Mechanism of Triple Helix Circulation, Cluster-Engine, and Cluster-Reactor: A Case Study on Greater-Montreal Aerospace Cluster

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Abstract

In light of the global expansion of the aerospace industry in recent years, many countries are looking to form aerospace clusters. Greater-Montreal[1] in Quebec is the world's most popular and the fourth-largest center of aerospace manufacturing. It is the only place where an entire aircraft can be assembled from locally manufactured components. Against this backdrop, this study focuses on the Greater-Montreal aerospace cluster's triple helix circulation. It has a positive mechanism for triple-helix circulation between the university, industry, and government. Accordingly, this paper examines and analyzes the triple-helix circulation based on a case study of some actors in the Greater-Montreal aerospace cluster.

Keywords: triple helix circulation, cluster-engine, cluster-reactor, organizational proximity, social proximity, Greater-Montreal aerospace cluster

1. Introduction

This study aims to elucidate the challenges of forming an aerospace cluster from the perspective of triple-helix circulation. Specifically, our targets are R&D consortiums, business support organizations, think-tanks, education, training institutions, and aerospace universities. Our interview survey was conducted in Greater-Montreal, which has drawn attention as a model aerospace industry cluster. The emergence of universities, industries, and the government – triple helix – can also be identified as a key factor in regional development. Therefore, this paper aims to investigate the mechanism of triple helix circulation through a case study of some actors in Greater-Montreal.

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[1] Greater-Montreal is the most populous metropolitan area in Quebec.

2. Review of Preceding Studies

In the last ten years, a broad range of studies has been conducted on aerospace clusters. The following studies have specifically focused on the Greater-Montreal aerospace cluster. Niosi and Zhegu (2005) in their study, in the light of knowledge spillover, provided an analysis of the most dynamic aerospace clusters around the world, including Quebec. Armellini et al. (2012) examined research on consortium and innovation in the Quebec aerospace industry. They analyzed and presented the framework adopted by the Quebec aerospace cluster to enhance cooperation between local enterprises and science and technology institutes in the development of pre-competitive technologies in the sector. A study by Gardes, Dostaler, Barry, and Gourmel-Rouger (2015) examined aerospace clusters and competitiveness poles, highlighting the cases of France and Quebec, where the local governments have invested significantly in them. Therefore, this paper considers the triple helix circulation in the Greater-Montreal aerospace cluster for reference to these articles.

3. Basic Concepts and Research Framework

(1) Basic Concepts

The basic concepts of this study are cluster and triple helices. According to Porter's (1998) concept, clusters are the geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of associated industries and other entities that are important for competition. They include, for example, suppliers of specialized inputs, such as components, machinery, and services, and providers of specialized infrastructure.

Etzkowitz's (2002) concept of the triple helix is a spiral model of innovation that captures multiple reciprocal relationships at various points in the process of knowledge capitalization. According to Etzkowitz, the triple helix denotes the university-industry-government relationship as a relatively equal, yet interdependent, institutional sphere that overlaps and assumes the role of others.

(2) Research Framework

The research framework of this study is as follows: First, we drew the cluster map of the Greater-Montreal aerospace industry based on our interview survey. Second, we introduce a case study of six actors in the Greater-Montreal aerospace cluster[2]. Third, we analyze the relationship between triple helix circulation and the actors in the

[2] This interview survey was conducted by the author in December 2019. For further details, see JSPMI-ERI (2020).

cluster. Fourth, we consider the mechanism of the triple helix circulation of the Greater-Montreal aerospace cluster using the original concept of cluster-engine and cluster-reactor.

4. Cluster Map of Greater-Montreal Aerospace Industry

At present, there are 206 companies: six OEMs, 15 equipment integrators, and 185 SMEs, in Greater-Montreal, accounting for more than 70% of Canadian aerospace R&D spending. This region registered an average annual growth of 5.1 % over 25 years (1993–2018), according to Aero Montreal (2019).

Figure 1 shows the cluster map of the Greater-Montreal aerospace industry, revealing how the aerospace cluster pattern was created. It can be classified into five main categories. The first encompasses universities and research institutes, which are exploring next-generation technologies and materials for aerospace and human resource development. The second is the training center for the MRO: maintenance, repair, and overhaul of the main aircraft and airframe. The third comprises associations supporting the Greater-Montreal aerospace industry. The fourth is the state/federal government and government-affiliated organizations related to the aerospace industry. The fifth aspect includes aircraft and parts makers, and SMEs. It also includes unions. As mentioned above, the Greater-Montreal aerospace cluster is formed by a few sectors and many actors, which are correlated. In this context, Niosi and Zhegu's (2005) study on the cluster analyzes its structure in light of the concept of knowledge spillover.

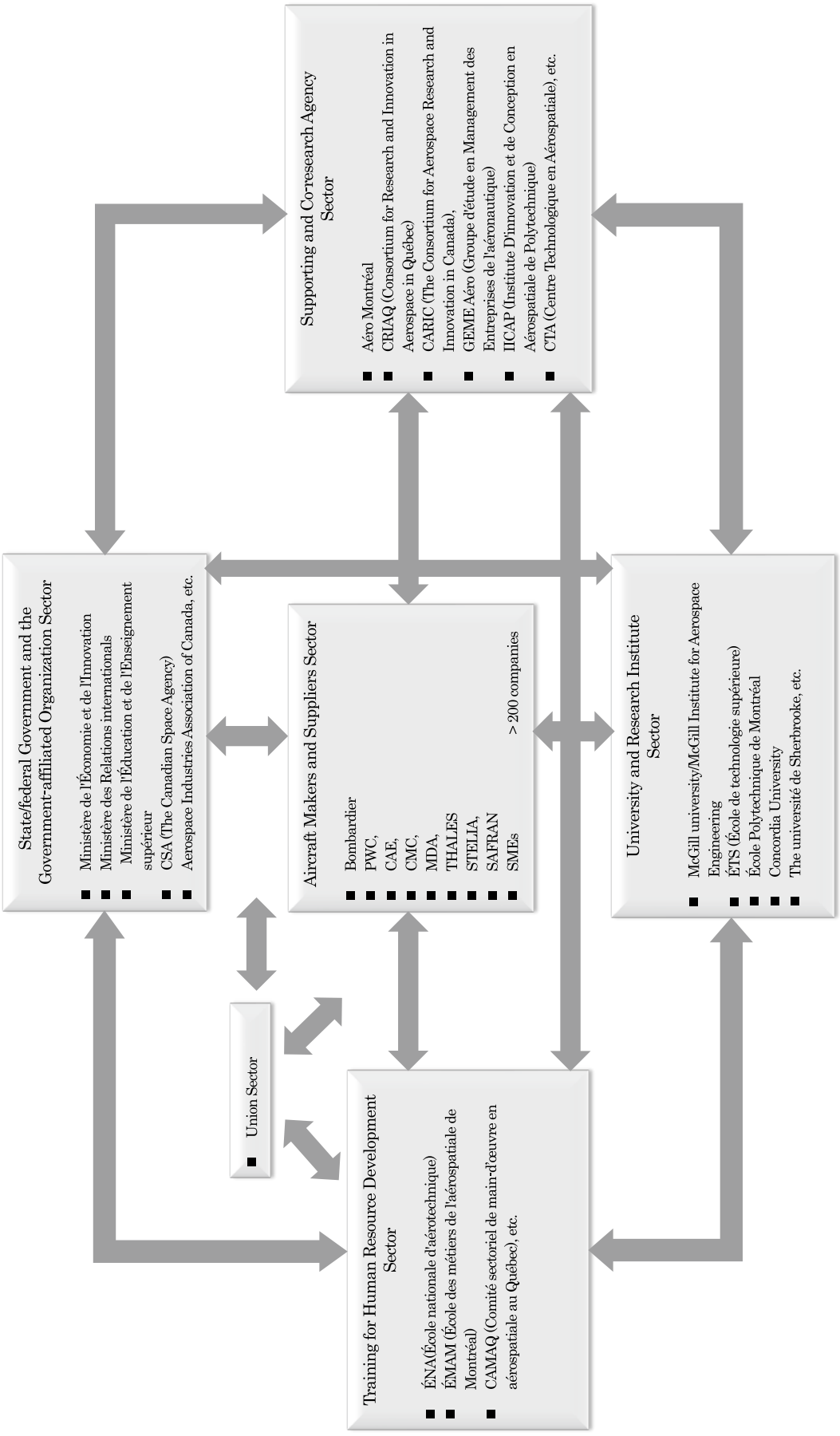
5. Case Study for Actors of the Greater-Montreal aerospace cluster

As demonstrated in Figure 1, there are many actors in the Greater-Montreal aerospace cluster. Subsequently, we conducted a case study on the following: the McGill Institute for Aerospace Engineering (MIAE), École de Technologie Supérieure (ETS, or School of Higher Technology), Montreal Polytechnic, Consortium for Research and Innovation in Aerospace in Quebec (CRIAQ), Aero Montreal, and Comité sectorial de main-d'oeuvre en aérospatiale (CAMAQ). This case study was based on the information and data collected from the interview survey.

(1) MIAE

MIAE plays a leading role in the field of aerospace engineering at McGill University. The institute promotes McGill's aerospace expertise and lobbies for collaborative projects with industry, research institutes, and universities worldwide. Students who are members of MIAE participate in industry tours, conferences, aerospace design team challenges, and paid industry internships. The institute's mission is to promote McGill's

Figure 1. Cluster Map of Greater-Montreal Aerospace Industry in Quebec



stellar aerospace community and showcase it to the world. In recent years, there has been a trend toward utilizing artificial intelligence (AI) for the R&D of technologies and materials in the aerospace field. About 30 % of McGill University students are studying abroad, of which about 20 % are from the francophone world. Consequently, graduates of McGill University and MIAE have contributed to the formation of a global network between French-speaking countries and Greater-Montreal.

(2) ETS

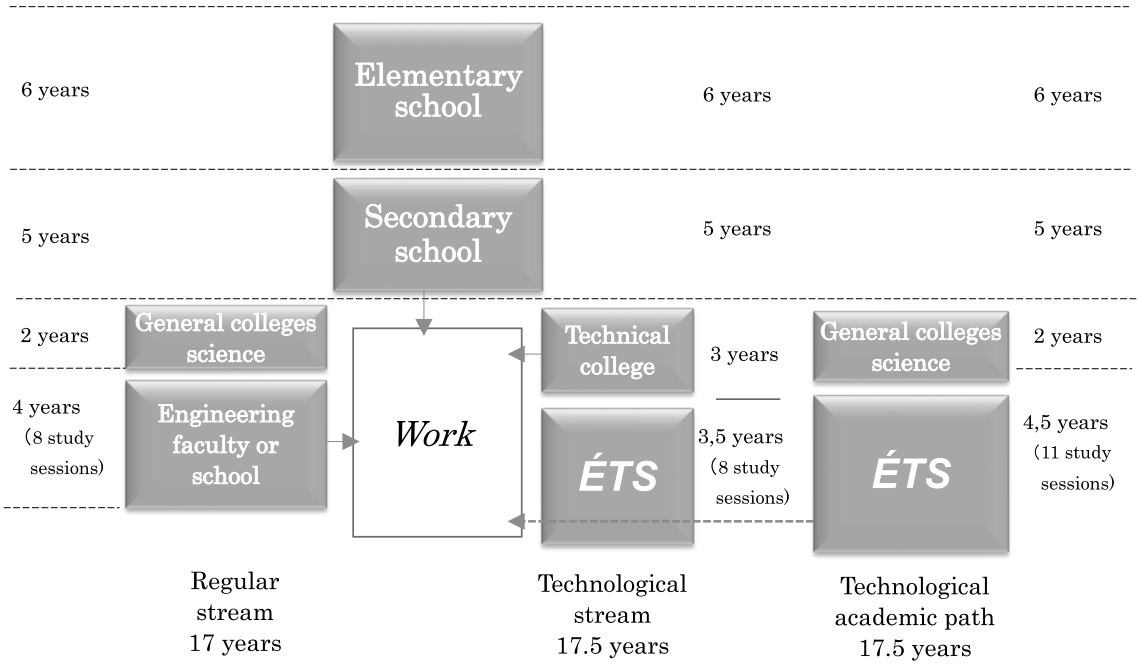
ETS was established in 1974 and specializes in engineering and technological transfer education as well as applied research. It trains engineers and researchers who are recognized for their practical and innovative approaches. ETS has a unique partnership with businesses and industry, including SMEs and large companies. It has over 10,700 students, with more than 2,800 at the postgraduate level. Additionally, 60 % of its research activities are conducted in collaboration with the industry. The school has approximately 770 employees, including over 200 professors and senior lecturers. ETS is associated with many companies, and nearly two-thirds of its graduates are placed in SMEs every year. Its education system and research work are practical and contribute to the development and innovation of SMEs. Figure 2 shows the up-gradation of the technology continuing education stream of ETS, emphasizing its unique education system for the Great-Montreal aerospace industry.

(3) Montreal Polytechnic

Polytechnique Montréal also referred to as Montreal Polytechnic, is a flagship of engineering in Quebec and is one of Canada's leading engineering education and research institutions. Since its establishment in 1873, Montreal Polytechnic has trained nearly 50,000 engineers, specialists, and researchers. It is a key player in Quebec's engineering and innovation sector, in addition to serving as a partner of choice for many innovative businesses not only in Quebec and elsewhere in Canada, but also across the globe. Montreal Polytechnic trains highly qualified research personnel in the aerospace and transportation sectors. They are constantly pushing the boundaries of energy efficiency, notably reducing the environmental impact caused by the transportation of people and goods, and also working to develop increasingly better-performing aircraft. Furthermore, researchers strive to boost the productivity and competitiveness of aerospace firms through the widespread use of digital technologies and support innovation in manufacturing. Montreal Polytechnic offers a unique environment for research, collaboration, and learning, both for the quality of equipment and expertise. It functions as a multidisciplinary hub for aerospace and transportation

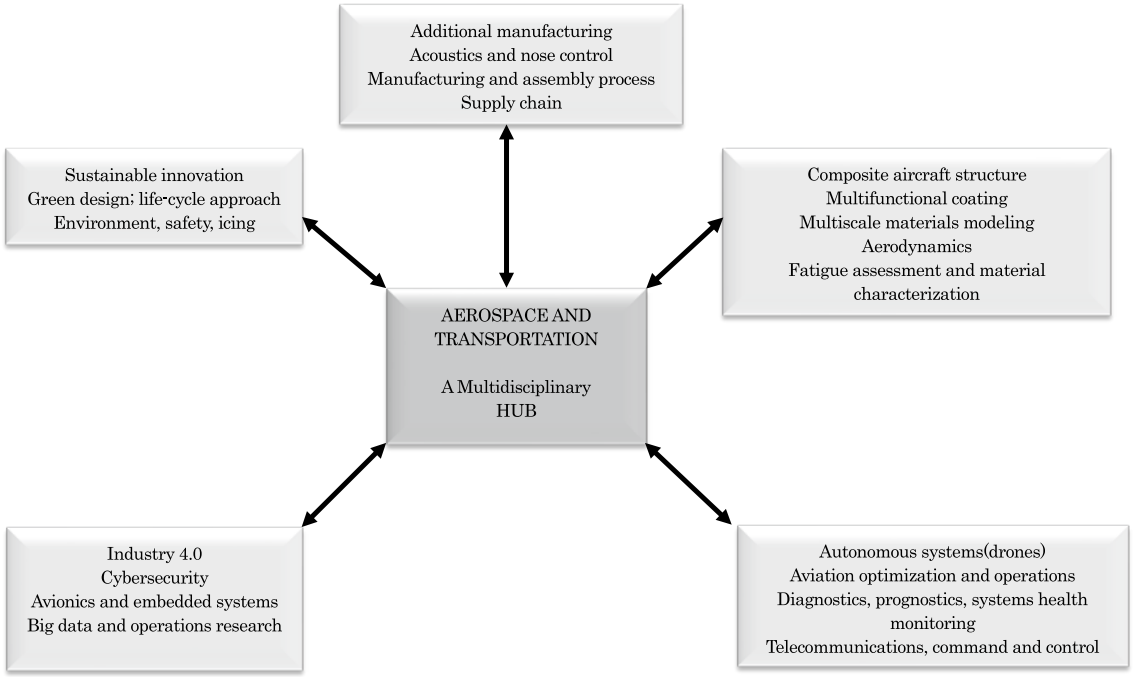
(see Figure 3).

Figure 2. Upgrading a Technological Continuing Education Stream of ETS



Source: ETS (2017).

Figure 3. A Multidisciplinary Hub for Aerospace and Transportation of Montreal Polytechnic



Source: Montreal Polytechnic (2019).

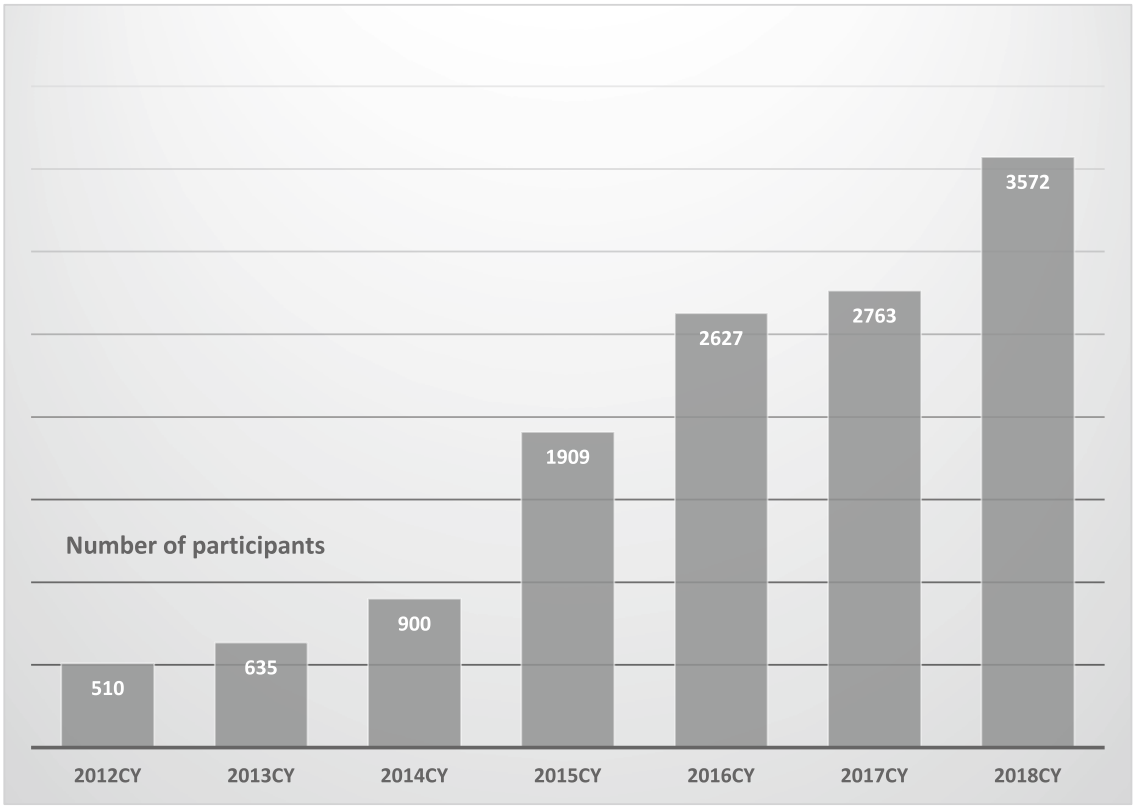
(4) CRIAQ

CRIAQ is a non-profit organization established in 2002 with financial support from the provincial government. Its mission is to increase the competitiveness of the aerospace industry by stimulating business innovation through collaborative R&D. It brings together ecosystems and develops a new generation of innovators to strengthen Quebec's technological leadership in cutting-edge aerospace applications, such as digital aviation, future air mobility, and sustainable aerospace. CRIAQ is the driver of innovation and a pioneer of collaborative research, generating and promoting dialog and collaboration between the industry and academia. It provides access to a network of renowned experts and funding to carry out pre-competitive research projects in aerospace in partnership with more than 300 stakeholders. It is a unique model for collaborative research conducted by companies of all sizes, with involvement from universities and research centers. In recent years, the business environment surrounding the world's aerospace industry has changed significantly due to the emergence of Industry4.0. Accordingly, CRIAQ is establishing new support for collaboration with AI venture companies and traditional SMEs that account for 85% of its partners. There is another organization called the Consortium for Aerospace Research and Innovation in Canada (CARIC), a non-profit similar to CRIAQ, which was established in 2014 with federal government grants. CARIC generates and promotes collaboration between players in the aerospace industry to achieve excellence in competing on a global scale.

(5) Aero Montreal

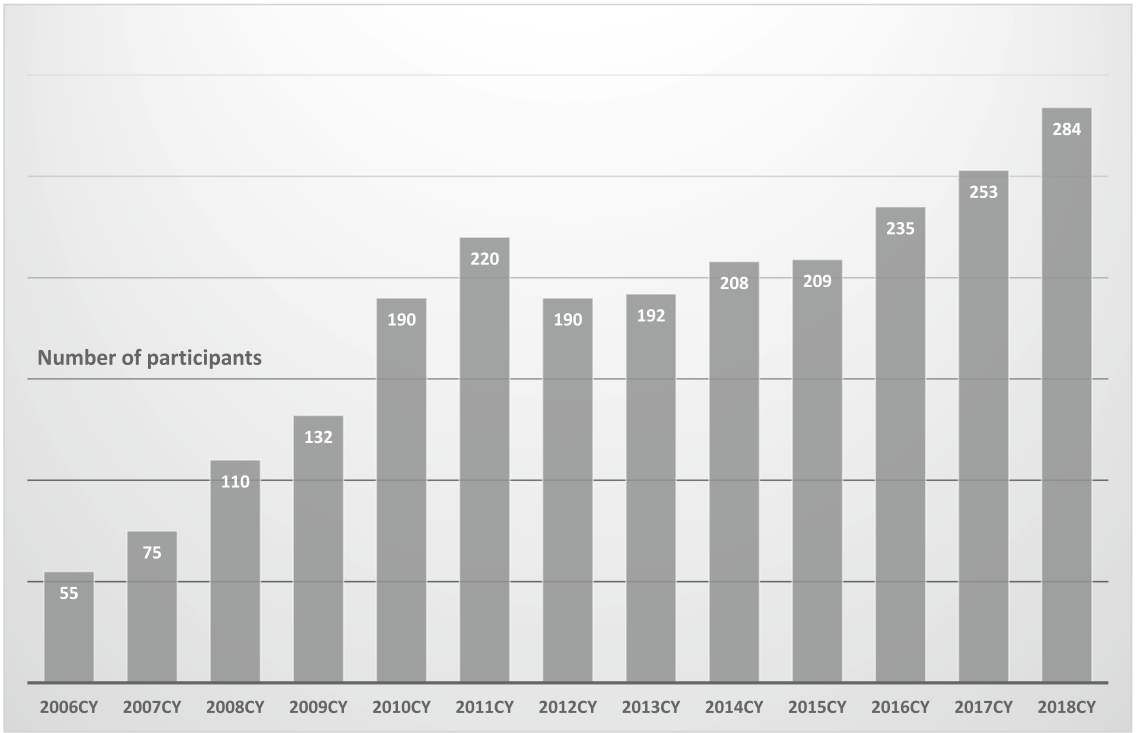
Aero Montreal is a strategic think-tank established in 2006 that groups all the major decision-makers in Quebec's aerospace sector including companies, educational and research institutions, associations, and unions. Its mission is to mobilize industry players around common goals, and concerted actions to increase cohesion and optimize the competitiveness of the Greater-Montreal aerospace cluster. Furthermore, it aims to promote the growth and expansion of the cluster to ensure that it can continue to create wealth for Montreal, Quebec, and Canada. Aero Montreal is adopting a strategic action plan that includes the creation of working groups dedicated to six areas of intervention: supply chain development; branding and promotion; innovation; human resources; defense and national security; and commercialization and market development. Currently, Aero Montreal has hundreds of people, who contribute to the success and dynamism of the Greater-Montreal aerospace cluster. It connects with multiple stakeholders and creates a new business model for the aerospace industry that includes SMEs (see Figure 4 and Figure 5).

Figure 4. Industry Mobilization



Source: Aero Montreal (2018), p. 44.

Figure 5. Participation in SME Events



Source: Ibid., p. 44.

(6) CAMAQ

The foundation of CAMAQ (also known as the Aerospace Workforce Sector Committee in Quebec) dates back to 1978. From 1983 to 1994, it was ten years ahead of Quebec's labor force policy, based on a sectoral and parity approach. It changed its name in 1993 and became the first sector committee for this new policy. CAMAQ promotes professional development prospects and excellence in the Quebec aerospace workforce, which includes the aerospace and airport industries. Besides, CAMAQ works proactively to meet the needs of businesses and employees in the sector. It has been doing fieldwork that has contributed to the evolution of a culture of consultation among aerospace industry partners in terms of manpower and training for over 35 years. CAMAQ collects and analyzes strategic information to enable it to act upstream and in an informed manner in addressing issues affecting the sector's workforce, and value sharing, cooperation, cohesion, pooling of expertise, and team spirit for collaboration (see Table 1). It is also committed to making decisions and providing training programs that conform to the needs of the Quebec aerospace industry. The practical training for manufacturing, assembly, machining, and maintenance of airframes uses many facilities at the Montreal School of Aerospace Trades (EMAN). CAMAQ has also contributed to the development of human resources for the Greater-Montreal aerospace industry.

Table 1. Partners of CAMAQ

Sectors	Partners
Contractors	Airbus Bombardier Pratt and Whitney Canada Bell Helicopter Textron Canada Ltd. CAE Inc.
OEMs	CMA Electronics Heroux-Devtek L3 Technologies Mas Inc. Mda Safran Landing Systems Thales Canada, Avionics GE Aviation Bromont Canada Innotech Execaire Aviation Group Lockheed Martin Canada Rolls-Royce (Canada) Inc.
Worker's Associations	International Association of Machinists and Aerospace Workers UNIFOR
Associations and Public Bodies	Aero Montreal Centre for Advanced Aerospace Manufacturing Technologies (CTFA) Aeronautics and Space Institute of Canada (CASI) Canadian Space Agency Aerospace Research and Innovation Consortium in Quebec (CRIAQ)
Educational Institutions	Scholl of Advanced Technology (ETS) The Montreal School of Aerospace Trades (EMAN) Concordia University Laval University Montreal Polytechnic The National Aerotechnic School (ENA) Sherbrooke University McGill University

Source: CAMAQ (2020).

6. Discussion

(1) Organizational proximity and social proximity

As mentioned above, there are many actors in the aerospace cluster in Greater-

Montreal, Quebec, with their roles and functions. Almost all of them exist in and around Montreal, forming a community of knowledge based on geographical proximity. However, it is important to understand that geographical proximity does not automatically translate into a close relationship. It creates the potential for a relationship, but for this to develop, organizational proximity is imperative, as indicated by Gardes, Dostaler, Barredy, and Gourmel-Rouger (2015).

Those in the Greater-Montreal aerospace cluster participate in the same committees and collaborate in R&D relating to new materials and parts for the airframe. Consequently, these are mutually beneficial features. Given that Montreal is the French-speaking capital of Quebec, those in the aerospace cluster have a common social and cultural base. This may be denoted as social proximity, which is useful for global communication and for conducting businesses with people and firms of La Francophonie. It is also associated with social capital that has accumulated over the long term and is deeply related to the formation of the cluster, as elucidated by Ramhorst-Vejzagic, Huggins, and Ketikidis (2009). In this manner, a layered network based on the trust of many actors exists in Greater-Montreal.

(2) Function of "Boundary Spanner"

According to the aforementioned case study, we can say that the keywords of the Greater- Montreal aerospace cluster are collaboration and intervention, which are functions of "boundary spanner." Boundary spanning facilitates transactions and the flow of new information and knowledge between organizations and associations. Specifically, we believe that the function of a "boundary spanner" is to fill the structural hole, as advocated by Burt (1995).

Members of the cluster can acquire and use the knowledge and information for the new business model and new technologies over the network formed by the function of "boundary spanner." It circulates knowledge and information between different sectors through collaboration and intervention. Overall, CRIAQ or CARIC stimulate business innovation through collaborative R&D, and Aero Montreal conducts many programs to improve companies, educational and research institutions, associations, and unions; and CAMAQ works in consultation with partners in the aerospace industry. Conversely, Gardes, Dostaler, Barredy, and Gourmel-Rouger (2015) grouped these agencies in terms of the age and type of agglomeration (see Table 2). As Table 2 demonstrates, although these associations have different futures, they contribute to the activation of the Greater-Montreal aerospace cluster.

Table 2. Organic and Synthetic Aerospace Grouping in Quebec

Associations	Age of Organization			Agglomeration		
	Older	Middle	New	Organic	Middle	Synthetic
AIAC (Canada, 1964)*	○			○		
AQTA (Quebec, 1997)**	○			○		
CARIAQ (Quebec, 2001)		○			○	
CARIC (Canada, 2014)			○		○	
Aero Montreal (Quebec, 2006)			○			○

*: Aerospace Industries Association of Canada　**: Quebec Air Transport Association
Source: Gardes, Dostaler, Barredy, and Gourmel-Rouger (2015), p. 60.

(3) Cluster-Engine and Cluster-Reactor

Figure 6 shows the triple-helix circulation of the Greater-Montreal aerospace cluster. As highlighted in the drawing, the three cores are clustered with each other and circulate inside. The triple helix of the Greater-Montreal aerospace cluster forms "a meta-cluster" by the layered network of some clusters and actors. This "meta-cluster" is circulated through a certain mechanism. This may be explained by the concepts of the cluster-engine and cluster-reactor. First, the cluster-engine defines the power of acceleration for its activities. As mentioned earlier, Aero Montreal has certain functions for collaboration using many committees; that is, it plays a part in the cluster-engine of Greater-Montreal. Second, the cluster-reactor has defined support for the emergence of new business models and technologies through collaboration and co-research between different sectors and actors. We consider that CRIAQ and CARIC contribute to the role of the cluster-reactor for the Greater-Montreal aerospace cluster because they have many projects and collaborations with players at home and abroad.

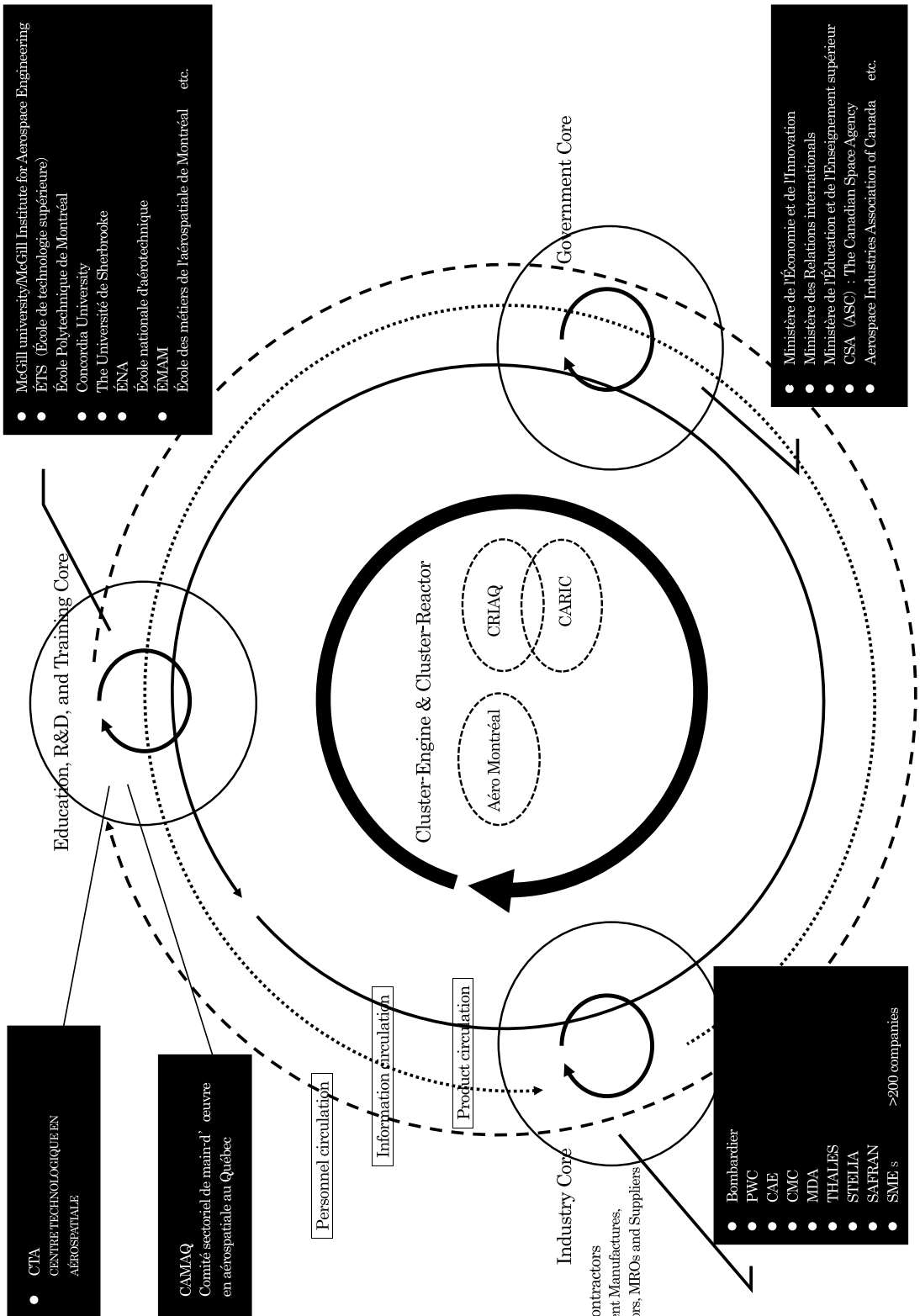
(4) Multiple Circulations

The Greater-Montreal aerospace cluster can, therefore, be explained by multiple circulations. Specifically, the triple helix circulation of the Greater-Montreal aerospace cluster consists of personal, information, and product circulations within individual helices and between them, such as companies, universities, research institutes, training centers, associations, unions, the provincial, and local governments. In this way, the triple helix circulation of the Greater-Montreal aerospace cluster has multiple routes for regional innovation, and these circulations can occur by the functions of the cluster-engine and cluster-reactor (see Figure 6).

7. Conclusion

In conclusion, cluster-engine and cluster-reactor have been confirmed to exist in the

Figure 6. Triple Helix Circulation of the Greater-Montreal Aerospace Cluster



Greater-Montreal aerospace cluster, by our study. Such a mechanism of triple helix circulation has many implications for the development of the Japanese aerospace cluster to create regional innovation that includes many Japanese SMEs. In the wake of the COVID-19 pandemic, the airline industry has been experiencing a great shock, and the market for aerospace products and manufacturing is shrinking rapidly around the world. However, the aerospace industry has no plans to change to ensure growth in the medium and long term.

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