Establishing an Effective Investment Ecosystem in Vancouver's Cleantech Cluster

by

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Abstract

Cleantech clusters are geographic concentrations of specialized companies in different sectors such as hydrogen and fuel cells. Vancouver's **investment ecosystem**, reflecting the interaction of stakeholders for related economic activities, must attract more financing to hydrogen fuel cell startups in the cluster. This problem jeopardizes the development and commercialization of hydrogen fuel cell technologies in Vancouver's ecosystem. I find that Vancouver's investment ecosystem offers credit supply, loan guarantees, and grants to startups at **Series A and B**, early investments to grow startups. I conducted thirty-six interviews with stakeholders in Silicon Valley, Cambridge, Singapore, Tel-Aviv, and Vancouver to compare the policy tools adopted to financially support startups. After analysing these ecosystems, I find that Vancouver lacks tax incentives and co-investment that could be adopted to financially assist startups. A combination of tax incentives, co-investments, loan guarantees, credit supply, and grants policy tools can help Vancouver establish a more successful investment ecosystem.

Keywords: investment ecosystems; cleantech clusters; hydrogen fuel cell startups; angel investors; venture capital; policy tools

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List of Acronyms

CAEATFA	California Alternative Energy & Advanced Transportation Financing Authority (United States)
CHBC	California Hydrogen Business Council (United States)
DOE	US Department of Energy (United States)
EDG	Enterprise Development Grant (Singapore)
EMA	Energy Market Authority (Singapore)
EPIC	Energy Commission's Electric Program Investment Charge (United States)
FCEVs	fuel cell electric vehicles
HFTO	Hydrogen and Fuel Cell Technologies Office (United States)
HTP	Hydrogen Transportation Program (United Kingdom)
IRAP	Industrial Research Assistance Program (Canada)
ITA	industrial technology advisor
IPO	initial public offering
IHL	Institutes of Higher Learning (Singapore)
ITC	Investment Tax Credit (United States)
NFIE	National Framework of Innovation and Enterprise (Singapore)
NRC	National Research Council (Canada)
NUSRI	National University of Singapore Research Institute - Suzhou
NSERC	Natural Sciences and Engineering Research Council of Canada (Canada)
OECD	Organisation for Economic Co-operation and Development
PIC	Productivity and Innovation Credit (Singapore)
PRI	Public Research Institutes (Singapore)
R&D	Research and Development
RTO	Research and Technology Organization (Canada)
SBLGP	California Small Business Loan Guarantee Program (United States)
SDTC	Sustainable Development Technology Canada (Canada)
SEPP	Sustainable Energy Policy Program (Canada)
SSHRC	Social Sciences and Humanities Research Council (Canada)
SR&ED	Scientific Research and Experimental Development (Canada)
SMEs	Small and Medium Enterprises
UK HFCA	UK Hydrogen Fuel Cell Association (United Kingdom)
VC	Venture capital

Glossary

Business cluster	Geographic concentrations of specialized and interconnected companies, suppliers, and institutions to support an industrial sector (Porter, 1990).
Business ecosystem	The interaction of organizations and individuals that contribute to economic activities for a region. The investment community is composed of members such as suppliers, lead producers, customers, investors, competitors, partners, and other stakeholders (Moore, 1994).
Cleantech	Businesses which develop and commercialize innovation that reduce negative environmental impacts through energy efficiency advancements, the sustainable usage of resources, or environmental protection activities (Dikeman, 2020).
Co-investment	Co-investment between private or public companies provides financial aid to other companies depending on their size in the market.
Credit supply	Banks or public agencies provide credit to grow a determined activity in a certain business. Once the activity has expanded, the business needs to return the money.
Grants	Money provided to a company to help them further their business. Grants do not need to be paid back and business owners are not required to give up equity in exchange for a grant. The most common sources of grants are distributed by governments, corporations, foundations or trusts.
Hydrogen and fuel cell technology	In a fuel cell, hydrogen energy is converted directly into electricity with high efficiency and low power losses. Hydrogen, therefore, is an energy carrier, which is used to move, store, and deliver energy produced from other sources (US Department of Energy, 2020).
Loan guarantees	The guarantor assumes the debt obligation of a borrower if that borrower defaults. A loan guarantee can be limited or unlimited, making the guarantor liable for only a portion or all of the debt.
Series A and B	Series A funding is considered seed capital since it is designed to help new companies grow. Series B financing is the next stage of funding after the company has had time to generate revenue from sales. Investors have a chance to see how the management team has performed and whether the investment is worth it or not.
Tax incentives	Fiscal policies are designed to incentivize or encourage a specific economic activity by reducing tax payments for a company in a country. There are tax incentives from national and/or local governments depending on the Tax Code of each state.

Executive Summary

Vancouver lacks a successful investment ecosystem to attract more funding to hydrogen fuel cell startups. Considering Vancouver has a notable number of hydrogen fuel cell companies, large cleantech ventures, and innovation hubs, the region has the objective to establish a more successful investment ecosystem in the current cleantech cluster. The provincial government, however, noted that hydrogen fuel cell startups encounter difficulties in obtaining financial support from angel investors and private venture capital firms to form an investment ecosystem (Government of Canada, 2019). Based on this concern, I pose the research question: **How can Vancouver establish a successful investment ecosystem for hydrogen fuel cell startups?**

Angel investors and venture capital firms are important stakeholders in investment ecosystems as they provide financial support such as series A and B investments and business advice to improve innovation among startups. The valley of death is a phase when startups have started their operations but have not yet generated revenue (Porter, 1990). The valley of death curve is a difficult phase for startups because they are at an intensified risk of failure. Investors can support startups with the financial means to operate their businesses and develop innovations that avoid the valley of death. In turn, public policies are important to provide the tools to attract more angel investors and venture capitalists to Vancouver and more generally to have a successful investment ecosystem. Policy tools are practices that the Canadian government could create, analyse and establish to increase investment in hydrogen fuel cell technologies. Thus, policy tools are key to attracting more investments and establishing a successful investment ecosystem in Vancouver.

I find that Vancouver currently offers credit supply, loan guarantees and grants to hydrogen fuel cell startups in Series A and B. After analysing Silicon Valley, Cambridge, Singapore, and Tel-Aviv, I find that Vancouver lacks tax incentives and co-investment as policy tools. Both tools present successful outcomes in the analysed ecosystems and could be adopted together with loan guarantees, grants, and credit supply to help Vancouver's startups. These policy tools together are able to assist the creation of a successful investment ecosystem in Vancouver. If Vancouver does not establish a more complete investment ecosystem, the main concern is that hydrogen fuel cell startups, together with their technologies and talent pool, will move to the United States or other

Canadian provinces. Financial support is essential to growing hydrogen fuel cell startups by enabling innovation in the local cluster, thus making Vancouver as competitive of a marketplace as other clusters.

Chapter 1.

Introduction

1.1. The Importance of Hydrogen Fuel Cells to Climate Change

The hydrogen fuel cell is an electrochemical cell that changes the energy of hydrogen and oxygen into electricity while producing water as waste (Staffell et.al, 2019). It is an energy storage device that can overcome the intermittency of solar and wind for vehicles where solar or wind is not possible (Staffell et.al, 2019). Hydrogen fuel cells are a potential clean energy source that countries can adopt to reduce carbon emissions since hydrogen fuel cells produce less air pollutants when compared to fossil fuel combustion. Some governments are developing clean energy policies to consider hydrogen fuel cells to mitigate climate change. In this way, hydrogen fuel cell technologies offer a potential transition to a low-carbon economy in the transportation sector, given their similar performance, operation, and consumer experience to fossil-fueled technologies (Dodds et al., 2015). Thus, hydrogen fuel cells offer alternative clean energy storage for vehicles in which governments are establishing policies to support hydrogen fuel cell technologies.

Hydrogen fuel cells are important for energy-intensive applications that are reliant on fossil fuels such as long-range transportation and heating. It is important to create eco-friendly innovations using hydrogen fuel cells to mitigate current climate change effects. Ballard company started its production of fuel cell technologies that led to more investments in fuel cell manufacturing in the 1990s (Foresight, 2020). Vancouver prioritized R&D financing in the hydrogen and fuel cell technology subsector during the 1990s and 2000s (Foresight, 2020). The R&D financial support gave different companies the ability to grow their R&D activities, forming a pro-cluster. Vancouver has several startups, large enterprises and accelerators that have been developing hydrogen fuel cell innovations in the transportation sector (Zen and the Art of Clean Energy Solutions, 2020). Vancouver currently is one of the largest cleantech clusters in the world that produces different types of hydrogen fuel cell innovations (Zen and the Art of Clean Energy Solutions, 2020). However, Vancouver still relies on carbon-emitting sources in

the transportation and utility sectors. The hydrogen fuel cell is a versatile energy carrier which the city can adapt to the heavy-duty transportation sector or industrial buildings.

Even though the Canadian hydrogen fuel cells industry presents upward market potential in the long-run, Canada lags behind countries like the United States and the United Kingdom. In fact, the US has one of the largest hydrogen fuel cell sectors in the world, with an estimated investment of US$1.1 billion in 2017 (US Department of Energy, 2018). In California, for example, long-standing problems with air quality have led to rigid emissions regulations. These policies are driving cleantech research, development and technology adoption in the electricity and transportation sectors (Neufeld, 2019). The UK also presents a considerable number of hydrogen fuel cells investment. London's renewable energy investments reached US$12.1 million in public investments in 2011 (Fuel Cells Bulletin, 2011). The British government helps low-carbon firms by offering support for clean innovation and promoting low-carbon solutions at home (Carvalho and Fankhauser, 2017). In this way, clusters can obtain more financial activities in order to assist fuel cell startups. Compared to the US and UK, the Canadian government needs to address existing policies or new ones to foster hydrogen fuel cell technologies within the cluster to form an investment ecosystem in Vancouver.

Vancouver's cluster has potential hydrogen fuel cell innovations from startups that can establish a healthy investment ecosystem in the long-run. The creation of an effective investment ecosystem is an important discussion as the Canadian government needs to give more public incentives to boost investments and innovation into fuel cells and hydrogen (Foresight, 2020). The private sector also has a role to play as it can address the market concerns to design policies (Foresight, 2020). The city, nevertheless, does not currently have enough private investors to provide Series A and B investments that support hydrogen fuel cell technologies to form this market guidance when compared to other clusters. Based on this premise, I present the following research question:

How can Vancouver establish a successful investment ecosystem?

This research question will be comprised of sub-questions:

1. **What is the role of public and private sectors when promoting series A and B investments?**

2. **What is the level of specific financial policy tools to adopt in policies to attract private series A and B investments?**

    a. **How would the financial policy tools attract more investments to support hydrogen fuel cell startups?**

3. **What can Vancouver's cluster learn from other clusters with successful investment ecosystems?**

These questions delineate how the research will be conducted and the main factors that Vancouver must have to establish an investment ecosystem. Series A and B investments through venture capital and angel investors are important elements of a cluster since they provide financial assistance as well as business advice to develop startups. In this way, venture capital and angel investors help startups to pass through the valley of death because startups can have venture money during the first years of operations. The valley of death is a period when startups have started their operations but have not yet generated revenue (Porter, 1990). The valley of death curve is a challenging period for startup companies in which they are at heightened risk of failure (Porter, 1990). Startups series A and B have well-developed technology and it does not present a high risk of failure. However, launching a new product in the market can be a challenging task where the success of the innovation is uncertain. Startups have the risk of failure in terms of not finding the market niche and customers to sell the product. Startups require understanding potential customers and how they would buy the innovations. If Vancouver does not establish an investment ecosystem, the main negative consequence is those hydrogen fuel cell startups together with their technologies and talent pool will be moving to the United States. The necessity for well-developed financial support is essential to growing hydrogen fuel cell startups by promoting innovation in the cluster and making Vancouver as competitive of a marketplace as other clusters. The following section introduces the current literature on how the government can use policy tools to help Vancouver establish an investment ecosystem that prevents hydrogen fuel cell startups to enter the valley of death.

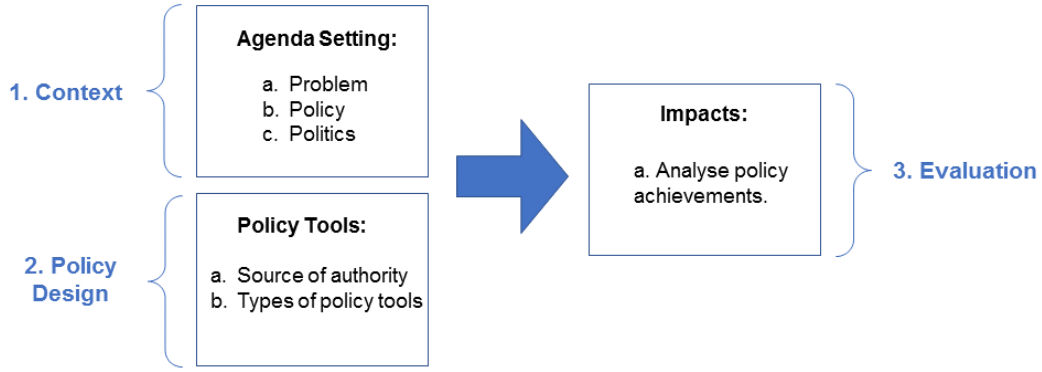
1.2. **Literature Review**

This literature review aims to highlight the way Vancouver should establish a successful investment ecosystem to support hydrogen and fuel cell startups. The attraction of private equity investments to Vancouver would increase the financial options for startups and prevent the valley of death. The valley of death curve is challenging for startups because numerous expenses must be borne before a new product or service can begin generating revenue. These include predictable costs, such as renting office space and paying employees, as well as other costs which are harder to predict, such as marketing and R&D expenses. Surviving the valley of death curve marks a significant milestone in the life of a startup as it stands a better chance of reaching maturity. In order to attend to startups' needs and attract Series A and B investments, it is important to understand the process of designing policies with specific tools to apply in the investment ecosystem. Investment ecosystems can create connections among investors to provide series A and B for startups. Ecosystems can also channel financial, human, and other resources to help entrepreneurs develop their startups to address rising environmental challenges. Thus, an investment ecosystem provides mechanisms to leverage technology and compete against other companies within a cluster.

The literature presents different perspectives on adopting and analysing policy tools to financially support hydrogen fuel cell startups in Vancouver's cluster. Policy tools are techniques that governments create, analyse or implement public policy options (Howlett, 2019). The implementation of policy options depends on the intervention level governments are willing to have and the needs of the policy's group target (Howlett, 2019). Howlett also emphasizes the importance of considering the perspectives of different stakeholders involved in policy options (2019). In the hydrogen and fuel cell sector, investors, startups, large enterprises, NGOs and associations are the most relevant players that should be considered when analyzing the level of public intervention applied to form an investment ecosystem. In order to attract Series A and B investments to hydrogen fuel cell startups, the public and private sectors should bring into consensus the use of specific types of policy tools. Auld et al. adopt the analytic framework that divides the literature into context, policy design and evaluation. This model aims to guide the main aspects of adopting policy tools that will support more

investments to startups by forming an ecosystem. Howlett and Lejano used this structure to organize the core activities to establish an effective policy analysis (2013). As shown in Figure 1, context is the process when a concern such as a high carbon emission level arrives on the public agenda (Auld et al, 2014). Second, policy design is how the government intervenes to address carbon emission levels (Auld et al, 2014). Third, evaluation of the policy designs to analyse if they could mitigate carbon emission levels by creating alternatives (Auld et al, 2014). Overall, the framework of process, policy design and evaluation will be adopted to delineate how Vancouver's cluster can attract Series A and B investments to prevent startups from failing during the valley of death.

Figure 1: Analytic Framework



Source: Adapted from Auld et.al. 2014

The literature review is organized in three aspects that can explain the importance of establishing an investment ecosystem in Vancouver's cluster. Figure 1 visualizes the main steps that should be taken to analyse how designed policies can attract more Series A and B investments to startups in Vancouver's cleantech cluster. The three aspects organize the analytical framework of this research to answer the way Vancouver can attract private equity investors to build a stronger investment ecosystem. The first element, context, highlights the problems and explains the current public and private roles through projects or policies to promote Series A and B investments. Second, policy design identifies the sources of authorities who design policies and select the tools used. This aspect explains the level of financial policy tools adopted in ecosystems to attract more Series A and B investments which assist hydrogen fuel cell startups. Third, policy evaluation validates which policy design and tools would apply to Vancouver based on other successful investment ecosystems. The

next sub-sections explore each of the three elements of the analytical framework to understand their importance to attract investments and reduce the risk of the valley of death among startups.

1.2.1. Context

Agenda setting is important to bring the current problem of investments to public attention that will develop potential policy options to mitigate the concern of hydrogen fuel cell investments. The hydrogen fuel cells are in the context of clean energy alternatives to mitigate climate change in which have been enduring public discussions for policy changes. Kingdon defines policy entrepreneurs as individuals who can influence policy and receive benefits from it (2016). In terms of the hydrogen and fuel cell sector, policy entrepreneurs are the accelerators, startups, associations, and investors that have been promoting hydrogen fuel cell alternatives to the local and national governments to change the current policies. For instance, the Carbon Disclosure Project (CDP), a British non-governmental initiative that catalyzed climate change mitigation and adaptation efforts on the part of large corporations, public experts, and policymakers (Mintrom and Luetjens, 2017). This example also supports Kingdon's argument of advocacy among policy entrepreneurs to include specific concerns in the agenda. Policy entrepreneurs advocate having their interests included in the agenda while politicians have their concerns. The political spectrum across different stakeholders is always combined to bring alternatives such as hydrogen fuel cell technologies or reduction of carbon emissions in today's discussions. The political stream is when politicians give attention to a specific concern through the agenda. Bolin gives the example of early eagerness amongst politicians around the 1990s to act in response to the threat of climate change in line with the increasing attention from scholars and the private sector that was given to environmental issues (2010). Overall, Auld et al. explain that the government has the background knowledge to solve the problem through policy implementation that is part of the public-agenda setting (2014).

1.2.2. Policy Design

Policy design is categorized as the policy tools applied to address specific policy options. According to Auld et al., policy design is divided into sources of authority and types of policy tools (2014).

Sources of Authority

Sources of authority should guide the government's policy options to understand the types of concerns that should be addressed. Based on Avant et al., sources of authority are "the ability to induce deference in others" (2010). In Vancouver's cleantech clusters, the sources of authority are investors, cleantech associations, utility corporations and hydrogen fuel cell startup enterprises while the government acts in the background. This cluster has a hybrid source of authority as the private sector rules the social or market forms and it involves governments directly in rulemaking, implementation or adjudication (Bözel and Risse, 2005). Auld et al. argue that communication between authorities is essential to highlight the main needs of the market to the government (2014). The authors also explain that there should be a consensus between the private sector authorities and the government so as to address the market concerns and provide potential solutions (Auld et al., 2014). Clean energy businesses and investors see public policies as complementary to their technologies (Bözel and Risse, 2005). The private sector, however, generally does not agree that the government should select potential startups or technologies in a specific industrial segment (Bözel and Risse, 2005). Therefore, the public sector's role is to create policy options applicable across sectors by adopting policy tools that address market struggles such as the lack of Series A and B investments.

Types of Policy Tools

The second aspect of policy design is types of instruments such as regulation and expenditure. The literature defines government regulations as "legal obligations based on legislation that prohibit certain types of [behaviour] or that requires the explicit permission of the government to engage in specified activities" (Winfield, 2009). Public regulations tend to include some penalties if violated. When the hybrid source of authority includes regulations, the penalties will differ and may have the threat of future government intervention, the loss of market access or market share, or the loss of public reputation (Winfield, 2009). A hybrid source of authority presents a multilevel structure so as to engage the different public and private levels of authority (Abbott and Snidal, 2014). The private sector works together with the government to provide the necessary support to small companies and local investors. Thus, Vancouver's cluster has authorities that can change policies and address more financial tools to assist startups in the hydrogen fuel cell sector. Expenditure can be an effective policy tool in the hybrid

source of authority. Expenditure means “controlling money to seek behavioural change and their focus on capacity building and implementation” (Andonova et al., 2009). Expenditure tools can be incentives such as grants and subsidies or disincentives like tax. Under expenditure policy tools, there are financial implementation tools that are investment techniques of governance to provide treasure resources to other stakeholders (Howlett, 2019). Countries such as the US and UK have adopted different types of policy tools to support financial activities among cleantech clusters. The most common tools are tax incentives, co-investments between the government and VC companies, and loan guarantees and credit supply.

Tax incentives are tools used by the government as they allow the private sector to have more autonomy. Maslove defines tax incentives as “special provisions in the tax law providing for preferred treatment and consequently resulting in revenue losses or gains” (Maslove, 1978). In other words, governments can use tax regulations to promote business activities growth. Moreover, tax incentives can be blended with other financial sources, range in size and significance, and can be used together with other policy tools (Surrey, 1970). Howlett explains that tax incentives involve deductions from corporate or personal income (2019). This means that tax incentives’ effect on a target group is determined by the marginal rate of taxation individuals or firms must pay. Tax incentives, nonetheless, have different outcomes depending on the group that the government decided to target (Surrey, 1970). For investors, tax incentives are beneficial to increase the size of their firms while startups prefer tax incentives to improve their staff and in-house production (Surrey, 1970). Thus, tax incentives need to be planned according to the public goals of supporting the investment ecosystem.

Co-investments are also alternatives to balance the amount of public spending in a determined sector. Preferential procurement or co-investment between the public and or private sectors involves the use of government purchases to subsidize companies such as venture capital or investors such as angels that accept provisions of contracts (Howlett, 2019). This policy tool can facilitate investments in small businesses and regional development schemes since investors receive government contracts if they agree to locate factories or other services in assigned regions (Bajari and Tadelis, 2001). In this sense, co-investments support the attraction of different firms necessary to grow a regional economy.

Loan guarantees, credit supply and grants are important to improve R&D activities, support innovation prototyping and market niche research among startups. These policy tools enable startups to gain capital and promote their technologies to venture capital as viable innovations to be commercialized. According to Maslove, loan guarantees and credit supplies act as subsidies to the extent that government backing helps to “secure loans thereby raising the reliability of borrowers, altering the types of borrowers who might otherwise not qualify for loans, or reducing interest payments and charges that individuals and companies would otherwise have to pay” (1978). Howlett explains that these tools can be precisely targeted and are often considered to be less intrusive than grants and direct cash or tax transfers, making them a popular choice for policy designs in designated sectors (2019). Moreover, a business grant is seed money for a business startup or project, usually offered by government agencies, nonprofits, or certain businesses (Howlett, 2019). They do not have to be paid back, but there are usually strict reporting criteria to make sure the grant recipient is meeting the goals of the grant initiative (Howlett, 2019). Overall, loan guarantees, credit supply and grants help startups obtain private equity investments to foster their technologies and enter the market.

In summary, policy tools are the main ways that the government can support startups. Vancouver’s cluster needs more financial policy tools to attract more Series A and B investments to help startups avoid the valley of death. Policy tools are necessary to strengthen the existing source of authority by forging stronger connections among stakeholders and encouraging the entry of new ones where governance gaps exist. Overall, the policy tools are practices that the government can create to help startups, and investors grow the cluster and establish an investment ecosystem.

1.2.3. Policy Evaluation

Policy evaluation is the outcome of the agenda-setting and policy design processes that aimed to establish policies or programs. According to Pal (2010), there are different types of policy evaluation such as process, impact, efficiency, and accountability. The research will focus on the impact evaluation, that is “whether the policy had accomplished its own goal” (Auld et al., 2014). As Howlett (2014) notes, policymakers and politicians are more often blamed for failures than praised for successes. They may be less likely to advocate for climate policy innovations for fear of

being blamed when an experiment fails. Indeed, Bovens et al. remind us that ‘‘policy evaluation is an inherently normative act, a matter of political judgment’’ (2006). In other words, in assessing the effects of policy instruments, one must understand who exactly is doing the evaluation. Thus, an impact evaluation should analyse if specific policies reached their main goals based on the agenda-setting.

1.2.4. Conclusion

The policy tools framework provides the analytical framework for this research that will be used to answer the research questions and give recommendations to Vancouver. The literature offers potential explanations for different ways that the governments together with the private sectors among different clusters can cooperate to attract more Series A and B investments to help startups. Investors have a positive perspective on public initiatives as long as the government helps businesses to facilitate their financial activities. The current literature is adopted not only to identify the main sources of authority in Vancouver and other cases but also to identify the policy designs and tools currently used. These policies together with their tools help the policy targets to develop business activities. The activities reflect the design of policies and the utility of tools to achieve investment goals. There is an absence of in-depth analysis necessary to highlight which policy tools would be more beneficial to Vancouver’s startups, which this research also seeks to fill to understand the coordination among authorities to create policy designs and their tools when attracting more Series A and B investments and avoid the valley of death.

1.2.5. Case Selection

The case selection aims to analyse potential case studies that can be adopted to understand how Vancouver can establish a more successful investment ecosystem. Case selection will be based on the measures of success and the ecosystem lifecycle stages. Measures of success such as total funding per startup, the total number of deals, and firms are the leading values to compare the most successful ecosystems in the world. The ecosystem lifecycle stages follow those indicators to organize the ecosystems depending on their level of performance. Once the cases are selected, the methodology section will explain how the cases will be compared to Vancouver and the types of data gathered to analyse the ecosystems.

The research uses a small-N study as a comparative method that applies existing information on policy design to new cases. Small-N samples use two or more cases to allow an in-depth analysis of each case by isolating a cause from a complex event sequence that provides answers to the current research questions. Mill's Method of Difference was adopted in the research because it compares the most common characteristics but differs in one main aspect related to the hypothesis of interest. It is important to have a careful selection of cases for analysis, so the cases do not lead to misleading results. In order to avoid selection bias, the table below presents ten cleantech clusters based on the measures of success. The table gathers three measures of success that are total funding per startup, total capital originating from private equity deals and firms. These indicators evaluate the success of overall investment activities of the ecosystems across ten clusters in 2019. The timing was not considered when choosing clusters because of specific market conditions and policies adopted in different investment ecosystems. These unique market conditions and policies may have external factors that contributed to the formation of the current investment ecosystems. In this case, it is challenging to compare the ecosystems using the measures the success based on timing.

Table 1: Measures of Success – 2019

	Measures of Success		
	Total Funding Per Startup (2019)	**Total Capital Originated from Private Equity Deals (2019)**	**Total Investment from Private Equity Firms (2019)**
Silicon Valley	$465 billion	$136.5 billion 946 deals	$256.4 billion 882 exits
New York	$452 billion	$103.5 billion 320 deals	$320 billion 239 exits
Boston	$437 billion	$2 billion 194 deals	$2.5 billion 194 exits
Beijing	$391 billion	$739 million 122 deals	$1.5 billion 100 exits
Toronto-Waterloo	$300 billion	$ 2.3 billion 103 deals	$ 2.9 billion 105 exits
Cambridge	$374 billion	$791 million 345 deals	$935 million 328 exits
Tel-Aviv	$297 billion	$8.26 billion 522 deals	$9.9 billion 434 exits
Vancouver	$260 billion	$924 million 72 deals	$802 million 67 exits
Singapore	$275 billion	$1.2 billion 166 deals	$1.7 billion 122 exits
Copenhagen	$225 billion	$2.8 billion 155 deals	$1.1 billion 150 exits
South Korea	$212 billion	$2.4 billion 107 deals	$900 million 106 exits
The Netherlands	$200 billion	$2 billion 93 deals	$873 million 91 exits

Source: Statista, Crunchbase and Genome Startup – 2019

Table 1 summarizes the measures of success per case study in 2019. It shows that Silicon Valley has the largest early-stage funding, deals and firms compared to the other ecosystems. Boston, New York and Beijing have the leading values of funding while Berlin, Tel-Aviv, Cambridge, Vancouver, Singapore, Copenhagen, South Korea and the Netherlands have moderate numbers of funding, deals and firms. Singapore, Toronto-Waterloo and Vancouver have almost the same amount of funding but deals and firms are greater in Singapore and Toronto-Waterloo. This means that startups in Singapore and Toronto-Waterloo are expanding their innovations in the market with the support of more private equity firms. **As seen in Table 1, Vancouver is in the eighth position of funding and last in deals and firms, thus, it is important for Vancouver's ecosystem to attract more Series A and B investments to support startups while avoiding the valley of death.**

The clusters mentioned in the table have different ecosystem lifecycle phases that will be compared based on the proposed indicators. Investment ecosystems develop through ecosystem life phases, each with a different set of characteristics and objectives based on the measures of success. In order to have an in-depth comparison of cleantech clusters' investment ecosystems, the clusters are divided into attraction-integration and early-globalization phases. The lifecycle phases are important to understand how the policy tools affect the level of competition among startups across clusters (Startup Genome, 2021). Table 1 shows in green the attraction-integration phase which represents clusters' funding, deals and firms' investments above $1-6 billion (Startup Genome, 2021). The clusters have a high flow of communication and knowledge into the ecosystem that sustainably keeps their startups integrated with the global network of knowledge and the ability to produce leading-edge business models to achieve a high global market reach (Startup Genome, 2021). Systems in the early-globalization phase, seen in yellow in Table 1, are characterized as a series of funds, deals, and firms that account for $100-800 million of the investment ecosystems' resources (Startup Genome, 2021). However, early-globalization phase lacks financial resources to top ecosystems globally (Startup Genome, 2021). The stage focuses on increasing global connectedness with founders of top ecosystems (Startup Genome, 2021).

Attraction-Integration Phase: Silicon Valley, New York, Boston, Beijing, Toronto-Waterloo and Cambridge

Silicon Valley, New York and Boston have policy tools that help establish the investment ecosystems. Tax incentives are the most common policy tools used in the US for accelerating cleantech innovation (Thomson Reuters, 2021). Tax incentives reduce taxation burdens to startups which can facilitate their testing and production of innovations. For instance, the Investment Tax Credit (ITC) is a tax credit for renewable energy projects including solar, geothermal and fuel cell energy (Thomson Reuters, 2021). Under the ITC, entrepreneurs or owners of energy projects can claim a tax deduction of up to 30% of their project's capital costs (Thomson Reuters, 2021). Consequently, Silicon Valley, New York and Boston have the highest numbers in all indicators when compared to the other ecosystems due to its business strategy of reaching out to new market niches. Most companies from the states of California,

Massachusetts, and New York use the ITC to support their innovations because it facilitates startups' private investments and growth (Thomson Reuters, 2021).

Policy tools such as tax incentives help the private sector to improve their business activities which results in more funding, deals and firms in investment ecosystems. Samila and Sorenson explain that Silicon Valley, New York and Boston have successful ecosystems because VC firms have specialized advisors to expand startups' innovation to different market niches during Series A and B funding (2011). As such, Table 1 shows that American startups have the highest investment values per startup when compared to the other clusters. The number of deals in Silicon Valley, Boston and New York also proves that investors use the strategy of funding different startups to have a higher chance of exits (NVCA Venture Monitor, 2019). In this way, exits happen when startups have successful financing rounds and market insertion that branch out their businesses nationally and even internationally (NVCA Venture Monitor, 2019).

Table 1 emphasizes that the West Coast retained its perennial status as the top region, with nearly 47% of VC dollars last quarter of 2019 (NVCA Venture Monitor, 2019). The New England region has 8.8% of deal value while New York had 21.3% of deal value (NVCA Venture Monitor, 2019). Boston has a considerable number of investors that are prone to invest in fintech, health sciences and cleantech. New York, the heart of the mid-Atlantic region, also has series A and B investments in health sciences and cleantech, but most startups are acquired by multinationals before reaching stage B (NVCA Venture Monitor, 2019). Therefore, American investors have the experience to create strategies for market expansion that increase startups' product commercialization in market niches across the country.

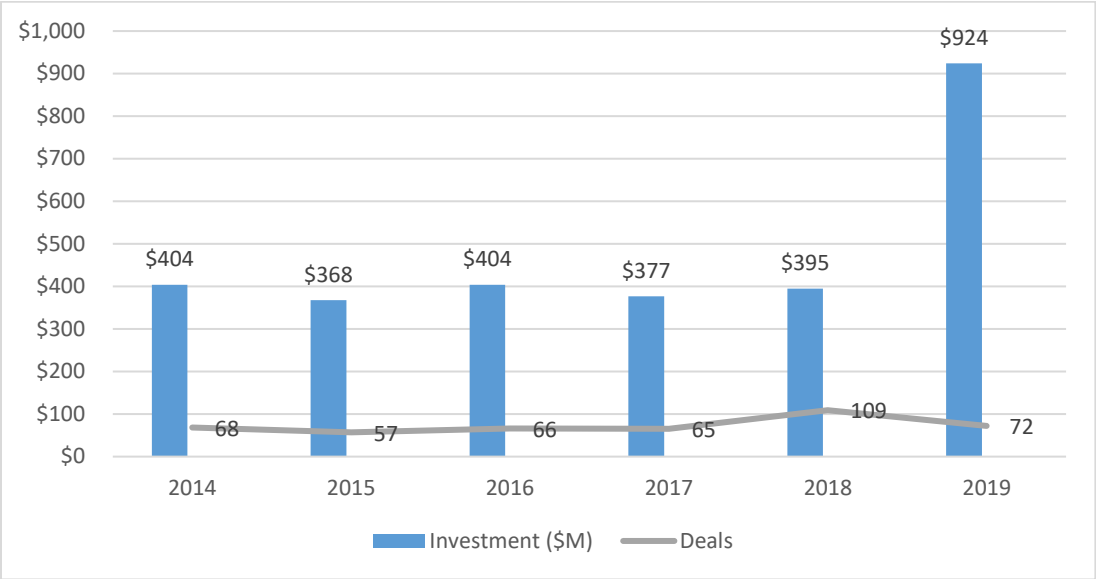
In the US, tax incentives supported the private sector to improve funding, deals and firms in the investment ecosystems. In contrast, the Chinese government established Beijing's Zhongguancun Science Park (or Z-Park), the first pilot project in Beijing, in 1988 (Zhou, 2010). While the government used policy tools to develop the Z-park, Beijing's first group of tech entrepreneurs in the 1980s were from Lenovo, Founder and Unis. These companies started evolving the Z-Park in the 1990s and early 2000s (Zhou, 2010). In 2019, the government introduced $2.2 billion in private capital to cleantech projects and is committed to paying about $14.9 million in loan interest for

startups to reduce borrowing costs by 20% (Zhongguancun Science Park, 2019). The Chinese government is the investor in the local businesses that provides co-investments, loan guarantees or credit supply to startups. Therefore, the Chinese government directly invests in potential small companies that can grow in the long-run without any support from foreign private investors.

In Toronto-Waterloo, the provincial government provides credit supply as a policy tool to help startups develop clean technologies. The Sustainable Energy Policy Program (SEPP) is one of the most famous programs in Toronto-Waterloo because it brings together several researchers in the University of Waterloo's Natural Sciences and Engineering Research Council of Canada (NSERC), Social Sciences and Humanities Research Council (SSHRC), provincial associations and the private sector (Government of Ontario, 2020). This program provides R&D activities for hydrogen and fuel cell startups that are planning to grow in the early-stages of the cluster (Government of Ontario, 2020). Most credit supply policy tools target R&D improvement and prototyping among startups. In Vancouver, universities also receive funding from federal agencies to help develop R&D activities. However, Vancouver’s universities prioritize funding to health sciences and not hydrogen and fuel cells when compared to Toronto. Thus, the Sustainable Energy Policy Program is promoting development in clean technology among startups that promote R&D activities and prototyping to insert innovations into the market.

Figure 2 shows the overall Canadian financial trend that raised an average of $924M in 2019, a 134% increase when compared to 2018 (PwC Canada, 2019). Additionally, deal activity in 2019 fell sharply to 72 deals while 2018 had 109 (PwC Canada, 2019). The activity, however, remains above previous years as larger average deal sizes drove gains in funding (PwC Canada, 2019). As seen in Table 1, Toronto-Waterloo had $300 billion in funds and $2.3 billion among 103 deals while exits counted for $29.3 billion among 105 exits. Toronto-Waterloo has more deals and exits in its ecosystem. This means that startups are staying and growing their business activities for a longer time in Toronto-Waterloo.

Figure 2: Annual Financing Trend- Hydrogen Sector for Canada



Source: PwC Canada 2019

The Cambridge Science Park has played a pivotal role in the cluster since 1970 because it transformed the region into a leading technology space (Cambridge Science Park, 2021). Cambridge's ecosystem is successful because investment companies diversified across sectors such as health sciences, cleantech and AI, and invested in startups that are members of accelerators or from academia (Mason and Yannis, 2013). Moreover, the British government also provides different types of policy tools that help startups. For instance, the UK Innovation Corridor has the Hydrogen Transportation Program (HTP) that gives grants and seed funding to startups that are developed in universities, accelerators or labs (UK Government, 2020). This assistance helps startups improve their R&D and prototyping in research labs or universities, and enter the market. As such, Cambridge has a $3.5 billion total of funding startups and $791M deals obtained in 2019. These numbers reflect policy tools and investments provided by private equity firms. Investors plan to exit those startups as the British government has provided policy tools that support hydrogen fuel cell technologies to enter the market. Thus, the Cambridge Science Park has a world-class reputation for curating the ecosystem, and as such, it is the destination of national and international business investors.

Early-Globalization Phase: Tel-Aviv, Vancouver, Singapore, Copenhagen, South Korea and the Netherlands

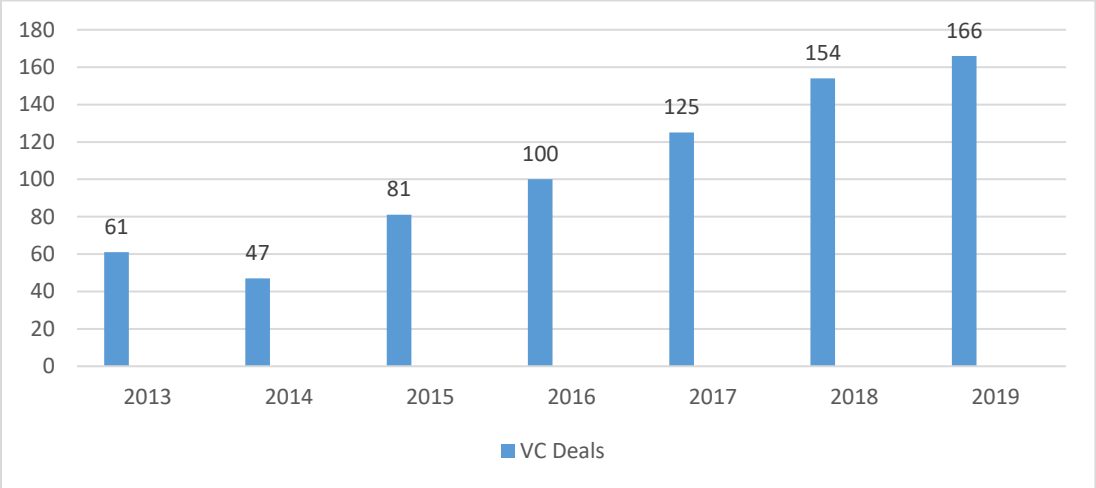
Tel-Aviv has a successful investment ecosystem because Israeli startups develop business goals to grow their companies in the local market with investors' support and partnerships with local enterprises. Wonglimpiyara argues that startups have a well-defined business strategy for market expansion which contributes to getting Series A and B funding (2006). The policy tools improve innovation in the ecosystem as they encourage capital for entrepreneurial efforts. As such, the total investment number per startup was $297 billion in 2019 (Hao, 2018). Avnimelech and Teubal also attribute startups' ability to pitch investors on their short- and long-term goals as a reason for these successful deals (2009). Funding for the hydrogen and fuel cell industry also promotes I-Cap because it provides incentives for more research on innovations in the related fields (Hao, 2018). In addition, Israeli startups partner with local companies to promote their innovations (Hao, 2018). Therefore, Tel-Aviv's investment ecosystem is successful because it supports startups that are willing to grow with the support of investors and local partner companies in the ecosystem.

The spin-off of Vancouver's hydrogen fuel companies started in the 1990s due to the success of Ballard Power Systems. This company targeted R&D activities to make hydrogen and fuel cell technology commercially viable (Innovate BC, 2008). In order to achieve its vision of providing clean energy solutions across a range of applications, Ballard identified customers up front and worked with them to identify applications for hydrogen fuel cells in their products (Innovate BC, 2008). The success came with the first IPO in 1995 which created a spin-off effect of other companies being formed in the hydrogen fuel cell sector (Innovate BC, 2008). Even though Ballard has provided a considerable increase in investments and spin-offs of hydrogen fuel cell innovations in North America, it failed to launch an investment ecosystem in which Vancouver could be recognized internationally (Auld et al. 2014). Vancouver presents a substantial increase over the last five years which indicates the presence of investors in funding more startups at Series A and B. Vancouver has some policy tools such as loan guarantees, credit supply, and grants that help startups develop their innovations. Vancouver had $802M among 67 exits in 2019 which is a reduced number when compared to $928M among 93 exits in 2018 (Genome Startup, 2019). Table 1 shows that investors could provide a total of $260 billion per startup in 2019 (Genome Startup Report, 2019). This is

a large number when compared to $210 billion in 2018 (Genome Startup Report, 2019). However, Vancouver lags behind Toronto that has grants to support R&D improvement and prototyping in the hydrogen and fuel cell sector. Thus, Vancouver has grown its investment support to startups using the support of policy tools such as loan guarantees and credit supply.

Singapore has a successful investment ecosystem because the government has policy tools that provide Series A and B funding to startups. Singapore's public sector has recently started increasing its investment ecosystem to foster more private equity that helps startups. Figure 3 highlights that the total number of VC deals has gradually increased for Singaporean startups (Statista, 2019). Per Siddique, et al., Singapore proves that adjusting VC deals with market timing and using investors' expertise to advise startups are crucial to developing a successful investment ecosystem that fosters innovation among startups (2010). In this sense, investors reduce the risk of failure at the initial phases which facilitates startups to obtain faster market exit. In 2019, startups had $1.7 billion in 120 exits while they obtained $1.3 billion across 110 in 2018 (Statista, 2019). Thus, Singapore's ecosystem had a consistent investment evolution that brought national investors to provide the necessary expertise and market timing needed to make deals and exit startups in the market.

Figure 3: Total Number of VC Deals in Singapore from 2013 to 2019



Source: Statista, 2019

Similar to Singapore, the Danish government has started providing policy tools to increase the number of private equity investments in the ecosystem. Policy tools could

improve the interactions between investors and startups to obtain Series A and B funding. Rosiello et al.. emphasize that Copenhagen has the financial support of public and private accelerator offices together with the university which facilitates commercializing R&D products (2013). In Copenhagen, startups have a substantial number of exits because VC firms provide a network of large enterprises and other investors that startups can easily get an initial public offering (IPO) (Mason and Yannis, 2013). The role of CLEAN, the Danish cleantech cluster, is to facilitate and develop projects that ensure business activities for startups (Gaarn-Larsen, 2020). CLEAN has CityDataExchange that was created by the City of Copenhagen and the Capital Region of Denmark (Gaarn-Larsen, 2020). The innovative CLEAN aims to bring together leading global companies with Danish startups to create clean energy data to explore, consume and publish public and private data (Gaarn-Larsen, 2020). Consequently, accelerators and academia offer an infrastructure that prepares startups to obtain funding as well as facilitates investors' choice to make deals and fund different types of startups.

South Korea has a considerable number of fuel cell technologies for utility-scale power generation. South Korean government has been providing 75% of cleantech budget for R&D grants and tax incentives that helped the creation of solar or wind energy companies and others since 2010 (Stangarone, 2020). The country's six power generation companies have deployed about 300 MW of fuel cell power in 2020 (Stangarone, 2020). South Korea has introduced several initiatives to increase power generation from renewable and new technologies (Stangarone, 2020). The government released a Hydrogen Economy Roadmap in 2019, calling for 15 GW of stationary fuel cells by 2040 (Stangarone, 2020). However, the COVID-19 pandemic has changed the Roadmap and established the Korean New Deal (Stangarone, 2020). This policy tool is divided into two planks, the Digital New Deal and the Green New Deal. Under the Green New Deal, the Moon administration aims to accelerate South Korea's transition from a carbon-dependent economy to a low-carbon economy and is committed to spend 42.7 trillion won on green projects by 2025 (Stangarone, 2020). As part of the Green New Deal, South Korea has set a new target to have 200,000 hydrogen vehicles on the road by 2025 (Stangarone, 2020). Moreover, the Green New Deal will expand subsidies for hydrogen vehicles. Hydrogen-powered trucks will be eligible for subsidies from 2021, and subsidies from fuel rechargers for commercial vehicles will become available in 2022. All hydrogen vehicles will be eligible for state subsidies by 2025 (Stangarone,

2020). The energy initiative is not only to promote energy innovation, but also to provide cleaner solutions and GHG emission reductions.

In the Netherlands, the Enterprise Policy was established in 2010 to reduce regulatory burdens and support the TopSector Approach. This approach lies in nine top sectors in which enterprises and knowledge institutes work together with the government to strengthen their innovation systems and competitiveness (Government of the Netherlands, 2020). The Dutch companies and research centres in these top sectors play a leading role in the world and promote their interests through joint planning in areas such as knowledge and innovation, internationalization, human capital, regional involvement, and reducing regulatory pressures (Government of the Netherlands, 2020). The approach also supports the WBSO R&D tax credit scheme that which businesses pay lower wage tax and lower national insurance contributions, and self-employed entrepreneurs can deduct a fixed amount for R&D when filing their income tax return (Government of the Netherlands, 2020).

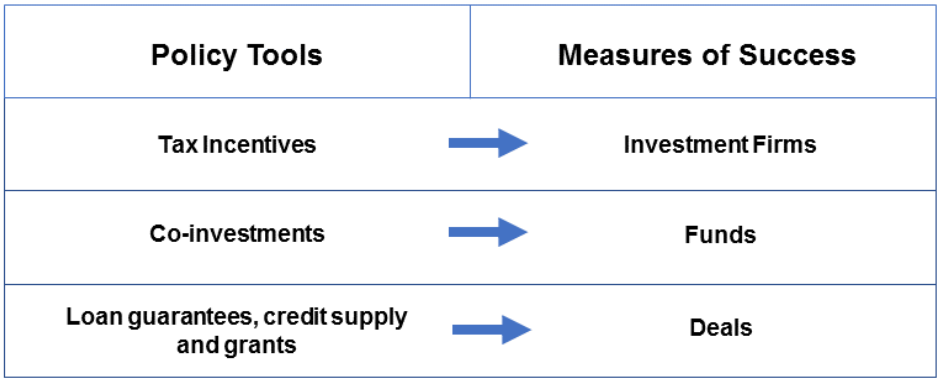
In summary, successful ecosystems have higher funding per startup, the number of deals, and firms. Silicon Valley, New York, Boston, Beijing, Toronto-Waterloo, and Cambridge have the leading values while Tel-Aviv, Vancouver, Singapore, Copenhagen, South Korea and the Netherlands have moderate values of funding, deals and firms. The analysed investment ecosystems are positive examples of how the Canadian government can design and implement policy tools. It is important to select the ecosystems that not only presented higher performance indicators but also are at the same attraction-integration phases. Silicon Valley has the most successful investment ecosystem across all compared cases followed by Cambridge, Tel-Aviv and Singapore. Thus, the research adopts a comparative case analysis of four successful ecosystems in Silicon Valley, Cambridge, Tel-Aviv and Singapore. They have been selected due to their higher measures of success and for being at the same or a later stage in the lifecycle phases when compared to Vancouver.

Research Methodology

The methodology delineates tax incentives, co-investment, loan guarantees, credit supply and grants as the policy tools and the number of firms, funds and deals as the measures of success. In order to measure the variables, a comparative research approach is adopted. The four presented case studies are the basis of my comparison

which will guide the results from the factors. The table below depicts the connection between the policy tools and measures of success that are tested in the study.

Figure 4: Connection between Policy Tools and Measures of Success



Source: Author, 2020

The figure shows the relation between potential independent and dependent variables. Tax incentives would provide more capital attraction to startups whereas more public-private investments would bring more available funds to startups. Finally, by encouraging private borrowing and risk-taking, loan guarantees, credit supply and grants can increase the number of deals. Overall, the variables will guide the purposive sampling of primary and secondary data.

Purposive sampling was adopted to select the cases with a particular purpose so as to analyze unobtrusive data from both primary and secondary sources. Based on the selected case studies, a mixed methods study enables an in-depth analysis of how Vancouver can establish an effective investment ecosystem. A mixed methodology permits a more complete utilization of data than separated quantitative and qualitative data collection and analysis. However, the data needs to be transformed in some way so that both types of data can be integrated during the analysis. Using rigorous procedures in collecting and analyzing data appropriate to each method's tradition, the research can produce a relevant analysis to answer the research question. In order to collect qualitative and quantitative data for the variables, the research conducted interviews and collected financial data in datasets from Hockeystick, S&P Capital and Thomson and Reuters (Table 2).

Table 2: Summary of Applied Data Sources

Unobtrusive Data	Semi-structured Interviews
✚ Foresight ✚ The Canadian Hydrogen and Fuel Cells Association ✚ Hockeystick ✚ Thompson Reuters ✚ S&P Capital IQ	✚ Government, investors, associations and startups. ✓ Questions about: ✓ Investors' concerns ✓ Startups' needs ✓ Government and association decision-making

Source: Author

The following sub-section will delve into the unobtrusive research of quantitative and qualitative data to measure the variables.

Unobtrusive Research

Quantitative data did not lend itself to advanced statistical tests, but the data were merged and normalized to compare the cases. The data normalization process used two-dimensional tables that each column corresponding to an attribute of the value represented in the table. Data normalization avoids data discrepancies and duplications while providing data integrity. The normalized data were filtered per case so as to slice and dice the data of each indicator in order to examine the values from different perspectives. Bar charts were used as data visualizations to analyse each indicator per case study. Since bar charts are suitable for continuous values, the bar graphs show comparisons among the categories. The X-axis of the charts shows the years being compared, and the Y-axis represents the total capital of each indicator measured per case. Overall, the graphs provided consistent results to compare the cases and provide further recommendations for Vancouver's ecosystem.

The selection process for potential interviewees was done through publicly available websites. Public websites can speed up the process of finding and contacting participants. After selecting interviewees on public websites, the snowball technique was used to recruit future participants. The initial contact was through email as there is no permission needed from organizations for this research project recruitment. Using the snowball technique, the contacts first obtain permission from the interview candidate before providing their information. The recruitment focused on government officials and other experts in the field of clean energy, managing partners from venture capital firms,

and angel investors who preferably have already had the experience of investing in cleantech startups, and startups' CEOs. The interviews were conducted using synchronous online applications due to the Covid-19 pandemic. A synchronous online interview resembles a real-time research interview as it allows real-time communication with two or more users.

In a semi-structured interview, the interviewer guides the interview but permits various aspects of the topic to arise naturally and in order. Although the interviewer comes with questions prepared and gives directions, the interviewee is an active subject and not merely a reporter of facts and experiences. When formulating semi-structured questions, leading questions were framed in such a way as to suggest that one answer is not expected or preferred. The elaboration of questionnaires considered double-barrelled and confrontational questions as the main concerns to avoid among interviewees. Double-barrelled questions ask for an answer on more than one dimension. Confrontational questions are when a respondent is concerned about the consequences of answering a question in a particular way. Overall, the questions used simple and direct language to communicate with all interviewees (see appendix A).

The research has received the Ethics Approval for interviews with potential interviewees who could contribute to the data collection (see appendix B). The interview data analysis followed three steps that are data reduction, coding and drawing conclusions. Data reduction refers to the process of selecting, focusing and simplifying, abstracting and transforming the data that appear in written-up field notes or transcriptions. The data not only needs to be condensed for manageability but it also has to be transformed to make it intelligible in terms of the issues being addressed. Coding assigned the interview material to different categories according to the variable to which they relate. The data was also coded to ensure confidentiality among participants' identities and opinions. In coding interview data, open questions require coding frames that are government, startups, investors and associations to analyse the responses. Once sequences of text are marked with codes, sequences of text marked with each code are collected. Drawing conclusions involves stepping back to consider the meaning of the analysed data and access their implications for the research question. In summary, the data analyses the variables to understand how Vancouver can establish a successful investment ecosystem, but the research has limitations which will be highlighted in the following section.

a. Limitations of the Study

The research faces some limitations such as the limited number of case studies, variables, and timing restrictions. First, the selected case studies have similar types of hydrogen fuel cell companies when compared to Vancouver. These cases had more successful financial activities than Vancouver; however, four cases are not enough to acknowledge all the main factors that Vancouver's cleantech cluster needs to improve its investment ecosystem. With only four comparative cleantech clusters, the research presents a limited number of variables to assess the main factors for establishing a successful investment ecosystem. There are other important variables that should be taken into consideration, but Vancouver's cleantech cluster is relatively new and there is a lack of statistical data to analyze other variables. My research depends on private and public sector data as well as interviews. I also did not conduct field research in the case studies due to timing and public health restrictions. In this sense, I did not do enough interviews to gather more data so as to analyze the variables and provide more findings to the research.

b. Structure

The structure of this research project started with an overview of the formation of investment ecosystems within cleantech clusters and their importance to local economies as well as statistical facts on Vancouver's cleantech cluster. Chapter 2 analyses the outputs of the policies for hydrogen fuel cell startups based on the current authorities across all cases. Chapter 3 addresses the analysis of the most adopted policy tools in ecosystems to attract Series A and B investments to hydrogen fuel cell startups through interviews with authorities. Chapter 4 concludes with a summary of significant findings and recommends factors necessary to support an investment ecosystem in Vancouver's cleantech cluster.

c. Conclusion

The research concludes that policy tools play important roles to help encourage investment in hydrogen fuel cells and the establishment of a successful investment ecosystem. The measures of success show that Vancouver does not have a comparable number of funds, deals and firms for the number of startups when compared to other ecosystems. Consequently, the measures of success highlight that Vancouver's ecosystem adopts policy tools inspired by the cases studied to build up its ecosystem.

Chapter 2 compares the measures of success that are total equity per firm, funds and deals across all cases. The measures are important to understand the factors that Vancouver is lacking to establish a successful investment ecosystem.

Chapter 2.

Increasing the Number of Firms, Funds and Deals in Vancouver's Investment Ecosystem

2.1. Introduction

The chapter highlights the measures of success are total equity of firms, funds and deals across Silicon Valley, Cambridge, Tel-Aviv, Singapore and Vancouver. The case selection is based on higher performance indicators and the same or attraction-integration phases of investment ecosystems. The comparative analysis selects Silicon Valley, Cambridge, Tel-Aviv and Singapore because of their higher measures of success and are at the same or attraction-integration in the lifecycle phases when compared to Vancouver. The three indicators present different outcomes depending on the analysed investment ecosystem. Each ecosystem has different characteristics of public and private intervention to attract more investments to support hydrogen fuel cell startups within a cleantech cluster. Thus, the outcomes try to understand how Vancouver can establish a more successful investment ecosystem when compared to the other cases.

2.2. The Slow Growth of Firms, Funds and Deals in Vancouver Compared to Silicon Valley, Cambridge, Tel-Aviv and Singapore

Total equity of deals, firms, and funds are common ways of measuring success among Silicon Valley, Cambridge, Tel-Aviv, Singapore and Vancouver. Private equity is ownership or interest in an entity that is not publicly traded. A source of investment capital, private equity comes from investment firms that purchase stakes in private companies or acquire control of public businesses with plans to take them private (Baygan, 2010). Baygan emphasizes that measuring deals explains the creation and development of relationships between startups, investors, and other transaction professionals to secure both the quantity and quality of deals (2010). Moreover, Jeong et al. highlight the importance of evaluating the investment companies (2020). Measuring the investment funds are also important to analyse the capacity of startups to pitch their innovation to obtain funds as well as the investors' network to provide capital (Jeong et

al., 2020). Funds manage pooled investments in high-growth opportunities in startups and other early-stage firms (Jeong et al., 2020). Finally, the equity per firm is important to identify the investors that can provide different types of investments and handle risks of failure in the long run (Jeong et al., 2020). The policy tools come from the coordination of authorities to define market needs and address specific policy designs to the government. The compared ecosystems have the same policy tools, but they present different results depending on the ecosystem.

Table 3 summarizes all measures of success across the studied cases in fifteen years of private equity investments. It shows that Silicon Valley and Cambridge have the largest equity per firm, funds and deals compared to the other clusters. Tel-Aviv, Singapore and Vancouver have a considerable number of deals and funds.

Table 3: Summary of Measures of Success from 2005-2020 across Clusters

	Measures of Success			
	Total Equity of Firms Series A and B (2005-2020)	Total Equity of Funds Series A and B (2005-2020)	Total Equity of Deals Series A and B (2005-2020)	Total Amount:
Silicon Valley	$ 6,499,520,373	$ 2,633,838,836	$ 4,572,253,957	$13.7 billion
Cambridge, UK	$ 3,630,119,796	$ 1,832,223,444	$ 2,284,729,881	$7.8 billion
Tel-Aviv	$ 1,025,040,642	$ 540,905,249	$ 660,431,236	$2.4 billion
Singapore	$ 965,880,162	$ 775,332,990	$ 893,056,331	$ 2.7 billion
Vancouver	$ 902,120,041	$ 700,843,334	$ 807,478,297	$2.5 billion

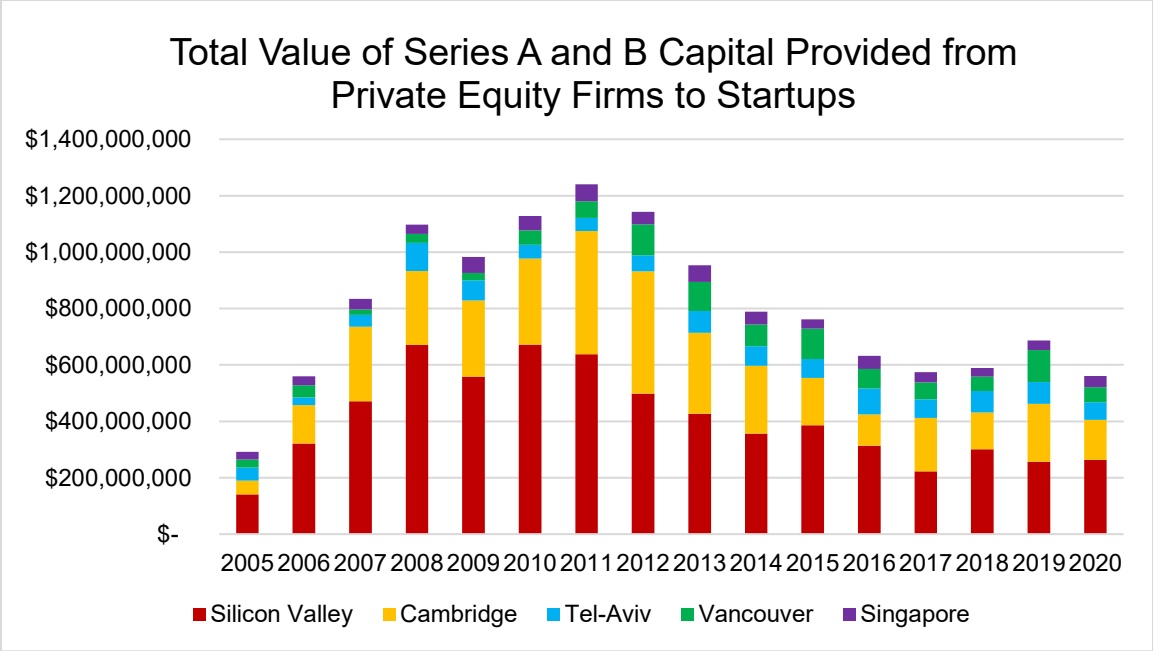
Source: Thomson Reuters Eikon and Hockeystick, 2020

The values presented in the table demonstrate a ranking across different sized clusters. In this case, Vancouver lags Silicon Valley and Cambridge, but it has closer results to Tel-Aviv and Singapore when comparing numbers of firms, funds and deals. The following graphs show the fifteen-year timeframe across all three measures of success to compare the case studies. The result is that Silicon Valley and Cambridge present the fastest growth when compared to other clusters. Tel-Aviv, Singapore and Vancouver have similar trends, yet the growth in the last years was higher in Tel-Aviv and Singapore when compared to Vancouver. Consequently, the data reinforce the fact that Vancouver needs to improve its measures of success to grow investments among hydrogen fuel cell startups.

2.2.1. Total Value of Equity per Firms

Greater concentration of investment firms such as venture capital and angel investors can help to provide more Series A and B funding to fuel cells and hydrogen technology. Investors are attracted to places where innovation flows within the cluster. In this case, successful clusters have a plethora of investors which facilitate investment activities. Silicon Valley and Cambridge are the clusters with the highest numbers of private investment firms while Tel-Aviv, Singapore and Vancouver had the lowest numbers. Figure 5 shows, across all case studies, the total equity in cleantech firms from 2005 to 2020.

Figure 5: Total Value of Series A and B Capital Provided from Private Equity Firms to Startups 2005-2020



Source: Thompson Reuters, Capital S&P and Hockeystick, 2020

The amount of investment coming from private equity firms are essential in an effective investment ecosystem as hydrogen fuel cell startups need capital to grow their business activities. Figure 5 shows Silicon Valley has the highest number of investment firms for financing hydrogen and fuel cells. The heterogeneity of private equity firms establishes and fosters startups because it expands the innovation sectors that investors fund. Even though the numbers have slightly decreased in 2012 and remained roughly constant since that heterogeneity facilitates private equity firms to invest in startups. As

such, Complex Network Theory explains the success of private equity firms in Silicon Valley (Ferrary and Granovetter, 2009). This theory views the ecosystem as a complex network where actors in the private sector have interdependent financial nodes (Ferrary and Granovetter, 2009). Based on this definition, Silicon Valley presents a complex network where investors interact with other agents in the same ecosystem such as public agencies, banks and large firms (Ferrary and Granovetter, 2009). Thus, the successful results of this connection show financing, collective learning and selection of innovative hydrogen and fuel cell products among startups in Silicon Valley.

The graph shows that Cambridge has the second largest value of private equity firm investment. Since Cambridge became a hub of innovation in hydrogen and fuel cells in the last ten years, some British and other European private equity firms decided to invest in Cambridge's startups. In Cambridge, the composition of private sector investors has changed, and significant financial support from private equity firms becomes more important than public grants (Mason and Pierrakis, 2013). Private equity firms are important stakeholders in the ecosystem because they help devise policy tools. In this case, the investors aim to improve the commercialization of innovations in the market while encouraging the implementation of policy tools to foster hydrogen and fuel cell technologies. Therefore, once the investment ecosystem was well-established, policy tools sustain private equity firms in Cambridge's cluster while the private sector directs market needs to innovation.

In Tel-Aviv, the government played an important role when attracting more private equity firms to compose the cluster that helped hydrogen fuel cell technologies. Figure 5 shows an improvement in firms' investments between 2015 and 2020. The reason for this growth is the government's investments that contributed not only to the early emergence phase of the financial market in the 1990s but also after the development of preconditions associated with the private equity demand between 2015 and 2020 (Avnimelech and Teubal, 2009). While enhancing investments from private equity firms among hydrogen fuel cell startups, different policy tools composed the ecosystem to support the firms to remain in Tel-Aviv. This public assistance is fundamental to growing the ecosystem as shown in the graph. Thus, the government attracted more private equity firms that supported the investments in hydrogen fuel cells and established the success of the investment ecosystem.

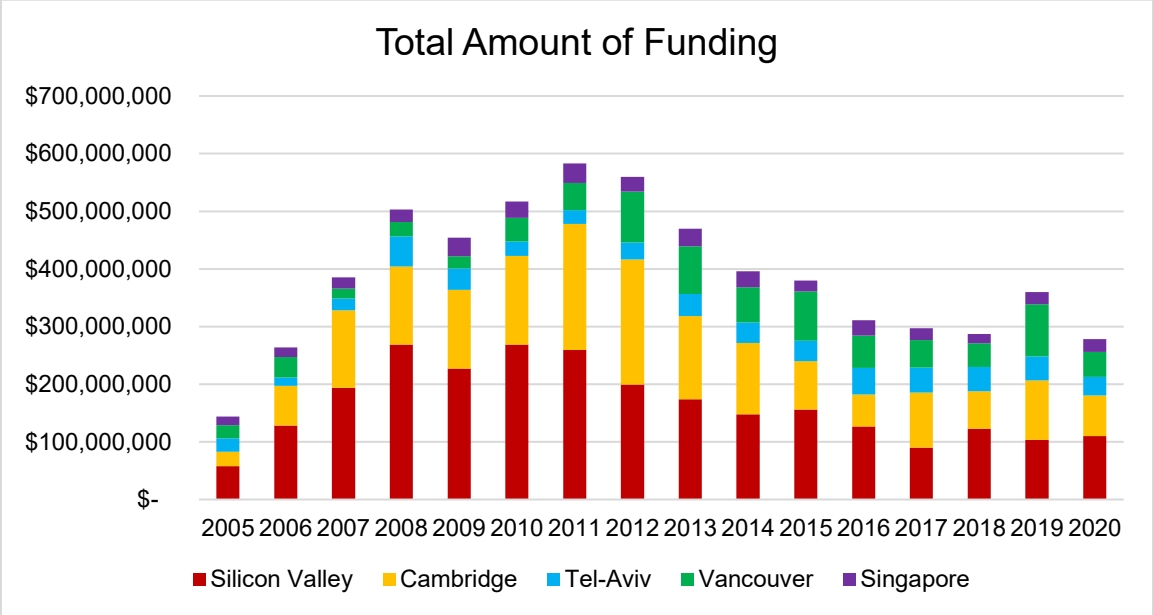
The graph shows that Singapore increased the number of private equity firms between 2012 and 2019. The growth of firms is the result of the National Framework of Innovation and Enterprise (NFIE) which aimed to commercialise hydrogen fuel cell technologies developed through startups participating in the Public Research Institutes (PRI), Institutes of Higher Learning (IHL) or private laboratories (Bruton, Ahlstrom and Singh, 2010). By 2014, financial activity has increased significantly as Singapore attracted more private equity firms (Koh and Phan, 2015). The prevalence rate of private equity firms investing in hydrogen fuel cell startups increased from 10.7% in 2005 to 20.1% in 2014 (Koh and Phan, 2015). Thus, the Singaporean government could set up a national program that attracted more private equity firms to invest in hydrogen fuel cell startups.

The graph demonstrates the growth of private equity firms in the last seven years in Vancouver's investment ecosystem. This upward trend highlights that Vancouver could increase the number of investments coming from private equity investors. The private sector was able to identify the needs of startups and find market niches for hydrogen and fuel cells. Private equity companies are also filling a niche that allows the necessary capital for startups in an ecosystem (Samila and Sorenson, 2011). This private equity firm niche will increase the supply of capital which stimulates the production of new financial firms in the region (Samila and Sorenson, 2011). However, most investors encourage startups to move their businesses to Silicon Valley because it has more economic and social resources. In order to continue the growth of private equity firms, the government and other stakeholders should promote Vancouver as a potential cluster to commercialize hydrogen and fuel cells. Thus, an expansion in financial intermediation together with the cluster's promotion improves the allocation of capital and can stimulate growth.

2.2.2. Total Amount of Funds

Series A and B investments are important to establish and foster hydrogen fuel cell manufacturing and sales among startups in any successful investment ecosystem. Early-stage capital can originate from public, private, or public-private partnerships. In Figure 6, the numbers highlight the number of funds provided by private investors across all cases from 2005 to 2020.

Figure 6: Total Amount of Funding 2005-2020



Source: Thompson Reuters, Capital S&P and Hockeystick, 2020

Figure 6 presents the total amount of private equity funding to startups among the clusters. Silicon Valley has the leading values of private equity funding when compared to the other clusters. However, the graph shows that the number of funds dropped from 2012 to 2020 when compared to previous years in Silicon Valley. The reason for this downward trend was the growth of innovations in hydrogen and fuel cells which diluted the private equity shares among different investors. The government did not provide more investments than the private sector between 2014 and 2020. Public funding does not crowd out private funds as it may cause a reduction in industry returns (Wonglimpiyara, 2006). The case of Silicon Valley has shown that the funding and the equity stakes undertaken by different actors in the private sector highly motivate startups to perform their best in fuelling growth and innovation (Wonglimpiyara, 2006).

In Cambridge, Series A and B funds had a peak in 2011 and 2012, but they decreased from 2015 to 2020 (Figure 6). Even though Cambridge experienced this decrease, tax incentives helped startups reduce their tax burden and make more businesses with other companies. In order to provide Series A and B, the British government had a strategic objective and a long-term commitment to enhancing capital in the local market. Policy processes were dynamic to adapt to the specific needs of startups and investors in Cambridge's cleantech cluster (Mason and Pierrakis, 2013).

Figure 6 also highlights that Cambridge has a successful investment ecosystem because the government was a significant source of Series A and B funds (Mason and Pierrakis, 2013). Moreover, the form of intervention has shifted in its emphasis from the public sector making direct investments in startups to co-investment funds such as venture capitalists (Mason and Pierrakis, 2013). Thus, Cambridge has the government and private equity investors providing funding to hydrogen fuel cell startups.

Figure 6 shows that Tel-Aviv experienced growth in private equity investments between 2013 and 2020. The success of investments in Tel-Aviv is associated with Porter's Competitive Diamond Model. The model is the basis of the successful Israeli ecosystem that had public and private pre-conditions to fund hydrogen fuel cell startups (Wonglimpiyara, 2006). Consequently, strong government-led policy tools attracted investors to the ecosystem (Wonglimpiyara, 2006). The government-targeted policies and financing programs generated crowding-in effects boosting venture capital investments as well as private venture capital supply in the local market (Wonglimpiyara, 2006). Tel-Aviv's cleantech cluster, therefore, is driven by the policy tools and investments from the public and private sectors which make Tel-Aviv a successful global investment ecosystem.

The graph shows that Singapore increased the number of investments from 2014 to 2020. The growth was an outcome of different public approaches to improve investments in Singapore's ecosystem. Singapore's government adopted three approaches so as to foster and shape the investment ecosystem (Cheah, 2016). First, is the promotion of the Triple Helix Model that connects industries, universities, and government to deliver a common agenda that fosters innovation and increase the number of investments in startups (Cheah, 2016). Second, the "born global" approach is the strength of triple helix dynamics as it provides the basis of the country's strategy to invest in startups (Cheah, 2016). As such, Singapore has two initiatives DxD Hub and NUSRI Suzhou in which startups can go to foreign markets either through a physical launchpad like the NUSRI Incubator or through virtual connections such as the DxD Hub (Cheah, 2016). Third, Singapore created the agglomeration cluster-based approach (Cheah, 2016). The Launchpad @one-north project illustrates the planned agglomeration strategy to invest in startups within the cluster (Cheah, 2016). By connecting all key stakeholders in the ecosystem in the same geographic location, the Launchpad has developed the highest-density cleantech hub in the world (Cheah, 2016).

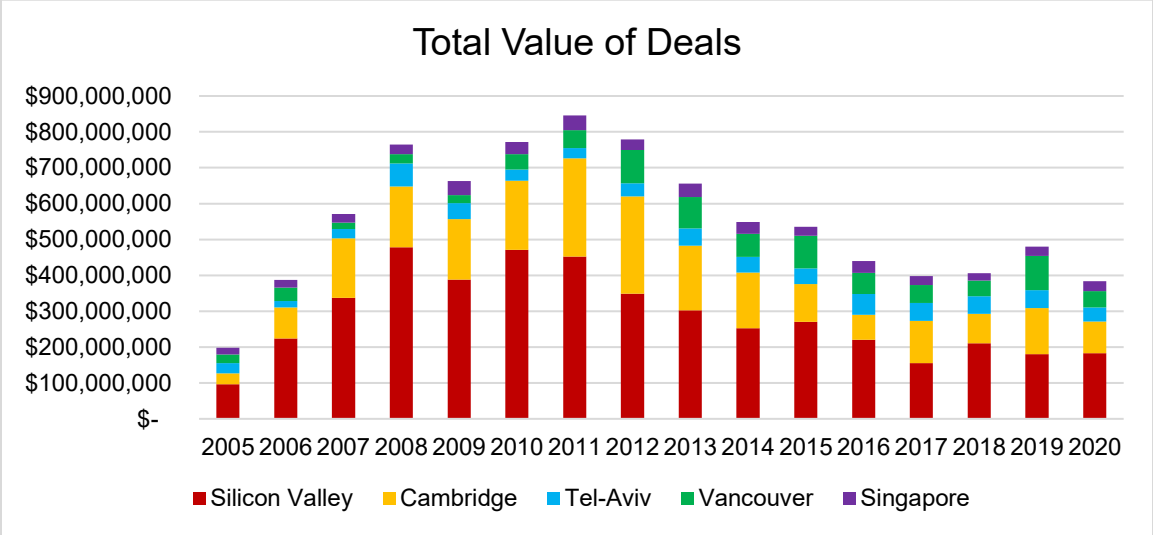
Thus, the direct participation of Singapore's government brought more investments through effective public and private incentives that fostered innovation among hydrogen fuel cell startups (Koh and Phan, 2015).

Funding in Vancouver increased slightly between 2011 and 2019 as seen in Figure 6. Most of the funds came from public agencies and some private investors that provide Series A and B investments. It is challenging for Vancouver to attract more funds without a more effective ecosystem. Bringing more private equity funds to provide more capital can be a challenge to interest top-tier private equity firms (Lerner, 2009). Vancouver needs to highlight the quality of hydrogen and fuel cell innovations that can attract recognized finance companies with a particular interest in hydrogen and fuel cells to drive local growth (Lerner, 2009). Thus, the lack of an investment ecosystem presents a potential barrier to entry for new venture capitalists and increases the expectations for greater future investment in hydrogen and fuel cells.

2.2.3. Total Number of Deals

Venture capital support is in line with the importance of environmental technologies both in terms of the number of deals and the amounts invested. The number of deals is the output of policy tools that allow investors and startups to make businesses in the ecosystem. Startups can benefit from policy tools to get more capital that increases their business activities. Figure 8 reflects the number of deals from 2005 to 2020 across all studied clusters.

Figure 7: Total Value of Deals 2005-2020



Source: Thompson Reuters, Capital S&P and Hockeystick, 2020

Figure 7 shows that Silicon Valley is leading the number of deals when compared to the other clusters. The number of deals was the highest in 2008, 2010, and 2011, but it had the lowest values between 2014 and 2020. The reason for the fewer deals was the low quantity of startups pitching to private equity firms. Moreover, Silicon Valley has minimal venture capital public intervention which decreases the number of deals made between public agencies and startups (Wonglimpiyara, 2006). The government helps creates a prosperous business environment while private equity firms perform business functions to achieve and sustain competitive advantage (Wonglimpiyara, 2006). Silicon Valley, thus, is successful because the government complements and does not substitute conventional private equity financing.

Figure 7 presents a stable number of deals in Cambridge between 2012 and 2020. Cambridge has a well-established investment ecosystem to support deals between investors and startups to launch hydrogen fuel cell innovations (Rosiello et al.., 2013). The combination of effective public agencies and private sector incentives to make deals with startup facilitate the ecosystem's growth (Rosiello et al.. 2013). The deals facilitated startups to get more capital and expertise to develop their innovations and find a market niche. In this case, Cambridge has different investors from the private and public sectors that can make deals with startups and build a prosperous ecosystem.

Tel-Aviv has slightly increased the number of equities per deal in the last five years according to Figure 7. Tel-Aviv's startups could obtain deals with public and

private investors that supported the development of their hydrogen and fuel cell innovations. Policy-makers started a process to establish a domestic and private financial sector in order to support startups by increasing investments and consequently deals (Avnimelech and Teubal, 2009). This support started in the early 2000s to foster innovation-led design among startups (Avnimelech and Teubal, 2009). Then, the level of deals increased in the following years as seen in the graph. Thus, the process of developing public financing initiatives attracts more investments and deals from the private sector that have helped advance the cleantech cluster.

Figure 7 shows that Singaporean startups could obtain deals from public and private investors over time. The number of deals could increase because Singapore's venture capital has cultivated a clean technology orientation with an emphasis on funding Series A and B ventures that sets it apart from most Asian financial industries. Some public programs and incentives have been launched to attract different stakeholders to collectively make deals with startups in the cleantech cluster. Consequently, the deals could double the number of Singapore-based startups in the cleantech sector from 2,800 in 2004 to 5,500 in 2014 (Koh and Phan, 2015). Therefore, the government has an emphasis on promoting cleantech creation capabilities in order to facilitate deals among startups in the cleantech cluster.

The graph shows how Vancouver improved the number of deals from 2010 to 2020. The ten-year period presented a steady growth for startups which could make more deals with private firms or public agencies. The Canadian government supports accelerators and incubators for startups to develop their innovations and try to insert them into the market. The current concern is the lack of local private equity investors to increase the number of deals made to startups. Investors are necessary to speed the process of investment and market readiness because of their capital and expertise. The Canadian government does not have the knowledge to help startups to grow in the market without effective private sector guiding startups. Thus, Vancouver increased the number of deals but needs more investors to make deals with startups to commercialize hydrogen fuel cell innovations.

Overall, Silicon Valley and Cambridge have the leading number of firms, funds, and deals in their investment ecosystems while Tel-Aviv, Singapore and Vancouver are growing slightly.

2.3. **Conclusion**

This chapter compared three measures of success: total equity funds, firms and deals invested in hydrogen fuel cell startups across Silicon Valley, Cambridge, Tel-Aviv, Vancouver and Singapore. The data summarized that Silicon Valley and Cambridge have the leading investment ecosystem as they show the largest equity per firm, funds and deals compared to the other clusters. Tel-Aviv has a substantial number of deals and funds while Singapore and Vancouver have almost the same number of firms, funds and deals. The data demonstrate that Vancouver has significantly fewer firms, funds and deals. The next chapter examines policy tools to find ways Vancouver can bring more investment to hydrogen fuel cell startups and establish a successful investment ecosystem.

Chapter 3.

The Lack of Effective Policy Tools in Vancouver's Investment Ecosystem

3.1. Introduction

This chapter aims to compare the perceptions of the policy tools used in all ecosystems studied after receiving feedback from interviewees. The selected interviewees were the main authority groups that are government, associations, investors and startups across investment ecosystems. They explained their cluster activities and which policy tools benefited their clusters based on designed policies (see appendix C). They emphasized the five policy tools most adopted across all cases that are tax incentives, co-investment, credit supply, loan guarantees and grants. Policy tools are necessary to fund hydrogen fuel cell startups and establish a successful investment ecosystem. I argue that tax incentives and co-investments should be adopted together with loan guarantees, credit supply and grants so as to financially support startups in Vancouver. The BC government emphasizes that *"a range of policy support, financial support, tax support is what Vancouver needs. If the government just remains ambivalent to the fact that British Columbia got world-leading hydrogen and fuel cell cluster, [this] cluster is not going to [be] recognized and valued"* (BC Government). Overall, the chapter highlights the importance of having a combination of policy tools to attract more investments to startups in Vancouver's ecosystem.

3.2. Main Authorities of Investment Ecosystems across Cases

Coordination among stakeholders is crucial to using the policy tools that can attract more private equity firms, funds and deals to startups. The authorities were interviewed to understand how policy tools can facilitate the access of capital to hydrogen fuel cell startups (Appendix C). In this way, the information gathered from thirty-six authorities in Vancouver, Silicon Valley, Cambridge, Tel-Aviv and Singapore were compared to highlight the main aspects of each hydrogen and fuel cell sector. The main sources of authority are government and crown corporations, investors, hydrogen

fuel cell startups and large companies, associations and accelerators in Vancouver, Silicon Valley, Tel-Aviv, Singapore and Cambridge. I conducted thirty-six semi-structured interviews in which the interviewer guides the interview but permits various aspects of the topic to arise naturally and in order. When formulating semi-structured questions, leading questions were framed in such a way as to suggest that one answer is not expected or preferred. The following section will present the key takeaways from authorities by comparing the five policy tools across all case studies.

3.2.1. Policy Tool 1: Grants in Investment Ecosystems

In Silicon Valley, the Hydrogen and Fuel Cell Technologies Office (HFTO) offers different grants to startups developing innovations using hydrogen or fuel cell applications. For instance, the California Energy Commission's Electric Program Investment Charge (EPIC) program invests in scientific and technological research to accelerate the transformation of the electricity sector to meet the state's energy and climate goals (California Energy Commission, 2021). The program gives the necessary grants to support new clean energy technology ventures that could meet the requirements of potential private equity investors in the long-run (California Energy Commission, 2021). It provides entrepreneurs with access to the networks, funding opportunities, mentoring, facilities, and expertise needed to take their inventions from the idea stage to the impact stage (State of California, 2021). The US Department of Energy (DOE) also encourages capable startups or small companies to consider doing business with DOE (State of California, 2021). Procurement is an important role the American government plays to be the first buyer of innovations. Some associations in British Columbia take California grants and procurement as references to Vancouver. An association highlights that

> "Sustainable procurement is one of the main roles that the Canadian government should do to establish a successful investment ecosystem. The Canadian government should be the first, second and even third buyer of sustainable innovation to grow the startups" (Association, Vancouver).

Similar to Silicon Valley, Cambridge has the Fuel Cell Electric Vehicle Fleet Support Scheme that aims to accelerate the growth of the commercial market of fuel cell electric vehicles (FCEVs) (UK Government, 2020). The scheme is implemented under the powers of the Science and Technology Act 1965. The UK government runs the

Scheme that provides more than £2M grants to public and private sector organisations to buy FCEVs (UK Government, 2020). The Scheme has two separate streams, each of which can fund up to 75% of costs (UK Government, 2020). First, the public sector fleets provide support to government bodies for the deployment of FCEVs that are not in competition with commercial activity (UK Government, 2020). In this case, the British government has the procurement role to purchase sustainable innovations (UK Government, 2020). The 75% can cover insurance, fleet management, vehicle servicing, user training, fuel, project reporting and dissemination (UK Government, 2020). There is no cap on the sum awarded to public sector organisations acquiring these vehicles (UK Government, 2020). Second, the program supports private enterprises that can get a maximum of £200,000 per business to cover up to 75% of the cost of acquiring a fleet of FCEVs, car insurance, fuel and project reporting (UK Government, 2020).

> "Most of the British startups that develop fuel cell vehicles can commercialize their innovations in the European market. Europe has a large marketplace of innovative products and services whereas Canada has a very small market, so that puts Canadian startups in a marketing challenge" (Association, UK and Vancouver).

The British government is also associated with grant support given to students who are willing to develop innovations and open startups. In Cambridge, most hydrogen fuel cell startups are formed at the University of Cambridge because they can connect startups with investors and large companies (UK Government, 2020). The university is part of the Cambridge Science Park that has facilitators such as investors, professors, tech experts and mentors who guide students when creating innovations (Cambridge Science Park, 2021). The Park provides easy access to different large cleantech businesses, investors and partners to financially support startups formed at the University (Cambridge Science Park, 2021). Thus, the British government provides enough grants to Cambridge startups to develop innovations and create connections in the Park that can create successful spinoffs in the market.

In contrast to Cambridge, Vancouver's startups that started in universities had effective funding but poor market connections. According to a startup,

> "universities in Vancouver are not very well connected within the entrepreneurial space. We did not know a lot about other grant programs and other sources. Once we joined some accelerators and connected to some friends, we increased the startup's boundaries and became aware of

> who we should contact in Vancouver to grow our business" (Startup, Vancouver).

The Israeli government considers grants important funding support to startups' market growth. According to the R&D Law and the Innovation Authority's vision, the Authority grants are designed to encourage technological and industrial R&D and innovation (Israel Innovation Authority, 2020). As such, the Innovation Authority's budget for grants was $484M for startups in 2019. The grants focus on addressing market failures such as innovative, less familiar sectors that are high-risk and that offer long-term gains in the Israeli innovation ecosystem (Israel Innovation Authority, 2020). The private market does not invest the required capital or its investments are very minimal (Israel Innovation Authority, 2020). This occurs when the private sector disregards market gains that do not translate to revenues, and when the private sector tends to stick with familiar sectors that are relatively low risk and offer short-term gains (Israel Innovation Authority, 2020). The Innovation Authority's grants make up a significant share of the total investment and can significantly impact developments (Israel Innovation Authority, 2020). In 2018, grants were provided to 40% of startups in clean energy and technologies which proves that industries with an inherent market failure such as cleantech rely on grants to attract more private equity investments in the long-run (Israel Innovation Authority, 2020). Thus, the Innovation Authority plays a key role in funding start-ups in segments that have inherent high risk with long-term gains such as cleantech to offer long- term contributions to Israel's market and economy.

The Singaporean government provides grants to startups that are planning to develop sustainable innovations in the local market. For instance, the Enterprise Development Grant (EDG) is Singapore's small business grant for providing financial assistance to startups (Enterprise Singapore, 2020). Singaporean SMEs can obtain up to 70% government grants to defray the costs of qualifying projects (Enterprise Singapore, 2020). It is designed to help SMEs build internal capabilities in three main areas: core capabilities, innovation and productivity and market access (Enterprise Singapore, 2020). These three areas highlight that the Singaporean government offers grants from developing internal core capabilities during the early phases to innovating for productivity growth and expanding overseas in the late stages (Enterprise Singapore, 2020). However, startups that have already developed the three main capabilities tend to expand their businesses to other countries (Enterprise Singapore, 2020). The local

market is small and lacks business partners to expand the business size and find more customers.

The National Research Council (NRC) is the primary national Research and Technology Organization (RTO) of the Canadian Government in science and technology R&D. The Industrial Research Assistance Program (IRAP) has been stimulating SMEs' development through technological innovation since 1965 (National Research Canada, 2018). This is accomplished by identifying and understanding technology issues and opportunities so as to provide linkages to other businesses and R&D expertise in Canada (Government of Canada, 2018). R&D requires a considerable budget for firms to do proper research, test, and create prototypes before selling and eventually reach too early and late the majority of the local market (Government of Canada, 2018). Approximately 56% of science-based SMEs serve specialized market segments that large firms may find unprofitable, by adopting flexible production processes that can offer personalized products (Government of Canada, 2018). Taking advantage of their close relationships with their customers, science-based SMEs are often better positioned to take the basic technical innovations made by large firms and turn them into new products (Government of Canada, 2018).

IRAP is the single most important program of the federal government to help fund R&D and build innovative SMEs; however, it has two main concerns related to grants. First, with the 7,631 funded firms during 2016-2017, IRAP has reached a very small proportion considering the 1.17 million SMEs in Canada (Crane, 2018). Based on a startup based in Vancouver,

"They [IRAP] position themselves as a funding program for small to medium businesses. The problem is they do not fund small to medium businesses and their R&D projects. They only find companies that are making more than a million dollars in revenue a year, so they do not need to provide a lot of money and companies have less risk to fail. Startups are getting ten thousand dollars to hire some staff full-time" (Startup, Vancouver).

IRAP has also decreased its assistance among startups due to a lack of communication between industrial technology advisors (ITA) and startups to deliver R&D

grants (Crane, 2018). This is an issue for startups since they need the support of ITAs to obtain funding from the program and grow their companies. For a startup,

> "The ITA was not the expert in our field of innovation that did not facilitate to support the needs of our startup, so the person helped us to complete the applications to get some grants. We stayed one year without receiving a considerable amount of grants because the ITA did not provide the money. There was a lack of communication between the ITA and NRC to understand the needs of startups. This under communication was also related to the field of expertise of the ITA that was different than our innovation (Startup, Vancouver).

The interviewed startup is concerned about the lack of grants, communication, and ITA's expertise provided to the innovation. In this case, IRAP should support the startups and increase the communication between ITAs and NRC. Most public programs offer to fund narrow industrial sectors because they lack experts to understand different sectors and guide entrepreneurs to disrupt the market and succeed with their innovations (Lerner, 2002).

Associations highlight the issue of startups trying to enter the small market size in Vancouver. The little market does not provide many options for customers, partners, investors, or even competitors to commercialize innovation. For an association,

> "The lack of a local market jeopardizes the startups to raise capital. It is possible to raise grants early on and participate in demonstrator projects. The city of Vancouver's demonstrator project is excellent. It's a great place to try out your technology, but what they are completely and utterly lacking is the next piece which is how you sell your product. Grants cannot help you grow enough to commercialize innovations, so the lack of other capital incentives takes away one of the most important pieces of the puzzle to make a clean tech company viable and how startups can become financially sustainable." (Association, Vancouver)

The Canadian government has a burden to provide all R&D grants that SMEs need without the significant support of the private sector and other actors. The size of the BC market and the lack of robust supply chain partners or local customers is a major disadvantage. Consequently, it jeopardizes R&D activities among SMEs due to a lack of effective delivery of these grants and no communication between these two groups to understand the SMEs' needs. However, the proximity to the US market can help the government to understand exports that could form a supply chain. The geographical proximity between Canada and the US put Vancouver's startups in a better position than

Israeli and Singaporean startups. Israel and Singapore have small market competitors that force small businesses to export innovations to other countries.

> "The Canadian government should purchase more innovations from startups. Grants try to help startups bring their products to market, which ironically, without purchasing innovations. The Canadian government is helping startups to be bought out by other companies from other places" (Association, Vancouver).

The Canadian government also provides the Sustainable Development Technology Canada (SDTC) investments. It serves as a springboard to help companies unlock future investment, customers and support (Sustainable Development Technology Canada, 2020). SDTC helps high-potential companies take that next leap and achieve market readiness by funding the development and demonstration of clean technologies (Sustainable Development Technology Canada, 2020). SDTC is a non repayable contribution that allows up to a maximum of 75% government funding from any level for a project (Sustainable Development Technology Canada, 2020). SDTC funds on average 33% of eligible project costs and requires a minimum of 25% private funding, which can include in-kind contributions from consortium partners (Sustainable Development Technology Canada, 2020). At least 50% of eligible project costs must be incurred in Canada (Sustainable Development Technology Canada, 2020). For startups, the technology has been proven at a small scale, shows promise, and has the potential to deliver a transformative environmental benefit. Startups need to demonstrate and validate the solution in a market setting. SDTC runs a competitive funding process, working on a continuous intake basis and approving funding every two months (Sustainable Development Technology Canada, 2020). After an initial screening process, SDTC matches startups with an Investment Lead who will guide them through SDTC's funding process.

> "SDTC is a positive program that the Canadian government offers to startups. I could get financial assistance for my business during its first two years. SDTC is the main support that the federal government can offer to startups that are planning to stay in Canada during their early-stages" (Startup, Vancouver).

The concern of most startups and associations is the lack of procurement roles in the federal, provincial and local governments. Based on the Association,

> "The Canadian government does not understand the importance of doing sustainable procurement. I mean, the federal, provincial and municipal levels of

> government should have procurement to create successful and quite large Canadian companies just buying Canadian solutions for the government. The European Union has been the global leader in sustainable procurement. European countries have between 10 and 15% of the GDP to purchase innovations. That percentage creates billion-dollar companies just buying solutions" (Association, Vancouver).

3.2.2. Policy Tool 2: Loan Guarantees in Investment Ecosystems

Loan guarantees are important financial resources for startups to develop hydrogen fuel cell innovations. Loan guarantees are auxiliary financial sources for startups to get Series A or B funding in Silicon Valley. California Hydrogen Business Council (CHBC) advocates for SMEs to produce more hydrogen fuel cell technologies as clean, zero-emissions energy vehicles. Private banks are members of the CHBC which offer loan guarantees to hydrogen fuel cell startup that are developing hydrogen fuel cell zero-emissions energy vehicles.

In Silicon Valley, loan guarantees are the main alternatives to hydrogen fuel cell startups that are willing to grow their innovation and find investors (Investor, Silicon Valley). The California Small Business Loan Guarantee Program (SBLGP) assists small businesses with the creation and retention of jobs (Investor, Silicon Valley). The tools help startups to get capital and return it when they raised Series A or B investments. In Silicon Valley, loan guarantees offered from private banks help innovations to reach a certain market while credit supply targets R&D activities among startups (Associations, Silicon Valley). "The SBLGP enables small businesses to establish a favorable credit history with a lender so the business may obtain loans in the future on its own without the assistance of the program" (Investor, Silicon Valley). Venture capital investors in Silicon Valley believe that:

> "There are a lot of investors with a lot of money in Silicon Valley who are willing to invest because they are more familiar with the landscape, types of projects, and maybe more educated" (Investor, Silicon Valley).

In Silicon Valley, most loan guarantees are available to hydrogen and fuel cell startups doing innovation for the transportation sector. Transportation companies and angel investors are aware that startups cannot make money the first time (Investor, Silicon Valley). They try to provide loan guarantees to startups developing hydrogen and fuel cell technologies useful to the transportation sector. Angel investors in Silicon Valley

also consider the benefits received from loan guarantees before investing in phase A or B to startups (Investor, Silicon Valley). Startups agree that loan guarantees are useful to obtain Series A and B investments in the long-run (Startup, Silicon Valley). Startups highlight that:

> "We (startups) make deals with loans from angels or banks. Then, we can roll to series B with a venture capitalist. [Any] money whatsoever for a venture on this is secured by a physical asset or some other type of asset that can be used in case of a default" (Startup, Silicon Valley).

The Israeli Government Loans Foundation Scheme and British Bank Loans Program have similar paths of loan guarantees for cleantech startups. Startups from both clusters receive loan guarantees from the government when developing innovations during the pre-seed investment stage. This loan helps startups to raise more capital from their products as well as get a higher valuation from angel investors (Startup, Tel-Aviv). Investors have a positive perspective on loan guarantees at early-stages as this benefit guides them to invest in promising startups. Tel-Aviv and Cambridge give loan guarantees to expand in-house production while credit supply supports the commercialization of this production to early customers. For instance, the Israeli Fuel Cells Consortium and UK Hydrogen Fuel Cell Association (UK HFCA) provide loan guarantees to startups that aim to hire and train new scientists and engineers in the field. This support offers an in-house expansion that allows startups to speed up the testing phase of their innovations. In Tel-Aviv, private equity firms provide capital to hydrogen fuel cell startups to expand their production and find more partnerships (Startup, Tel-Aviv). Overall, Tel-Aviv and Cambridge prioritize the growth of R&D activities and innovation production to find early customers by providing loan guarantees as a policy tool.

In Singapore, Energy Market Authority (EMA) provides loan guarantees to startups that can develop hydrogen fuel cell innovations for the transportation sector to make potential partnerships with large Asian companies. Singapore stills forming the connections between private large and small companies with public support. According to Singaporean angel investors, "the government has attracted several incubators, accelerators, and investors to set up a cluster in Singapore" (2020). Most Singaporean startups get public loan guarantees before getting into an angel or VC investments (Startup, Singapore). For a Singaporean investor, "credit supply certainly helps startups

financially. [In Singapore,] startups receive credit supply for R&D activities for three years" (Investor, Singapore). In Singapore, three years of loan guarantees are crucial to startups that are trying to find customers for newly developed products in hydrogen and fuel cells. Getting loan guarantees to prove that startups have credibility, then private investors provide the extra funding necessary to produce and commercialize the innovation. Thus, Singapore has authorities in the public and private sectors that addressed loan guarantees as a policy tool to facilitate the capital provision to cleantech startups.

In Vancouver, hydrogen fuel cell startups get some loan guarantees from Crown corporation banks to insert their technologies into the market. Loan guarantees provide funding to startups to start finding their early customer or accelerators to test their prototypes. Loan guarantees also help startups to find investors in the US that funded their hydrogen fuel cell technology. According to hydrogen fuel cell startups in Vancouver,

> "loan guarantees are useful to us and other early-stage companies […]. [Moreover,] there has been a lot of work among crown corporations and government to provide some types of loans and credit supply. This is where the economic commissioners should be bringing early-stage companies together as teams and incubators and then marrying them with potential customers or development partners in the ecosystem" (Startup, Vancouver).

The Canadian government supports loan guarantees to startups: Venture capital and angel investors have positive views of startups that get loan guarantees before reaching out to their private equity capital (Investor, Vancouver). Taking the perspective of the private sector, a VC company proposed an alternative to giving more loan guarantees to startups.

> "There's this idea of creating sandboxes: Places where [startups] can demonstrate and try the technology, and where [investors] can come and see different clean technologies. It would facilitate the private or public sector to provide loan guarantees" (Investor, Vancouver).

Investors in Vancouver agree on providing loan guarantees to support small business growth. Investors explain that:

> "Loan guarantees are good [because] most companies in the early stages are not making revenues. Getting tax incentives [does] not really help them in the

short run. Direct cash infusion such as loans does help them because it allows them to hire people for projects along" (Investor, Vancouver).

Authorities emphasize that loan guarantees are policy tools that can help to establish a successful investment ecosystem in Vancouver. Loan guarantees can help startups to obtain some level of capital before getting Series A and B investments that will further develop their hydrogen and fuel cell technologies. Silicon Valley and Cambridge have the presence of investors and other private companies to provide loan guarantees while Vancouver, Singapore, and Tel-Aviv relied on public support. The Canadian government, however, does not present enough loan guarantees to startups. Most startups need to apply for grants that require intensive R&D activities and previous investment portfolios. Some Canadian crown banks and other corporations provide loan guarantees to startups, but these public companies are very risk averse and have limited capital to support hydrogen and fuel cell technologies. Most startups rely on public grants, yet they require intellectual property, a high level of R&D activities and investment portfolios (Government, Vancouver). In contrast, the governments of England, Singapore and Israel have provided loan guarantees to startups that need to test their fuel cell and hydrogen pilot projects to find potential investors in Series A and B. In the studied cases, authorities from the public and private sectors reinforce the importance of having loan guarantees as policy tools to develop clean energy technologies. Overall, loan guarantees can be used as policy tools to attract more investors to ecosystems as well as get more capital to raise Series A and B investments.

3.2.3. Policy Tool 3: Credit Supply in Investment Ecosystems

In Silicon Valley, Research & Development Tax Credit gives public funding to startups that attract more private equity investments in the long-run. The California Energy Commission offers credit supply to startups that are in their early steps of prototyping and R&D activities. In Silicon Valley, credit supply helps the development of different hydrogen fuel cell innovations among startups. According to investors, "credit supply is an important type of funding to series A and B startups because they help develop R&D" (Investor, Silicon Valley). In this sense, this policy tool helps apply the R&D to specific products or services to enter the market. It gives financial assistance to specific activities that startups need money to make their innovation unique (Association, Silicon Valley). Startups also highlight that credit supply helps them create close

relationships with private equity investors that provide a critical catalyst for mobilizing more financial resources for their innovations (Startup, Silicon Valley). Consequently, the connection between investors and startups increases the degree of trust for transactions in the cluster (Startup, Silicon Valley). Thus, credit supply is an effective policy tool that helps startups to develop their R&D and prototypes to obtain more private equity investments.

In Cambridge, the British government provides credit supply to support startups that are developing R&D activities to be market-ready in the long-run. The R&D tax credits scheme allows startups to claim back a significant amount of development costs in cash each year. Credit supply was the most common funding option among startups between 2015 and 2020 because private companies did not provide much Series A and B for startups (Startup, Cambridge). The credit supply policy tool could provide R&D support to startups developing intense hydrogen fuel cell technology in-house to commercialize them in the long-run. Currently, R&D Tax Credits mean that you can generally claim back up to 32% in research and development costs each year, which even includes staff and contractor costs (Innovate UK, 2021). Credit supply was able to give funding to foster Series A and B funding for startups within five years and be inserted into the market in three years. Consequently, this policy tool helped to improve the commercialization and partnership of startups which promote more deals in the cluster (Startup, Cambridge). Credit supply was the main policy tool that provided capital to R&D in hydrogen and fuel cell to obtain more private equity funds and deals after testing prototypes with early customers to be market ready.

The government plays an important role in providing credit supply to startups in Tel-Aviv. The Israeli government provides the Credit Supply SMEs Program to startups before getting private equity funds. Credit supply helps startups get their early customers to add to the portfolio of financial companies. Once startups develop their innovations and find customers, private equity firms can assist them to gain more customers and find partnerships. Therefore, the government designs the main policies based on the feedback received from academia, investors, and startups that communicate the needs for hydrogen and fuel cell technologies. Thus, the Israeli government supports credit supply for hydrogen fuel cell startups to make deals or funds with private equity investors in the long-run. The Credit Supply SMEs Program creates an added value to the industry which is five to ten times higher than the governmental investments, and these

investments do not push private investors away, but rather create a significant and separate addition to the Israeli R&D (Israeli Innovation Authority, 2020). In this sense, Tel-Aviv's startups obtain credit supply to further get funds or deals with private equity firms that can speed the process of entering and growing in the market. Thus, Tel-Aviv's startups relied on credit supply as Series A and B funds to further make deals with private equity firms that could foster innovation to enter a market niche.

The Singaporean government offers credit supply at the prototyping level to startups that will reach out to private investment firms and communicate their financial needs to commercialize innovations at later stages. The Productivity and Innovation Credit (PIC) Scheme offers credit to any business owners that invest in activities involving innovation. It fosters prototyping which develops knowledge-based assets for the cluster (Government, Singapore). According to a startup, "the scheme is an incentive to businesses to invest in innovation that can improve their operational efficiency and productivity which promotes the growth of the company" (Startup, Singapore). Public sector organizations such as accelerator and incubator offices play direct roles to provide credit supply and prototyping phases (Government, Singapore). Credit supply provides supportive capital focusing on regional development and competition to attract more private equity investors (Government, Singapore). In this case, the accelerators and incubators accommodate startups to get credit supply while testing their prototypes which will grab the attention of venture capital firms or angel investors (Startup, Singapore). Singaporean government, therefore, has a strong commitment to providing credit supply by funding startups prototyping hydrogen fuel cell innovations in accelerators or incubators.

The Canadian government provides credit supply to reach support business activities from startups in Vancouver. Intensifying the business activities will speed the process of the R&D testing phase with early customers. The Canadian government has some crown corporation banks that provide credit supply to startups. Most public financial support, however, is focused on pre-early stages that are pre-seed funding such as grants (Government, Vancouver). The current credit supply options do not support startups to reach out to private equity firms that can potentially grow their businesses in Vancouver. Vancouver's cluster has been growing the number of deals over the fifteen years, yet it is not enough to give the necessary support to fuel cells and hydrogen technologies. Investors explain that highly networked venture capitalists have

successful investment performance as they have implications for institutional investors choosing which firms to invest in (Investor, Vancouver).

BC Associations and startups also addressed the importance of having investors who are less risk averse when funding startups.

> "It is harder to raise capital in Vancouver than it is to raise money in Silicon Valley and the UK. The conditions are very difficult because Vancouver has a very bad reputation among investors who tend to want a quick fix. They want to turn $1 into $100 within a year" (Association, Vancouver).

For startups:

> "We got an offer of $300,000 for 15% of the company so that is less than two and a half million dollars. We rejected the offer because it was very low, the investor offered that amount in case our startup fails. We were looking at structural advice and were not ready for investment. After two years, the startup had a $5 million valuation that needed little guidance to improve the company at the early-stages" (Startup, Vancouver).

Risk aversion is the main concern among authorities because it impedes startups to find the capital necessary to grow their businesses in the local market. Credit supply can reduce the risk aversion and increase the number of funds from private equity investors to startups.

3.2.4. Policy Tool 4: Co-Investments in Investment Ecosystems

Co-investments happen between the public or companies to offer financial support to other companies such as startups. Co-investment should be aligned to effective policy designs to foster hydrogen fuel cell technologies across industrial sectors which will attract more investments to Vancouver's ecosystem. Co-investment through capital or expertise is a policy tool adopted in some analysed clusters such as Silicon Valley and Cambridge. For instance, the California Energy Commission, the state's primary energy policy and planning agency, has the Clean Transportation Program. It supports co-investment between the public and private sectors because it adopts zero-emission hydrogen fuel cell electric cars by expanding California's network of hydrogen refuelling stations. Silicon Valley also has a strong connection with private investors that can co-invest to support specific hydrogen fuel cell innovations.

Co-investment in Silicon Valley is within the private and public sectors in the market. Startups receive co-investments when they present prototyping and a plan to sell their innovation in a market niche. According to Californian associations, “Silicon Valley has a trend of making partnerships between venture capital companies, so the risk is diluted, and more company shares stay in investors' hands” (Association, Silicon Valley). Startups from Silicon Valley do not mind obtaining co-investments as they can increase their networks and even sell their innovations at a higher price (Startups, Silicon Valley). Moreover, co-investments support startups to demonstrate new clean technologies at scale for different sectors (Investor, Silicon Valley). Co-investments increase the chances of innovations to be inserted in market niches faster as investors or government are leading startups to grow in the market.

In Cambridge, the UK Hydrogen Fuel Cell Association (UK HFCA) not only provides tax incentives but also co-investment with private equity firms to help startups to develop their innovation. The Office has partnerships with private equity investors that provide some share of funding to startups that are members of the UK HFCA. The co-investments help startups to grow their technology and find potential market niches. Consequently, co-investment is important to make potential deals between startups and investors in the long-run. In Cambridge, the government is an investor to encourage cleantech startups to test their ideas and risk them to succeed or fail (Startup, Cambridge). For every successful public intervention spurring entrepreneurial activity, there are many failed efforts (Startup, Cambridge). Cambridge has a significant number of co-investments between companies or government.

The Low Carbon Innovation Fund is a co-investment initiative worth over £100m aimed at SMEs operating in the East of England developing or deploying environmentally beneficial technologies. In co-investment, the key point is how to increase the number of innovations and establish more companies that have value creation to the cleantech cluster. This is a long-term objective that needs support from the public and private institutions (Startup, Cambridge). Both types of organizations can provide capital as well as policy mechanisms that enable startups to create more innovative goods and commercialize them which results in company growth (Startup, Cambridge). Startups from Cambridge explained that private equity companies can create agreements to fund startups “if the companies see a potential in the innovation

being developed, it will support the startup through co-investments […]" (Startup, Cambridge). In this case, investors from Cambridge emphasize that:

> "Co-investment has a positive return where the government could benefit from job creation. […] They can do the same kind of job creation but also have the benefit of a return for those startups that are successful and grow to become large companies in the local market" (Investor, Cambridge).

Most of Cambridge's co-investments happen through the Low Carbon Innovation Fund that is between the government and private companies such as venture capitalists or other businesses from a specific industrial sector.

Most startups can get the Low Carbon Innovation Fund, a co-investment initiative worth over £100m aimed at SMEs operating in the East of England developing or deploying environmentally beneficial technologies (Innovate UK, 2021). Low Carbon Innovation Fund 1 (LCIF1) has invested over £20M and helped close funding rounds as a lead investor worth £75M (Innovate UK, 2021). LCIF1 invested in early stage, environmentally beneficial ventures, with the creation of positive economic impact as the fund's primary objective (Innovate UK, 2021). Low Carbon Innovation Fund 2 (LCIF2) invests £11M to help close funding rounds worth at least £30M (Innovate UK, 2021). LCIF2 invests in early and late-stage ventures that make measurable reductions to greenhouse gas emissions, with the creation of financial return and sustainability as the fund's primary objective (Innovate UK, 2021). In the same way, the government sustains and promotes cluster development by improving the infrastructure and flow of resources; co-investing and funding innovation (Association, Cambridge).

The Israeli government does not provide co-investments to hydrogen fuel cell startups. However, Tel-Aviv is a unique case because it produces hydrogen and fuel cell technology within Israeli startups as well as attracts American multinationals to cooperate in the local investment ecosystem (Startup, Tel-Aviv). Similar to Cambridge's startups, most Israeli companies have started in universities or research labs, so founders know to develop new technologies based on the current cleantech product (Startup, Tel-Aviv). Moreover, American large corporations make partnerships to bring Israeli small companies to the US market (Startup, Tel-Aviv). American companies invest in Israeli startups as a way to grow their activities (Startup, Tel-Aviv). These co-investments have considerably expanded the size of the staff in the local market

(Startup, Tel-Aviv). Most startups have partnerships with larger companies that facilitate the growth of hydrogen and fuel cell research and other business activities.

In Singapore, co-investments have the participation of large Asian companies such as Nissan, Toyota, and Mitsubishi to help startups to commercialize their innovations in the market. Most of the co-investments are partnerships made between large companies and startups regulated under the Singapore Energy Market Authority (EMA). This Authority regulates the private sector activities in Singapore so as to promote more capital and attract more businesses to Singapore. Co-investments, however, are more limited to the medium and large enterprises because they have less chance of failure and more innovations to commercialize in different markets.

The Singaporean government does not provide co-investments to startups, but Singaporean startups have the support of public policies that allow multinationals to co-invest in hydrogen and fuel cell technologies. As a Singaporean startup says: “Government wants to attract businesses to Singapore, so they provide financial incentives for large businesses to come to Singapore and then some usually some sort of high-profile business” (Startup, Singapore). The Singaporean government reinforces this point by saying “Singapore tries to import expertise and individuals to grow the cluster” (Government, Singapore). The interviewed private equity investors support the government’s initiative. A successful investment ecosystem is related to the ability of the private sector to provide external financial resources within a business networking to foster the size of tech startups (Investor, Singapore). Venture capitalists are prepared to accept failure when funding as 90% of startups does not reach the main market stream. As financing startups is inherently risky, investors combine their financial contributions into a pooled investment, which is then used to invest in several companies (Investor, Singapore). This way, investors diversify their portfolios and risk (Investor, Singapore). VC companies have profit-driven companies in which they are gambling that returns from successful investments will outweigh investments lost in failed startups (Investor, Singapore).

In Vancouver, co-investments usually occur with large American companies if startups have reached late investment stages. Vancouver uses the co-investment tool as a way to grow large companies and not startups. Vancouver’s private sector is small and does not offer the local business networking necessary not only to fund innovative

products but also to co-invest potential cleantech startups (Startups, Vancouver). The BC government also does not have enough capital or expertise to support the needs of startups. From the BC government's perspective, co-investments should be implemented when the government has already created significant policies that address the market needs. As highlighted in the following quote:

> "Government of Canada has not yet made a strong policy commitment to hydrogen. How do startups then expect to have a province, which has a relatively small population, to make this kind of commitment and finance. Co-investment is a long-term perspective not only from a policy perspective but also from a financial perspective. The province is slowly adopting hydrogen, co-investment is difficult to do at this moment" (BC Government).

Similar to the BC government, Associations in Vancouver's cluster believe that:

> "The federal and provincial governments do not have enough initiatives that address cleantech innovations to have co-investment agreements. The level of coordination between the public and private sectors will not be effective to provide co-investments" (Associations, Vancouver).

Since the governments have not designed effective hydrogen policies yet, Vancouver's ecosystem lacks co-investments between private companies or public-private investments. In Vancouver, startups emphasize that:

> "The government needs to set up the policy environment for allowing the development of clean power. A regulatory environment allows flexibility and in how to create co-investments. Then, the private sector can invest capital and have certainty of what the government is going to do in the long term in British Columbia" (Startup, Vancouver).

After interviewing authorities, Vancouver should consider co-investments with startups because they improve business networking that can potentially provide more capital to startups in the long-run.

Overall, co-investments are important to well-developed investment ecosystems such as Silicon Valley and Cambridge. Silicon Valley and Cambridge have effective co-investments between private companies that financially assist startups while Singapore and Tel-Aviv have multinationals corroborating to provide Series A and B to startups. Vancouver, however, does not present designed hydrogen policies from the federal and provincial levels that jeopardize the number of hydrogen and fuel cell technologies being

produced. Consequently, private equity investors are not attracted to the investment ecosystem which reduces the co-investment opportunities for hydrogen fuel cell startups. Thus, co-investment is a policy tool necessary not only to provide capital at Series A and B for startups but also to attract private investors if there are designed hydrogen policies that support the ecosystem.

3.2.5. Policy Tool 5: Tax Incentives in Investment Ecosystems

Tax incentives are policy tools that can help improve the number of investments in hydrogen fuel cell startups in any investment ecosystem. Tax incentives are implemented to reduce the taxation burden of startups to grow their innovations in the market. In this way, tax incentives can create the environmental conditions for innovations to flourish in the market. This policy tool gives the necessary support to establish an effective bond between the government and businesses. Thus, tax incentives are important to tackle the growth of hydrogen fuel cell technologies by decreasing taxation among startups in investment ecosystems.

Silicon Valley has effective coordination between the public and private authorities to address the current concerns of hydrogen and fuel cells to implement policy tools. It has a well-developed network of authorities that promote discussion panels to address issues and elaborate solutions that the government considers in its clean energy policies. In Silicon Valley, for instance, the government has the California Alternative Energy & Advanced Transportation Financing Authority (CAEATFA) that is a sales tax exclusion from both state and local sales tax collection on equipment purchases for qualifying businesses that conduct qualifying activities (Investor, Silicon Valley). Sales tax rates vary by jurisdiction ranging from 7.5% to 10% (Investor, Silicon Valley). This tax incentive helps startups to grow their staff and commercialize their innovations. Tax incentives are beneficial to startups that are growing the number of staff and business activities for more than two years in the local market. Tax incentives help startups to make partnerships with local investors or other cleantech businesses, so they can sell their innovations to potential customers. As such, a California Association highlights the importance of providing taxation support to startups. They affirm that:

> “By reducing taxation to startups, they will develop their innovations faster and find more than one investor to assist in their market growth” (Association, Silicon Valley).

Silicon Valley has the private sector to guide the startups while the government provides tax incentives and other benefits. After interviewing a startup that first established its business in Vancouver and then moved to Silicon Valley, “it is easier to get tax incentives from the US than BC. Silicon Valley helps startups at their early-stages, the government does not wait for your business to grow, it provides support in each step you take to grow” (Startup, Silicon Valley). Startups can make better deals at Series A or B in Silicon Valley due to investment offers and public incentives. Thus, California’s government provides tax incentives to help the startups to develop hydrogen fuel cell innovations in the cleantech cluster.

The British government takes a different approach than the California government. It offers Enterprise Tax Incentives Scheme once startups have started prototyping their technologies and intend to partner with local cleantech companies to commercialize their technologies. The UK Hydrogen Fuel Cell Association (UK HFCA) focuses on applied research, development, and innovation to advance hydrogen and fuel cells for transportation and other applications enabling energy security and resiliency (Office of Energy Efficiency & Renewable Energy, 2021). The Office provides tax incentives to startups that are part of their programs to advance innovation. These tax incentives are important for startups to obtain private equity capital from investors. When reducing taxation, startups can save their capital to invest in the technologies and attract more investments to support their innovations.

The British government provides Enterprise Tax Incentives Scheme to startups that have prototyping in the transportation, utility and health sectors. The government promotes prototyping by reducing taxation costs because startups can test their innovations to find a specific market niche (Startup, Cambridge). This process leads to the capital attraction in Series A and B which support the commercialization of the prototype (Startup, Cambridge). The main British tax incentives support prototyping projects of startups and other cleantech companies by offering up to 30% of the approved prototyping expenditure (Startup, Cambridge). After interviewing some startups from Cambridge, they use tax incentives to reduce the costs of commercialization of tested prototypes (Startup, Cambridge). Overall, startups use tax incentives to partner with other companies that can invest more in prototyping and find potential customers.

The Israeli and Singaporean governments do not provide tax incentives. Israel and Singapore offer tax incentives to medium and large enterprises because they have less risk to fail and more chances to expand business activities in the market. In Israel, the Preferred Technology Enterprise supports tax incentives to companies that are engaged in the technology sector and are part of a group of companies with aggregate annual revenues of around $5 billion (Investor, Israel). Companies also need a venture capital fund that has invested at least $3 million in the company (Investor, Israel). Singapore, for example, offers three years of tax exemption to SMEs (Startup, Singapore).

According to a startup, “the business has tax exemption up to 50% of tax on the next $200,000 normal chargeable income. It applies to the first three consecutive assessment years of the company (Startup, Singapore). This incentive supports the private sector grow its partnerships with local companies. However, startups are jeopardized by the tax burden because the governments do not offer incentives to grow innovation in the local market.

In Vancouver, startups use the Scientific Research and Experimental Development (SR&ED) Program tax incentives that encourage R&D activities in Canadian companies. The SR&ED Program provides more than $3 billion in tax incentives to over 20,000 claimants annually, making it the single largest federal program that supports business R&D in Canada (Government of Canada, 2021). These tax incentives come in three forms: an income tax deduction, an investment tax credit (ITC), and, in certain circumstances, a refund (Government of Canada, 2021). According to a startup,

> “SR&ED gives you real money to solve real problems and real products. We had to go through a vetting process, but thankfully that was quite straightforward for us. We are in the tech industry that was exploding on track to success, so we hired experienced engineers to help develop our innovation. We received an income tax deduction from SR&ED that helped pay the salaries of engineers in the first years. We were solving a very real problem, and we knew how to do it and nobody else knew how to do it, so we have a bit of a short path from the government's perspective” (Startup, Vancouver).

Most startups, however, “need an accountant to explain the SR&ED process, but the accountant takes some percentage of your claim. Workers also need to keep track of the hours that they have worked on R&D. It is very hard to count the hours spent in R&D activities because it involves a team of five engineers. The staff can spend hours working on a tiny part of the R&D to form an innovative product for the startup” (Startup, Vancouver).

SR&ED gives capital to help startups in the first three years, but it could be extended to five years to help more startups in the long-run. Private investors believe that:

“Vancouver can get more strategic investment such as tax incentives. [The BC government] can help startups and medium size companies that [can] either improve investments or […] take a stake in the startup with private equity investors […]” (Investor, Vancouver).

Similar to investors, the BC government believes that tax incentives are important policy tools to attract more investments, however, they reduce money collection from taxpayers. The government considers this concern when designing cleantech policies (BC Government). The following quote summarizes the issue with tax incentives: “The challenge with tax incentives is that it is very difficult to pitch internally because there is a cost to the government there” (BC Government). While investors encourage tax incentives to be inserted in Vancouver as a useful policy tool, the government does not support tax incentives to startups as they can get loan guarantees or credit supply from public agencies or banks.

Overall, successful investment ecosystems such as Silicon Valley and Cambridge provide tax incentives to startups that already have Series A or B investments. These ecosystems showed that hydrogen fuel cell startups use tax incentives to alleviate some tax burdens not only to increase their business and prototyping but also to grow to partnerships that can commercialize hydrogen and fuel cell technologies. Even though Singapore and Israel do not have tax incentives for startups, the public intervention model reflects a developmental state's role in fostering hydrogen and fuel cell technologies among SMEs. By contrast, the Canadian government provides tax incentives to startups

for up to three years, but SR&ED should provide tax incentives for at least five years to grow businesses in the local market.

In sum, Silicon Valley and Cambridge use tax incentives, co-investments, loan guarantees, credit supply, and grants as policy tools. In contrast, Tel-Aviv, Singapore, and Vancouver mainly use loan guarantees, credit supply, and grants to help startups with seed funding and Series A and B. Tel-Aviv and Singapore, however, offer tax incentives and co-investments to medium and large companies while Vancouver does not offer long-run tax incentives to local businesses. Vancouver's investment ecosystem does not provide enough tax incentives and no co-investments to startups when compared to Silicon Valley and Cambridge. The lack of key policy tools handicaps startups to foster and commercialize hydrogen fuel cells in the market.

3.3. **Conclusion**

This chapter compared policy tools for startup finance across Silicon Valley, Cambridge, Tel-Aviv, Singapore, and Vancouver. The interviewees were the main authorities that were composed of government, associations, investors, and startups in each ecosystem. They described the strengths and weaknesses of their cluster and the policy tools most adopted based on designed policies. Policy tools are important to fund hydrogen fuel cell startups and establish a successful investment ecosystem. I find that Vancouver's investment ecosystem offers credit supply, loan guarantees, and grants to hydrogen fuel cell startups in Series A and B, but it lacks more tax incentives and co-investments as policy tools to help foster innovation. Silicon Valley and Cambridge have tax incentives, co-investments, loan guarantees, credit supply, and grant policy tools that help in hydrogen fuel cell innovations. The American and British governments also provide procurement services to be the first buyer of innovation from domestic startups. Procurement is not often practiced in Singapore, Tel-Aviv, and Vancouver due to the policy tools provided to startups. Similar to Vancouver, Tel-Aviv and Singapore do not provide enough tax incentives and co-investments. However, Tel-Aviv and Singapore have a more effective organizations with loan guarantees, credit supply and grants to provide better assistance to startups that depend on those policy tools to grow their businesses. All five policy tools presented successful outcomes in the analysed ecosystems and could be adopted together with loan guarantees, credit supply and grants to financially support startups in Vancouver. The concluding chapter will

summarize the comparative analysis across investment ecosystems and provide recommendations to Vancouver to establish a successful investment ecosystem.

Chapter 4.

The Combination of Tax Incentives, Co-Investments, Loan Guarantees and Credit Supply as Policy Tools in Vancouver's Investment Ecosystem

Clean energy sources such as hydrogen fuel cells can be applied to decrease carbon emissions because they generate less fossil fuel. The introduction illuminated the lack of a successful investment ecosystem that Vancouver should establish to financially support hydrogen fuel cell startups in the cleantech cluster. Venture capital and angel investors can assist hydrogen fuel cell startups to pass through the valley of death by providing more capital at Series A and B. The literature review oriented the analytical framework of this research to ask how Vancouver can establish a successful investment ecosystem that attracts private equity investments to help hydrogen fuel cell innovations in the cleantech cluster. First, I explained the concerns and the public and private roles to provide Series A and B investments. Second, the discussion of policy design highlighted the authorities who establish policies and reflect in the measures of success and policy tools. Third, the section on policy evaluation provided recommendations to Vancouver based on other successful investment ecosystems. If Vancouver does not establish a successful investment ecosystem, the main negative consequence is hydrogen fuel cell startups will likely move to Silicon Valley or other clusters.

Chapter 2 presented the measures of success that are private equity firms, funds and deals across Silicon Valley, Cambridge, Tel-Aviv and Singapore. Each analysed ecosystem has a partnership of public and private intervention to financially support hydrogen fuel cell startups within its cleantech cluster. The indicators show that Silicon Valley and Cambridge have the leading values of equity per firm, funds and deals compared to the other clusters. Tel-Aviv has a substantial number of deals and funds while Singapore and Vancouver have almost the same number of firms, funds and deals. The measures of success prove that Vancouver lags in numbers of firms, funds and deals that limit the attraction of capital and growth of hydrogen fuel cell startups. The measures of success highlight the problems facing Vancouver's investment ecosystem compared to Silicon Valley, Cambridge, Tel-Aviv and Singapore.

Chapter 3 analyses tax incentives, co-investments, loan guarantees, credit supply and grants as policy tools that are implemented in investment ecosystems to financially assist startups. The interviewees were part of authority groups such as government, associations, investors and startups across Silicon Valley, Cambridge, Tel-Aviv, Singapore and Vancouver. I find that Vancouver's investment ecosystem offers credit supply, loan guarantees and grants to hydrogen fuel cell startups in Series A and B, but it lacks tax incentives and co-investments as policy tools to help foster innovation. Silicon Valley and Cambridge have tax incentives, co-investments, loan guarantees, grants and credit supply policy tools that help in hydrogen fuel cell innovations. Similar to Vancouver, Tel-Aviv and Singapore do not provide tax incentives and co-investments. However, Tel-Aviv and Singapore have a more effective organization with loan guarantees, grants and credit supply to provide better assistance to startups that depend on those policy tools to grow their businesses. All five policy tools presented successful outcomes in the analysed ecosystems and could be adopted together with loan guarantees, credit supply and grants to financially support startups in Vancouver. Table 4 summarizes the key findings of the research.

Table 4: Summary of Measures of Success and Policy Tools across Investment Ecosystems

	Measures of Success Series A and B (2005-2020)				**Policy Tools**				
	Total Equity of Firms	Total Equity of Funds	Total Equity of Deals	Total amount:	Grants	Loan Guarantees	Credit Supply	Co-investments	Tax Incentives
1.Silicon Valley	$ 6,499,520+	$ 2,633,838+	$ 4,572,253+	$13.7 billion	The government supports new clean energy technology startups that could develop R&D in different clean energy applications.	Private banks offer loan guarantees to startups that need to expand their market reach.	Californian government provides credit supply to R&D activities to startups, so they can develop prototypes.	Co-investments help startups to fund their innovations to enter the market.	Tax incentives from the Californian government are for startups to grow their staff and commercialization their innovation.
2. Cambridge, UK	$ 3,630,119+	$ 1,832,223+	$ 2,284,729+	$7.8 billion	The British government provides grant support to students who are willing to develop innovations and open startups.	Startups can get loan guarantees from banks or financial companies. Startups need to show at least one prototype to obtain loan guarantees that support the development of other prototypes to become market ready.	The British government offers R&D credit supply to startups that are developing intense technology to commercialize it within 10 years timeframe.	The government and private equity companies offer co-investments that help growing early-stage startups.	The British government offers tax incentives once the startups intend to partner with other local companies, so they can get a larger amount of funds from investors in the cluster.

3.Tel-Aviv	$ 1,025,040+	$ 540,905,249	$ 660,431,236	$2.4 billion	The Israeli government provides grants to encourage technological and industrial R&D and innovation in the local market.	Loan guarantees are offered by banks or public agencies to startups that have in-house expansion and testing of innovation.	The Israeli government provides credit supply to startups before getting private equity. Private equity helps Israeli startups to gain more customers and network to find partnerships.	Israeli government or companies does not provide co-investments to most Series A and B startups. Co-investments target medium size companies.	Israeli government does not have tax incentives for startups in series A and B, they target medium or large companies.
4.Singapore	$ 965,880,162	$ 775,332,990	$ 893,056,331	$ 2.7 billion	Singaporean government gives grants to startups that are developing sustainable innovations.	Singaporean government gives loan guarantees, so startups can develop their innovations in the local market.	Singaporean government offers credit supply to startups for prototyping tests.	Co-investments have the participation of large Asian companies when startups are ready to commercialize their innovations in the market.	Tax incentives are provided to medium size companies, but not for startups in Series A and B.
5.Vancouver	$ 902,120,041	$ 700,843,334	$ 807,478,297	$2.5 billion	IRAP and SDTC give grants to R&D activities among SMEs and some startups.	Startups can get some loan guarantees from Crown corporation banks. These loans help startups to insert their technologies into the local market.	The Canadian government provides credit supply to startups that are intensifying business activities and testing their prototypes in the market.	Co-investments usually occur with large American companies if startups have reached late stages.	The governments (federal or provincial) do not offer tax incentives to startups.

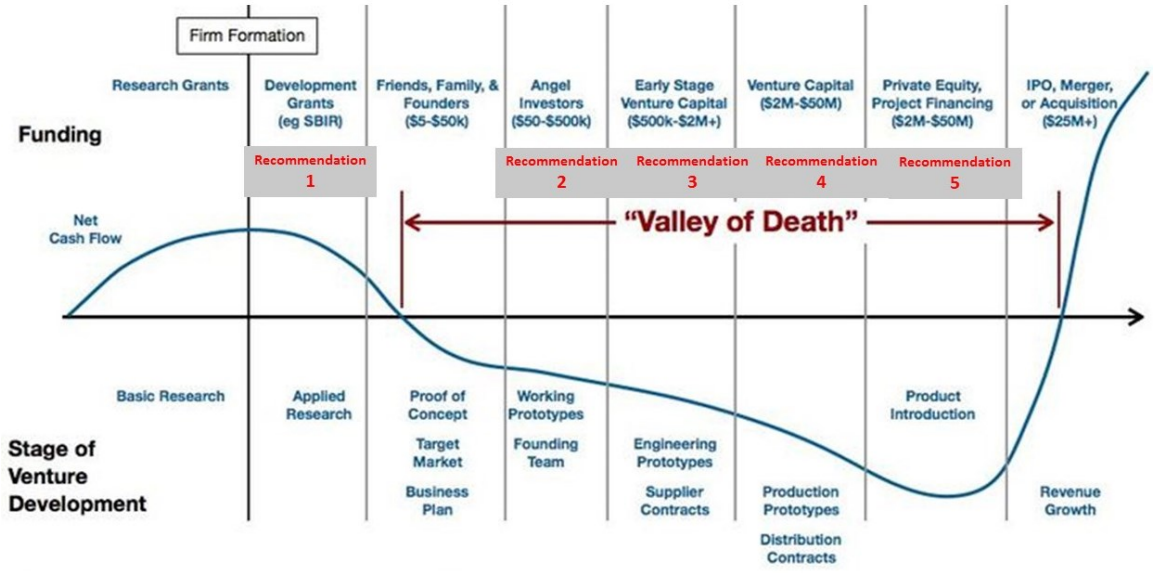
Source: Author, 2021

The table demonstrates that investment ecosystems have different results of measures of success based on the application of policy tools to help startups. Silicon Valley and Cambridge have the leading values of firms, funds and deals as they use a combination of tax incentives, co-investments, loan guarantees, credit supply and grants as policy tools to foster innovation. In contrast, Tel-Aviv, Singapore and Vancouver have a lower number of firms, funds and deals because they use loan guarantees, credit supply and grants to startups. However, Tel-Aviv and Singapore have more successful investment ecosystems because they provide effective tax incentives and co-investments to startups at later financial stages while Vancouver's startups tend to leave the cluster to obtain tax incentives or co-invest with foreign large companies. Thus, the following section provides recommendations for Vancouver's ecosystem.

4.1. Recommendations to Establish an Investment Ecosystem in Vancouver

The following recommendations are the steps Vancouver should follow to develop a successful investment ecosystem in the long-run. Figure 8 summarizes the recommendations based on the funding stages and the valley of death that startups need to go through before succeeding in the market.

Figure 8: Recommendations based on the Valley of Death



Source: Adapted from UC Davies, 2021

The following policy recommendations are depicted in the picture above that provide support to policymakers.

4.1.1. Recommendation 1

The Industrial Research Assistance Program and Sustainable Development Technology Canada could provide more grants during Series A and B funding to Vancouver's startups. The federal government should consider the Fuel Cell Electric Vehicle Fleet Support Scheme that accelerates the growth of the commercial market of hydrogen and fuel cells to fuel cell electric vehicles in the UK. The other program stream that Vancouver should consider is academic grants to hydrogen and fuel cell innovations. The British government provides grant support to students who are willing to develop innovations and open startups. Similar to the UK, the Canadian government should also have the procurement role to purchase sustainable innovations from local startups. Grants can help startups to develop their R&D activities while procurement is important to commercialize innovations. Thus, Vancouver should follow the UK grants' program and procurement strategies as they provide grants to startups during seed funding and Series A and B stages while being the first customer to purchase innovation from startups.

4.1.2. Recommendation 2

Vancouver's startups can create sandboxes to pilot the innovation and apply for loan guarantees from private financial companies. The Israeli Government Loans Foundation Scheme gives loan guarantees to startups when developing innovations during the pre-seed investment stage. This is Tel-Aviv's model that helps startups find loans to invest in R&D activities to improve their hydrogen fuel cell technologies. Tel-Aviv's investors reduced risk aversion due to the provision of loan guarantees to startups. In Vancouver, loan guarantees from the provincial government can help startups to raise more capital from their products as well as get a higher valuation from angel investors Consequently, Tel-Aviv's loan guarantees give the opportunity for startups to make more deals with private equity companies.

4.1.3. Recommendation 3

Vancouver's startups engaging with accelerators and incubators could obtain more credit supply from Crown corporation banks. The BC government should consider the Research & Development Tax Credit that gives public funding to startups to attract private equity investments in Silicon Valley. This program helps early-stage startups to develop their innovations in accelerators and incubators to find potential investors in the long-run. In Vancouver, Crown corporation banks should provide credit supply that could be used to test prototypes as it is important to understand the strength and weaknesses of hydrogen fuel cell innovations to mitigate the technical concerns before selling to customers. Credit supply could target hydrogen fuel cell startups to promote the prototype testing phases with specific market niches.

4.1.4. Recommendation 4

The Scientific Research and Experimental Development Program tax incentives encourage R&D activities in Canadian companies. However, more tax incentives could help hydrogen fuel cell startups in Vancouver reduce their tax burden. By following the model of Silicon Valley, the provincial government could set up tax incentives for hydrogen fuel cell startups and their customers. In Silicon Valley, the California Alternative Energy & Advanced Transportation Financing Authority has tax exclusion from both state and local sales tax collection on hydrogen and fuel cell products. Tax incentives would assist in improving staff and commercialization of hydrogen fuel cells such as in Silicon Valley. Vancouver's startups would be able to grow in the local market which would attract more investors to the ecosystem in the long-run.

4.1.5. Recommendation 5

The Canadian and provincial governments should design policies to regulate the entrance of multinationals to co-invest in hydrogen fuel cell innovations. Vancouver should consider co-investment between private multinational companies. The Canadian and provincial governments would be responsible for allowing multinationals to establish their businesses in Vancouver. Vancouver should consider more multinationals that focus on clean energy innovations from different parts of the world. In this case, Vancouver should follow Singapore's idea to attract more multinationals developing

products in fuel cells and hydrogen to co-invest with local startups and investors. The Singapore Energy Market Authority regulates the policies to allow multinationals to co-invest in hydrogen and fuel cell technologies. Opening the market to more multinationals can partner with current investors which will bring more funds to startups. Thus, these large enterprises could co-invest with other SMEs in Singapore to provide more capital and business networks to hydrogen fuel cell startups.

Table 5 summarizes the five main policy tools with their respective implementers and activities based on the recommendations. The activities depend on how much public intervention each policy tool may need to support startups and investors that will grow the investment ecosystem in Vancouver. Since the public sector works at a different pace than the private sector, the policy impacts are divided between short-run and long-run. The short-run impact targets some specific policy modifications that can increase the number of firms, funds and deals for startups. In contrast, the long-run impacts present fully implemented policies that establish an effective investment ecosystem that can bring more firms, funds and deals to Vancouver. Thus, the table explains how the government should implement the policy tools based on the findings as well as the impacts of the policy tools to establish an investment ecosystem in Vancouver.

Table 5: Policy Implementation

Policy Tools	Implementers	Activities	Short-Run Impacts on Policy Implementation (5 years)	Long-Run Impacts on Policy Implementation (10 years)
Tax Incentives	BC government	By reducing taxation through SR&ED, private equity firms would provide more capital and deals to startups.	It is expected to increase funds and deals coming from different firms. This would boost the number of innovations inserted in the market.	Enlarge the talent pool and growth of startups to medium and large enterprises.
Co-investments	Federal and BC governments	Following the reference of the Singapore Energy Market Authority, opening Vancouver's market to more multinationals that have clean energy activities. Startups would have more partners with different companies that can increase their funds. Private equity firms would be attracted to the market and offer higher capital values and deals to startups.	Increasing business partnerships with startups would increase the number of private equity firms' offers and funds by 25% and deals by 35%.	Creating an investment ecosystem with different business sizes and investors to provide more offers, funds and deals to startups that can develop and sell their innovations faster.
Loan Guarantees	BC government	Taking the Israeli Government Loans Foundation Scheme as a reference, Vancouver's startups can showcase their innovations to potential investors, increasing the chances of more private equity firms' investments, series A and B funding and deals.	Increase the chances of obtaining loan guarantees that can assure more startups to gain more firms' capital, deals and funds that will grow the investment ecosystem.	Loan guarantees would be a popular policy tool among cleantech startups. It will grow the number of investors, funds and deals for startups in Vancouver.

Policy Tools	Implementers	Activities	Short-Run Impacts on Policy Implementation (5 years)	Long-Run Impacts on Policy Implementation (10 years)
Credit Supply	BC government	Based on the Research and Development Tax Credit, Vancouver's incubators and accelerators would collaborate with Crown corporation banks. By having more credit supply, startups could obtain more funds and deals from different private equity firms.	Increasing the number of startups in incubators and accelerators that get credit supply, will improve the number of firms that provide funds and deals.	Developing the current incubators and accelerators to partner with Crown corporations would facilitate startups to obtain more funds and deals while increasing the number of firms in Vancouver's investment ecosystem.
Grants	Federal government	The Industrial Research Assistance Program and Sustainable Development Technology Canada would increase 20% of grant values to startups. They would make startups' innovations more valuable to private equity firms that would offer more funds and deals.	Grants would increase public intervention by allowing the Canadian government to be the first buyer of innovations from startups.	The Canadian government would take a serious procurement role to facilitate the commercialization of innovations in the Canadian government.

Source: Author, 2021

4.2. **Final Words**

Vancouver offers credit supply, loan guarantees and grants to cleantech startups at Series A and B. After analysing Silicon Valley, Cambridge, Singapore and Tel-Aviv, Vancouver lacks tax incentives and co-investment as policy tools. Both tools present successful outcomes in the studied ecosystems and could be implemented simultaneously with loan guarantees, grants and credit supply to help Vancouver's startups. These policy tools together can help the establishment of a successful investment ecosystem in Vancouver.

Our analysis concludes that Vancouver lacks a successful investment ecosystem to attract more funding to cleantech startups in the hydrogen fuel cell energy sector. Vancouver has a considerable number of hydrogen fuel cell small companies, large

cleantech ventures and innovation hubs. If Vancouver does not create a more comprehensive investment ecosystem, the major concern is that hydrogen fuel cell startups, together with their technologies and talent pool, will move to the United States or other Canadian provinces. Financial support is crucial to growing hydrogen fuel cell startups by allowing technology in the local cluster, thus making Vancouver as competitive of a marketplace as other clusters.

The study presents some limitations. The case studies have a limited quantity of factors, making it difficult to generalize the findings in other countries. Moreover, hydrogen fuel cell energy is a relatively new sector in clean energy when compared to other clean energy sources such as wind and solar. Governments have been developing policies to accommodate hydrogen fuel cell energy as potential renewable energy in their countries. It would be important to do field research in the UK, Singapore, Silicon Valley and Tel-Aviv in the long-run. The field research would facilitate the analysis of the policy tools used across different startups.

As with all research, this investigation into investment ecosystems identifies additional questions and opportunities for further research. Three questions stand out. In the analysed case studies, qualified staff and experts in hydrogen and fuel cell work are essential to growing startups. The talent pool in Vancouver has been growing due to immigration policies that allow international experts to move to the cluster. However, the talent pool is not very large and diverse as in the other cases studied. Based on the size of Vancouver's talent pool, the first potential research question is: How can a diverse talent pool positively influence Vancouver's cleantech cluster? Most investment ecosystems thrive cleantech startups when ruling governments prioritize climate change concerns. The case studies present a higher number of investments in clean energy during liberal governments while the funding dropped in periods of conservative governments. As such, how can the cleantech sector overcome conservatives' governments that do not establish climate change actions? Friends & family investment is a type of investment that significantly supports startups across Vancouver, Silicon Valley, Cambridge, Singapore and Tel-Aviv. Friends & family have become the main source of investments to cleantech startups before reaching out to public grants, private equity investments and angel investors. A future research question might be: What is the market impact of the friends & family investment stage to startups to obtain more funds from angel investors in the long-run? The research provided some comparative analysis

across case studies, but there are questions that should be answered in further research analysis.

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Appendix A.

Interview Questionnaires

Interview Questionnaire: Government

1. What are your main responsibilities as [job title]?
2. How is the communication with different stakeholders such as public agencies, small businesses, and academia?
3. How do you define success in the BC fuel cells and hydrogen sector?
4. What are the main challenges for the fuel cell and hydrogen sector to raise capital in the early-stages?
5. How much interest and funding comes from the private sector?
    a. What's the nature of it, whether it's Canadian or foreign, from venture capital or companies (like auto companies), etc.
6. How the government relates to the sector and contributes to sector strategy?
    a. Do they have regular meetings, or personal relationships or share boards to define things like funding and training strategies, etc.
    b. Could you give an example of a recent situation?
7. What are the advantages and disadvantages of co-investments to hydrogen and fuel cell innovations?
8. In your opinion, do you think tax incentives would attract more investment firms to BC?
    a. If yes, how would they help?
    b. If no, why not?
9. Does the government overcome the lack of private investments to provide credit supply and loan guarantees to cleantech startups?
10. Why is not there more investment? What is limiting it?
    a. How could the government make it more attractive?

Venture Capital Questionnaire:

1. What kinds of startups have you worked with?
2. What types of startups are you seeking to work with?
3. What are the most important financial criteria to provide early-stage funding for cleantech startups?
4. What are the major financial challenges for venture capital companies to provide early-stage capital to cleantech startups?
5. What is the role for public policy in terms of providing financing for startups?
6. Have you cooperated in the past with government to support startups through financing or other vehicles?

7. In your opinion, does co-investment between the government and venture capital firm provide more funds to cleantech startups?
    a. If so, what are the pros or cons of co-investment?
    b. If not, why not?
8. What kind of public incentives would benefit venture capital companies to improve their financial activities?
9. In your opinion, do you think more corporate tax incentives would attract more VC firms to Vancouver?
    a. If yes, how would they help?
    b. If no, why not?
10. What are the advantages and disadvantages of credit supply and/or loan guarantees to support private equity?
11. What can be learned with venture capital investments for cleantech startups in other countries?
12. Do you have anything else you would like to mention?

Questionnaire: Associations

1. What are your main responsibilities as an Operations Manager in the CHFCA?
2. How is the communication with different stakeholders such as government, private corporations, and universities?
3. What kinds of decisions do you make?
    a. Can you give an example of (a specific decision he talks about and it's related to the research)?
4. What are the key strengths of hydrogen and fuel cell sector in Vancouver?
    a. How can Vancouver potentialize (what are the next steps) these strengths to grow the cluster?
5. What are the main challenges faced by hydrogen and fuel cell sector in Vancouver?
    a. How does the industry overcome these challenges?
6. What types of hydrogen and fuel cell technologies are being developed in Vancouver?
    a. Can you give an example of how are they being developed? Industry being developed, who is helping, who's giving $?
7. Can you give an example of project or product that received financial support from the association?
8. What are the main roles of public and private sectors to help the hydrogen and fuel cell industry in Vancouver?
    a. What are the main pros and cons of each sector?
9. In your opinion, do you think the government should provide more tax incentives to increase the number of investment firms in Vancouver?
    a. If yes, how would it help?
    b. If no, why not?

10. How can co-investment between the public and private sectors help cleantech startups?
    a. Can you give an example?
11. Can you tell a situation where fuel cell/hydrogen technology received loan guarantees or credit supply?
12. What can be learned with other hydrogen and fuel cell industries?
13. Do you have anything else that you would like to share?

Questionnaire: Startups

1. What is your role in the startup?/ What's the specialization of your startup?
2. What types of decisions do you make?
3. What are the main long-run goals of X startup?
4. What is your strategy for convincing venture capital or angel investor to invest in your company? What are the key factors you address?
5. Can you give an example of cleantech product being developed in your startups?
    a. Did credit supply or loan guarantees help to develop this product?
        i. If yes, how?
    b. How are you selling this innovation?
6. Can you give me an example of a challenge to commercialize cleantech innovation in Vancouver?
    a. How should they be solved?
7. How can tax incentives help to commercialize technologies?
    a. Can you provide an example?
8. What role, if any, do you see for the public sector in terms of aiding start-up's access to finance?
9. What can be learned with public and/or private investments for cleantech startups in other countries?
10. Do you have anything else you would like to mention?

Appendix B.

Ethics Approval

SFU RESEARCH ETHICS

Minimal Risk Approval – Delegated

Study Number: 2020s0021
Study Title: Establishing an Effective Investment Ecosystem in Vancouver's Tech Cluster

Approval Date: March 2, 2020
Principal Investigator: Di Maio da Cunha, Ester
SFU Position: Graduate Student
Expiry Date: March 2, 2021
Supervisor: Hira, Anil
Faculty/Department: Political Science

SFU Collaborator: N/A
External Collaborator: N/A
Research Personnel: N/A
Project Leader: N/A

Funding Source: N/A
Funding Title: N/A

Document(s) Approved in this Application:

- Study Detail, version 2 dated 2020 February 17
- MA Research Proposal, version 2 dated 2020 February 17
- Interview Consent Form – Tech Startups, version 2 dated 2020 February 17
- Interview Questionnaire – Tech Startups, version 2 dated 2020 February 17
- Email and Phone Recruitment Scripts – Tech Startups, version 1 dated 2020 February 17
- Interview Consent Form – Angel Investors, version 1 dated 2020 February 17
- Interview Questionnaire – Angel Investors, version 1 dated 2020 February 17
- Email and Phone Recruitment Scripts – Angel Investors, version 1 dated 2020 February 17
- Interview Consent Form – Venture Capital, version 2 dated 2020 February 17
- Interview Questionnaire – Venture Capital, version 2 dated 2020 February 17
- Email and Phone Recruitment Scripts – Venture Capital, version 1 dated 2020 February 17
- Interview Consent Form – Government, version 2 dated 2020 February 17
- Interview Questionnaire – Government, version 2 dated 2020 February 17
- Email and Phone Recruitment Scripts – Government, version 1 dated 2020 February 17

The application for ethical review and the document(s) listed above have been reviewed and the procedures were found to be acceptable on ethical grounds for research involving human participants.

The approval for this Study expires on the **Expiry Date. An annual renewal form must be completed every year prior to the Expiry Date. Failure to submit an annual renewal form will lead to your study being suspended and potentially terminated.** The Board reviews and may amend decisions or subsequent amendments made independently by the authorized delegated reviewer at its regular monthly meeting.

This letter is your official ethics approval documentation for this project. Please keep this document for reference purposes.

This study has been approved by an authorized delegated reviewer.

SIMON FRASER UNIVERSITY ENGAGING THE WORLD Page 1 of 1

SFU RESEARCH ETHICS

Annual Renewal Approval

Study Number: 20200021
Study Title: Establishing an Effective Investment Ecosystem in Vancouver's Tech Cluster

Annual Renewal Date: December 9, 2020
Principal Investigator: Di Maio da Cunha, Ester
SFU Position: Graduate Student
Expiry Date: December 9, 2021
Supervisor: Hira, Anil
Faculty/Department: Political Science

SFU Collaborator: N/A
External Collaborator: N/A
Research Personnel: N/A
Project Leader: N/A

Funding Source: N/A
Funding Title: N/A

Document(s) Approved in this Application:
Annual Renewal submitted 2020 December 5

The approval for this study expires on the **Expiry Date**. **Failure to submit an annual renewal will lead to your study being suspended and potentially terminated.** If you intend to continue to collect data past the term of approval, you must submit an annual renewal at least 4 weeks before the expiry date.

This letter is your official Annual Renewal Approval documentation for this project. Please keep this document for reference purposes.

The annual renewal for this study has been approved by an authorized delegated reviewer.

Appendix C.

Sources of Authorities

Authority Groups:	Main Interviewed Institutions:
Government and Crown Corporations	1. **Vancouver:** Government of British Columbia 2. **Vancouver:** Business Development Bank of Canada (BDC) 3. **Vancouver:** Export Development Canada (EDC) 4. **Silicon Valley:** California Energy Commission 5. **Singapore:** Government of Singapore 6. **UK:** Energy UK
Investors	1. **Vancouver:** Chrysalix 2. **Vancouver and Silicon Valley:** Fort Capital 3. **Vancouver and Silicon Valley:** Upper Stage Ventures 4. **Vancouver and Silicon Valley:** Pangea Ventures 5. **Vancouver:** VANTEC 6. **UK:** Cambridge Future Tech 7. **UK and Silicon Valley:** Primera Impact 8. **Singapore:** IDM Venture Capital 9. **Singapore:** Purpose Venture Capital 10. **Israel:** F2 Venture Capital
Hydrogen Fuel Cell Startups and Large Companies	1. **Vancouver:** Ballard 2. **Vancouver:** Ekona Power 3. **Vancouver and Silicon Valley:** Illuming Power 4. **Vancouver and Silicon Valley:** HTECH Hydrogen 5. **Vancouver:** Zen Clean Energy Solutions 6. **Vancouver:** Dusk Energy Group 7. **Vancouver and Silicon Valley:** Thomson Power 8. **Vancouver and Silicon Valley:** FP Innovations 9. **Vancouver:** Hydra Energy 10. **Vancouver and UK:** General Fusion Inc. 11. **Vancouver:** Loop Energy Inc. 12. **Silicon Valley and UK:** American Battery Technology Company 13. **Vancouver:** Moment Energy
Associations and Accelerators	1. **Vancouver:** Foresight 2. **Vancouver:** The Canadian Fuel Cells and Hydrogen Association (CFCHA) 3. **Vancouver:** New Ventures BC 4. **Vancouver:** Vancouver Economic Commission 5. **UK:** Cambridge Cleantech 6. **Vancouver:** Clean Energy Research Group (CERG) 7. **Silicon Valley:** Carbon Free Group

Source: Author, 2021