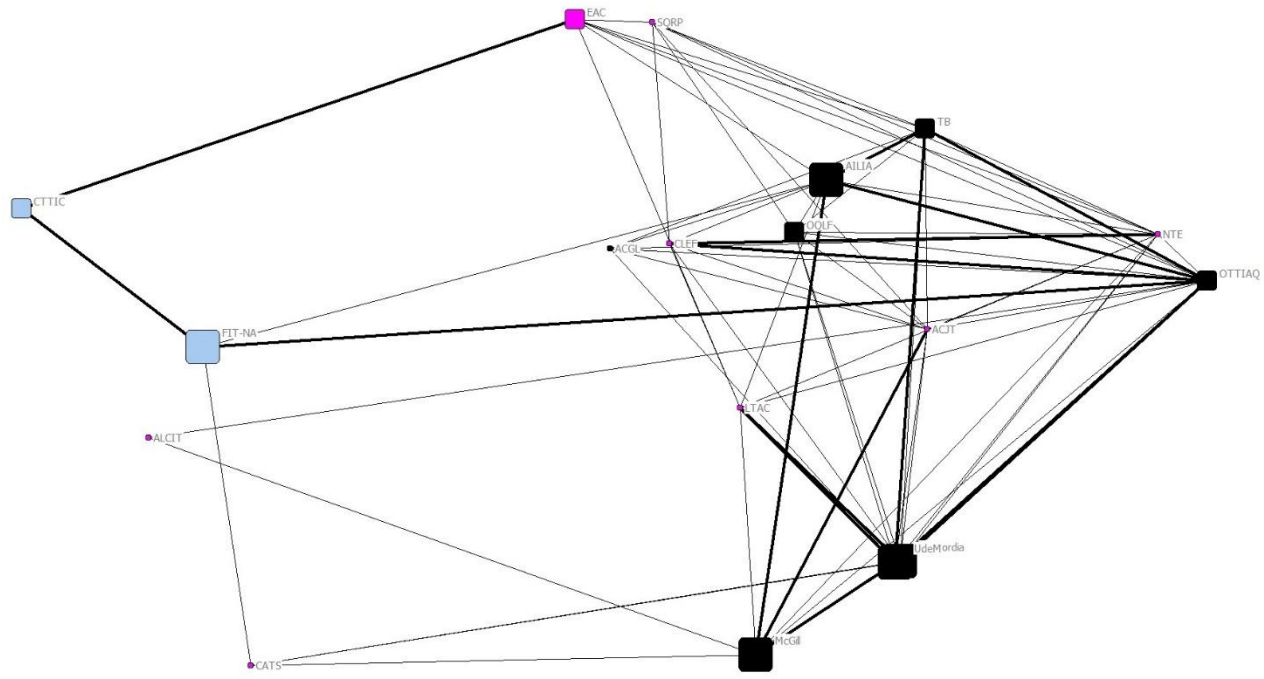


Figure 7: Central actors, by size and absorptive capacity

Although the nodes with the greatest absorptive capacity certainly tend to concentrate towards the head of the network, as opposed to the tail, one of the most central actors (NTE) has low absorptive capacity. As such, it appears that while institutions with the greatest relative absorptive capacity do indeed tend to be somewhat more central, the power of ties can allow nodes with lower absorptive capacity to come out ahead.

The power of connections is further reinforced by Bonacich centrality measures, which, as mentioned, places a lot of weight in relationships with core and central (i.e. powerful) nodes. Table 6 shows that the four nodes with the greatest beta values were assigned a value of 2+ for size and 3 for absorptive capacity. However, size-3 institutions appear at both the top and the bottom of the list, and two institutions with the greatest relative absorptive capacity (ACGL and OQLF) appear in the bottom half of the list. This suggests that while size and absorptive capacity are not a determining factor of Bonacich centrality, it is at the very least a soft prerequisite.

6.8 External pipelines

As mentioned in the methodology, there were some issues encountered with compiling data for external pipelines. However, certain observations can nonetheless shed light on the network and institutional interactions.

First, let's look at a portrait of the entire network with the identified pipelines, next to the table of betweenness centrality measures (note that nodes with a score of 0.000 were not included in the table for purposes of concision):

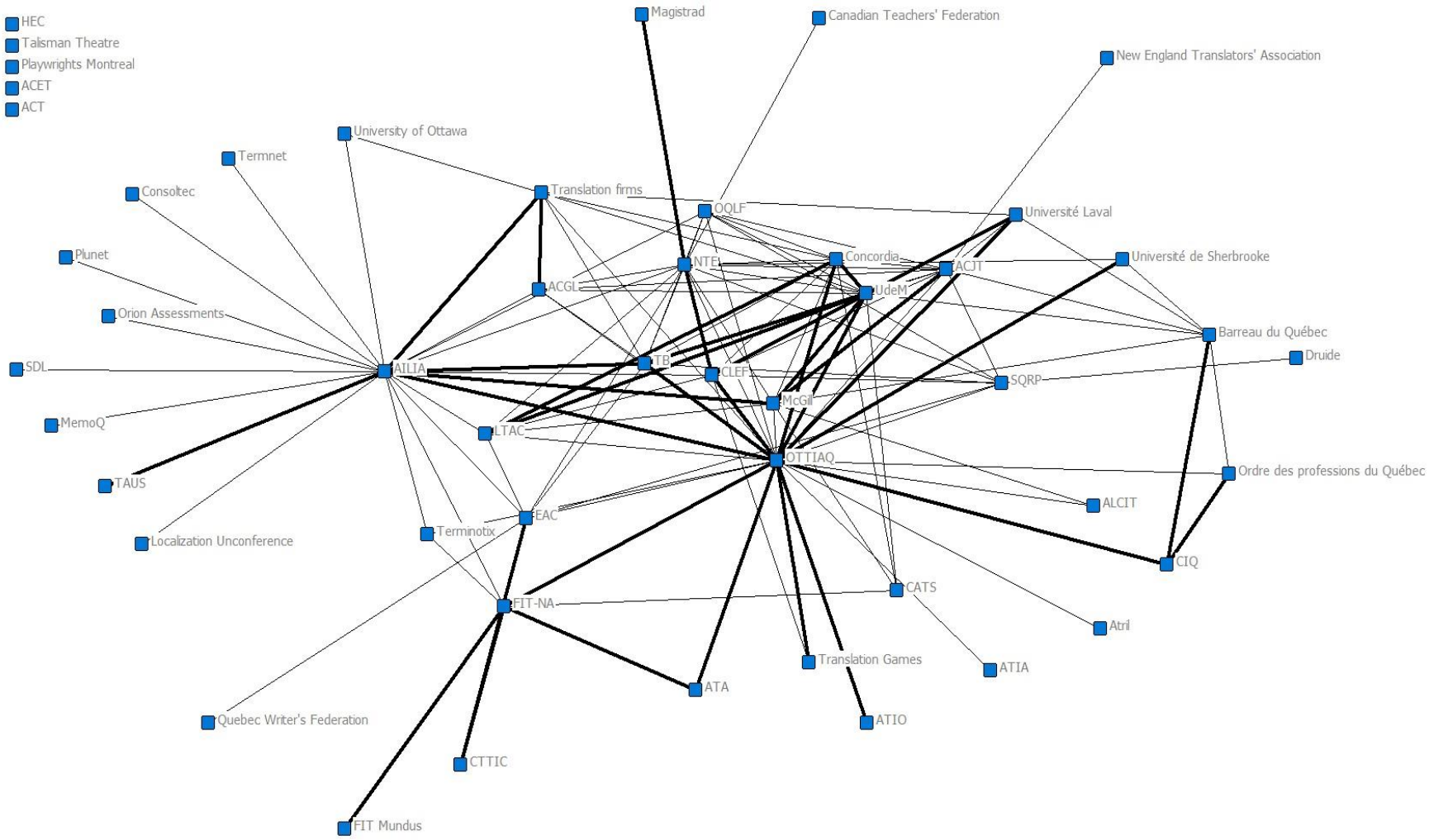


Figure 8: Network with pipelines

Table 10: Betweenness centrality and Bonacich centrality of network with pipelines

	Betweenness	Beta Centrality
OTTIAQ	**366.309**	**5882.892**
AILIA	364.434	3800.741
NTE	116.773	3389.180
FIT-NA	73.348	1589.728
EAC	70.913	1665.591
ACJT	58.034	2875.780
SQRP	45.974	1694.484
McGill	40.097	2965.857
CLEF	24.156	2843.847
UdeM	18.447	3916.670
TB	17.881	3532.539
Translation firms	17.673	2327.778
Concordia	12.043	3459.457
Barreau du Québec	9.472	1197.727
OQLF	9.225	2151.040
LTAC	5.845	2659.578
ACGL	4.837	2113.632
CATS	3.617	899.572
Université Laval	3.524	1797.493
Université de Sherbrooke	2.247	1231.402
CTTIQ	1.467	492.676
CIQ	1.342	1175.793
Ordre des professions du Québec	1.342	711.963

As illustrated by Figure 8: Network with pipelines, the number of pipelines maintained by certain actors gives the network certain hub-and-spoke properties, which are much more conducive to innovation and absorptive capacity. Although Table 7: Betweenness centrality values demonstrates that the nodes with the highest betweenness centrality are not necessarily those with the greatest attributed absorptive capacity, it remains that the number of reported pipelines are encouraging.

A look at *who* AILIA is connecting to is particularly interesting. In keeping with its private sector members, AILIA has strong connections with actors that are likely to have more vertical relationships (translation firms, translation software firms, etc.). Although OTTIAQ also has relationships with these

types of players, they are fewer in number and intensity. This would suggest that though AILIA and OTTIAQ were rated at the same relative absorptive capacity, and that OTTIAQ has the greater Bonacich score, AILIA's stronger connection to the private sector—both in terms of private sector members and private sector ties—might be a particularly promising gateway for external information regarding the disruptive technologies.

NTE holds on to its position towards the top of the list, both in terms of betweenness and Bocacich centrality, and finds itself immediately behind heavy lifters such as universities, OTTIAQ, AILIA and the Translation Bureau because again, it has invested in its partnerships, not only with other universities, but also with its very own pipelines, one which, significantly, represents a true bridge outside of the translation industry (Canadian Teachers' Federation). The ACJT is quite high on the list on both of these measures, for the same reasons: in addition to its connections to core actors with significant prestige (McGill University, OTTIAQ, etc.), it also has significant pipelines outside the network (Barreau du Québec).

OTTIAQ also maintains two significant bridges outside of the translation industry, namely, the Conseil interprofessionnel du Quebec, and the Office des professions du Quebec. Although not represented on the network, these two nodes are the gateways to all the other professional orders in Quebec, and therefore represents very valuable pipelines.

Although LTAC also identified actors that could have represented bridges outside the translation industry (Talisman Theatre, Playwrights Montreal), the relationships were measured to be below the minimum threshold of the 3-point scale. The same applies to the relationship reported by SQRP with HEC.

A look at Figure 8: Network with pipelines further suggests FIT-NA's surprising impact on the network, i.e. due it its strong ties with the ATA (American Translators' Association), which, though part of the translation industry, is nonetheless across the border and represents an interesting pipeline. However, the network also demonstrates that OTTIAQ has the same strength of tie to this node, pointing to yet another redundancy in the network.

Finally, given that many respondents added various "Translation Firms" to the roster, it is not surprising that Translation Firms obtained such a high betweenness value. This is entirely consistent with cluster literature, which names firms as one of the constituting elements of the cluster. As alluded to earlier, however, there is a positive correlation between having direct ties with translation firms and absorptive capacity. Indeed, OTTIAQ, Concordia, UdeM, TB and AILIA and ACGL all have direct ties with translation firms, and they all have the highest rated absorptive capacity.

Notably absent from any reported pipelines are actors from the neighbouring AI cluster, or other high-tech industries that have the necessary absorptive capacity to adapt to disruptive changes.

7 Discussion of findings

7.1 Overview

This research set out to quantify institutions and institutional interactions in isolation in order to better understand their roles and contributions in the context of clusters through, notably, a study of their structural properties. To that end, data on the institutional network of the Montreal translation cluster was collected and then analyzed in keeping with a network analysis methodology, allowing us to test the propositions about these institutions.

This chapter is divided as follows. The first section builds on and contextualizes the findings uncovered in the previous chapter. While the benefit of network analysis is that the resulting quantitative findings are easily generalizable to other networks (universality of networks), in this case, it is particularly important to situate these findings back into their context, via the case study, in order to cross-fertilize the literature and also contribute to the cluster literature.

The second section builds off the theoretical contributions to the literature, the case study and the interviews to propose practical application of the research findings for the Montreal translation cluster.

Finally, the third section summarizes the limitations of this research.

7.2 Contextualized findings

P1: Institutions tend to organize in hierarchical network structures.

As mentioned, the institutions in the Montreal translation cluster have in fact organized as a core-periphery structure, corroborating P1. Hierarchical structures intuitively lend themselves quite well to rule-based institutions that are designed to ensure the efficiency and stability of systems (Nelson and Nelson 2002; Bathelt and Glückler 2014), because hierarchies themselves are established based on a certain order: the "elite" nodes represent the powerful core that has the most privileged access to information (Guiliani and Pietrobelli 2011), and this core dictates to a certain extent the structure at the periphery, where the nodes prioritize establishing relationships with the core nodes as opposed to each other. Indeed, as it is in the nature of institutions resist innovation as a source of uncertainty, instability and inefficiency (Nelson and Nelson 2002; Bathelt and Glückler 2014), it is normal for institutional change to be slower than technological change (Edquist and Johnson 1997; Nelson and Nelson 2000). As such, it would be strange if institutions were to organize in a network structure that promotes innovation, such as a small-world network. Rather, they have organized in a network structure—the core-periphery structure—whose very properties tend to hamper opportunities for creativity, innovation and creativity (Guiliano and Pietrobelli 2011), precisely because the structure encourages both peripheral nodes and

core nodes to invest in relationships at the core, rather than the build bridges that could lead to different knowledge combinations. In this case, as the institutional literature is perfectly reflected in the network literature, where the structure reflects the nature and modus operandi of institutions themselves, I advance that this would be a tendency of institutional networks in general.

The structure itself, however, is not exactly typical of textbook core-periphery structures. For one, not all core nodes have high absorptive capacity. The network is also quite dense, and demonstrates very short distances between nodes, pointing to a the overconsolidation that is typical of the sustained phase of the cluster life cycle (Porter 1998; Sölvell 2008), which is not entirely surprising given the long, shared history of institutions, their proximity to one another, and their homogeneity. There are both positive and negative aspects to a highly interconnected structure characterized by such dense, close relationships.

One benefit is that due to the trust-based efficiencies (Djelic 2004), the shared language of actors (cultivated through a generalized meaningful participation in cluster activities) that reduces cognitive distances (Bathelt et al. 2004), and the short distances between nodes, any knowledge that enters the network is likely to be shared throughout the network. Whether it is readily assimilated is based on the individual nodes' absorptive capacity.[19] The second benefit is undoubtedly its resilience, as was demonstrated in the attacks on the network. However, this resilience comes at the price of a certain diversity and bridging ties that would allow for an influx of new knowledge. In a period marked by repeated technological disruptions, this is maladaptive.

Indeed, despite the benefits derived by such close ties, the literature states that overembedded relationships remain a predictor of failure (Bathelt et al. 2004; Huggins and Johnson 2010). Although some network stability is critical, too much stability can lead to institutional isomorphism, groupthink (Porter 1998), and technological and cognitive lock-in (Johnson and Huggins 2010). As mentioned in the literature review, these characteristics have a number of impacts. They make it more difficult to create new linkages between different industries, which in turn limits future options and opportunities for innovation and makes the network vulnerable to external shocks (Menzel and Forhnal 2007; Turkina et al. 2019)—in other words, without outer-cluster linkages to the industries leading the disruptive changes affecting the translation industry, the Montreal translation cluster remains vulnerable. There is also a greater risk of

[19] On this point, it is important to note that although the institutions' absorptive capacity was rated on a scale of 1 to 3, this scale was relative and specific to the cluster itself. In other words, the characteristics mentioned above also lead to the development of a shared attitude towards technology, and although some network actors are clearly ahead of the pack in this respect, the case study demonstrates that the rest of the actors are following suit, and doing so much more rapidly than in the case of CAT tools.

cluster isolation (Guiliani and Pietrobelli), and as the Montreal translation cluster is shielded from certain external shocks due to historically high demand, driven in part by provincial and federal legislation, isolation can be particularly disastrous.

The network analysis and case study did, however, reveal interesting potential for the cluster. Trade associations, though small, represent an incredible opportunity for pipelines. As some of the trade associations in this network represented a non-linguistic specialization (e.g. literature, education, law), they shared a specific language with other clusters. When trade associations, such as the NTE and the ACJT, couple their bridging potential with a strong network centrality or a core position—achieved through a conscious intention to invest in partnerships (interviews with Ms. Leblanc and Mr. Fortier)—they have the potential to inject significant knowledge diversity into the network.

Furthermore, Mr. Barabé, the President of the Board of Directors at OTTIAQ, is not only highly cognizant of the issues surrounding AI-fueled technological disruptions, but he furthermore intends to go "knock on their doors" in order to build the necessary bridges with the neighbouring AI cluster. His plan to approach this cluster with a potential joint project to develop a "neutral and impartial international standard to evaluate machine translation" (interview with Mr. Barabé). This project is highly promising because it is not only being led by the most influential actor in the network, but it also identifies common ground for the two clusters on which to build a meaningful bridge.

P2.1: Institutions are naturally inclined to be brokers.

Although two nodes emerged as the main brokers for this network (OTTIAQ and EAC), it remains that 8 of the 18 nodes scored high betweenness centrality values (greater than the mean), easily corroborating P2.1. There is a strong alignment between the roles played by network brokers and that played by institutions, both in the conceptualizations (e.g. to facilitate, the mediate, to channel) provided by the institutional literature (Steiner 2006; Wolman and Hincapie 2014; Carpinetti and Lima 2013; Burt 2004; Jackson 2008), and as illustrated in the case study.

As a case in point, the institutions in the Montreal translation do exhibit generous information sharing. Not only are training, conferences and newsletters available to all, but it is common practice to offer discounts and incentives to members of other institutions. Institutions also frequently promote and participate in each other's events in various capacities. Finally, as mentioned, there is a great deal of mobility of members, staff and administrators between institutions. The case study noted multiple examples of community members wearing different hats (there are several instances of people being members of more than one institution; university staff and faculty are often administrators of or

volunteers in other institutions, etc.). In light of all of the above, it is clear that brokerage comes naturally to these institutions.

P2.2: Network with too many brokers are at risk of developing redundancies.

There are three measurements that can help to determine network redundancies: network density, average geodesic distances, and betweenness centrality. High interconnectedness (Guiliani and Pietrobelli 2011), which can materialize as high density, low geodesic distances and a large proportion of actors with high betweenness centrality measures, point to a network with structural inefficiencies, i.e. where actors, at a cost, create or maintain too many links serving the same purpose. Although the cost of creating or maintaining links with similar or proximal (i.e. proximal distance, shared language, similar absorptive capacity) actors is relatively low, there are also limited benefits (Jackson and Rogers 2005). In the same vein, although distant (i.e. out of cluster) nodes might be more costly and difficult to achieve and maintain, they inject diversity into the network (Menzel and Forhnal 2007; Guiliani and Pietrobelli 2011) and create structural holes (Burt 2004), which in turn fuel innovation.

Although the above measurements, in and of themselves, corroborated the high interconnection and therefore the redundant tendencies of the network, this was further illustrated by an attack on the network (see Section 6.6, Network resilience). The presence of so many brokers made any attack on the network largely moot, which in turn strongly corroborated P2.2. The network showed itself to be extremely resistant, even at the removal of OTTIAQ, which time and time again has proven itself to be a key network actor. Indeed, even when both OTTIAQ and AILIA were removed, the network retained a relatively high density and short paths. In other words, this network is characterized by redundancy; even the removal or core or central nodes does little to impact the network's performance, which necessarily implies that many relationships are being maintained at a cost (Jackson 2008; Jackson and Rogers 2005) and for no or little benefit.

A significant impact on the network came with the removal of a peripheral actor, FIT-NA. This can be explained by its strong connections to other network nodes that are either loosely connected to the network (CTTIC) or outside of the network (ATA, FIT Mundus). Although these connections remain within the translation industry, they cross provincial, national and even continental boarders, and creates rare

structural holes within an otherwise tightly interconnected network. In other words, FIT-NA introduces some diversity to a network in *need* of diversity.[20]

P3: Networks with an overreliance on horizontal relationships are at risk of developing redundancies.

As mentioned in the literature review, institutions can only establish horizontal relationships with other actors; their interactions are necessarily cooperative in nature. (Turkina et al. 2019) Intuitively, horizontal relationships do not have the same drive for expansion as vertical relationships, as the latter incorporates a strong competitive component. Furthermore, based on the interview with Mr. Barabé, institutions are more likely to form meaningful partnerships and agreements only with other institutions that have similar mandates or objectives. This is also compounded by the fact that the mandate of institutions is often territorially bounded.[21] As a result, institutions appear to be driven, by multiple factors, to establish and maintain ties with proximal actors.

In sum, although a network comprised entirely of institutions is a theoretical exercise and no cluster would be exclusively comprised of horizontal relationships, this exercise has certainly demonstrated the risk of redundancy when there is an overreliance on horizontal relationships.

P4.1: Institution size is positively correlated to absorptive capacity for technological advancements.

Although the network analysis showed that size was not the only factor, there was nonetheless a very strong positive correlation between the size of institutions and their absorptive capacity, corroborating P4.1. It is important here to remember that the scores assigned to the institutions with regard their potential absorptive capacity was *relative* to the rest of the network. Although translation is quickly being transformed in an industry where technological competencies are arguably as important as linguistic competencies, it remains an industry with highly traditional views, which are certainly reflected in its institutions. It is also important to note that the relative absorptive capacity of these institutions, even the university's translation-related programs of study and faculties, is nowhere near as high as that of translation firms with their own R&D departments.

[20] This finding, however, must be measured against certain considerations. First, although FIT-NA inject diversity, notably through its connections with the ATA and CTTIC, OTTIAQ also has connections with ATA, and would like to engage in talked with CTTIC to study the possibility of resuming that relationship (interviews with Mr. Barabé and Ms. Cousineau). However, translation associations in Mexico are also members of FIT-NA, and although they have yet to sit at the table in a meaningful way (interview with Ms. Cousineau), they represent potential for new structural holes.

[21] OTTIAQ: protection of the Quebec public; Translation Bureau: provide translation services to the federal government departments to comply with the requirements set forth in the *Official Languages Act*; AILIA: to promote and increase the competitiveness of the Canadian language industry.

Figure 6: Actors grouped by size strongly corroborates proposition P4.1, insofar as the actors with the greatest absorptive capacity also tended to be larger. Resources are required to maintain and update absorptive capacity, whether in the form of research or other means of upgrading capabilities and knowledge so as to be able to recognize and interact with knowledge that is external to the organization. (Cohen and Levinthal 1990) The exception to this proposition is the ACGL, though its high absorptive capacity can be explained by the fact that its members are all firms, some of which do in fact conduct their own R&D. In other words, its relationships have allowed the ACGL to overcome the limitations of size.

It should be noted that as many of the institutions with high absorptive capacity (i.e. more positive or proactive approach to technology and technological disruptions) also exert a great deal of influence over the network, it can be assumed that they will exert a positive influence over the network as the cluster works to adapt to change.

P4.2: Institution size is positively correlated to network centrality.

This network analysis did *not* conclusively show that institution size was positively correlated to network centrality. Three centrality measures were used in the network analysis: ego network centrality (number of connections), Bonacich centrality (connection with prestigious actors), and betweenness centrality (brokerage potential). Although OTTIAQ consistently led the pack across all measures, the NTE and the ACJT came in immediately after on ego network centrality (number of first- and second-degree connections); UdeM, Concordia and the Translation Bureau on Bonacich centrality (the larger actors had the most connections with prestigious or powerful network actors); and EAC, AILIA and the NTE on betweenness centrality (most connections with more peripheral or bridging actors).

In other words, although size appears to be a factor in some centrality measures, particularly those that factor in certain strategic considerations like prestige and brokerage potential, the fact remains that two small trade associations had more first- and second-degree connections than the largest network actors, barring OTTIAQ. In other words, that fact that smaller network actors to create and maintain a comparable or even greater number of relationships than the larger players, regardless of the value of those relationships, once again shows that relationships can allow any institution to overcome the limitations of size.

It appears, however, that the benefits derived by relationships is probably disproportionately strong for small players in a highly interconnected network, insofar as network density decreases the cost associated with creating and maintaining relationships. As such, actors such as the NTE and the ACJT, who arguably have far less resources than the larger and more prestigious players, such as universities, are

able to develop highly advantageous brokerage positions through their number of relationships. It would be interesting to research whether the power of relationships has the same degree of impact in a more sparsely connected network.

P5: Constructive institutional knowledge flows have a positive impact on cluster health, and stagnant knowledge flows have a negative impact on cluster health.

The cluster literature is unanimous in assigning a strong role to the institutional environment (Porter 1998; Sölvell 2008; Steiner 2006, Menzel and Forhnal 2007), and recent research has moreover greatly contributed to defining the different functions of institutions in economic geography (Turkina et al. 2019; Carpinetti and Lima 2013; Wolman and Hincapie 2014; Bathelt and Glückler 2014; Huggins and Johnston 2010). And as mentioned above, just as adaptive institutions and institutional environments can help the cluster adapt to technological change, maladaptive institutions and institutional environments can have the opposite effect. (Bathelt and Glückler 2014; Nelson and Sampat 2001; Tebaldi and Elmslie 2008)

There were two types of structural knowledge flows observed in this network: intra-network knowledge flows, and extra-network knowledge flows, and both affect cluster health in different ways.

Due to the network's high interconnection (i.e. high density, number of brokers, long history, high industry participation), intra-network knowledge flows were extremely productive. Once knowledge enters the network, it is sure to spread. There are a number of benefits to this, including high trust, low transaction costs, shared concerns about quality, etc., which in turn appears to allow the institutional network to work together to uphold a strong narrative about quality. There are many examples of productive intra-cluster knowledge flows that have a positive impact in and on the institutional network, particularly from actors with advantageous brokerage positions—which, as the literature states, network actors can leverage to benefit the network (Burt 2004; Jackson 2008). The text below will provide three examples of these behaviours.

NTE

In the case of the NTE, building extensive, meaningful relationships with a host of network actors has been part of the make-up of its organizational culture since the very beginning. Ms. Leblanc spoke extensively of the importance of the network actors helping each other out to, among other things, survive in the industry, and as an industry. (Interview with Ms. Leblanc) In other words, although the NTE certainly taps into its network position to offer its members benefits such as interesting rebates with partners, professional development or opportunities for networking, ultimately, part of its *raison d'être* to bolster the industry and make sure everyone sticks together.

ACJT

The ACJT is able to successfully leverage its network position to take action on the network by advocating for a number of legal proceedings impacting the translation industry. Due to the legal background of its president and members ("we have knowledge that predisposes us to know where to intervene" [interview with Mr. Fortier]), the ACJT is able to conduct a targeted watch on the industry and the provincial and federal governments, and they try to intervene when possible, for instance to ensure that securities documents are consistently translated for French speakers and to compel the Translation Bureau to provide the necessary financial, material and human resources to ensure compliance with the *Official Languages Act*. (Interview with Mr. Fortier)

Translation Bureau

Historically, the Translation Bureau has had an incredibly positive structuring role on the translation industry in Canada. In order to satisfy the language needs of a country characterized by both bilingual and bijuridism, and eventually, to ensure the constitutional rights of its citizens under the *Official Languages Act*, it has become the largest employer of translators in Canada (Hamilton 2010), a major purchaser of translation services and a recognized standards bearer (AILIA 2016), notably through the high quality standards of translation on federal government documents and then websites, the acquisition of a terminology database that is has been updating for decades and made available to the public free of cost, and the publication of a widely used style guide. Of note is that, through its relationships with universities, the Translation Bureau not only helped steer translation-related technological advancements (early machine translation technology), but also helped train translation students and interns, preparing multiple generations of translators for the market. Although there are growing criticisms against the Translation Bureau, the case study makes clear its historical contribution to the industry, made in part possible through its connections with universities.

However, despite being productive, these intra-knowledge flows appear to lack diversity of knowledge inputs, which is critical for new knowledge combinations, absorptive capacity and innovation. And this lack of diversity stems from its problematic extra-network knowledge flows.

Specifically, the overall network structure and dynamics are not highly conducive to producing new knowledge combinations and avoiding lock-in. The high density, the core-periphery structure, the observed redundancies, and the lack of pipelines to high-tech sectors are all signs of the maladaptiveness in the overall institutional environment, and can be observed on the ground in a resistance to technological advancements, the frustration felt over the changing business models, and an overall sense

of loss of control over the changing landscape. Although there are benefits of a strong interconnection, such as trust, low transaction costs, shared concerns about quality, and knowledge sharing within the network, the institutional network suffers from some isolation. This hinders its ability to inject knowledge diversity and cultivate a critical absorptive capacity with respect to the disruptive technologies, which in turn compromises its ability to help the Montreal translation cluster launch into a new growth phase.

Despite this, the network nonetheless exhibits certain positive characteristics that could lead to positive change. As mentioned, the positive aspect of network density is that once knowledge enters the network, it is bound to spread rapidly throughout the network. As such, if certain key nodes were to strengthen and use their absorptive capacity and/or leverage out-of-cluster partnerships to create new knowledge combinations and opportunities for the network, the institutional network could reposition itself to properly bolster the entire cluster to enter a new growth phase. What is even more promising is that based on the interview with Mr. Barabé, OTTIAQ is poised to do just that—i.e. build bridges with the high-tech sector via a common project. This would have the impact of creating structural holes and injecting diversity and new value into the network. It would also strengthen OTTIAQ's own absorptive capacity, and as OTTIAQ is already a strong broker in the network, it would allow OTTIAQ to disseminate new ideas and best practices throughout the network, and synthesizing them for the network to promote their adoption. (Burt 2004)

Another promising actor in terms of extra-network knowledge flows is AILIA. Despite the coherence of the institutional network of the Montreal translation cluster, the translation industry as a whole remains quite fragmented, and one of AILIA's objectives is to reach out to stakeholders to "pull in the same direction together," particularly with respect to goals such as professionalizing the industry and ensuring the "wellness" of the industry. (Interview with Ms. Steinberg) This intention is well reflected in the network, which shows that AILIA has connections with a range of network stakeholders, from trade associations, to universities, to more peripheric actors like FIT-NA, as well as to a host of out-of-network actors in both the private and public sectors. Its reach is particularly well illustrated in Figure 8: Network with pipelines, which show AILIA as the hub of a wheel-and-spoke structure. In other words, although these connecting actors remain in the translation industry, AILIA demonstrates a strong tendency to branch out, in particular to the private sector, and very significantly to translation software companies such as MemoQ and Terminotix. And, as discussed, since it is normal that the private sector pull ahead of institutions in terms of adapting to technology (Edquist and Johnson 1997; Nelson and Nelson 2000), it

follows that a stronger influence from this sector may have a positive impact on the broader institutional environment, especially in this case.

In light of the above, it is necessary to modify the proposition as follows:

P5: Cluster health requires that both intra-network and extra-network institutional knowledge flows be constructive.

This finding builds on Huggins and Johnson (2010), insofar as although the network's intra-network knowledge flows are overwhelmingly positive, it comes at a high cost of a lack of diversity, which points to a major structural problem with its extra-network knowledge flows. In other words, the institutions demonstrate maladaptive behaviours, insofar as they have over-invested in their intra-network relationships, at the huge expense of bridging relationships, which, though more costly to create and maintain, would inject some much needed diversity into a cluster struggling with technological disruption. According to the literature, this can have numerous negative ramifications. For one, it can lead to a disbalance between the institutional environment and the innovation shaping the industry, which can materialize as institutional barriers that hinder the adoption of new technologies. (Tebaldi and Elmslie 2008). Institutions also risk creating conditions for lock-in for actors by limiting their perceptions and opportunities, ruling out innovative technological solutions, and supporting ineffective technologies and maladaptive hierarchies (Bathelt and Glückler 2014). And in fact, some of these behaviours were noticeably present in the case study over the years, particularly with respect to the resistance to new technologies. However, acceptance of NMT, both on the ground and by the institutions, is occurring much more rapidly than with CAT tools, which is highly encouraging and indicates that the network may be working to emerge from its isolation.

7.3 Practical applications for the Montreal translation cluster

The principal issues of the institutional network of the Montreal translation cluster that should be addressed relate to its network density and lack of constructive external pipelines.

First, given the density of the institution network and the redundancy of certain ties, a good overall practice would be for network institutions to analyze their relationships and ensure that they are obtaining value for what they are investing in terms of time and money. While it is less costly to create ties with other nodes in your neighbourhood or network, these ties nonetheless represent a cost. If an actor maintains ties with four similar nodes that deliver similar benefits, it may be worthwhile to cease maintaining two or three of those ties and invest on a more distant relationship (i.e. outside the cluster).

The second issue—that of the lack of constructive external pipelines—can be concretely addressed on three levels: 1) through network-wide concerted action; 2) through the niche actions of trade associations; and 3) through bridge-building by strategically connected network players.

Network-wide concerted action

As mentioned earlier, although institutions were rated on the scale of 1 to 3 for their absorptive capacity, this rating was assigned 'on a curve' that was specific to this network. The fact remains that the translation industry as a whole, and particularly the industry in Quebec and Canada, remains quite traditional in certain respects. It is necessary for all actors to extend the necessary effort to, simply, learn about AI and NMT and increase the network's overall absorptive capacity. An excellent and accessible source of information, located in Montreal itself, is the Montreal AI Ethics Institute, whose mission is to "help define humanity's place in a world increasingly characterized and driven by algorithms […] by creating tangible and applied technical and policy research in the ethical, safe and inclusive development of AI."[22] (Past meetups have focused on education, the future of work, skills for the modern economy, data private, etc.) This would help increase absorptive capacity, determine how to make AI-driven applications work for them (i.e. appropriate the tools), as well as prevent knee-jerk fear responses to these advancements.

Niche actions of trade associations

Smaller trade associations can have a disproportionately positive impact on such a dense network because they can take advantage of low-cost ties to significantly increase their brokerage potential while using their complementary expertise (law, education) to develop or strengthening connections outside of the translation cluster and effectively inject diversity into the network. NTE could, for instance, have conversations with the Canadian Federation of Teachers to find common ground with respect to high tech-fueled disruptive changes, and use their position as broker to synthesize it and adapt it for the translation industry. Of note, learning how social media and interactive learning tools have transformed the classroom might provide insight on how another 'traditional' profession engaged in change management efforts to counter resistance to new technologies. Similarly, the ACJT could leverage its connections with various faculties of law and the Barreau du Québec to learn how the legal professional is grappling with these sea changes.

Bridge-building by strategic actors

[22] https://montrealethics.ai/about/

Although it is important for the network as a whole to improve its absorptive capacity, it is particularly important for certain strategic actors to do so, as they can in turn exert their influence over the network to help it adapt to change. As mentioned, one key way to increase absorptive capacity is to create and maintain connections with out-of-cluster actors from whom they can learn. In this respect, it would be especially impactful if OTTIAQ follows up on its plans to 'knock on doors' to work with the stakeholders making the developments in machine translation. One possible scenario Mr. Barabé proposed was to bring together 5 to 10 language professionals with particular competencies in this respect, and "go knock on the door of Yoshua Bengio" (figurately speaking) and say "listen, we want to contribute. We don't want to put obstacles in your way, we want to contribute, but we also want to help you create guidelines because as it stands, it doesn't work" (interview with Mr. Barabé). What's more, given AILIA's ongoing work and expertise in developing standards, its connections with the private sector, and the geographic proximity of the Montreal and Ontario-based clusters, it could prove an highly valuable ally for these efforts.

OTTIAQ could also continue to exploit its connections with the CIQ and the OPQ. The CIQ in particular is a grouping of all of Quebec's 46 professional orders, representing industries such an engineering, nursing, midwifery, administration, chemistry, medicine, psychoeducators, etc.[23] Although there is evidence of new knowledge combinations between OTTIAQ and some of these orders—Mr. Barabé often made several comparisons with the organization of the profession of pharmacists, and looks to this industry as a inspiration for a way forward in certain respects—OTTIAQ could further invest in these relationships in order to, in the same vein as the trade associations, find common ground with the different professions, particularly with respect to how different professions are impacted by AI, and how they have found ways to adapt.

One of the strengths of the Translation Bureau is its particularly high absorptive capacity, as demonstrated by its development of its own machine translation technology. The Translation Bureau is the only network actor that could improve overall network health by, as opposed to branching out, consolidating its relationships within the network. Network actors could not only learn a lot from the Translation Bureau, but based on the case study, it appears that the Translation Bureau would also benefit by accepting more input by network institutions, on a number of fronts. Indeed, in keeping with the example of its machine translation technology, despite its technological competencies, because the Translation Bureau did not sufficiently consult network institutions, there was tremendous generalized

[23] https://professions-quebec.org/en/quebec-interprofessional-council/about-us/members/

uproar when the technology was implemented in the federal government (due to a highly problematic roll out), and the technology was eventually scaled back.

7.4 Limitations of findings

Any research study will contain limitations, and two in particular have been identified for this research.

Although one of the great benefits of network analysis is that the resulting findings are highly generalizable, it remains that the data was collected in a specific industry, at a specific point in time. In other words, despite the context provided by the case study, this network analysis remains a snapshot. It would be valuable to repeat this experience in perhaps less traditional industries to see if the network structure, densities and redundancies are repeated, and are therefore truly specific to institutional interactions. It would also be interesting to repeat this experiment in a less dense network, to determine if smaller actors can achieve similar gains. Finally, it would also be interesting to produce a second portrait of the institutional network of Montreal translation cluster in a few years' time, particularly if the institutional network succeeds in building constructive out-of-cluster bridges and enters a new growth phase. However, a longitudinal study providing several snapshots over time is outside the scope of this research.

Second, one of the critiques made against the existing body of literature in cluster theory is the one-sided focus on firms. The same critique could be made against this research, i.e. the focus is entirely on institutions. Although it would be valuable to create a network with all the players in the cluster, doing so would go outside the scope of this research, as well as go against the original intent, i.e. to focus the spotlight and learn more about an understudied actor in clusters, in an effort to better isolate their role and contribution in cluster health.

8 Conclusion

This research sought to flesh out the impact of institutions in clusters, notably through their ability to assist clusters in their ability to adapt to technological change and promote cluster health. It set out to do this through a cross-fertilization of the cluster literature, institutional literature and network literature. Specifically, this research built off of Nelson's theory of institutions (2006, 2015), which positions institutions as both a reflection of the wider institutional environment while simultaneously allowing an abstraction of institutions (i.e. institutions as organizations) for purposes of analysis, to create an institutional network that was studies through the lens of network theory in order to determine both the structural properties characterizing the institutional environment as a whole as well as the characteristics of institutions. The findings were then recontextualized in cluster theory.

In terms of structural properties, it was found that in keeping with the nature of institutions described in the literature (exhibition of a certain resistance to innovation as a source of uncertainty, instability and inefficiency), institutions tend to organize themselves in hierarchical network structures, which also have certain structural characteristics that can hamper innovation (i.e. as opposed to small-world structures, which are optimally designed to promote innovation and creativity).

More specifically, the institutional network of the Montreal translation cluster produced a highly dense core-periphery structure with short geodesic distances between nodes. Although these latter two characteristics allow for a more even distribution of information and knowledge than a typical core-periphery structure, they also result in a high level of redundancies in terms of connections, which decreases the opportunity for structural holes and diversity. This reflects the findings of the case study, insofar as the institutional network demonstrated extensive homogeneity and interconnection, notably due to a long, interwoven history, a high degree of trust (due in part to a high mobility and participation of stakeholders throughout the network) and embedded relations.

This research also found that both intra-network and extra-network knowledge flows were critical to cluster health. In this case, although intra-network knowledge flows were productive (i.e. flowed throughout the network), albeit not optimal (insofar as redundant ties increased homogeneity and reduced the potential for innovation), the lack of network flows across cluster boundaries, and pipelines to the AI or high tech cluster in particular, reinforced the lack of diversity in intra-network knowledge flows, explaining the resistance to technological advancements and changing business models observed in the case study. However, plans by a prominent network actor, OTTIAQ, to reach out to its neighbouring

AI hub to propose a joint project to create guidelines and/or international standards to evaluate the output quality of machine translation may go a long way in remedying these shortfalls, as well as increase the network's overall absorptive capacity regarding the new technologies. Trade associations were also found to be advantageously placed to leverage their secondary areas of expertise (e.g. education, law) to bridge other clusters and inject new knowledge in the network.

Another significant contribution of this research is that it proposes an alignment between the institutional and network theory on the subject of brokers. In other words, the finding that institutions are naturally inclined to be brokers corroborates the conceptualization of institutions as facilitators and mediators, as proposed by the institutional view of clusters. However, this research also proposes that the presence of a high proportion of brokers in a network acts as one of the contributing factor to the density and redundancy observed (the other factor being an overreliance on horizontal relationships).

Finally, the presence of two small trade associations in the core of the structure, combined with their high scores on a number of centrality measurements, demonstrates that while size is certainly a factor in gaining prestige, impacting a network and benefiting from a network, small players can overcome their limitations of size by creating and maintaining partnerships. The power of partnerships was also evident in the disproportionately high absorptive capacity of the ACGL. However, this finding must be considered in light of the particularly high density of the test institutional network, as the particularly low relative cost of connections in this network may have played a role in allowing these small players to maintain so many ties. In other words, although a highly interconnected network is not optimal for overall network health, it does appear to give a boost to smaller players.

While this exercise—conducting a network analysis on a solely institutional network—is hypothetical, in the sense that no real-world network is comprised entirely of institutions—it did allow to study institutions in such a way as to isolate their role and contribution to clusters. As such, a number of generalizations can be made and applied to the cluster literature.

For one, we propose that a cluster with a disproportionately large institutional environment may struggle with innovation, creativity and adaptability. It is also proposed that a highly interconnected institutional network, as observed in this case study, is typical of the institutional environments of clusters in a sustained growth phase, which are characterized by a set developmental path, few new entrants and a consolidation of actors. Finally, even though the institutional environment must by definition have less absorptive capacity than the private sector, it is nonetheless important to invest in the absorptive capacity

of institutions in order to mitigate a naturally-occurring resistance to change that could eventually prove maladaptive for the cluster as a whole.

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APPENDIX A:
SAMPLE QUESTIONNAIRE

Name of institution:

Name and position of repondent:

INSTRUCTIONS

1. To answer the following 10 questions (A to J), simply check all the institutions that apply.

2. If you check "Other institutions and/or firms," please list all the institutions and/or firms that apply on the designated line on the following page.

		Ordre des traducteurs, terminologues et interprètes agréés du Québec (OTTIAQ)	Carrefour des langagiers entrepreneurs (CLEF)	Association of Legal Court Interpreters and Translators (ALCIT)	Literary Translators'Association of Canada (LTAC)	Network of Translators in Education (NTE)	Société québécoise de la rédaction professionnelle (SQRP)	Concordia University	Université de Montréal	McGill University	Translation Bureau	Office québécoise de la langue française	Editors' Association of Canada - Quebec/Atlantic	Canadian Translators, Terminologists and Interpreters Council (CTTIC)	FIT – North America	Association de l'industrie de la langue (AILIA)	*Other institutions and/or firms*
A)	Your institution attended an event organized by:																
B)	Your institution follows these institutions on social media:																
C)	Your institution advertised (on social media or through its mailing lists) an event organized by:																
D)	Your institution has subscribed to the mailing lists of the following institutions:																
E)	Your institution organized an event jointly with:																
F)	Your institution sponsored or was a speaker at an event organized by:																
G)	Your institution is a member of an issues/consultation/industry table with the following institutions:																
H)	Members from the following institutions receive incentives (e.g. discounts for membership, events) from your institution:																
I)	The following organizations are *formally* qualified as your institution's "partners":																
J)	The following organizations are *informally* qualified as your institution's "partners":																

Definitions

Institution: A public or non-profit organization that plays a supportive role in the industry, whether directly through its mandate (e.g. education and training of workforce, protection of professional interests, protection of the public, optimization of business environment) or indirectly through the influence it wields on the industry (e.g. in terms of quality standards, lobbying potential, ability to set prices) due to its size, historical significance, partnerships, etc.

Firm: A private organization whose primary purpose is to make profit.

Other institutions and/or firm (please list all that apply on the designated line)	
A)	
B)	
C)	
D)	
E)	
F)	
G)	
H)	
I)	
J)	

APPENDIX B:
LIST OF INSTITUTIONS IN MONTREAL'S TRANSLATION CLUSTER

Institution	Respondent	Description	Sources
OTTIAQ (L'Ordre des traducteurs, terminologies et interprètes agréés du Québec)	Donald Barabé, President	The Ordre des traducteurs, terminologues et interprètes agréés du Québec is one of the 46 professional orders in Quebec. Formerly known as the Société des traducteurs du Québec (STC), OTTIAQ received its letters patent in 1992 and changed its name as per legislative requirement. No longer a trade association, OTTIAQ has assumed a mission to protect the public. In this new capacity, OTTIAQ strives to uphold the integrity of three language professions (translation, interpretation and terminology), and to that end grants, oversees and revokes the reserved titles of Certified Translator, Certified Interpreter and Certified Terminologist, provides continuing education, organizes conferences, etc. OTTIAQ, however, does not govern exclusive practice (i.e. language professionals do not require OTTIAQ certification to be able to practise their profession). OTTIAQ is part of the legislative framework of the profession and is a strong voice in the profession in Quebec.	ottiaq.org
CLEF (Carrefour des langagiers entrepreneurs)	Diana Marquez, Treasurer, member of the board of directors	The Carrefour des langagiers entrepreneurs is a grassroots trade association created in 2007 with a view to breaking the isolation of translators, improving and standardizing working conditions, promoting the profession and ensuring a better integration of the next generation of professionals. Although this association eventually decided to broaden its scope to extend to all language professionals, translators form the core of members. CLEF has further defined its mission to promote networking among the different actors in the industry, defend the political and professional interests of independent language professionals, provide services, rebates and other benefits to its members, and provide opportunities for training and networking. Of note, CLEF has also created and administered the largest closed-group Facebook discussion group for language professions, with over 1600 members as of May 29, 2019.	https://langagiers.org/
ACJT Association Canadienne des juristes-traducteurs	Louis Fortier, C. Tr. C. Adm., President	The ACJT was founded in 1988 to promote the field of legal translation as well as the status of legal translators in Canada. Based in Montreal, the ACJT is particularly active in advancing legal translation by assisting universities in their efforts to develop adapted university programs, as well as by intervening in a number of legal files (in particular by reaching out to the Barreau du Québec), including, of note: 1) to ensure compliance with s. 40.1 of the Quebec *Securities Act*, which states that all prospectus	https://acjt.ca/a-propos/ Interview with Louis Fortier

		documents must be drawn up in French only, or in both French and English; 2) to back a case against the federal government to compel the latter to provide the necessary financial, material and human resources to ensure compliance with the *Official Languages Act*; and 3) to back the plaintiff in Fisch v. Translation Bureau, who is requesting authorization to file a collective suit against the Translation Bureau.	
ALCIT (Association of Legal Court Interpreters and Translators)	No respondent	The Association of Legal Court Interpreters and Translators "is a collective of professionals who have an interest and training in legal translation and interpretation." Members work in organizations such as courts of law, in particular at the Municipal Court of Montreal and the City of Montreal Policy Department.	http://www.atij.ca/
LTAC (Literary Translators Association of Canada	Alexander St-Laurent, Coordinator	The Literary Translators' Association of Canada was created in 1975 in response to a lack of recognition ("tolerated as a necessary evil") of literary translation and the poor working conditions that did not promote the profession's development. Its mandate is to further "the interests of literary translators in national organizations such as the Public Lending Right Commission and the Creators Copyright Coalition." The LTAC does this by highlighting the role of literary translation in providing access to Canada's culture, participating in Canada's literary life, and organizing public events such as readings, lectures and panel discussions, often in partnerships with literary festivals, universities and other organizations. Although its mandate is pan-Canadian, most of its activities take place specifically in Montreal (Plateau Workshops) or in Eastern Canada. Furthermore, its office is located inside Concordia University, in Montreal.	http://www.attlc-ltac.org/en/history/ http://www.attlc-ltac.org/en/mandate/
NTE (Network of Translators in Education)	Lucie Leblanc, C. Tr., President	The Network of Translators in Education was established in 1985 to bring together independent and employed language professionals working in the field of education. It acts as a "peer support network," and has a dual purpose to encourage information sharing on French and English terminology and usage in education, as well as to offer members and other language professionals' opportunities for training, upgrading and professional development. The NTE's office is located in Ottawa, but has been included on this roster as it regularly sends representatives to Montreal industry events.	http://rte-nte.ca/about/mission-statement/
SQRP (Société québécoise de redaction	Marie-Noël Pichelin, réd. a., Présidente	The Société québécoise de la rédaction professionnelle is a non-profit organization that received its letters patent in 1993 to, among other things, bring together copywriters, establish criteria for quality copywriting, evaluate the	https://sqrp.org/

professionnelle)		quality of texts it receives, and keep a register of the people who meet the Société's criteria. Although not a professional order governed by the *Professional Code*, the SQRP is a body that certifies the competencies of copywriters and promotes the interests of its members as well as the certification of "certified copywriter" (rédacteur agréé) in the communications sector. Note that this certification does not act as a permit, but rather provides recognition of the person's professional competency (i.e. label of quality). This SQRP's office is located in Montreal. Although not an association for translators, it has been included on the roster as a French counterpart to the Editors' Association of Canada. Furthermore, many translators become members of the SQRP.	
Concordia University	Christine York, C. Tr., Full Professor, Director of Undergraduate Translation Programs	Concordia University, located in Montreal, offers a number of translation programs and certificates at the undergraduate and graduate level through its French Studies department. The French Studies department coordinates internships for undergraduate students and liaises with employers through the Institute for Co-operative Education, as well as conducts research in the field of translation studies.	https://www.concordia.ca/artsci/francais.html
Université de Montréal	Georges Bastin, Full Professor, Director of Translation Programs	Université de Montréal, located in Montreal, offers a number of translation programs and certificates at the undergraduate and graduate level through its Linguistics and Translation department and faculty of continuing education and boasts the greatest number of graduates in translation among all universities offering programs of study in translation, as well as the greatest number of programs recognized by OTTIAQ for certification. Similarly to Concordia University, it also offers its students opportunities to complete internships in translation and terminology, as well as conducts research in the field of translation studies.	https://ling-trad.umontreal.ca/accueil/ https://ottiaq.org/etudiant-aspirant/formation-universitaire/
McGill University	No respondent	McGill University offers a number of undergraduate and graduate translation certificates, as well as programs in translation through its School of Continuing Education. Internships are not arranged within the department, but through the university-wide Internship Offices Network. Although it once offered an OTTIAQ-recognized Bachelor of Arts in translation, this was no longer the case for the 2018-2019 school year.	https://www.mcgill.ca/study/2018-2019/faculties/continuing/areas_of_study/translation_and_written_communication/scs_trans_tran

			slation_programs https://www.mcgill.ca/internships/mcgill-internship-offices-network https://ottiaq.org/etudiant-aspirant/formation-universitaire/
OQLF (Office québécoise de la langue française)	No respondent	The Office québécoise de la langue française is mandated by the *Charter of the French language* to define and oversee the Quebec policy on official languages, terminology and francization in the private sector; to make sure that French is the normal and everyday language of work, instruction, communication and business; to define, develop and ensure the application of francization programs; and monitor the evolution of the linguistic situation in Quebec, among other things. As part of its mandate to regulate and monitor the French language and define and conduct Quebec policy on linguistic officialization and terminology, the OQLF offers free use of a quality terminological database through its website, which is widely used by translators in Quebec, along with a host of other language-related tools. What's more, the OQLF has a significant number of terminologists to research and feed this terminological database, and is sometimes present at industry events.	http://www.oqlf.gouv.qc.ca/office/mission.html http://www.legisquebec.gouv.qc.ca/en/showdoc/cs/C-11
Translation Bureau, Public Services and Procurement Canada	Josée Marengère, Senior Advisor for Outreach and Parternships	The Government of Canada's Translation Bureau in 1934 in order to centralize the federal government's translation services. The Translation Bureau is the largest employer of translators and other language professionals in Canada today. It is also recognized as a standard bearer, due to the role it played furthering research in machine translation in the 1970s and 80s, and for providing free access to a host of resources, such as Termium, the terminology database used by all translators today, the *Canadian Style Guide*, etc.	https://www.erudit.org/en/journals/meta/1992-v37-n2-meta336/004305ar/
Editors Association of Canada	Gail Spivak, President	The Editors' Association of Canada, a federally incorporated non-for-profit organization governed at the national level by an executive council, offers a certification program and organizes a national conference for English language professionals involved in editing. Although the national office is in Toronto, the EAC does have a	http://www.editors.ca/members/readup/hist_struct/index.html

		Quebec/Atlantic branch that is quite active in Montreal through its offer of workshops and regular presence at area conferences.	
CTTIC (Canadian Translators, Terminologists and Interpreters Council)	No respondent	The Canadian Translators, Terminologists and Interpreters Council strives to be recognized as a national body representing professional translators, interpreters and terminologists, and in that capacity, maintain and promote professional standards to ensure high-quality community in Canada, namely through a national standardization examination. Although its headquarters are located in Ottawa, OTTIAQ was until 2012 the largest affiliated member of CTTIC, and was therefore until then a part of the Montreal translation cluster.	http://www.cttic.org/mission.asp Interview with Donald Barabé
FIT-NA (International Federation of Translators – North America)	Diane Cousineau, C. Tr.*, FIT North American representative	The International Federation of Translators (Fédération internationale des traducteurs) is an international grouping of associations of translators, interpreters and terminologists whose goal is to promote professionalism in these disciplines, notably by seeking to improve conditions for the professions around the world, upholding translators' rights and freedoms of expression, and supporting its member associations in their respective missions. Specifically, it aims to bolster the network of existing associations, encourage and facilitate the creation of new associations in countries where they do not exist, provide member associations with industry information, and promote the recognition of the represented professions, among other things. FIT North America is one of three regional centres that promote the FIT's activities in their designated regions, namely by organizing meetings to strengthen ties between members associations and liaison with the FIT Council. FIT North America has been included in the Montreal network as OTTIAQ is a member, FIT activities or themed days are often advertised in Montreal, FIT representatives are often present in Montreal, and the first FIT international headquarters was originally housed by OTTIAQ's headquarters. Furthermore, the FIT-NA representative is also OTTIAQ's Executive Director.	http://www.fit-ift.org/what-is-fit/
AILIA	Sharon Steinberg, President	AILIA is the Canadian not-for-profit trade association of language service companies whose mission is to promote and increase the competitiveness of the Canadian language industry nationally and internationally through advocacy, accreditation and information sharing. Members include corporate bodies, institutions, individuals (e.g. freelancers) and students.	https://www.ailia.ca/en/membership https://www.ailia.ca/en/about-ailia/our-

		Of note, they have created a working group to create a national standard for translation services. Although located in Toronto, a number of prominent Montreal industry representatives are seated at the board or chair important committees within this national organization.	volunteer-board
ACGL (Association des conseil en gestion linguistique)	Dominique Bohbot, C. Tr., Honourary board member and former president of the ACGL	The ACGL is an association that brings together the decision-makers and owners of linguistic firms. The ACGL is particularly committed to shining the spotlight on the added value created by working with professional language firms, offering networking opportunities for its members, and offering training and workshops on current issues, including, more recently, the Canadian standard in translation, the added value of certification, new technologies, and calculating the true cost of services.	http://lacgl.org/
CATS (Canadian Association of Translation Studies)	No respondent* Current president: Christine York, C. Tr. (Concordia)	CATS was created in 1987 to promote research in translation studies, offer a platform for discussion for matters relating to the teaching of translation studies, and disseminate research findings to members and other researchers. (Note that CATS is a separate association from the Canadian Association of Schools of Translation (CAST)). CATS was included in the Montreal translation cluster because, although it is a national organization, a significant proportion of members and volunteers at CATS are based in one of the Montreal-area translation universities.	http://act-cats.ca/about/history-purpose/

APPENDIX C:
SIZE OF INSTITUTIONS

SCALE:

1: 0 to 250 **2: 251 to 3500** **3: 3501 +**

Institution	Size	Justification	Source
OTTIAQ	2	2100 members	https://ottiaq.org/lordre/
CLEF	1	109 members	https://langagiers.org/repertoire/
ACJT	1	160 members	Correspondence with Marie-Claude Fournier, Secretary of ACJT, dated May 31, 2019
ALCIT	1	No information available, but assumed to have under 250 members	http://www.atij.ca/
LTAC	1	220 members	Correspondence with Alexander St-Laurent, Coordinator of the LTAC, dated June 10, 2019
NTE	1	84 members	FlashInfo, March 13, 2019
SQRP	1	153 members	https://sqrp.org/repertoire-des-membres/page/8/
Concordia	3	50,000 students	https://www.concordia.ca/about.html
UdeM	3	46,000 students	https://www.umontreal.ca/l-udem/en-chiffres/
McGill	3	40,000 students	https://www.mcgill.ca/es/registration-statistics
TB	2	1800 employees	https://aiic.net/page/6240/government-of-canada-translation-bureau/lang/1
OQLF	2	230 employees	https://www.oqlf.gouv.qc.ca/rdiprp/demandes/20160422_documents.pdf
EAC	2	1300 members	https://www.editors.ca/about-editors-canada
CTTIC	2	3500 members, represented by 7 institutional members	http://www.cttic.org/member.asp
AILIA	3	Thousands of members and employees, represented by 61	https://www.ailia.ca/en/membership/membership-categories

		members from all membership categories[24]	
FIT	3	80,000 translators, represented by 100 associations	https://www.fit-ift.org/about/
ACGL	1	*No available numbers[25]	http://lacgl.org/
CATS	1	80 members	http://act-cats.ca/wp-content/uploads/2019/05/R%C3%A9pertoire-2018-2019.pdf

[24] Although the exact number of members and employees represented by AILIA's 61 members is not available on their website, it is safe to assume that the number is greater than 3500 as some of the institutional members include OTTIAQ and McGill, it is safe to assume that AILIA belongs in category 3.

[25] Although ACGL does not publish member information, based on their activity participation rate, as represented in their newsletters (about 15 to 30 people per activity) and that members principally represent small- and medium-sized employers, and given that the purpose of this research is to measure institutional interactions, it is safe to value their institutional imprint at 1.

APPENDIX D:
INSTITUTIONS' INTERACTIONS WITH TECHNOLOGY

SCALE:

1: Least interaction **2: Average interaction** **3: Most interaction**

Institution	Size	Justification	Source
OTTIAQ	3	Although OTTIAQ offers training on disruptive technologies, both as part of its continuing education portfolio (offered by outside partners) and through its annual conference (offered by guest speakers following a call for proposals), for many years it upheld a spirit of extreme caution with respect to disruptive technologies, as evidenced by a warning on the home page of its website. However, there are plans to update the warning on using machine translation. Furthermore, during the interview with Diane Cousineau, she stated that though machine translation was a challenge, it was important for the profession to view it as a tool as opposed to a threat: "In the right hands, it can be very productive and interesting, and if you don't see it like that, you're missing the boat."	https://ottiaq.org/mise-en-garde/ Interview with Diane Cousineau, ED of OTTIAQ and representative for FIT-NA
CLEF	1	Although there is a section on its website for resources/new technologies, the technologies themselves are not the disruptive ones under study (AI, NMT, or even CAT tools). Rather, they are articles regarding optimizing the use of Internet and social media, etc.	https://langagiers.org/ressources/
ACJT	1	No mention of disruptive technological challenges facing the industry	https://acjt.ca/
ALCIT	1	No mention of disruptive technological challenges facing the industry	http://www.atij.ca/
LTAC	1	No mention of disruptive technological challenges facing the industry	http://www.attlc-ltac.org/
NTE	1	No mention of disruptive technological challenges facing the industry	https://rte-nte.ca/fr/
SQRP	1	No mention of disruptive technological challenges facing the industry	https://sqrp.org/
Concordia	3	Research institution: Assumed to have the greatest interaction with technology and absorptive capacity	https://www.concordia.ca/about.html

UdeM	3	Research institution: Assumed to have the greatest interaction with technology and absorptive capacity	https://www.umontreal.ca/l-udem/en-chiffres/
McGill	3	Research institution: Assumed to have the greatest interaction with technology and absorptive capacity	https://www.mcgill.ca/es/registration-statistics
TB	3	The Translation Bureau is actively involved in research, developing, in collaboration with the National Research Council, its own machine translation tool	https://www.cbc.ca/news/canada/ottawa/online-translator-defended-1.3433919
OQLF	3	The OQLF works with leading research institutions (MILA, Computer Science and Electrical Engineering departments at Université Laval and Université de Sherbrooke) to fuel its terminological database	https://www.oqlf.gouv.qc.ca/ressources/bibliotheque/dictionnaires/vocabulaire-intelligence-artificielle.aspx
EAC	1	No mention of disruptive technological challenges facing the industry	https://www.editors.ca/
CTTIC	2	CTTIC's website is incredibly out of date; however, its 7 members are translation associations with mandates to protect the public, and consequently borrow an approach consistent with that of OTTIAQ	http://www.cttic.org
AILIA	3	Although there is little information on its website regarding disruptive technologies, other than a couple basic pages, AILIA's approach to disruptive technologies is to embrace it, and is working with its members (which include MNEs and other firms that leverage these technologies) to structure its integration into the industry	https://www.ailia.ca/en/the-industry/language-technology https://www.ailia.ca/en/news-and-resources
FIT	3	FIT has produced a number of position statements that either touch or focus on disruptive technologies (impact on future of profession, statistical machine translation (SMT), etc.), but does does not go into detail, and has yet to issue a statement on NMT; however, its latest World Congress in 2017 featured presentations on the latest technologies as well as disruptive technologies	https://www.fit-ift.org/position-statements/ https://www.fit-ift.org/brisbane-2017/
ACGL	3	Members are translation firms that are required to stay cutting edge to remain; recent training on latest technological developments	http://lacgl.org/fr/calendrier-des-activites-2018-2019/

CATS	1	Despite being associated with research institutions, the institution's focus appears to be more on the theoretical aspects of translation studies; no mention of technological challenges on website	http://act-cats.ca/