The design of local ecosystems within a global technology entrepreneurship challenge

Jasmine Ariana Shaw

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Abstract

Global organizations, often part of a business ecosystem, are continuously striving to expand their reach in local communities but they face significant adoption challenges. These multilevel systems have a natural hierarchy, which can be analyzed from a design perspective. Leveraging constructs from design science, glocalization, and business ecosystems, this research examines Technovation, the world's largest technology entrepreneurship program for girls. Through an embedded multiple-case study, Technovation is described using ecosystem frameworks, then a cross-case analysis of six chapters from Canada and Mexico identifies similarities and differences, and global ecosystem requirements are specified as design rules. There are three key findings. First, local ecosystems have a different architecture than the global ecosystem. Second, chapters are influenced by passive and active forces. Third, design rules create boundaries for local adaptation of global components. These insights will assist managers, ecosystem designers, and Technovation practitioners navigate the complex, global context in which they operate.

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1 Introduction

Collaboration is crucial to the success of modern day organizations. Climate change, gender inequity, and rapid digitization of society are but a few examples of the problems businesses are facing, and their solutions will demand it. Business ecosystems are an organizational form that facilitate collaboration by offering structure and purpose.

Achieving a suitable structure and aligning stakeholders around a shared purpose is not automatic: a business ecosystem must be intentionally designed with these features. In the design science literature, design is a process that leads to the creation of an artifact which bridges the gap between problem and solution spaces. Ecosystems are also an artifact which mediate interdependent collaboration of stakeholders (Sunna, 2016).

Organizations are also expected to participate in broader global networks, while executing key activities at a local level. The symbiosis of “generalization and specialization” (Henfridsson, Mathiassen, & Svahn, 2014) underpins the concept of glocalization: standardizing a model or idea at the global level, while enabling differentiation at the local level. In business ecosystems, generalization and specialization co-exist when the leader develops a standard offer, often known as a platform, that enables contributors to build complementary offers on top of it (Iansiti & Levien, 2004).

Over the years, important concepts from the design and complex systems literature have been borrowed by management scholars. However, the concept of design rules, introduced by Baldwin & Clark (2000), has so far remained exclusively within the systems and software domain. Design rules are system parameters that convert

interdependence into hierarchy by constraining the implementation of other parameters.

These three foundational theories have a multilevel aspect, which is important for this research. Glocalization describes behaviour across the global-local dimension and is inherently multilevel. Business ecosystems are often comprised of multilevel actors, such as individuals, communities, or firms. Lastly, design rules preside at the highest level of a system and impact all lower level parameters.

The field setting for this research is Technovation, a global not-for-profit that empowers girls and families to solve problems in their communities by using technology and entrepreneurship. The author's personal experience as a female engineer was highly motivating in her decision to study this organization. Additionally, Technovation was a novel field setting for ecosystem studies. While entrepreneurial ecosystems create ventures, and business ecosystems create products, Technovation leverages the ecosystem form to create opportunity and self-efficacy. The study of an ecosystem whose output is a social good has, to the knowledge of the researcher, yet to be explored. This addresses the call to action from prior studies (Sunna, 2016; Muegge, Bailetti, & Sunna, 2018) to determine whether process platforms are applicable to other ecosystem types.

The research conducted herein was multilevel – it sought to understand how local (lower-level) Technovation chapters operate in the context of a global (higher-level) ecosystem. The intersection between glocalization and business ecosystems has yet to be explored empirically. At the conclusion of their study, Radziwon & Bogers recommended that “comparative studies of two or three ecosystems from different countries and representing different cultural origins” (2019: 585) be conducted. Other studies (Sunna,

2016; Colombelli, Paolucci, & Ughetto, 2019) also identified a gap in the understanding of how regional differences impact ecosystem properties. This research closes the gap by examining multiple Technovation chapters from Canada and Mexico.

This thesis also revived the study of design rules, which links the glocalization and business ecosystem constructs: Technovation is positioned as a global ecosystem with defined design rules that local chapters abide by. Integrating all three constructs into a single study was the final motivation for conducting this research.

1.1 Objective

The objective of this research is to examine Technovation, the global technology entrepreneurship competition, and its local ecosystems. As well, to bring together business ecosystems and glocalization theory using the construct of design rules in order to extend our knowledge of these three domains. There are three guiding research questions:

1. What is Technovation, and can it be described using frameworks from the ecosystem literature?
2. What are the similarities and differences between local Technovation chapters?
3. What are the design rules for local Technovation chapters as defined by the global organization?

1.2 Deliverables

This thesis produced the following deliverables:

1. Case reports specifying the global Technovation ecosystem and local chapters;
2. Cross-case analysis of similarities and differences between six local Technovation

chapters;

3. Design rules describing the boundaries of local Technovation chapters;
4. Explanations relating regional characteristics, design decisions, and ecosystem structure; and
5. A framework for multilevel globalization.

1.3 Relevance

This research is relevant to five stakeholder groups: advocates for gender diversity in STEM (science, technology, engineering, and math), education institutions, researchers, the Government of Canada, and Technovation practitioners.

In recent years, increasing gender diversity in STEM has been a priority for several organizations. In 2018 the Government of Canada launched the Women Entrepreneurship Strategy (WES) Ecosystem Fund, valued at \$85 million, to bolster the Canadian women entrepreneurial ecosystem (Government of Canada, 2019a). Smaller scale, localized programs are also popping up across the nation to strengthen the pipeline of female founders – for example, SheBoot by Invest Ottawa (<https://www.investottawa.ca/sheboot/>). To effectively leverage this funding, it is imperative to educate the next generation of female founders on opportunities for entrepreneurs. This thesis sheds light on a successful program that builds entrepreneurial skills in girls, which could be modelled by other organizations.

This thesis is also relevant to higher education institutions, which play a critical role in cultivating a problem solving mindset in the next generation. To meet the diversity and talent demands of STEM industries, these institutions are held accountable to

initiatives such as the Engineers Canada 30 by 30

(<https://engineerscanada.ca/diversity/women-in-engineering/30-by-30>), intended to increase the national percentage of licensed female engineers. The findings of this thesis may help universities leverage the ecosystem organizational form, or, participate in an existing ecosystem that advances their diversity goals.

The Government of Canada – particularly the Ministry of Small Business and Export Promotion – may also be interested in the findings from this thesis. As of 2019, the Ministry had pledged 2 billion dollars to “double the number of women-owned businesses by 2025” (Newswire, 2019). The field setting, Technovation Girls, has provided over 20,000 girls with hands-on technology entrepreneurship education. The research findings expose the critical success factors of Technovation, which may be highly relevant to the Ministry in its assessment of future projects.

For researchers, this thesis offers a wealth of nascent ideas and frameworks to build upon. Further, in recent years, the design and ecosystem domains have been converging (e.g. Mezen, 2014; Sunna, 2016; Adner, 2017). The articulation of design rules as a contributing factor in ecosystem design is a new addition to this joint body of knowledge, and will therefore be highly interesting to scholars in these fields.

Lastly, Technovation practitioners – Regional Ambassadors, mentors, and other individuals involved in their local chapter – may benefit from the findings of this thesis. In particular, the cross-case analysis offers a detailed comparison of six Technovation chapters which practitioners can draw on in order to enhance their own program. With the rapid globalization of Technovation, and the organization’s commitment to reaching even

more regions, lessons learned will be highly valuable for emerging chapters.

1.4 Contribution

There are several contributions of this thesis. First, it builds upon previous business ecosystem studies within the Technology Innovation Management (TIM) program at Carleton University. Using an embedded case study approach, this research bridges three knowledge domains – contributing insights on regional variance between ecosystems, the adaptation of ecosystems in local environments, and the specification of design rules as ecosystem boundaries.

The second contribution of this thesis is the specification of an ecosystem in a novel field setting; that is, where economic outcomes are not the sole aligning force between actors. Critical elements of the Technovation ecosystem are identified and related back to the mission of the organization.

Champions of women in STEM also benefit from this specification of the Technovation ecosystem. Applying the same approach for ecosystem mapping as well as the resultant glocalization framework may help them a) identify the salient components of and b) design and/or adapt other ecosystems intended to empower women through technology education.

Lastly, evidence-based recommendations were developed and refined over the course of this research. Five stakeholder groups can leverage these recommendations to create public policy that fosters entrepreneurship, design powerful ecosystems that support women in STEM, or simply learn from the experiences of other Technovation practitioners to improve their local chapter.

1.5 Overview of method and expected results

The research presented in this thesis was conducted according to the case study method (Yin, 2018). The case study was multilevel, spanning the global Technovation organization and six local chapters in Canada and Mexico. At a time when diversity is increasingly critical to an organization's success, thorough investigation of an exemplary case that has positively impacted over 100,000 girls, youth, and other underrepresented individuals (Technovation, 2020) is particularly salient.

1.6 Organization of the document

This thesis is organized as six chapters, each structured into sections and subsections. Chapter 1 has presented an introduction to the overall research. Chapter 2 presents an overview of four literature streams that formed the theoretical foundation for this study. Chapter 3 describes the case study methodology employed in this study. Chapter 4 provides a summary of the data and results, while Chapter 5 elaborates on the answers to the research questions. Chapter 6 asserts the key findings of the thesis.

2 Literature review

This chapter presents the literature review of four topics: design, business ecosystems, glocalization, and case study research. Through the review of the first three topics, salient concepts were extracted and built into the theoretical framework of this thesis. The fourth topic presents background material on conducting an effective case study, particularly one which is multilevel. Select examples of multilevel case studies on business ecosystems were reviewed.

Table 1 organizes the literature according to the four streams and summarizes the key points. The following sections briefly review each stream, and the final section is a synthesis of the salient lessons for this research.

Table 1: Literature review summary

Stream	Key highlights of the stream	Key references
Design	<ul style="list-style-type: none">• Designing complex systems requires knowledge beyond the initial problem context• Hierarchy and decomposability enable the evolution and reusability of components• Modularity is a series of flexible patterns which comprise the structure of a system; to enforce modularity, a designer defines design rules	<ul style="list-style-type: none">• Alexander (1964)• Baldwin & Clark (2000)• Parnas (1972)• Simon (1962)• Simon (1996)
Ecosystems	<ul style="list-style-type: none">• Ecosystem structure is the configuration of actors to realize a shared value proposition• There are three primary ecosystem orientations, based on its objective: business, entrepreneurial, and innovation• The anchor of an ecosystem can be a platform, actor, process, or value proposition	<ul style="list-style-type: none">• Adner (2017)• Bailetti & Bot (2013)• Dattée, Alexy, & Autio (2018)• Iansiti & Levien (2004)• Moore (2006)• Muegge (2013)

Stream	Key highlights of the stream	Key references
Glocalization	<ul style="list-style-type: none"> • Global and local forces are interdependent • Glocalization processes are a means for ideas or concepts to travel across the global-local dimension • In organizations, glocalization involves individuals as catalysts, who bring in global ideas and adapt them to the local context 	<ul style="list-style-type: none"> • Drori, Höllerer, & Walgenbach (2014)
Case study research	<ul style="list-style-type: none"> • Building theory from case study research requires precise constructs, purposefully selected cases, and protocols guiding data collection, analysis, and presentation • Case study design should be assessed against validity tests • Researchers should strive for parsimony between the case selection and unit of analysis 	<ul style="list-style-type: none"> • Eisenhardt (1989) • Suddaby (2010) • Yin (2018)

2.1 Design

The first stream is the foundations of design. This topic is presented first as it introduces several perspectives that are adopted by later streams. Table 2 summarizes the four design perspectives reviewed in this section.

Two pioneers of design science, Christopher Alexander and Hebert A. Simon, attest that the purpose of design is creating: either “form” (Alexander, 1964), or “artifacts” (Simon, 1996).

According to Simon, design involves mediating the boundary between an artifact’s inner and outer environment. The external environment dictates conditions under which the artifact must function – that is, it provides the goals of the artifact. How the inner environment of an artifact is constructed so as to meet these goals is not of particular concern. In fact, Simon argues that “if the inner system is properly designed, it will be adapted to the outer environment, so that its behavior will be determined in large

part by the behavior of the latter” (1996: 11-12). A well-designed system is therefore adaptive – its behaviour can be predicted by the external conditions, regardless of what caused those conditions. As an example, Simon argues that an artifact designed to operate as a counter reacting to pulses “could again be made independent of the physical character of the exterior pulse – the counter could be made to count anything” (1996: 9).

For Alexander, the design process involves aligning the form (solution) with its context (original problem space). Alignment is denoted as “fitness” (1964: 15), the “relation of mutual acceptability between [context and form]” (1964: 19). Good fitness in a design is not always easily detectable. However, the negative consequences of poor fit, or “misfit”, are often observed, felt, and experienced by users. Thus, good fitness is achieved by minimizing the consequences of misfit.

Alexander describes two cultures that shape the behaviour of designers: unselfconscious and self-conscious. In the former, rigid tradition leads to swift resolution of any misfit – failures are directly reacted to, and addressed. The system tends towards equilibrium, or fit, because of the prompt reaction time that prevents failures from propagating. In self-conscious culture, an individual expresses themselves through and is more attached to form. Therefore the ability of the system to adapt to misfit is inhibited, because it depends on a singular person to react – who, given the occurrence of the misfit – now questions the value of their design.

The *architecture* of a system is the structural organization of its components. In earlier writing, Simon describes systems “composed of subsystems that, in turn, have their own subsystems, and so on” (1962: 468) as hierarchic. *Hierarchy* is thus a structural

property of these systems. *Nearly decomposable* structures are ones in which “the interactions among the subsystems are weak, but not negligible” (1962: 474). Near decomposability introduces stability and enables rapid evolution of the system, because incremental changes can be made to subsystems with little impact on adjacent ones.

Parnas (1972) also defines decomposability as a system property, referring to its breakdown of components (or *modules*). Meanwhile, hierarchy refers to a nested configuration that “hides” properties of lower-level components from higher-level ones. Thus, “hierarchical structure and ‘clean’ decomposition are two desirable but independent properties of a system structure” (1972: 1058). He also argues that this information hiding may be beneficial in the evolution of the system.

More recent writing on design use similar terminology. Baldwin & Clark offer a simple definition of the design process as “inventing objectives ... of human intelligence and effort, [which] are called ‘artifacts’” (2000: 2). A design on its own is simply the description of an artifact; the design process is an iterative means of creating a form that satisfies certain objectives which could not be met by an existing form.

An alternative perspective on design presented by Dorst is “the resolution of paradoxes between discourses in a design situation” (2006: 17). “Paradoxes between discourses” are evolving and conflicting lines of thinking. In this perspective, the nuanced nature of design problems is explicitly acknowledged. In fact, Dorst dedicates half of the “creative design” (2006: 15) process to reframing the problem. Creativity and exploration are key to reconciling the paradoxes and creating a solution. This perspective resonates with Alexander’s suggestion that designing is often “based on a hunch” (1964:

91), rather than sound principles.

Table 2: Design perspectives within the literature

Design perspective	Source
Creation of an artifact that interfaces between an external and internal environment	Simon (1962; 1996)
Shaping a form to minimize misfit with its context	Alexander (1964)
Description and selection of all structural properties of an artifact	Baldwin & Clark (2000)
"Resolution of paradoxes between discourses"	Dorst (2006:17)

2.1.1 Modularity

One of the core constructs within design science is *modularity*. This construct is foundational for the ecosystem and glocalization literature as well.

Modularity is formally defined by Baldwin & Clark as “interdependence within and independence across” (2000: 63) components. Components are represented as an abstraction (e.g. a subsystem), with interfaces (connections) between them that hide information from the other components (2000: 63-64). Baldwin & Clark acknowledge that the concept of modularity is not novel – Simon discussed it in his seminal text (granted, using the term near-decomposability instead). Parnas likens modularity to “hierarchical structure” (1972: 1057), in which components are organized such that they can function independently of others.

Baldwin & Clark identify three outcomes of modularity: a) “[increasing] the range of ‘manageable’ complexity” by reducing trial-and-error, b) “[allowing] different parts of a large design to be worked on concurrently” because of limited interdependencies, and c) “[accommodating] uncertainty” within hidden modules (2000: 90-91). These conclusions build on earlier works: Simon (1962) recognized point b) in his famous metaphor, whereby a modular system allowed a certain watch maker to frequently pause

and restart their watch-making with little impact on efficiency. Parnas (1972) recognized the flexibility hidden modules offer, in his thought experiment of hierarchic software.

2.1.2 Design rules

Building off the modularity construct, Baldwin & Clark introduce the concept of *design rules* as enforced design parameters. Design parameters are small descriptive units of an artifact. Design rules minimize iterations within the design cycle by converting interdependencies between parameters into a hierarchy. For the remainder of the design process, these design rules “affect other parameter choices but they themselves cannot be changed” (2000: 68). Because design rules have a significant impact on the architecture of a system, an understanding of the real-world interdependencies between components is critical to avoid designing systems with unrealistic parameters. Nonetheless, the iterative nature of the design process is inevitable. Because “the initial set of design rules will be incomplete” (2000: 76), the emergence of new interdependencies will force designers to revisit the rules.

Although not explicitly identified as design rules, Parnas (1972) refers to different types of “design decisions”. Akin to design rules, system level decisions “affect more than one module” (1972: 1054) and are critical early in the design process.

In order to achieve a complete set of design rules, architects must ensure they capture three aspects of a system:

1. Architecture
2. Interfaces
3. Integration protocols and testing standards

Architecture refers to the modules in a system and their role; interfaces refer to the interoperability of modules; and integration protocols refer to tests that may be conducted to evaluate whether the system operates as intended and its modules adhere to design rules (Baldwin & Clark, 2000).

Another concept that builds upon design rules are *modular operators*. These are actions that designers take to either convert a system into a modular one, or to modify a modular system. Baldwin & Clark (2000) identify 6 operators:

1. Splitting
2. Substituting
3. Augmenting
4. Excluding
5. Inverting
6. Porting

Splitting is the first step in creating a modular system, by severing dependencies between components. Subsequently, any of the operators can be applied to individual modules to enhance or modify the system design.

Substituting involves replacing one module with another for economic purposes. An example of substitution would be incorporating a commercial-off-the-shelf (COTS) product that performs the same functions as the existing module, but is more economically viable.

Augmenting and excluding involve adding or removing modules from a system, respectively. These operators are typically invoked together. A designer may create the

framework for a system, and enable users to configure it themselves by adding or removing modules. This design means the system is “modular in use” (2000: 136). Alternatively, the designer may introduce new functionality altogether through new modules, provided the existing framework is flexible enough to accommodate them.

Inverting is “the action of taking previously hidden information and ‘moving it up’ the design hierarchy” (2000: 138). That is, a hidden module is converted into a visible module that other modules have access to. Inversion may be applied for efficiency purposes. For example, if a system has several unique instances of a function across several modules, they could be converted into a global function accessible by the individual modules.

Lastly, porting involves breaking a module down into “internal” and “external” components, and then leveraging the external component as a means to translate the internal components to another system. The internal components are fully independent as they “will not affect the surrounding system, and the system will not affect them” (2000: 140); they need only communicate with the translator module.

Invoking these operators offers flexibility at two levels: the design itself, and design parameters. By defining new design rules and re-configuring individual modules, a system can be entirely transformed – the levels of hierarchy can be increased or decreased, functionality can be added or removed, and performance can be optimized globally or locally.

2.1.3 Design evolution

Simon’s notion of the nearly decomposable system is one with strong interactions

within and weak interactions across components. The independence built into such systems enables components to evolve along individual trajectories with minimal impact to other components. Simon argues that a hierarchical structure with “a set of stable subsystems” (1996: 193) has the advantage of evolving more rapidly than a non-hierarchical system.

According to Baldwin & Clark (2000), modularity encourages rapid design evolution by providing options for enhancing and re-configuring the system. This is because a modular structure allows for participation by “decentralized actors” (2000: 223) working on the system at the same time. Contrary to biological evolution, the design evolution process is intentional, because it is enabled by humans. These designers are “seeking something (value or fitness) in a complex environment” (2000: 223).

2.2 Business ecosystems

Following the year 1993, references to *business ecosystems* exploded in management scholarship. Introduced by James F. Moore through an ecological analogy, the hundreds of articles that followed have covered a diverse array of studies, including: structural analysis of ecosystems (its components, architecture, and roles), the dynamics of ecosystems (how they are formed, designed, and evolve), and types of ecosystems (extending beyond business into innovation and entrepreneurship). Each aspect is explored in detail in the following subsections.

2.2.1 What are business ecosystems?

Despite popularity in management research, there is little alignment on ecosystem theory. In fact, one of few agreements among scholars is that there is no agreed-upon

theory. This is best explained by authors of recent articles:

- There exists a “cornucopia of constructs” describing similar ideas, with no clear relation between them (Adner, 2017: 39)
- “There is no consensus yet among researchers about how to best describe and characterize a business ecosystem” (Muegge et al., 2018: 4)
- “A lack of theoretical consistency concerning innovation ecosystem terminology may intensify the fuzzy landscape of research” (de Vasconcelos Gomes, Facin, Salerno, & Ikenami, 2018: 30).

This section reviews the expansive ecosystem literature and distills the salient elements. Table 3 presents these elements, extracted from key studies.

Table 3: Business ecosystem elements

Ecosystem properties	Source
1. Firms 2. Innovation co-evolution 3. Competition and collaboration	Moore (1993)
1. Interdependence 2. Common fate 3. Keystone and/or dominator, niche	Iansiti & Levien (2004)
1. Contributors of innovation 2. Shared vision 3. Competition and cooperation 4. Co-evolution of innovation, markets, and hierarchies	Moore (2006)
1. Risks (initiative, interdependence, integration) 2. Intermediaries (adopters), complementors, focal firm (interdependencies herein) 3. Whole (“coherent, customer-facing solution) is greater than sum of its parts (contributions)	Adner (2006)
1. Multi-sided platform 2. Members (customers, complementors, investors, community leaders) 3. Creates value for customers	Bailletti (2010)

Ecosystem properties	Source
<ol style="list-style-type: none"> 1. Economic actors (organizations/individuals) 2. Platform 3. Shared outcome 4. Governance oversight 5. Activities structured by an institution 6. Inbound/outbound resource flows (to/from platform and developer community) 	Muegge (2011a)
<ol style="list-style-type: none"> 1. Conceptual location 2. Anchor point 3. Boundaries 4. Elements 	Muegge (2011b)
<ol style="list-style-type: none"> 1. Platform 2. Governance oversight 3. Leaders and feeders 4. Shared purpose 5. Activities (process) to achieve shared purpose 	Bailetti & Bot (2013)
<ol style="list-style-type: none"> 1. Operate within connected communities 2. Manages technological and social change 3. Shared architecture 4. Shared values 	Moore (2013)
<ol style="list-style-type: none"> 1. Platform 2. Platform leader(s), complementors, and users 3. Platform evolution 	Gawer & Cusumano (2014)
<ol style="list-style-type: none"> 1. Context 2. Cooperation 3. Construct 4. Configuration 5. Capability 6. Change 	Rong, Hu, Lin, Shi, & Guo (2015)
<ol style="list-style-type: none"> 1. Platform 2. Sides 3. Control over contractual terms of direct interactions 4. Desired outcomes 	Sunna (2016)
<ol style="list-style-type: none"> 1. Activities 2. Actors 3. Positions 4. Links 	Adner (2017)
<ol style="list-style-type: none"> 1. Network of actors (institutions) 2. Anchor tenant 3. Activities (feedback mechanisms) 4. Governance 	Colombelli et al. (2019)
<ol style="list-style-type: none"> 1. Interdependent actors 2. Keystone actor 3. Platform-based 4. Competition and cooperation 5. Co-evolutionary lifecycle 	de Vasconcelos Gomes et al. (2018)
<ol style="list-style-type: none"> 1. Activities 2. Actors 3. Architectures 	Kapoor (2018)

Ecosystem properties	Source
1. Sides 2. Platform 3. Controls 4. Desired outcomes	Muegge et al. (2018)
1. Product or service system boundaries 2. Multilevel social network 3. Actors with unique attributes, decision principles, and beliefs 4. Coherency	Tsujimoto, Kajikawa, Tomita, & Matsumoto (2018)
1. Co-evolution 2. Interdependencies 3. Orchestration 4. Proximity	Radziwon & Bogers (2019)

Commonality between the authors' definitions are the following three elements:

1. Actors: An ecosystem consists of a set of interdependent stakeholders who embody unique roles.
2. Anchor: Actors are anchored around a point – be it a platform, another actor, a value proposition, or a process – that guides the ecosystem activities.
3. Activities: Actors perform activities to accomplish the objectives of the ecosystem.

Table 4 summarizes the three ecosystem elements and their key properties, which are elaborated in following subsections.

Table 4: Ecosystem elements and properties

Element (First-level)	Property (Second-level)	Key sources
Actors	Interdependence	Iansiti & Levien (2004) Adner & Kapoor (2010) Adner (2017) Radziwon & Bogers (2019)
	Relative position	Iansiti & Levien (2004) Adner (2006) Adner (2017)
	Coopetition	Moore (1993) Moore (2006) de Vasconcelos Gomes et al. (2018)

Element (First-level)	Property (Second-level)	Key sources
Anchor	Bounds the ecosystem	Bailetti (2010) Bailetti & Bot (2013) Gawer & Cusumano (2014) Adner (2017)
	Centrally positioned	Iansiti & Levien (2004) Colombelli et al. (2019)
	Shared purpose	Bailetti & Bot (2013) Moore (2013) Tsujiimoto et al. (2018)
	Enable differentiation	Bailetti & Bot (2013) Moore (2013)
Activities	Resource flow	Muegge (2011c) Kapoor (2018)
	Co-evolution	Moore (1993) Moore (2013)
	Delivery of value proposition	Bailetti (2010) Bailetti & Bot (2013) Kapoor (2018)
	Leadership & governance	Moore (2013) Colombelli et al. (2019)

2.2.1.1 Actors

The importance of a diverse set of actors within an ecosystem is emphasized by Moore: “The variety of services [offered by the ecosystem] depends on the variety of organisms making [it] up and the ability of the organisms to join in unique and useful combinations” (2013: 27).

Other authors suggest who these actors may be. For Adner (2006) and Gawer & Cusumano (2014), similarly to Moore, they are firms. Adner & Kapoor argue that other players such as “upstream suppliers and downstream customers and complementors” (2010: 326) are relevant; for Iansiti & Levien (2004), membership is extended to other firms (suppliers or buyers), institutions, partners, competitors, customers, regulatory bodies, and media outlets. A later definition by Adner generalizes the term actor to include all “entities that undertake the activities [actions to be undertaken in order for the

value proposition to materialize]” (2017: 43). Embracing a more general definition is useful when analyzing different types of ecosystems in which firms are not necessarily a focal actor.

The roles that actors play in business ecosystems have been discussed extensively. Typically there is a leader, which Moore argues is essential: “co-evolving companies must do more than satisfy customers; a leader must also emerge to initiate a process of rapid, ongoing improvement that draws the entire community toward a grander future” (1993: 79). In order to attract partners, the leader, or *keystone*, must fulfill certain responsibilities. Contributing key resources such as a “set of common assets” (Iansiti & Levien, 2004: 73) – or more bluntly, “something the ecosystem needs and being the only practical source” (Moore, 1993: 81) – enables innovation and brings stability to the ecosystem. Conversely, to encourage partners to develop complementary solutions, the ecosystem leader should “refrain from entering as a competitor” (Gawer & Cusumano, 2014: 422). They should also be aware of who their ecosystem competitors are – which may be other ecosystems (Moore, 1993) – and develop a strategy to either challenge them or adopt the rival offer (Gawer & Cusumano, 2014). Actors within the ecosystem therefore play a delicate game of “coopetition”: cooperating to support the overall success of the ecosystem, yet competing for a critical position within it. Moore (2006: 73) describes this best:

In a business ecosystem, the leaders of a multitude of firms come together around a broad vision of a future they want to make happen. They understand that establishing this future will require both cooperation and competition among their firms.

As alluded to in the preceding paragraph, partners are expected to develop complementary solutions that create value for the entire ecosystem. To do so, they will usually leverage resources provided by the keystone. By supporting and integrating these assets into their own solution, partners continually reinforce the leader's position in the ecosystem. However, according to Iansiti & Levien, these *niche players* have their own strategy: “[developing] specialized capabilities that differentiate it from other companies in the network” (2004: 77). Further, Moore suggests that partners are intrinsically motivated to join the ecosystem, and “work together to benefit the community” (2006: 55), while creating potential for future opportunities in the market.

Another perspective on ecosystem roles is provided by Hurmelinna-Laukkanen & Nätti. They examine orchestrator roles for the actors involved in management of innovation processes. They found that roles are driven by the orchestrator's capabilities and defined by the activities they undertake. Examples of these roles include *developers*, *promoters*, and *liaison*. They are responsible for “developing and strengthening the (in)tangible assets”, “engaging actors into an innovation development process”, and “operating as an external intermediate between network members or networks” (2018: 70).

Regardless of the types of actors in an ecosystem, “the crucial element is co-dependence on future survival” (Radziwon & Bogers, 2019: 575). Because the outcomes are shared by all ecosystem actors, contributing to their partners' success means contributing to their own success. The innovation potential of an ecosystem relies on each and every actor: “with each party giving its best, the ecosystem as a whole gives its

collective best” (Moore, 2013: 54).

2.2.1.2 Anchor

In terms of the ecosystem anchor, several forms have manifested in the literature. *Platforms* are among the most common (e.g., Iansiti & Levien, 2004; Bailetti & Bot, 2013; Gawer & Cusumano, 2014). Defined as “a set of technological building blocks and complementary assets” (Muegge, 2011a: 5), they create an infrastructure that simultaneously guides and bounds the activities of the ecosystem. Platform leaders seek to increase the value of the platform, and complementors seek to develop their own solutions by building upon it. This mutual dependence on the platform stimulates network effects – “positive feedback loops that can grow at exponentially increasing rates” – since “they become harder to dislodge by rivals or new entrants, with the growing number of complements acting like a barrier to entry” (Gawer & Cusumano, 2014: 421-422). This also creates a competitive advantage for these ecosystems.

While most empirical studies of platforms refer to tangible assets (e.g. a mobile application), other examples include *process* based platforms, e.g. Bailetti & Bot (2013), Mezen (2014), and Sunna (2016). In these studies, the Lead To Win ecosystem is “anchored around a process for venture creation that helps founders of technology startups move from the idea stage through the opportunity stage”. This venture creation process emulates a technology entrepreneurship startup lifecycle. A process platform is a repeatable methodology which, similar to technology platforms, produces different outcomes (or companies, in the case of Lead To Win).

The anchor may also be an individual actor, or “anchor tenant” as is the case for

regional entrepreneurial ecosystems (Colombelli et al., 2019). This actor typically possesses resources or status which enable them to shape the evolution of the ecosystem. As well, they are centrally positioned so they can easily connect other important actors to the ecosystem.

Lastly, a value proposition may also be the anchor point for an ecosystem. Actors who are required to realize this value proposition are within the boundaries of the ecosystem, and configured in such a way that their collective contributions achieve the value proposition (Adner, 2017). Therefore, the anchor creates boundaries for the ecosystem.

Muegge (2011b) took an ontological perspective on the ecosystem construct, and identified four dimensions along which prior studies had classified and described ecosystems. The anchor is one dimension, but its form (e.g. platform, keystone actor) is not prescribed.

2.2.1.3 Activities

The third common element of business ecosystems is activities – the work that actors undertake to meet the ecosystem objectives. Moore’s description includes “[working] cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations” (1993: 76). Iansiti & Levien suggest activities include “[joining] forces to manufacture and distribute a single personal computer”, or “[coordinating] to provide ... a software operating system” (2004: 70). In his study of the Eclipse Foundation, Muegge observed “[maintaining] and [extending] the platform”, “[performing] a portion of their [case companies’] R&D”, and

“[inventing] new business models” (2011a: 9).

Adner generalizes activities as “discrete actions to be undertaken in order for the value proposition to materialize” (2017: 43). In addition to contributing to the ecosystem, actors also have “compelling value propositions” from which they derive value by participating in the ecosystem (Bailetti & Bot, 2013).

Within the literature, certain activities have surfaced as critical to the sustainability of an ecosystem. Kapoor (2018) argues that transactions between stakeholders ultimately depend on the value to be created. Ecosystems with a different value creation protocol would result in a different configuration of actors, and therefore resource flow. The concept of co-evolution is core to Moore’s seminal discussion on ecosystem. Ultimately, this activity is not something that actors explicitly undertake, but rather is something they are subject to: “Each company has its own unique and evolving configuration, shaped in constant interaction with other companies” (Moore, 2013: 43). Lastly, governance is an explicit activity commonly carried out by a keystone actor. Colombelli et al. describe this activity as spurring “economic growth, technological change, and innovation” (2019: 514), while also giving structure to the ecosystem by “establishing the rules that regulate the interactions between parties and [lending] legitimacy to the other members” (2019: 508). Actors seeking to lead and govern an ecosystem must be prepared to take responsibility for it in its entirety. This requires “shared vision, management systems from aligned road maps to certification and testing” (Moore, 2013: 43).

2.2.2 Business ecosystem formation

While ecosystem evolution has not received the same attention as ecosystem structure, it is an important concept in understanding the dynamics of this complex configuration.

In his seminal paper, Moore (1993) describes a four-stage lifecycle model for the evolution of a business ecosystem: *birth*, *expansion*, *leadership*, and *self-renewal* or *death*. The first stage is focused on defining and delivering a value proposition. The second stage involves scaling the solution to reach a broader market, while rivaling other ecosystems' offers. In the third stage, an ecosystem leader emerges to balance standardization (to attract complementary innovation) with control (to maintain their solution's position in the market). Lastly, the fourth stage requires adapting to the new ecosystem landscape – including competitors – or, refusing to embrace these fundamental and ultimately facing obsolescence.

Rong et al. (2015) observed a correlation between Internet-of-Things (IoT)-based platform ecosystems and industry phases: as the industry becomes more mature, the platform becomes less open to contributions by customers or complementors.

Colombelli et al. (2019) examine how the governance structure of an entrepreneurial ecosystem evolves. They presented a three-phase model: *consolidation*, during which the ecosystem structure evolves from hierarchical to relational. In the first phase (*birth*) a focal actor ushers in and develops new ecosystem. As the value of the ecosystem increases with contributions of other actors, the role of the focal actor became less central in the oversight of the ecosystem (*transition*). However, the strategic role of

other actors has not yet solidified, and important actors may be missing. Finally, the third phase of the entrepreneurial ecosystem (*consolidation*) depends on a shared purpose that transcends the actors, rather than a sole actor as the “leader and feeder” (2019: 517).

A complex systems perspective on business ecosystem evolution enabled through dynamic control is introduced by Dattée et al. (2018). In their study, the ecosystems were built around generative (new) technologies which were disrupting the industry architecture. Without a priori commitment from partners, the ecosystem leader continually influenced the direction of the ecosystem, monitored its behaviour, and updated their expectations. This process is guided by feedback loops (both reinforcing and balancing), which managers control through *influencing, monitoring, and updating*. Dynamic control of the feedback mechanisms is an attempt to realize (or capture) the potential value created by the ecosystem.

Dedehayir, Mäkinen, & Ortt (2018) examine the evolution of actors’ roles and responsibilities during ecosystem genesis. They describe an initial definition phase of roles, resources, and ecosystem objective; followed by contributing knowledge, connections, and formulating the offer; and finally, integrating necessary actors and resources to deliver the offer. Notably, they observe that the number of actors in an ecosystem increases exponentially as it evolves.

Taking a design perspective, Muegge et al. (2018) propose a method for replicating existing business ecosystems in a different region. This methodology does not concern the evolution of an ecosystem over time, rather the source of its creation. Building on Sunna’s (2016) empirical study of Lead To Win, the process involves:

identifying the features of an existing multi-sided platform ecosystem, mapping it to the new region by selecting key components, and preparing a launch plan in the new region.

2.2.3 Types of ecosystems

Within the literature, different ecosystem orientations have been discussed. The variation between these orientations is related to the overall objective of the ecosystem.

Three main types were observed:

1. Business ecosystems
2. Innovation ecosystems
3. Entrepreneurial ecosystems

In a traditional business ecosystem, the orientation is towards products and services. Definitions of these ecosystems include terminology such as “co-evolve” (Moore, 1993; Moore, 2006), “customer problems” (Bailetti, 2010; Low & Muegge, 2013), “customer-facing solution” (Adner, 2006; Adner, 2012), and “technology”/“technologies” (Iansiti & Levien, 2004; Gawer & Cusumano, 2014; Aarikka-Stenroos & Ritala, 2017). The primary objective is to foster a cooperative environment which enables the development of technologies or solutions to address specific customer pain points.

Innovation ecosystems are oriented towards a value proposition or value creation. They are not bounded by a specific product or service, but rather aim to create opportunities for future product innovation. A key feature of the case study conducted by Dattée et al. was indeed the uncertainty of the technological road map for the ecosystem, described as a “mind-blowing space of exploration” (2018: 476) by one interviewee.

Dedehayir et al. suggest that innovation ecosystem genesis – characterized by “uncertainty and technological infancy” (2018: 26) – closely mimics new product development innovation. Thus, while similar to business ecosystems in that a product or service is likely to emerge, innovation ecosystems focus more broadly on expanding the technological potential of a particular industry.

Lastly, entrepreneurial ecosystems are oriented towards venture creation. In this type of ecosystem, there is typically a diverse set of stakeholders, including academic institutions, economic partners, entrepreneurs, and other regional organizations, whose objective is to foster job and venture creation in a specific region. Bailetti describes the Lead to Win ecosystem as “a job-creation engine” (2010) for Canada’s Capital Region; meanwhile Colombelli et al. (2019) observe that Turin’s entrepreneurial ecosystem is comprised of a vast network of institutions.

Across the three orientations, similar ecosystem structures can be deployed. For example, both business (Intel) and entrepreneurial (Lead to Win) ecosystems operate in a platform configuration (Gawer & Cusumano, 2014; Bailetti & Bot, 2013, respectively).

2.3 Glocalization

A key objective of this thesis is examining variation between regional Technovation chapters. The underlying theoretical concept for this analysis is *glocalization*. Coined by Roland Robertson, he argues that the “global” and “local” are not in fact mutually exclusive. He notes that in prior research, “much of the talk about globalization has tended to assume that it is a process which overrides locality” (1995: 2). Glocalization does not consider the diffusion of global models, ideas, and practices as

compressing the world, rather as the path towards “new forms of heterogeneity”

(Roudometof, 2019: 805).

In Robertson’s older studies, he considered “local” to exist relative to the “global” – both impacted by, and impacting it. However, his recent work urges scholars to consider the local as a *place* – “a location create by human experiences” (2019: 806) – that does not solely exist in relation to the global, but as an entity in itself.

In addition to Robertson’s concept of glocalization, the Hofstede dimensions are useful constructs for characterizing national culture. In early work, Hofstede surveyed a vast array of IBM employee data which, aggregated at the national level, illuminated several patterns of behaviour. These patterns led to the six Hofstede cultural dimensions, “aspect[s] of a culture that can be measured relative to other cultures” (2011: 7), as follows:

1. *Power distance, related to the different solutions to the basic problem of human inequality;*
2. *Uncertainty avoidance, related to the level of stress in a society in the face of an unknown future;*
3. *Individualism versus collectivism, related to the integration of individuals into primary groups;*
4. *Masculinity versus femininity, related to the division of emotional roles between women and men;*
5. *Long term versus short term orientation, related to the choice of focus for peoples efforts: the future or the present and past;*
6. *Indulgence versus restraint, related to the gratification versus control of basic human desires related to enjoying life.*

The primary source for the remainder of this section is the 2014 book by Drori et al., *Global Themes and Local Variations in Organization Management*. This book is a collection of edited studies, both theoretical and empirical, on glocalization within the

context of formal organizations. Individual authors are cited in subsequent paragraphs.

Glocalization is defined as “a complex process that fuses the global and the local, and interlaces worldwide similarity with cross-national variation” (2014: 3). The terms global and local are relative rather than absolute – the boundary between them is subjective, and largely based on the frame of reference. That is, a city may be local relative to a state; just as a state may be local relative to a nation. Regardless of where the line is drawn, global and local forces are interdependent and mutually reinforcing. Global “ideas, structures, and models” (2014: 10) influence local outcomes; and adaptation of these items at the local level often feeds back into the global context in a boomerang effect. This back-and-forth behaviour involves “dynamic, often oscillating, relations between global and local levels” (2014: 10).

Glocalization consists of three main elements: “what”, “who”, and “how”. “What” refers to any idea, behaviour, activity or other entity that is subject to the process of glocalization. “Who” refers to the change agents that enact the glocalization process, “be they individuals, organizations, or nation states” (2014: 12). Lastly, “how” describes mechanisms of the glocalization process. The process consists of 4 phases, depicted in Figure 1. In this diagram the subject (circle) is an “idea or model” (2014: 10).

Figure 1: Glocalization process (Drori et al., 2014)

There are three axes along which glocalization occurs: vertical, horizontal, and temporal. The vertical axis is the global-local dimension – which can be considered as a continuous spectrum. The horizontal axis spans “regions, sectors, fields, or organizations” (2014: 8) which exist at the same level. Finally, the temporal axis involves the sequencing of glocalization processes and “path dependence” (2014: 9) between phases.

Within the organizational context, globalization is realized through several forms: multinational companies, partial organizations, and meta-organizations (Ahrne & Brunsson, 2014). With respect to multinationals, local units or subsidiaries tend to mirror the structure and processes of the parent company, that is they “apply the same rules ... as they apply at home” (2014: 42). Meta-organizations (such as the European Union, North Atlantic Treaty Organization, and the Fédération Internationale de Football Association) are membership-based, typically exhibit a flat hierarchy, and facilitate connections between local entities. Partial organizations on the other hand are not driven by membership, but rather standardization, achieved through certification and

compliance. In the public (e.g. university) domain, rankings are a popular means of achieving standardization (Sahlin, 2014).

Several authors describe techniques that actors use to facilitate glocalization: *storytelling* and *accounts*. The former involves constructing a narrative to convey messages that may not be effectively captured through other means. It is used as “a management tool, a communication tool, and a marketing tool” (Czarniawska, 2014: 72). Meanwhile, accounts are “central discursive ‘tools’” (Meyer, R. E., 2014: 81) that facilitate glocalization processes by reaching consensus and minimizing dissent among stakeholders. *Re-contextualization* is a transformative process by which these accounts are adapted to their new context, dictated by the expectations of local actors (Meyer, R. E., 2014).

In the concluding chapter, J. W. Meyer argues that the glocalization of formal organizations takes place within the realm of “expanded rationalization” (2014: 415). The “rise of common world doctrines of human rights, environmental sustainability, and social transparency” (2014: 415) create a baseline for the legitimacy of formal organizations. They are expected to uphold these values; those which do not will simply not be as successful in transmitting their ideas to local contexts. Conversely, regions that are not attenuated to global ideas – more generally, modernity – do not host many formal organizations. Since local actors must embrace such ideas in order for glocalization to occur, ideas that do not resonate with their values will be rejected.

2.4 Case study research

In this section, literature that describes or uses the case study research method was

reviewed. This stream is different from the previous three, as case study research is not part of the theoretical framework of this thesis, nor is this theory being validated. It is provided for reader's benefit, in order to properly follow along the progression of the research. Exploring the central tenants, challenges, and benefits of case study research also greatly helped the researcher in the preparation and design of this case study.

2.4.1 Overview of case study research method

The case study research method has been used in numerous disciplines. Yin's definition has two elements: *scope* and *features*. The scope involves "an empirical method that investigates a ... phenomenon ... in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident" (2018: 15). Meanwhile, features include: "many more variables of interest" (2018: 15), relevance of prior theory, and convergence of multiple evidence sources. In a case study, the researcher does not exhibit control over nor influence the phenomenon; rather, they *observe* behaviour.

According to Yin, the case study process has six iterative steps (Figure 2). See Section 3 for details on the adaptation of Yin's process for this thesis. The first step, *plan*, involves determining whether a case study is in fact the appropriate research method, by examining research questions and phenomenon. The second step, *design*, shapes the entire case study. The researcher identifies the components of the design, selects tactics for ensuring validity of the design, and selects a design (single- or multiple-case; embedded or holistic) that aligns with the phenomenon and context. The third step, *prepare*, focuses on logistics and operational issues. This includes developing a case

study protocol to guide the research, addressing ethical considerations, acquiring appropriate material and personnel to conduct the study, and executing a pilot case study. Fourth is to *collect* evidence. Yin describes six types of evidence: documentation, archival records, interviews, direct observations, participant-observation, and physical artifacts (2018: 114). He also recommends following four core principles during the data collection phase: 1) using multiple sources of evidence to strengthen the findings, 2) separating the raw evidence from the final report, 3) maintaining bi-directional traceability from the sources of evidence to the findings, and 4) relying on social media – sparingly and with caution – only as a source of secondary evidence. The fifth step, *analysis*, is based on an analytic strategy and several techniques. An analytic strategy is the lens through which the researcher views and analyzes the evidence (i.e. whether validating existing theory or developing a new theory). A technique is the mechanism for analyzing the data. The five techniques include pattern matching, explanation building, time-series analysis, logic models, and cross-case synthesis (2018: 33). Lastly, step six is to *share*. In this section Yin offers tips on identifying and writing for specific audiences, structuring and formatting the case report, and composing an exemplary report.

Figure 2: Case study process (Yin, 2018)

2.4.2 Theory building from case study research

There are two primary methods of theory development: *deductive* and *inductive*.

Using deductive methods, “researchers begin with hypotheses and test them with data” (Eisenhardt, Graebner, & Sonenshein, 2016: 1114). On the other hand, inductive research involves “[generating] theory from data” (2016: 1113). Case studies may follow the inductive method when limited rival theories are available to validate. Three key features of the inductive research method (whether case-based or not) are:

1. Deep immersion: An exploration of the phenomenon of interest is enhanced through multiple modes of data collection.
2. Theoretical sampling: Strategic data collection to address the research question(s), and “enabling meaningful comparisons that lead to better theory” (2016: 1114).
3. Grounded theory-building: An iterative process whereby continuous reflection on the data leads to enhancements or modifications to the data collection, analysis, and interpretation.

Eisenhardt et al. suggest that inductive research is effective in tackling *grand challenges* – “complex problems with significant implications, unknown solutions, and intertwined and evolving technical and social interactions” (2016: 1115). If conducted rigorously, these methods can generate insights into grand challenges by amplifying their extremity and novelty, revealing constructs that underlie theory, and, in multi-case study research, identifying configurations (states of constructs) that yield desired results.

Theoretical strategy has a significant impact on the overall research. As such, Eisenhardt & Graebner (2007) argue that theory building, as opposed to theory testing, should be justified by clearly stating “why there is no existing theory that offers a feasible answer” (2007: 26). Gaps in the literature and accepted theories that leave the research question(s) unanswered can be used as justification; conflicting theories may not.

In earlier work, Eisenhardt (1989) described an 8-step process for developing theory from case study research. In this process, theoretical contribution is considered from beginning to end. It is not an inherent outcome of the research – it must be actively sought, by selecting “theoretically useful cases” (1989: 533) and performing “preliminary theory generation” (1989: 533). Eisenhardt suggests three metrics to evaluate theory resulting from case research: *parsimony*, *testability*, and *logical coherence* (1989: 548). Eisenhardt & Graebner (2007) also emphasize the importance of transparency in legitimizing an emergent theory.

Constructs are a key part of theory-building. They are defined as “conceptual abstractions of phenomena that cannot be directly observed” (Suddaby, 2010: 346). Early in the research process, *a priori* constructs can help “shape the initial design of theory-

building research” (Eisenhardt, 1989: 536). Suddaby identifies four components of constructs:

1. Precise definitions: These must “capture the essential properties and characteristics of the concept or phenomenon under consideration” (2010: 347), while avoiding circular logic. Authors may put forward new definitions of a construct, however addressing prior definitions can avoid confusion with readers.
2. Scope conditions: Presenting the “contextual conditions under which the constructs will or will not apply” (2010: 349) is important in legitimizing the theory. Authors should avoid over-generalization, especially in organizational theory which is sensitive to level of analysis. Types of conditions to consider are space, time, and values.
3. Semantic relationship to other constructs demonstrated: Constructs cannot be defined, nor do they exist in isolation. A new construct must be positioned relative to other constructs.
4. Coherence: In management research, it is common for an “umbrella construct” (2010: 351) to emerge which links together several constructs. This linking must “[demonstrate] greater resilience than its component elements” (2010: 351) to achieve coherence.

All inductive research should strive to produce a high-quality paper. Eisenhardt et al. suggest three quality factors. First is internal coherence and parsimony among the “relationships between constructs, and underlying logical arguments that support these relationships” (2016: 1120). Second is a truthful representation of the data within the

constructs and findings. Lastly, theoretical contribution is essential. Researchers should avoid the pitfall of a “beautifully written illustration of an existing theory” (2016: 1121).

In conclusion, theory building is a balance between diverging perspectives and/or data sources, and convergence on constructs and findings. The main drawback of theories emerging from case study research is generalizability. Since rich data is collected on unique and extreme cases, the theories may be useful in explaining the specific cases, as opposed to the entire population.

2.4.3 Multilevel research

This section provides an overview of select literature pieces on multilevel management research, including considerations and challenges. The purpose of reviewing this particular domain was to design a stronger multilevel case study.

Traditionally, management research has been conducted at either the “micro” (individual) level or “macro” (organizational) level (Hitt, Beamish, Jackson, & Mathieu, 2007). Hitt et al. (2007) argue that multilevel research in management scholarship could help generate theory that addresses the dynamic behaviour of organizations. Paruchuri, Perry-Smith, Chattopadhyay, & Shaw reckon that with “the general messiness of organizing across individuals, teams, and departments” (2018: 797), multilevel research is particularly appealing to practitioners and managers.

A key tenant of rigorous multilevel research is maintaining logical consistency between *theory*, *measurement*, and *analysis* (Hitt et al., 2007). This is echoed by other scholars including Paruchuri et al. (2018), and Carter, Meschnig, & Kaufmann (2015). Theory is concerned with a “focal unit” (Hitt et al., 2007: 1388) or entity, whose

relationship with other entities can be explained. How the entities influence one another across levels is an important aspect of multilevel theorizing (Paruchuri et al., 2018). Hitt et al. define measurement as “the level of the entities from which data are derived” (2007: 1389). While data can be collected at a level different from theory and analysis, researchers should provide justification for doing so. Lastly, Hitt et al. urge researchers to align the level of analysis and level of theory. Several techniques for multilevel analysis have been employed in recent management research, such as “within and between analysis”, “cross-level operator techniques”, and “random coefficients modeling” (2007: 1390). Paruchuri et al. also encourage the use of such models because they employ “techniques capable of partitioning the variance at multiple levels” (2018: 798).

Paruchuri et al. identify two pitfalls in multilevel research. First is the *failure to surface assumptions*, which manifests in three forms:

1. Inadequate selection of levels under study: This can be avoided by “fully [developing] an overarching premise, grounded in theories from each level” (2018: 798).
2. Lack of construct clarity: The level at which constructs are conceptualized should be based in theory. Variation and/or stability of the construct should also be understood.
3. Theory integration: Borrowing theories from single-level studies to explain multilevel phenomenon should be done carefully, by explicitly stating assumptions and how they do or do not translate to a multilevel environment.

The second pitfall is *misalignment of different components* (theory, measurement,

and analysis), which manifests in two forms:

1. Theory-measurement: Theorization about constructs at one level should be supported by measurement of data at that level.
2. Theory-analysis: Theorization about multilevel phenomenon should embrace techniques suited for multilevel analysis, to “fully explore multilevel conceptual implications” (2018: 800).

Notable sources of multilevel ecosystem research include Muegge (2011c), Colombelli et al. (2019), and Radziwon & Bogers (2019). The first is an embedded case study of the Eclipse Foundation and its projects, companies, and governance structures. In the second study, the researchers examined several units of analysis within a regional entrepreneurial ecosystem, including the anchor tenant, governance model, and ecosystem itself. The final study examined open innovation management by small and medium enterprises (SMEs) as units embedded within a business ecosystem.

An excellent example of multilevel research conducted in the TIM program is Mezen (2014)’s study of startup companies in the Lead to Win ecosystem. He observed a positive relationship between an individual entrepreneur’s participation in the ecosystem and its outcome on their business model. Data collected at both levels (i.e., to what extent the individual was involved with the ecosystem, and a log of the business model evolution) allowed him to propose an emergent multilevel theory.

2.5 Summary and synthesis of key findings from the literature

The emergence of common constructs between the design science, business ecosystem, and glocalization literature streams are discussed in this section. Additionally,

lessons learned are provided for managers, entrepreneurs, and ecosystem leaders.

The paradox of standardization and specialization is prevalent within all three streams. In software, a modular architecture enables the reuse of components in different applications. This naturally expands to platforms, a set of standard “technological building blocks” (Muegge, 2011a: 5) which enable complementary (specialized) innovation. Keystone leaders often use this strategy to maintain their status within the business ecosystem – ensuring that the complementors depend on their platform to develop new products. Lastly, glocalization emphasizes the duality of “universalizing and particularizing tendencies” which leads to a “family resemblance with all the other localized variants that accounts for the underlying universalizing dimension” (Meyer, R. E., 2014: 81). The global idea (platform) is adapted by local stakeholders (complementors) based on the unique characteristics of their environment.

Fitness is another construct prevalent across each literature stream. Originally introduced by Alexander as the mediator between a design problem’s context and solution, it emerges in both the glocalization and business ecosystem streams. Defined as the “relation of mutual acceptability between [context and form]” (1964: 19), achieving fitness is a key objective when designing an artifact. With respect to glocalization, the global model or idea is analogous to an artifact; when transmitted to a new context, it is adapted through “re-contextualization” in order to “gain legitimacy” (Meyer, R. E., 2014) – that is, achieve fitness – with the local context. The concept of fitness between a problem and its solution is also described as the elimination of paradoxes that exist within the problem (Dorst, 2006). In business ecosystems, a shared purpose creates coherency

between actors with conflicting motivations (Moore, 2006). Tsujimoto et al. define coherency as “the proportion of the actors whose behavior is naturally fit to their decision-making and behavioral principles in an ecosystem” (2018: 56). Notably, they discuss *natural* fitness between actors and the ecosystem; whereas in glocalization, the local actors actively *adapt* the global idea or model to *create* fit.

The *core-periphery* software architecture, originally described by Baldwin, MacCormack, & Rusnak (2014) is a system with a large core (a cyclic group consisting of functions with cyclic dependencies on each other) and relatively few peripheral functions (mostly independent from each other and the core). In ecosystems, platforms are intentionally designed as an indispensable component of the value creation and capture strategy, such that they are integrated into complementors’ offerings. This is also referred to as the keystone-niche dichotomy by Iansiti & Levien (2004). They argue that the importance of the keystone (or, the core of the ecosystem) “is such that, in many cases, its removal will lead to the catastrophic collapse of the entire system” (2004: 73). The core-periphery model is also represented in glocalization by the global and local, respectively. In terms of organizations, the core may be a central headquarters surrounded by peripheral branches, often located in different regions.

Several design-specific elements also appear in ecosystem literature. First, complex problems are often solved by incorporating new knowledge and perspectives. Ecosystems leverage communal resources – beyond a single actor’s knowledge and contributions – to realize the shared purpose (Bailetti, 2010). Second, hierarchy defines a specific architecture of path dependence between components in a system. Within

ecosystems, actors have a specific configuration architecture that enables value-creating activities (Adner, 2017). Third is the usage of patterns, commonalities between problems or system components that can be exploited to develop reusable solutions. Platforms are an excellent example of smart patterns, which “facilitate the generation of a potentially very large number of complementary innovations” (Gawer & Cusumano, 2014: 428) without developing entirely new core solutions. Finally, design is an evolutionary process that spans the problem and solution spaces. The evolution of an ecosystem depends on these complementary innovations that simultaneously diversify and specialize.

With respect to case study research and glocalization, there is an important connection. Glocalization is inherently multilevel, spanning the local-global dimension. Researchers of organizational glocalization behaviour should follow the guidance offered by management scholars (Hitt et al., 2007; Paruchuri et al., 2018; Carter et al., 2015) and ensure consistency across the level of theory, measurement, and analysis. A glocal idea is an entity that exists at several levels, and therefore data should be collected about both its recipient and source region, as well as the mechanism through which it was transmitted.

The salient lessons from this literature review are the following:

1. The universality of the standardization-specialization concept should be embraced by managers at all levels of operation. They can consider how to standardize certain processes, workflows, or products such that specialized solutions can be built on top of them.
2. Designing a platform with a core-periphery architecture may enable the ecosystem leader to extract more value by increasing the dependence of peripheral

innovations on the core.

3. When designing an ecosystem, create knowledge exchange opportunities to improve the value proposition for an actor to participate and contribute.
4. When designing an ecosystem, craft a value proposition that simultaneously: encourages the use of standardized assets (e.g. platform) and the growth of complementors' niche offers.
5. To reach consensus with a local population regarding a global issue/idea, employ a narrative that highlights either: fitness with the local environment, or its ability to bridge a gap between contradicting perspectives.
6. Researchers examining organizational glocalization should employ multilevel methods (with a consistent approach for theory, measurement, and analysis) to fully characterize the phenomena under study.

3 Research design and method

This chapter describes the research method undertaken for this thesis. The method follows Yin (2018)’s approach to case study research described in Section 2.4.1.

Accordingly, each section in this chapter covers one of the six phases in Yin’s process.

Table 5 summarizes the steps conducted in this case study.

Table 5: Research method steps

Step	Activity	Outcome
1	Define research questions, initial propositions, field setting, criteria for case selection, and data collection techniques	Research design
2	Develop the case study protocol, which includes protocol questions (lines of inquiry linked to research questions) and data collection procedures (key interviewees and participant groups, direct observation events, sources of archival data)	Case study protocol
3	Refine data collection procedures: <ul style="list-style-type: none">• Draft first level interview questions• Prepare template for data collection at events• Prepare template for archival data review	Table shells
4	Conduct data collection (Interviews, events, archival data)	Descriptive data about the cases
5	Conduct first level of data analysis: Construct maps and case reports of ecosystem structure for each case	Case reports
6	Conduct second level of data analysis: Cross-case comparison between cases at a regional and national level	Cross-case results
7	Conduct third level of data analysis: <ul style="list-style-type: none">• Explanation-building to link the ecosystem structure to design intent, and regional characteristics• Specification of design rules	Explanations and framework

3.1 Plan the case study

The research method adopted in this thesis is an embedded multiple-case study. Case studies are effective when studying research questions that take the form of “how” or “why”. Answering these questions involves “tracing of operational processes over time” (Yin, 2018: 10) – linking events, decisions, or external factors to the phenomenon under study. For this case study, explanations were sought to answer the following questions (the “how” and “why” are derived from the questions presented in Section 1.1):

As an organization that does not produce tangible products, innovations, or firms, how does Technovation map to the business ecosystem construct? How does a regional Technovation chapter localize the global processes and ideas? Why were certain regional decisions made? These pressing questions led to the selection of the case study method.

The case study method is often selected when the research question addresses “a contemporary set of events over which a researcher has little or no control” (2018: 13). In this thesis, the contemporary phenomenon under study is Technovation, a not-for-profit organization that empowers girls and families through technology and entrepreneurship (Technovation, 2019). The set of events comprising the individual cases are regional workshops and competitions over which the researcher had no control, as they were run completely independently. Thus, it was well suited for case study research.

As part of the planning phase, the researcher applied to and received approval from the Carleton University Research Ethics Board (CUREB)-B to conduct research involving human participants. The protocol was approved under Clearance numbers 111773 (data collection within Canada and the United States) and 112354 (data collection within Mexico).

3.2 Design the case study

The design of this study (Figure 3) is a hybrid between the single- and multiple-case designs presented by Yin (2018). The context is the 2020 Technovation Girls season, and the phenomenon is Technovation, which is comprised of embedded units: six regional chapters and one global organization. For this study, the units were treated as multiple cases, in order to conduct cross-case comparison and develop explanations

relating to regional characteristics. A holistic design (single context) was also necessary, to maintain the connection between the global and local. The cases themselves were bounded by the duration of the Technovation Girls program which ran from January 2020 to May 2020, followed by an international judging process and competition from May 2020 to August 2020.

Figure 3: Embedded multi-case design

3.2.1 Research design

Yin describes five components of the research design for a case study:

1. "A case study's questions;
2. Its propositions, if any;
3. Its case(s);
4. The logic linking the data to the propositions; and
5. The criteria for interpreting the findings" (2018: 27).

The following sections explore each component in further detail as it pertains to this thesis.

3.2.1.1 Research questions

The objective of this research is to examine the design of local ecosystems within a global organization. This is broken down into three research questions:

1. What is Technovation, and can it be described using frameworks from the business ecosystem literature?
2. What are the similarities and differences between local Technovation chapters?
3. What are the design rules for local Technovation chapters as defined by the global organization?

3.2.1.2 Propositions

This research is exploratory, and is not testing hypotheses. Therefore, *a priori* propositions are not offered. However, the research is based on scholarly literature in three areas: design rules, business ecosystems, and glocalization. The extent of previous research conducted in these fields provided a theoretical foundation for this study.

With respect to business ecosystems, there is no parsimonious theory agreed upon by scholars. Nonetheless, they have been studied deeply over the past two decades and several frameworks have emerged. In this study, four were used to map Technovation:

1. Multi-sided platform (Muegge & Mezen, 2017; Table 14)
2. Multi-sided platform (Muegge et al., 2018; Table 15, Table 16)
3. Multilevel system (Muegge & Mezen, 2017; Table 17)
4. Ecosystem as structure (Adner, 2017; Table 18)

Two frameworks were selected for the multi-sided platform representation because the platform view has become increasingly prominent within ecosystem

literature. Using two frameworks allowed the researcher to refine elements of the platform and its sides.

Additionally, as part of the literature review for this thesis, the author identified unique elements of a business ecosystem. Raw data was linked to these properties using the shell provided in Table 13. This approach differs from previous studies – which have simply mapped a phenomenon to particular frameworks – as it broadens the scope of analysis beyond elements contained within a single framework.

With respect to design rules, they are defined by Baldwin & Clark (2000) as an enforced design parameter. Design parameters are units of design that describe an artifact. According to the authors, a complete set of design rules for a given system address three aspects: architecture, interfaces, and integration.

Lastly, glocalization refers to the interdependency between global and local (Drori et al., 2014). Table 6, adapted from Drori et al. (2014), illustrates the scope of glocalization theory in this study. As this is a multilevel study of a single organization, only the vertical axis is relevant. The study is not examining several “equivalent entities” (horizontal axis), nor is it a historical account of Technovation (temporal axis).

Table 6: Glocalization theoretical framework

Glocalization axis	Elements of glocalization		
	What	Who	How
Vertical	In scope of this study		
Horizontal	Not in scope of study		
Temporal			

3.2.1.3 Cases

The cases in this thesis span three levels – an international organization, two

nations, and six cities. The case selection methodology employed purposive sampling which took into consideration theoretical and practical factors.

Theoretical sampling offers justification “such as replication, extension of theory, contrary replication, and elimination of alternative explanations” (Eisenhardt, 1989: 27). Further, “a particularly important theoretical sampling approach is ‘polar types,’ in which a researcher samples extreme (e.g., very high and very low performing) cases in order to more easily observe contrasting patterns in the data” (1989: 27).

Replication logic encourages case selection that exposes either similar or different results between cases. Between 6 and 10 cases allows for diversity within the sample; where some cases may be selected for supposed similarity, and others for supposed differences (Yin, 2018).

Table 7 identifies the cases selected, the region they belong to, and the rationale for their inclusion in this study.

Table 7: Case selection and rationale

Case	Region	Rationale
Technovation Global	Global	Representative of the global organization.
Ottawa	Canada	Resource model is based on an individual; capital city of Canada.
Montréal	Canada	Resource model is based on a board.
Calgary	Canada	Resource model is based on a university.
Guadalajara	Mexico	Longest standing Technovation chapter in Mexico.
Mexico City	Mexico	Capital city of Mexico.
Yucatán	Mexico	Newest Technovation chapter in Mexico.

Globally, there are over 90 Technovation chapters active across 53 countries. For this thesis, Canada was selected as one of the two nations for literal sampling: It is expected that the three cases within the nation exhibit a certain degree of coherency. Further, as the researcher is based in Canada, they had access to key resources and

informants to collect necessary data.

Within Canada, three cases were selected from a high-medium-low scale, representing the resource model of the Technovation chapter. The Calgary chapter is run by a university; Montréal by a committee; and Ottawa by an individual¹. The aim of using a tiered approach was theoretical replication.

Within Canada there are several active Technovation chapters other than those selected, including: Toronto, Vancouver, Waterloo, Edmonton, Winnipeg, Windsor, Hanover, Thunder Bay, and Niagara. They were also evaluated as candidate cases, however due to accessibility constraints, were not selected. One case for each tier (i.e., high-medium-low) was deemed sufficient for theoretical replication.

For the second region, Mexico was selected for theoretical replication, as its culture varies significantly from Canada's, according to the Hofstede cultural dimensions. Additionally, the Technovation chapters are organized differently than in Canada: there is a National Ambassador representing the entire country, in addition to Regional Ambassadors for each state. Practically, Mexico was also more accessible in terms of both: a) informants (via the Partnership Director, a member of the Technovation team); and b) travel. Compared to other candidate regions (Kenya, Palestine, and India), Mexico's relative proximity to Canada meant that direct observation was feasible.

Within Mexico, there are several active Technovation chapters. Through consultation with the National Ambassador, three prominent ones were selected: Jalisco (Guadalajara), Estado de México (Mexico City), and Yucatán (Mérida). The rationale for

¹Through data collection conducted after-the-fact, it was identified that Ottawa also has a committee.

case selection was not based on the same criteria as Canada (resource model); however, the National Ambassador indicated that the three chapters do vary in terms of organizational structure and content. Other chapters in Mexico include: Aguascalientes, Baja California, Colima, Guanajuato, Michoacán, Nuevo León, Querétaro, San Luis Potosí, Tabasco, and Veracruz.

The case selection rationale also considered similar features among cities. For example, Ottawa and Mexico City are both capital cities, which provided a common dimension for comparison.

3.2.1.4 Logical linking

Logical linking describes the analytic strategy and techniques used to link the case data to findings.

According to Yin (2018), there are four general analytic strategies for evaluating case data. For this thesis, a *grounded theory* approach was selected. As indicated by Yin, this method is appropriate when the data: has explanatory potential, or covers “an embedded unit of analysis within [the] broader case study” (2018: 169). Both these conditions were met for this case study. Further justification for this approach is that there is no existing theory describing the glocalization of ecosystems. To facilitate this approach, the researcher used a qualitative analysis tool *NVivo* to code the raw data against key topics derived from the literature. A snapshot of the case study database from NVivo is provided in Appendix H.

Two detailed analytic techniques were used in this thesis. First was cross-case comparison. This technique was selected because a primary focus of this research was

examining variance between regional ecosystems (cases), and specifying global design rules that impact regional ecosystem structure. The secondary focus of this thesis was understanding and explaining how and why this variation emerged, therefore explanation building was the second technique chosen.

3.2.1.5 Criteria for evaluating findings

Identifying and addressing rival theories is crucial to the legitimacy of a case study design and its findings. Wherever possible, the author attempted to counter the explanations produced in this thesis with rival explanations. Rival explanations relative to the findings are presented in Chapter 5, Discussion.

Prior to data collection, the following were suspect rival explanations:

1. Rival theory: Technovation is not in fact characterized as an ecosystem, but rather another organizational form such as an alliance or network.
2. Direct rival: Technovation chapters are not adapted locally, as they must strictly adhere to guidelines provided by the global organization.

3.2.2 Evaluating the case study design

There are several tests which can be used to assess the quality of a research design, as well as tactics for achieving validity. Table 8 lists the four tests and associated tactics, as defined by Yin (2018), and the approach taken within this study to achieve validity.

Table 8: Research design validity evaluation

Tests	Case study tactic	Means within this study
Construct validity	Multiple sources of evidence	<ul style="list-style-type: none"> • Interviews with multiple informants • Direct observation of case events • Archival data published by and on each case

Tests	Case study tactic	Means within this study
	Key informants review draft case study report	<ul style="list-style-type: none"> Regional Ambassadors and Technovation employees reviewed preliminary results The analysis was iterative; findings were updated and augmented based on feedback provided by informants
Internal validity	Explanation building	<ul style="list-style-type: none"> This data analysis technique leverages “how” and “why” data to explain how design decisions and regional factors led to observed behaviour and structures
	Address rival explanations	<ul style="list-style-type: none"> Rival explanations were considered and presented as part of the analysis
External validity	Replication logic (multiple-case study)	<ul style="list-style-type: none"> Theoretical and literal replication logic was considered in selecting seven cases
Reliability	Use case study protocol	<ul style="list-style-type: none"> A case study protocol was used. It provided guidance for data collection and minimized scope creep (particularly during interviews)
	Develop case study database	<ul style="list-style-type: none"> A case study database was used. Data was stored electronically and organized in a logical file structure
	Maintain chain of evidence	<ul style="list-style-type: none"> Bi-directional tracing between findings and data was maintained Data that did not trace directly to a finding was presented and explained

3.3 Prepare for the case study

In this phase, a case study protocol was developed in order to “anticipate several problems” (Yin, 2018: 94) and develop a mitigation plan. This protocol consisted of:

1. A case study overview;
2. Data collection procedures and strategies to obtain high quality data;
3. Protocol questions (lines of inquiry); and
4. Draft outline of the case study report (table shells).

3.4 Collect case study data

Data collection comprised of three modes, conducted in accordance with the case

study protocol:

1. Archival data;
2. Interviews; and
3. Direct and Participant-observation.

The subsections describe each mode in further detail.

3.4.1 Archival data

Archival data was the starting point for researching each case. To begin, the global case was examined to better understand Technovation and the overall context, and also develop preliminary findings and explanations to shape data collection for the regional cases. The Technovation Girls website (<https://technovationchallenge.org/>) provided an abundance of data including: internal studies, the program curriculum, the judging rubric, and access to the digital platform. Blog posts and a documentary film were also reviewed.

Regional chapter websites, if available, also served as a useful starting point for the cases in Canada and Mexico. They provided an overview of the chapter's organization, history, and key dates for the 2020 competition season. In addition, the researcher searched local business news publications, university-based publications, and the chapters' social media channels. The Ottawa and Montréal chapters produced handbooks for participants, which the researcher received a copy of.

A summary of archival data points for each case is shown in Table 9.

Table 9: Summary of archival data collected

Case	Number of relevant artifacts	Key sources
Global	54	Google Scholar Technovation website
Calgary	9	Calgary Herald University of Calgary website Workshop presentations
Montréal	6	Google Scholar Technovation Montréal website Student workbook
Ottawa	16	Business Source Complete Ottawa Business Journal Ottawa Citizen Carleton University Newsroom University of Ottawa Tabaret Student workbook
Guadalajara	13	The Guadalajara Reporter Mexico News Daily Universidad de Guadalajara
Mexico City	1	Universidad Nacional Autónoma de México
Yucatán	6	Technovation Girls Yucatán (Facebook) La Jornada Maya Yucatán Ahora Diario de Yucatán
Total	105	

3.4.2 Interviews

Interviews were a rich source of data for case-specific details. They were conducted both in-person and virtually. Globally, semi-structured interviews were conducted with Technovation employees, a board member, and the CEO. Questions were focused on the origins and evolution of the organization, its mission and objectives, and key activities and actors. Locally, semi-structured interviews were conducted with Regional Ambassadors, mentors, instructors, and representatives of partner organizations. These discussions focused on regional implementation, design decisions, and interactions with the global organization.

A summary of the interviews conducted is shown in Table 10.

Table 10: Summary of interviews conducted

Participant group	Case							Total
	Global	Calgary	Montréal	Ottawa	Guadalajara	Mexico City	Yucatán	
Employee	4	N/A	N/A	N/A	N/A	N/A	N/A	4
Board member	1	N/A	N/A	N/A	N/A	N/A	N/A	1
Regional Ambassador	N/A	2	1	1	1	1	1	7
Mentor	N/A	0	2	3	0	2	1	8
Instructor	N/A	0	1	2	0	0	0	3
Sponsor	N/A	0	0	2	0	0	0	2
Judge	0	0	0	0	0	0	0	0
Participant	N/A	0	0	0	0	0	0	0
Other	N/A	1	2	0	0	0	0	3
Total	5	3	6	8	1	3	2	28

3.4.3 Direct and participant-observation

Direct observation and participant-observation were used “to assess the occurrence of certain types of behaviors during certain periods of time in the field” (Yin, 2018: 121-122).

In terms of direct observation, the researcher attended several Technovation workshops and events in select regions, as shown in Table 11. They observed interactions between stakeholder groups, types of activities individuals were engaged in, and general management of the chapter. They also joined various communication channels, both global and local, and monitored some of the interactions between stakeholder groups.

For participant-observation they engaged directly with individuals, for example as a mentor, which involved guiding and supporting the students through several topics and exercises. The researcher also volunteered as a judge for the international competition. Through this process they scored six group projects from countries around the world.

Table 11: Summary of observation-based data collection

Case	Event
Global	1x Participated in the Technovation Girls quarterfinals judging process
Calgary	2x National celebration events
Montréal	3x Weekend workshops 1x Virtual workshop 2x National celebration events
Ottawa	1x Mentor training 8x Wednesday evening workshops 2x National celebration events ²
Guadalajara	1x Virtual workshop
Mexico City	1x Regional celebration event
Yucatán	1x Regional celebration event
Total	19

Initially, the researcher made travel arrangements to each of the three cities in Mexico, in order to attend workshops and conduct in-person interviews. However, due to the global COVID-19 pandemic and resultant travel bans, these plans were canceled. As such, participation was limited to virtual events and workshops.

3.5 Analyze case study data

The following steps were carried out to answer the research questions. First, all data pertaining to a single case was organized into a case report consisting of several table shells. Table 12 categorized the components and elements of the Technovation Girls program and local chapters; this information fed the other tables by providing tangible evidence of what Technovation is. Table 13 was used to evaluate whether Technovation can be characterized as a business ecosystem. Table 14, Table 15, Table 16, Table 17, and Table 18 were used to map the data to existing ecosystem frameworks.

²These events were held for all chapters in Canada, as such they are only counted as 2 events (versus 6).

Table 12: Table shell: Components and elements

Technovation region component	Technovation region element	Detailed description

Table 13: Table shell: Ecosystem properties

Ecosystem element (First-level)	Property (Second-level)	Technovation region
Actors	Interdependence	
	Relative position	
	Coopetition	
Anchor	Bounds the ecosystem	
	Centrally positioned	
	Shared purpose	
	Enable differentiation	
Activities	Resource flow	
	Co-evolution	
	Delivery of value proposition	
	Leadership & governance	

Table 14: Table shell: Multi-sided platform (MSP) representation (1)

Platform side	Participants comprising platform side	Value proposition for participants

Table 15: Table shell: Multi-sided platform (MSP) representation (2) – Part 1

Feature	Explanation of features	Technovation region
Sides	Platform sides	
	Characteristics of each side	
	<i>Expanded in Table 16</i>	
Platform	Processes	
	Components/Sub-components	
Controls	Contractual terms of direct interaction between sides	
	Openness	
	Membership rules for each side	
Desired outcomes	System-level objectives	

Table 16: Table shell: Multi-sided platform (MSP) representation (2) – Part 2

Side of platform	Contribution to the platform	Expected benefits from the platform

Table 17: Table shell: Multilevel system representation

Level of organization	Structure	Framework	Property	Technovation region
Organization of economic actors	Technovation ecosystem	Muegge (2011a)	Conceptual location	
			Anchor	
			Boundaries	
			Elements	
Organization of people	Technovation community	West & O'Mahony (2008)	Production	
			Governance	
			Intellectual property	
Organization of things	Technovation platform	Baldwin & Clark (2000, 2006)	Modularity	
			Option value	

Table 18: Table shell: Ecosystem as structure framework

Element of structure	Technovation region
Activities	
Actors	
Positions	
Links	

The researcher took a cross-sectional approach by completing the end-to-end case reports and cross-case analysis for a subset of cases: Global, Montréal, and Guadalajara. This allowed them to test whether the data fit with each framework. Challenges encountered with certain frameworks were identified through this initial analysis, and are explained in the Results chapter. Following this initial phase, the researcher proceeded with developing the remaining case reports.

Once the case reports were generated, tentative explanations for the observed behaviour within case case were proposed. The explanations linked the findings to “how” and “why” factors, such as design intent and regional characteristics of the case.

Finally, cross-case comparison was used to identify patterns. Cases were compared both within and across regions. Yin (2018) emphasizes the importance of considering the entire case, rather than its individual variables, when conducting this type of analysis. Hence, holistic parameters such as explanatory factors for cases were compared.

3.6 Share case study data

The findings of the case study are presented herein this thesis.

3.7 Summary

This chapter discussed the methods used to conduct an embedded, multi-case study in accordance with Yin (2018)'s 6-step process. In the next chapter, the results of the case study are presented.

4 Results

This chapter presents the results of executing the research method, including an overview of each case, specification of the Technovation ecosystem using various representations, outputs from the cross-case analysis, and articulation of design rules.

4.1 About Technovation

Technovation (<https://www.technovation.org/>), formerly Iridescent, is a global not-for-profit organization led by CEO and STEM champion Tara Chklovski. Its mission is to “[empower] girls and families to become leaders, creators and problem-solvers” (Technovation, 2019). Their mission is carried out by two programs: Technovation Girls (<https://technovationchallenge.org/>) and Technovation Families (<https://www.curiositymachine.org/>). Globally, the organization partners with prominent companies such as Google, Adobe, and Salesforce, as well as community partners who support various aspects of both programs.

Iridescent was founded in 2006 by Chklovski, who identified a significant gender and diversity gap in the engineering profession. Her goal in founding the organization was to create meaningful change for underrepresented individuals. The first program run by Iridescent, *Family Science*, took place at a school in Los Angeles in 2007 (Technovation, 2019). In 2010 Dr. Anuranjita Tewary, creator of the Technovation Challenge (today, known as Technovation Girls), reached out to Iridescent with an opportunity to pilot the program with 45 high school girls in the San Francisco Bay Area (Countryman & Olmsted, 2012). The resounding national success of the program in the

following years led to its global launch in 2013 (Torres, 2015). Since then, Technovation Girls has been the flagship program of the organization and is delivered in over 100 countries. Most recently, in 2018 the Technovation Families (formerly *AI Family Challenge*) program was launched (Technovation, 2019). This branch of the organization is not in scope of this thesis. All subsequent references to “Technovation”, “regional chapters”, or “global” refer to Technovation Girls.

The Technovation Girls program is a 12-week technology entrepreneurship competition for girls aged 10-18. Participants are tasked with identifying a meaningful problem in their community and developing a mobile application to solve it. Through lessons and exercises spanning ideation, design, coding, and pitching, participants are fully immersed in the product development lifecycle. At the end of the challenge, they are expected to submit a functioning application, a pitch video showcasing their product and accomplishments, and a business plan (for the senior division). Teams that advance to finals are able to attend the World Pitch event, and compete for a grand prize.

Being an international competition, Technovation has volunteers around the world who deliver programming locally. Cities or regions that run an official competition are known as chapters. Throughout this thesis they are referred to interchangeably as either “regional chapters” or “local chapters”. The individual responsible for overseeing a chapter is called the Regional Ambassador (RA). Within a chapter, there are several groups of volunteers, notably: mentors, who act as role models and guide participants throughout the entire competition; instructors, who deliver workshops on a specialized topic; and judges, who evaluate final submissions at the Regional Pitch Event.

4.2 Case overviews

4.2.1 Global

Technovation Global³ is comprised of core components (Table 19): the program itself, resources for key groups, and a support network. These components enable the delivery of a technology entrepreneurship competition for thousands of students around the world.

The Technovation Girls competition is a process that guides participants and volunteers. As a process it is sequential, and has inputs (registration), several steps (lessons, workshops), and outputs (the final project, prizes). Being an extracurricular program, extensive resources are available to support the volunteers who help run Technovation, as well as the participants while they are developing their projects. The network component connects individuals within and across groups.

Table 19: Technovation Global components and elements

Technovation Global component	Technovation Global element	Detailed description
Technovation Girls program	Curriculum	<ul style="list-style-type: none"> • 12-week lesson plan covering ideation, coding, entrepreneurship, and pitch material • Curriculum redesign (2020) • Translated versions of the curriculum
	Digital platform ⁴	Provides the following capabilities: <ul style="list-style-type: none"> • Volunteer and participant registration • Access to training material • Participant and mentor matching • Submission of final projects • Evaluation (judging) of final projects
	World Summit	<ul style="list-style-type: none"> • Virtual event for finalists in the competition • \$500 USD awarded to each team member of the 10 finalist teams • 2 Grand Prize Winners from junior and senior division • Special recognition awards for technology and people's choice

³The terms “Technovation Global” and “Global” refer to the case, a unit of analysis chosen for this research. “Technovation Girls” is the actual program that participants and volunteers register for.

⁴The digital platform – a technological asset – differs from the process platform described in Table 22.

Technovation Global component	Technovation Global element	Detailed description
Regional ambassador resources	Resource page	<ul style="list-style-type: none"> • Toolkit • Videos • Fundraising • Templates • Business cards
	Webinars	<ul style="list-style-type: none"> • 14 webinars total covering various topics
	Technovation staff members	<ul style="list-style-type: none"> • Regional support (Mexico, Latin America, Middle East; Asia; Africa; Europe, Canada, US) • Extensive one-on-one support • Support email staff
	Office hours	<ul style="list-style-type: none"> • 1hr/week/staff member
	Grants	<ul style="list-style-type: none"> • Funding available to chapters
Volunteer resources	Webinars	<ul style="list-style-type: none"> • Webinars total covering various topics
	Mentor resources	<ul style="list-style-type: none"> • Toolkit • Mentor training (mandatory) • Bi-weekly email • Mentor resource page (FAQ, submission criteria) • Mentor guide
	Judge resources	<ul style="list-style-type: none"> • Judge training (mandatory) • Instructions on evaluating submissions • FAQ • Email updates
Participant resources	Support email	<ul style="list-style-type: none"> • Weekly newsletter (curriculum, timeline, reminders)
	Submission guidelines	<ul style="list-style-type: none"> • Expected deliverable for junior and senior teams final submission.
	Rubric	<ul style="list-style-type: none"> • Rubric identifying how submissions will be scored.
	Code checklist	<ul style="list-style-type: none"> • Lists of coding elements to include in the application
Alumni program	Future opportunities	<ul style="list-style-type: none"> • Leadership opportunities • Coding camps
	Alumni coordinator	<ul style="list-style-type: none"> • Technovation staff member supporting the alumni program
Network	Slack	<ul style="list-style-type: none"> • Various channels for mentors, judges, and Regional Ambassadors
	Social media	<ul style="list-style-type: none"> • Instagram Live events (Problem solving tutorials #SolveItTeam; interviews with women in STEM)

4.2.2 Local

Calgary was the first Canadian city to host Technovation Girls, thanks to a unique connection: a distinguished University of Calgary alumni who happens to be the Technovation Global Ambassador. Through their extensive network across industry, academia, and government, the Global Ambassador convinced the University of Calgary

to champion the program. With support from the Dean of the University, the Global Ambassador recruited a Computer Science professor, Dr. Mea Wang, as the Regional Ambassador. In 2014, the inaugural Technovation Girls program in Canada was launched. Dr. Wang led the program for 5 years before transitioning the role to Dr. Lora Oehlberg. Dr. Oehlberg is a professor of Computer Science whose research is specialized in human computer interaction. In addition to leading Technovation, she hosts women in computing teas events to foster an inclusive culture at the University of Calgary. The case report for Calgary is presented in Appendix A.

The Technovation chapter in Montréal, Quebec was started in 2014 by two local women looking to have an impact on their community. Through the US Department of State's distinguished *International Visitor Leadership Program* (IVLP; <https://eca.state.gov/ivlp>) they met the Global Ambassador, who encouraged them to adopt the competition in their city. One of them has been serving as the Regional Ambassador ever since. Under their leadership for the past six years, the Montréal chapter has grown significantly: it has incorporated as a not-for-profit organization, partnered with several corporate and community organizations, and is now run by a team of more than a dozen women. The case report for Montréal is presented in Appendix B.

Technology expert, former IBM executive, and investor Jennifer Francis has been the driving force behind Technovation in Canada's capital region since 2015. Through a "friend of a friend" connection, Jennifer was introduced to the Global Ambassador. With early partners including the TIM program, Jennifer's former employer IBM, and local startup success story Shopify, the program gained credibility and has grown

tremendously in the past five years. Since its inception, over 700 girls have participated in Technovation Ottawa. The case report for Ottawa is presented in Appendix C.

Guadalajara is a metropolitan city in the Mexican state of Jalisco. Following an exodus of manufacturing jobs in the 1990's, the city "reinvested itself as a major center for research and development, programming, design, and other high-skilled tech occupations" (Selee, 2018). Since then, the city has seen a rise in startups and entrepreneurial ecosystems that simultaneously cultivate local talent and attract global talent. In 2010, Dr. Maria Makarova, a recent PhD graduate in engineering from Stanford University, stumbled upon the Technovation pilot program. After volunteering for the inaugural Technovation season and subsequently moving to Guadalajara, she was inspired to bring the program to her city. In 2013, Dr. Makarova officially launched Technovation in Mexico. The case report for Guadalajara is presented in Appendix D.

When Yanira Hernández – engineer, MBA holder, and project manager – heard about Technovation through a local radio show in 2015, she knew right away that she wanted to get involved. She reached out to the radio show guest speaker, Debbie Berebichez, the Global Ambassador for Technovation at the time, who connected her with Dr. Makarova. Yanira was encouraged by Dr. Makarova to leverage her strong technical and management background to start Technovation in Mexico City. Since 2015, she has led program activities, strategies, and a volunteer team. The case report for Mexico City is presented in Appendix E.

Mérida is the capital city of the Mexican state Yucatán. In 2018 Karla Patiño Leyva, a social entrepreneur based in Mérida, was looking for programs that focused on

female empowerment when she stumbled upon Technovation. Within five minutes of browsing the website, she had submitted an application to become the Regional Ambassador for the Yucatán. As a vibrant region with abundant resources for entrepreneurs, Yucatán is the most recent success story for Technovation in Mexico (The Yucatán Times, 2018). Karla leverages her strong connection with the startup community and partner organizations such as Women Who Code to offer an enriching program. The case report for Yucatán is presented in Appendix F.

4.3 Mapping to ecosystem properties

The first part of the first research question asks, “What is Technovation?”. In an attempt to codify ecosystem-like behaviour, the researcher conducted an extensive literature review (presented in Section 2.2), which built upon previous graduate-level coursework on the same topic. From this, key properties emerged. Table 20 maps data and specific examples from both global and local Technovation cases to these properties.

This first phase of analysis encompassed the global organization and regional chapters under study in order to provide a holistic view of the ecosystem.

Table 20: Technovation Global ecosystem properties

Ecosystem element (First-level)	Property (Second-level)	Explanation for Technovation	Examples
Actors	Interdependence	Among actors, there are interdependencies that span global and regional cases. The interdependencies are the social capital that fuel Technovation.	<ul style="list-style-type: none"> Regional chapters and global: Depend on each other for the curriculum, feedback, and guidance Participants and mentors: Support and value-added experiences Regional ambassador and mentors: Depend on each other for information, and to manage interactions with participants Global ambassador and Regional Ambassadors: Depend on each other to scale the program, and for support, guidance, and legitimacy (for new chapters)
	Relative position	The proximity between actors is not evenly distributed. Depending on their role, actors may be closer or further away from one another.	<ul style="list-style-type: none"> Global ambassador is closer to Regional Ambassador than other regional actors Regional ambassador is closer to Technovation Global than other regional actors Participants are closer to mentors than Regional Ambassador Partners are closer to Regional Ambassador than other actors Instructors are closer to Regional Ambassador than other actors
	Coopetition	Technovation thrives on collaboration: among participants, partners, and chapters. Although the program involves a competition, competition is not integral to the ecosystem.	<ul style="list-style-type: none"> Friendly rivalry among teams Regional ambassadors collaborate to share best practices Sponsors want to ensure they are well represented at events, workshops, etc. but do not seek to control the program
Anchor	Bounds the ecosystem	<p>Global: Commitment to supporting women and girls in STEM bounds membership.</p> <p>Local: The process creates a temporal boundary – the actors only interact for the duration of the competition.</p>	<ul style="list-style-type: none"> Global: Technovation actively seeks partners with existing initiatives for diversity in STEM, or that want to support these initiatives Montréal: The committee ensures that mentors are “engaged as part of a community throughout the entire program” (not necessarily beyond the program)

Ecosystem element (First-level)	Property (Second-level)	Explanation for Technovation	Examples
	Centrally positioned	This is not applicable to either the shared purpose or process as they are not actors. Technovation as an organization is centrally located in the technology hub of North America, Silicon Valley. Key actors including the CEO and Global Ambassador are connected to top companies through their personal & professional networks.	<ul style="list-style-type: none"> Global: As part of the <i>Tech Women</i> program, the Global Ambassador welcomes women from around the world to Silicon Valley. This environment provides the backdrop for recruiting Regional Ambassadors Global: Up until 2019 the World Pitch event was held in Silicon Valley, bringing together participants, Regional Ambassadors, and partners from around the world
	Shared purpose	Global: The anchor is the shared purpose. Local: The shared purpose is translated into the process.	<ul style="list-style-type: none"> Calgary: Mentors encourage participants to seek out role models in their careers, beyond Technovation Yucatán: The Regional Ambassador encourages girls to be autonomous to increase their self-efficacy
	Enables differentiation	Local: The process is adaptable by regions. It provides a framework rather than a blueprint. As long as regions comply with design rules, they can configure the framework as necessary for their local context.	<ul style="list-style-type: none"> Calgary: Teacher involvement is not prescribed by Technovation Global, but in Calgary they are the key set of individuals who deliver the program to students Yucatán: Additional sessions were held on topics relevant to empowerment and agency – not in scope of the official curriculum – but aligned with the shared purpose
Activities	Resource flow	There are continuous, bidirectional transfers between global and the regional chapters. Local: Members of various stakeholder groups are in constant communication with one another.	<ul style="list-style-type: none"> Global: Provides the curriculum, support, and other resources to regional chapters Guadalajara: Volunteers from Oracle translated the curriculum to Spanish and fed this back to global, to publish alongside the English curriculum

Ecosystem element (First-level)	Property (Second-level)	Explanation for Technovation	Examples
	Co-evolution	Regional ambassadors work with partners and their organizing committee (if applicable) to guide the direction of their chapter.	<ul style="list-style-type: none"> Calgary: As Technovation grew, the program was “upgraded” from the Department of Computer Science to the Faculty of Science, which offers additional resources, funding, etc. Ottawa: The Regional Ambassador, Shopify, and Carleton University have co-evolved over the lifespan of Technovation, from individually-led to committee-led As global receives feedback from participants, they continue to adapt their curriculum to respond to community needs
	Delivery of value proposition	Each actor has a unique value proposition that compels them to engage with the ecosystem.	<ul style="list-style-type: none"> Global (Influencers & community leaders): These individuals value the credibility and legacy of Technovation Ottawa (Regional Ambassador): The Regional Ambassador values the impact the program has on the girls, which she witnesses when participants ask for letters of reference, or when they accept internships at local tech companies
	Leadership & governance	<p>Global: Board of Directors provides guidance and support to the Technovation CEO and management team.</p> <p>Local: The Regional Ambassador, sometimes supported by a committee, is responsible for decision making.</p>	<ul style="list-style-type: none"> Montréal: Committee and Board of Directors provide logistic, organizational, and strategic oversight to Technovation Montréal Mexico: A national not-for-profit organization, Mentoralia, was formed to govern and scale the Technovation Girls programs in Mexico. 7 women are a part of the Mentoralia team.

For Technovation, the actors are individual volunteers, participants, and/or employees, as well as organizations. The anchor is simultaneously a shared purpose (global), the Technovation Girls process (local), joined by the focal firm. The activities are specific action these actors perform, or that they are subject to (e.g. co-evolution).

4.4 Mapping to ecosystem frameworks

In this section, results from the ecosystem mapping phase are presented.

4.4.1 Multi-sided platform representation (1)

The first multi-sided platform representation, which is based on Muegge & Mezen (2017), is depicted in Table 21. Technovation Global has 10 sides comprised of various actors (participants), both individuals and organizations; and each side has a value proposition that motivates the participants to engage with the platform. Sides are distinguishable by the role that they fulfill in the ecosystem; whereas participants (e.g. tech companies) may embody multiple sides.

Table 21: Technovation Global multi-sided platform representation (1)

Side of platform	Participants comprising platform side	Value proposition(s) for participants
Technovation employees	CEO Partnerships Corporate engagement Program coordinator Marketing & communications Event managers	Creating systems for women and families to solve problems through technology
Corporate sponsors	Adobe Google HSBC Salesforce Uber Others – see https://www.technovation.org/corporate-partners/	Alignment on initiatives that increase diversity in STEM Public demonstration of firm's support for diversity in STEM Employee engagement
Partners	UN Women Tech Women UNESCO	Supporting a program that has tangible impact on women in STEM
Global Ambassador	Champion for women and technology	Scale the Technovation Girls program globally
Board of directors	Representatives from top tech companies (often corporate sponsors)	Maintaining corporate engagement with Technovation
Volunteers	Regional Ambassadors Judges Mentors	Giving back to the next generation Being recognized as part of an international organization
Participants	Girls aged 10-18 from over 100 countries	Solving a problem they care about
Parents	Parents/guardians of participants	Doing what is best for their daughter
Student Ambassadors	Technovation Girls alumni	Professional development opportunities

Side of platform	Participants comprising platform side	Value proposition(s) for participants
Influencers and community leaders	University Deans CEOs of top tech companies City mayors Professional associations	Supporting women and girls in STEM Launching a credible, “ready-to-go” program, that has legacy

Several of these sides are present in both global and local instances of Technovation, including: partners, volunteers, and influencers. In the global instance, volunteers are represented as one side comprised of Regional Ambassadors, judges, and mentors; regionally, these participants occupy their own platform sides, because their role and contributions are amplified at the local level.

Conversely, sides such as schools and teachers are not present in the global instance. This is because of a management decision, explained by the Technovation CEO: “We’ve really steered clear of the school systems primarily because it’s been hard. Also because we have a logistical issue, it’s only a girls program”. Locally, schools play a critical role in recruiting and supporting girls throughout the duration of the program.

In terms of mapping to the regional chapters, this framework was easily adapted to the lower level of analysis and several platform sides were identified for all six cases. Section 4.5.1 presents details on the platform sides at the local level.

4.4.2 Multi-sided platform representation (2)

Table 22 and Table 23 present the results from mapping Technovation Global to the more recent multi-sided platform representation, based on Muegge et al. (2018). Two tables are provided in order to expand on specific contributions to, and expected benefits from each platform side.

Muegge et al. (2018), nor Sunna (2016), did not explicitly distinguish between

“process” and “components” in the explanations of their frameworks. Based on data from their field setting (Lead to Win), “process” was interpreted to mean a series of steps (i.e. the *what*), and components to mean the implementation details of those steps (i.e. the *how*).

Table 22: Technovation Global multi-sided platform representation (2) – Part 1

Feature	Explanation of features	Technovation Global
Sides	Number of sides	10
	Characteristics of each side	See Table 23
Platform	Processes	A cyclic process of recruiting, participating, and competing, with an optional feedback loop of re-engaging
	Components/Sub-components	Technovation Girls program Regional ambassador resources Volunteer resources Participant resources Student ambassador program Network
Controls	Contractual terms of direct interaction between sides	Registration, submission, judging must occur through the platform Official communications are sent from Technovation Global
	Openness	Within chapters, Global has no control over how sides interact Partners may recruit volunteers independently Global ambassador recruits Regional Ambassadors
	Membership rules for each side	Criteria for participant, mentor, and judge eligibility
Desired outcomes	System-level objectives	Increased self-efficacy of young girls and women Girls choosing to pursue studies in STEM fields

Table 23: Technovation Global multi-sided platform representation (2) – Part 2

Side of platform	Contribution <u>to</u> the platform	Expected benefits <u>from</u> the platform
Technovation employees	Knowledge	Personal satisfaction Salary
Corporate sponsor	Sponsorship Credibility Volunteers	Employee engagement opportunity Corporate social responsibility alignment
Partners	Support Visibility	Direct impact to their programs
Global Ambassador	Funding & support for Technovation Girls & World Summit Regional updates and insight	Scaling the program globally
Board of directors	Voluntary contribution of guidance & support	Maintaining corporate engagement
Volunteers	Time Resources	Personal satisfaction Recognition

Side of platform	Contribution to the platform	Expected benefits from the platform
Participants	Time Dedication	Knowledge Experiences Confidence
Parents	Support	Extracurricular opportunity for their daughter
Student Ambassadors	Visibility Recruitment	Professional development opportunities
Influencers and community leaders	Enabling Technovation in their region	Supporting women and girls in STEM Security, credibility & legacy of the program

Because of the explicit articulation of the platform and expected outcomes in the second framework, Muegge's (2011b) ecosystem dimensions can be used to classify Technovation Global as:

1. A collection of stakeholders
2. Anchored around the Technovation Girls process (Figure 4)
3. Bounded by platform rules for membership
4. Comprised of individuals and organizations

Figure 4: Technovation process

4.4.3 Multilevel system representation

The third framework used to map Technovation was Muegge & Mezen's (2017) multilevel system representation, shown in Table 24.

Table 24: Technovation Global multilevel system representation

Level of organization	Property	Technovation Global
Organization of economic actors (<i>Ecosystem</i>)	Conceptual location	<ul style="list-style-type: none"> • A not-for-profit organization and network of partners
	Anchor	<ul style="list-style-type: none"> • Shared purpose: To empower girls through technology
	Boundaries	<ul style="list-style-type: none"> • Partners must be committed to the shared purpose and mission of Technovation

Level of organization	Property	Technovation Global
	Elements	<ul style="list-style-type: none"> The organizations comprise individuals who participate in the community and develop/use the platform
Organization of people (Community)	Production	<ul style="list-style-type: none"> Technovation employees are responsible for producing and maintaining the curriculum, platform, and all other assets required to run the program The Board of Directors dedicate time, expertise, and personal connections to scale the program The “product” of Technovation is self-efficacy
	Governance	<ul style="list-style-type: none"> Led by CEO & founder Tara Chklovski The Board of Directors provides strategic oversight to the organization The Global Ambassador supports the growth of the program
	Intellectual property	<ul style="list-style-type: none"> The curriculum is publicly available online, but owned by Technovation Technovation makes no claims of IP over participants’ work
Organization of things (Platform)	Modularity	<ul style="list-style-type: none"> High modularity in design: The curriculum is comprised of independent lessons (units) High modularity in use: Roles in the Technovation platform are extendable, individuals can easily transition between them High modularity in use: The curriculum material is high-level, so it may be adapted by regional chapter instructors Low modularity in use: The curriculum is written in English which is not reusable by many regions
	Option value	<ul style="list-style-type: none"> High option value in design: Local programs may be enhanced by partnering with academic institutions, but are not required to deliver the program High option value in use: Participants are encouraged, but not required to submit their project in the Technovation Girls international competition High option value in use: Participants have the option to select any problem in their community High option value in use: Participants are encouraged, but not required to work with a mentor High option value in use: Participants may continue to work on their project after the competition is complete, but are not required to do so Low option value in use: Participants with no prior experience in technology may not be able to fully benefit from the program

Again using the Muegge (2011b) dimensions, in this representation, the

Technovation Global ecosystem is:

1. A level of organization
2. Anchored around a shared purpose
3. Bounded by a commitment to supporting girls and women in STEM
4. Comprised of organizations

The Technovation Global community:

1. Is responsible for the production of elements necessary to realize the shared purpose
2. Is governed strategically by a Board of Directors, and tactically by employees
3. Has control over the curriculum material, but makes no claims on the IP of participants' mobile applications or projects

The Technovation Global platform is:

1. A set of assets including the curriculum, participant/volunteer portal, and submission tool
2. A technology entrepreneurship competition process

4.4.4 Ecosystem as structure

The final framework used to map Technovation was Adner's (2017) ecosystem as structure representation. This framework has four elements: actors, activities, positions, and links. Although the original format was tabular (Table 18), after reviewing the raw data it was found that a graphic (Figure 5) better represented the structural elements.

Figure 5: Structural representation of the Technovation Global ecosystem

Using the Muegge (2011b) construct, in this representation the Technovation Global ecosystem is:

1. An alignment structure
2. Anchored around a focal firm
3. With no discernible boundaries
4. Comprised of actors and activities

In this representation, actors are represented as boxes. All sides from the multi-sided platform representation(s) are shown, except for influencers & community leaders, who act as a mediating agent between the Global Ambassador and partners.

The links are shown as arrows between actors. The transfers between the actors include information (feedback from the regional chapters to Technovation Global), funding (from a sponsor to Technovation Global), or material (resource packages and the curriculum, from Technovation Global to the regional chapters).

Activities and positions are not explicitly shown in this diagram. Based on Adner's definition of activities, these map to the Technovation process steps:

- **Recruiting** participants, volunteers, and partners
 - Running a social media campaign for volunteer applications and student registration
- **Participating** in the program
 - Preparing the curriculum, rubrics, and other material
 - Attending workshops and company visits
 - Developing a mobile application and business plan
 - Providing support, guidance, and mentorship to students
- Running the **competition**
 - Attending/organizing Regional Pitch Events
 - Submitting and evaluating thousands of projects
 - Selecting finalists
 - Attending/organizing the World Summit event
- Keeping people **engaged** after the season is complete
 - Becoming a student ambassador
 - Returning as a volunteer in the following season

With respect to positions, Adner suggests that actors have a fixed spot in the ecosystem. For Technovation, the not-for-profit organization (shown as the central “Technovation” box) resides upstream from all other actors. They flow information and resources to regional chapters and initiate several transfers to other actors. This position

is important in the ecosystem, as noted by a committee member of the Montréal chapter:

Seeing that foundation – coming from corporate, and having the global aspect being flowed down, it gives so much infrastructure and directive and clear vision and foundation.

Within the regional ecosystem instances, hierarchy is less prominent. Although Regional Ambassadors coordinate several activities and interface with Technovation Global, the general structure is much flatter. Mentors, participants, instructors and committee members are collaborating to learn together and support one another. This was evident as several volunteers cited co-learning as a primary benefit of participating in Technovation. For example:

Learning with the girls was worthy and incredible ... to code, to perform video editing, at the same time as them in order to guided and mentored [sic] them.
(Mentor, Mexico City)

I learned a lot through these workshops, that's one of the reasons why I'm involved. For sure it's amazing to see the girls evolve. That's impressive on its own. But I feel like when I mentored, and still today as part of the committee, I'm still learning a lot. It's great to have access to this type of content. (Committee member, Montréal)

4.4.5 Summary

Four business ecosystem frameworks were used to specify Technovation: a multi-sided platform representation (Muegge & Mezen, 2017); a second multi-sided platform representation (Muegge et al., 2018); a multilevel system representation (Muegge & Mezen, 2017); and a structural representation (Adner, 2017). Each specification was described using common elements from Muegge (2011b) as shown in Table 25.

Table 25: Summary of ecosystem specification

Ecosystem element	Multi-sided platform	Multilevel system	Ecosystem as structure
Conceptual location	Set of stakeholders	Level of organization	Alignment structure
Anchor	Process platform	Shared purpose	Focal firm
Boundaries	Platform membership rules	Commitment to shared purpose	N/A
Elements	Individuals & organizations	Partner & sponsor organizations	Actors & activities

4.5 Cross-case analysis

This section presents results of the cross-case analysis between the local cases.

4.5.1 Multi-sided platform representation

Table 26 is an overview of the multi-sided platform representation across each region. “S” indicates that the stakeholder group is a side of the platform; “P” indicates that the stakeholder group is a participant *within* a side (i.e. one of many).

Table 26: Cross-case analysis of local multi-sided platform stakeholder groups

Stakeholder group	Calgary	Montréal	Ottawa	Guadalajara	Mexico City	Yucatán
Participants	S	S	S	S	S	S
Mentors	S	S	S	S	S	S
Regional Ambassador	S	S	S	S	S	S
Partners	S	S	S	S	S	S
Instructors	S	S	S	S	S	S
Influencers	S	S	S	S	-	S
Teachers	S	P	P	P	P	P
Schools	S	S	P	P	S	P
Education system	-	-	S	S	-	-
Parents	S	S	-	-	S	S
Judges	-	-	-	S	S	S
Organizing committee	S	S	S	-	-	-
Clubs	-	-	-	-	-	S
Student Ambassadors	-	S	-	-	-	-
Board of Directors	-	S	-	-	-	-

Platform sides

As shown in Table 26, there are five core sides for each region: participants, mentors, the Regional Ambassador, partners, and instructors. The first three are “standard” roles defined by Technovation Girls, each with their own portal on the digital platform. Partners are not an official role on the Technovation platform, however Regional Ambassadors are encouraged to involve them in the process. According to the 2019-2020 Technovation Girls Regional Ambassador Handbook:

Involving community partners such as schools, after-school programs, nonprofits, or other local organizations to recruit students, provide meeting space, and leading students through the curriculum contribute to the strength and sustainability of the program.

One important similarity between both countries is the role of a national partner. In Canada this is Shopify, and in Mexico it is Oracle. Both organizations perform activities that contribute to the success of all chapters, beyond the boundaries of their physical sites. For the 2020 season, volunteers from Oracle translated the entire Technovation curriculum to Spanish, which is used by several chapters in Mexico. Shopify personnel created and shared common resources, facilitated in-person and virtual workshops for several regions, and hosted the National Celebration Event.

Instructors are experts in a particular topic, such as branding, sales, design, product management, or coding. They present the curriculum material at workshops and answer domain-specific questions.

Influencers are critical to establishing partnerships and growing the regional program. These are individuals (or organizations) with access to decision makers, who

advocate on behalf of Technovation. Influencers are particularly important when a chapter is just starting out, as they offer credibility and legitimacy to the program. Examples include connections from the school board of trustees (Ottawa), family members at sponsor firms (Guadalajara), and high-ranking university officials (Calgary).

Teachers and schools are important stakeholder groups. In each region, they perform slightly different roles. In Calgary, the teachers recruit students, coordinate weekly meetings between students and mentors (if there are additional mentors), and coach the students throughout the entire program. In the regions in Mexico, teachers are heavily involved, as they often take on the role of team mentor. Schools on the other hand refer to the institution itself, which provide facilities for students to work on their project.

Another interesting difference is where the education system is a side of the platform (Ottawa and Guadalajara). In both cases Technovation has the support from the local school board(s), a higher level than individual schools or teachers. This relationship facilitates access to both students and volunteer teachers, as the program is “pre-approved”. The Guadalajara Regional Ambassador spoke about this:

University of Guadalajara, their university campus got involved. And then there was interest from the people who oversee all the high schools. They did a push to have their teachers implement Technovation. That was actually super helpful.

They [University of Guadalajara] had female university students go to the surrounding high schools and invite girls to do a programming workshop and learn about Technovation. And they were really good at getting girls to show up and try it and sign up ... I think the closer they are in age, the more they engage and see it as a realistic thing for them to try out and participate in.

In terms of a formal partnership with the school board, the Ottawa Regional Ambassador

credited strong partnerships with local technology companies *and* academic institutions:

So getting schools to agree when I walked into the superintendent office at the Ottawa board, you're walking in with credibility that you wouldn't have if you were just an individual who'd set up their own not for profit. And I think that's what allowed me to get into the board level right from the start, which allowed Ottawa to scale. And I think you really need that.

In other regions, legal or administrative challenges prevented them from establishing a formal relationship with the school board. As the Montréal Regional Ambassador stated:

It's very, very hard to get into the schools ... You can't just go to a school board commission and pitch your project and they'll just spread it out. So it's almost like we have to go from one school to another.

The former Calgary Regional Ambassador described their efforts to work with the board:

We wanted to talk to the school board, say maybe this could be a some kind of official collaboration between the university and the school board. It was very, very hard for the public school to become like an official partner. It was a long negotiation. ... So after the long negotiation and all the legal consultant consultation we rolled it back to where we started. It's just direct school sponsored events, so it's entirely up to individual school to work it out.

In both Mexico City and the Yucatán, parents play an active role in the Technovation process, sometimes as mentors or instructors. In Montréal and Calgary, parents are provided regular updates but not directly involved in the program itself.

Judges represent a similar group of individuals as mentors and instructors – technology professionals, managers, and entrepreneurs. They are involved with Technovation for a shorter period of time, namely at the Regional Pitch Event. For 2020, in-person events were canceled due to COVID-19, hence there were no judges for the Canadian sites. However, in Mexico each region held a virtual event, where judges still evaluated the participants' projects.

The organizing committee is a collection of individuals responsible for oversight and administration of the chapter. The committee always includes the Regional Ambassador. In Calgary, it includes various representatives from the University of Calgary, mainly the Faculty of Science outreach office. In Ottawa, it is a set of representatives from key partner organizations, a mentor representative, and an instructor representative. In Montréal, the committee members have defined roles, covering all aspects of the program including the mentor community, partnerships, and curriculum development. In several cases, committee members have volunteered with Technovation in the past, and are looking to grow into a leadership position.

Clubs are a unique group observed only in the Yucatan. As organizations or institutions, they recruit mentors, provide workshops, resources, and facilities for participants, and may even have separate sponsors. Although their activities are fairly independent, they collaborate with the Regional Ambassador to ensure they follow official Technovation guidelines, and may participate in the Regional Pitch Event.

The Student Ambassador side is a defined Technovation role, however not all regions have adopted it. In Montréal, the presence of this side is tied to their objective of reaching a wider audience by leveraging the experiences of past participants.

Lastly, the board of directors is unique to Montréal because they are incorporated as a not-for-profit, which have a regulatory mandate to establish a board. It is complementary to the committee (which oversees logistics and administration), and provides strategic guidance and planning to ensure the long-term sustainability of the program.

Platform

The Technovation process platform did not vary widely between chapters. All six chapters had four components in common, although the implementation details varied: the program, events, a network, and resources. The program consisted of workshops, team meetings, and company visits. Each region had to recruit participants and volunteers, otherwise the program would not run. Events included regional or national end-of-season celebration events (virtual), industry or community events promoting Technovation and other STEM causes, and mentor networking. The network was comprised of various channels such as Slack or WhatsApp for communication. Resources included training packages, student workbooks, and translated versions of the curriculum.

In Ottawa, the program component was expanded by offering multiple variants of Technovation. They created a French program to cater to the city's large French-speaking population, as well as a "credit course" whereby students could receive a grade 10 credit for participating in Technovation (in addition to completing school-based lessons).

The three Canadian chapters also had organizational assets such as bank accounts, meeting space, personnel, and documentation. This reflects these chapters' decision to either partner with, or deliver Technovation through an institution (Calgary – the University of Calgary; Montréal – Technovation Montréal, a not-for-profit; Ottawa – Women Powering Technology). Note, this does not imply that the chapters in Mexico did not have organizational assets, just that there was no direct reporting of it.

Controls

Interactions between platform sides, whether controlled or open, varied from

region to region. For example, partnering with schools created some constraints. In Guadalajara, certain schools preferred teachers to be mentors, in which case the students would not interact with industry mentors. Also, male volunteers were required to partner with at least one woman in order to mentor a team of students. In Calgary, due to liability reasons, the university was not permitted to match mentors and students, which actually forced an open relationship between those two platform sides.

Interactions with partner organizations were typically controlled by the Regional Ambassador or keystone actor. This streamlined communication through a single person and provided consistent messaging from the Technovation chapter to external groups.

Most interactions between other sides – participants, mentors, and instructors – were observed to be fully open. At workshops – before COVID-19 – individuals socialized with others during breaks; outside of workshops, communication channels and social media platforms were bustling with people discussing various topics.

Desired outcomes

System level objectives for each region generally included the same points:

- Providing learning and growth opportunities for participants and mentors
- Increasing participants' confidence in their ability to solve problems
- Having a positive impact on participants' lives

Region-specific objectives included scaling the program to other parts of the province (Montréal), connecting technology professionals from the public and private sectors (Ottawa), and creating awareness of career opportunities for women outside of traditional fields (Yucatán).

4.5.2 Multilevel system representation

The researcher also mapped local Technovation chapters to the multilevel system framework. For the three regions in Mexico there was insufficient data collected, particularly at the economic actors level, to draw meaningful conclusions from this framework. The remainder of this section therefore discusses the Canadian chapters.

In this representation, the anchor was a keystone actor – the Regional Ambassador in Ottawa and Montréal, and the University of Calgary in Calgary. One notable difference at the economic actors level was the partnership model. In Montréal and Ottawa, the chapter and partners were interdependent. This is because the Regional Ambassadors, as individuals, required the support, funding, and legitimacy that partner organizations could offer. In Calgary, partners were complementary, but not essential to deliver the program. This is because the University has internal resources and personnel, as well as recognized status within the community to run the program independently.

The keystone actor – individual or University – translated to different production mechanisms at the community level, either voluntary or paid, respectively. Community governance activities were fairly consistent: providing oversight and strategic direction; the groups performing these activities varied.

The major difference at the platform level was program structure, which impacted modularity. In 2020, the season and resultant competition were greatly disrupted because of the global COVID-19 pandemic. In Calgary, completing the program in an online-only setting was limited by the program structure. In-school meetings normally facilitated by teachers came to an abrupt halt once COVID-19 hit. One of the University of Calgary

organizers speculated that with the lack of continuity, completion rates would drop drastically. In Montréal, workshops were held on a monthly-basis; these were more difficult to reschedule and also more significant if missed (due to adverse weather, for example) as a greater portion of the curriculum was covered in a single session. In terms of option value embedded in the platform, this led to differences at the “user” level – such as teams proceeding to the competition phase or not.

4.5.3 Structural representation

Using the same stakeholder groups from the multi-sided platform representation, the regional chapter structures were mapped using actors and links, similar to Figure 5. However, this framework did not provide valuable insight into design rules, regional characteristics, or evidence of ecosystem properties. Additionally, because such a small subset of participants from each chapter were interviewed, it was not possible to capture all possible transactions between actors.

4.6 Design rules

The final part of this research was to identify the design rules for Technovation. They are listed in Table 27. Design rules are program parameters or elements fixed by Technovation Global which flow down to the regional chapters, expressed as requirements. The design rule type is based on Baldwin & Clark’s (2000) classification, described in Section 2.1.2.

Table 27: Design rules for Technovation

Design rule expression	Type <i>Architecture Interface Integration</i>
Individuals must meet the student participation criteria to be eligible for registration in the Technovation Girls program.	Architecture
Individuals must meet the judge criteria in order to volunteer as a judge for Technovation Girls.	Architecture
Individuals must meet the mentor criteria in order to volunteer as a mentor for Technovation Girls.	Architecture
Individuals must meet the student ambassador criteria in order to volunteer as a Student Ambassador for Technovation Girls.	Architecture
Organizations must be aligned with the Technovation mission in order to become partners.	Architecture
Technovation Girls must be offered as a free program with no cost to participants.	Architecture
Regional Ambassadors require access to girls, access to mentors, and access to internet in order to start a new Technovation Girls chapter.	Architecture
Teams require access to internet in order to participate in the Technovation Girls program.	Architecture
Teams must meet the submission deadline in order for their project to be judged in the Technovation Girls competition.	Architecture
Teams will be categorized in an age division when they register in the Technovation Girls program.	Interface
Each team, mentor, and judge must register on the Technovation Girls platform.	Interface
Teams must use one of the approved coding languages if they wish to be eligible for judging in the Technovation Girls competition.	Interface
Judging must be done in accordance with the Technovation Girls rubric.	Interface
Submission items must be in English or have English subtitles.	Interface
The Regional Pitch Event must contain at least 10 teams in a division in order for the event results to formally count towards the Technovation Girls competition.	Interface
Questionnaires are distributed at the end of the season to evaluate increases in participants' interest in STEM and self-efficacy.	Integration
Teams should choose a problem within their community to solve.	Integration
Teams should comply with the submission guidelines and code checklist in order for their project to received the maximum possible points in the Technovation Girls competition.	Integration
Each Technovation Girls chapter must comply with the branding guidelines.	Integration
Technovation Girls chapters must not use "Technovation" in their organization's official name.	Integration
Regional Ambassadors must comply with the Code of Conduct.	Integration

Deriving the design rules was a 5-step process. First, the Technovation FAQ pages (<https://iridescentssupport.zendesk.com/hc/en-us/categories/115000091348-Technovation-Girls>) were reviewed for references to mandatory requirements (imposed either on the chapter, or a specific actor). Next, these requirements were cross-referenced against the interview data, to confirm whether local actors acknowledged the rules. Select

interviews with Regional Ambassadors and the Global Ambassador also revealed a few new design rules. Third, the design rules were expressed using natural language, according to Witt's (2012) nomenclature for articulating business rules. The fourth step was to identify a representative example of each design rule type, and categorize the remaining rules relative to these. Lastly, the resultant design rules were cross-referenced against the Technovation components (i.e., Table 19, Table 22). These two tables were selected to cover off both the programmatic and ecosystem components. This check confirmed whether there were design rules expressed for missing components. Not all design rules directly mapped – some were at a higher level than any one component. For example, the rule that states “*Teams require access to internet in order to participate in the Technovation Girls program*” impacts many aspects of the program – from the curriculum to digital platform to submission – yet is still a critical entry requirement.

5 Discussion

In this chapter, the three research questions are addressed, and findings are linked to theory and literature. Recommendations based on empirical evidence are offered to several stakeholder groups. Lastly, limitations of the study and opportunities for future research are discussed.

5.1 What is Technovation, and can it be described using frameworks from the ecosystem literature?

Technovation has many elements of a business ecosystem. Globally, Technovation is simultaneously: a multi-sided platform, a multilevel system, and an alignment configuration of actors. Locally, the multi-sided platform representation best captures the observed structures. The local ecosystems are not simply translations of the global ecosystem – their architectures are fundamentally different. The selected business ecosystem frameworks do not fully capture multilevel behaviour – such as anchors, boundaries, and elements that span and differ across the global-local continuum. The following subsections explore each framework and resultant findings in further detail.

5.1.1 Ecosystem properties

The following paragraphs discuss the evidence of ecosystem properties in Technovation, relative to the literature.

In terms of actors, they exhibited strong interdependence, meaning they “share the fate of the other participants in the ecosystem” (Iansiti & Levien, 2004: 77). One relationship that best illustrates this is between mentors and participants. Teams with a mentor have a more holistic learning experience and benefit from the exposure to role

models; meanwhile, mentors benefit from the teaching and leadership opportunities. The Technovation founder intentionally designed this into the process:

The mentors need to be learning new skills as much as the girls. So it's a co-learning model ... If the mentors don't see value, they're not going to come back, and if they're not going to come back then the girls will not get the dosage⁵ needed to develop and deepen their skills.

Therefore, the fate of mentors and participants are intertwined. Further, at an organizational level, the success of the program is influenced by this relationship: “we have found that teams that are connected with mentors are almost guaranteed to finish [the program]” (Technovation CEO).

The relationship between Technovation Global and its regional chapters resembles the keystone-niche dichotomy described by Iansiti & Levien (2004). As the keystone, Technovation Global “[provides] a stable and predictable set of common assets” (2004: 73) such as the curriculum and digital platform. As niche players, the regional chapters leverage these common assets to produce specialized offers (local Technovation programs) compatible with their region. They also differentiate themselves from other ed-tech and extra-curricular programs in the region in order to compete for funding and partnerships, as discussed next. The keystone also “helps participants respond to new and uncertain conditions” (2004: 73) – such as the COVID-19 global pandemic – by declaring that all in-person events must be canceled and moved online.

At an ecosystem level, Technovation competes with similar organizations. For not-for profits in the ed-tech industry, grant-based funding is imperative to their

⁵In this context, “dosage” refers to the thousands of hours of hands-on experiences and positive reinforcement required to build self-efficacy in a young person.

operations, and also highly competitive. In 2019, the *Innovation, Science and Economic Development Canada* institution released a grant called *CanCode*. The \$60 million program “aims to equip Canadian youth, including traditionally underrepresented groups, with the skills they need to be prepared for further studies, including advanced digital skills and science, technology, engineering and math (STEM) courses” (Government of Canada, 2019b). In an effort to scale Technovation across Canada, the Ottawa Regional Ambassador and Global Ambassador applied for this grant. However, they not awarded any funding; meanwhile, over two dozen Canadian-based organizations received funds.

Despite the fact that the program itself is a competition, there was little competitive behaviour observed between individuals. Among sponsors, there was no evidence that they competed against one another for the spot as “top sponsor”. As the Regional Ambassador of Calgary stated:

Technovation is sort of that neutral ground that, Google and Facebook and Apple and all of these people who would otherwise be competitors, can all agree that this is an awesome way to get more girls interested in coding. So, instead of trying to reinvent the wheel 50 times, let's think about this once in a way that has a global impact.

However, one instance of collaboration among competitors is not indicative of coopetition, as Bengtsson & Raza-Ullah (2016) clearly note in their systemic review of the concept. The ecosystem literature includes coopetition as a key property, yet does not fully unpack the underlying mechanisms. Future research could apply the Bengtsson & Raza-Ullah “dynamic multilevel model” (2016: 33) to an ecosystem setting, in order to explore coopetition in this complex and interdependent environment.

Based on the framework mapping shown in the previous chapter, Technovation

has 3 anchors: a process, a shared purpose, and a focal firm, as depicted in Figure 6.

Figure 6: Technovation ecosystem anchors

The process bounds the actors who directly interface with the competition – participants, volunteers, and the Regional Ambassador. However, for corporate sponsors and partners, the competition process is not as significant as the *impact* it has on the industry. Rather, they are anchored by a shared purpose of empowering women through technology. Lastly, the keystone actor (Technovation, the organization) is a bridge between the two levels, bounding the entire ecosystem. In other words, an ecosystem anchored by the same shared purpose could exist on its own; similarly, an ecosystem anchored by a technology entrepreneurship competition could also exist on its own. However, they are not separate, they are mutually reinforcing, and connected *through* Technovation.

The “centrally positioned” property does not apply to the shared purpose nor process anchors. These anchors are not positioned relative to other actors at the same “level”, therefore they are neither central nor peripheral. On the other hand, Technovation (the organization) is centrally located in Silicon Valley. This position is used as leverage

to form relationships with key partners. As well, it offers legitimacy to regional programs. As the Global Ambassador stated about the impact this had on the Regional Ambassador of Montréal:

That link with Silicon Valley was very important for [her] ... So the next time I went [to Montréal] during the pitch event ... I took my colleague from LinkedIn with me. And that really helped [her] cement the program. Because, I told you in the very beginning, it has to be a win-win in that very local environment. So for [her] to bring in people from Silicon Valley, for us to get a little bit of a, you know, media push, for her to be able to put it on the website really helped. And she's been running the program ever since.

Here, it is evident that Technovation's position in the technology hub of North America provided momentum to a regional program over 4,000 kilometers away.

Moore's most recent writing examines "third generation" business ecosystems – communities of ecosystems – connected by shared purposes of technology, standards, or business practices (Moore, 2013). For Technovation, the shared purpose comprises a set of values (diversity, learning, community) reflected in practice. The commitment from top companies to this purpose is evident by the initiatives they lead independently from Technovation – educational grants, summer camps, and leadership programs, to name a few. Sitting on the Technovation Board of Directors, providing funding and other in-kind resources are their direct contributions to the Technovation ecosystem.

In order for niche players to "develop specialized capabilities that differentiate it from other companies in the network" (Iansiti & Levien, 2004: 77), keystone actors "adopt architecture and standards that enable differentiation rather than enforce uniformity" (Moore, 2013: 30). In early ecosystem writing, specialized capabilities and

modular architectures largely referred to microprocessors and semiconductors. However, as demonstrated by Technovation, a shared purpose also enables differentiation. By aligning on key tenets (self efficacy, building confidence, problem solving), the realization of the shared purpose remains flexible: Regional Ambassadors may adapt the program to suit their local environment, while still adhering to high-level objectives.

Co-evolution within the Technovation ecosystem is best illustrated by example. In Ottawa, Jennifer Francis started Technovation alongside key partners: IBM, Shopify, and Carleton University. As the Shopify representative stated, in early days they were “involved, kind of in a scrappy way, where there was two employees supporting the program, totally on the side. There wasn't any team support or specific budget for it”. After a couple of years, the company formally adopted the program – providing dedicated resources and funding through their Social Impact Team. Meanwhile, Carleton University provided mentors, instructors, and judges – namely through the TIM Program. Shopify expanded their involvement to three other cities, co-located with their company offices (Toronto, Montréal, and Waterloo). Meanwhile, in Ottawa they continued to spearhead local initiatives, including a Technovation retrospective – a common practice for software companies. Through this exercise, the need for an organizing committee was identified. This formal group enabled better communication with volunteers, leading to increased mentor engagement and support. A long-standing mentor noted one improvement – a mentor information session – that was a direct result of the retrospective:

This is year three, there are a lot of really good changes. Initially, just with a mentorship session early on ... you could tell from the questions that people really appreciate it, because there were even some questions from year three or four

mentors, so it was really good to network.

Other initiatives, such as developing an official high school credit-course variant of Technovation, were the result of collaboration between all committee members. Now, 5 years since the inception of Technovation Ottawa, Carleton University will be formally managing the program starting in the 2021 season. Meanwhile, Shopify has become a national partner – supporting all Canadian Technovation chapters, regardless of geographical location. This story exemplifies “reciprocal interactions” (Muegge, 2011b: 22) between the process itself and ecosystem actors. Incremental support from one actor nudged others to contribute something, which then led others to contribute, and so on.

As shown in the multi-sided platform representation (Table 21), each side has a unique value proposition that “express how each stakeholder group experiences value differently” (Muegge & Mezen, 2017: 164). Delivery of each value proposition is not a separate activity, but is carried out through these reciprocal interactions, in which a contribution or action from one actor results in received value by another actor.

Locally, the Regional Ambassadors provide leadership by supporting participants and volunteers, as well as advocating on behalf of the chapter. They perform a multitude of tasks: setting up students with a mentor, tailoring the workshops to the community’s needs, and providing a vision for the future of the program, to name but a few.

Volunteers and partners recognize the level of dedication from Regional Ambassadors, and the value they create through activities such as branding, communications, and strategy.

In summary, as shown in Table 28, Technovation demonstrates behaviour

consistent with most of the core ecosystem properties identified earlier in this report.

Table 28: Summary of Technovation ecosystem properties

Element	Property	Supporting evidence for Technovation
Actors	Interdependence	Yes
	Relative position	Yes
	Coopetition	No
Anchor	Bounds the ecosystem	Yes
	Centrally positioned	Yes
	Shared purpose	Yes
	Enables differentiation	Yes
Activities	Resource flow	Yes
	Co-evolution	Yes
	Delivery of value proposition	Yes
	Leadership & governance	Yes

5.1.2 Technovation as a multi-sided platform

Both multi-sided platform representations of Technovation Global (Table 21, Table 22) include the same sides. However, the Muegge & Mezen (2017) framework includes *only* sides, whereas the Muegge et al. (2018) framework adds important elements such as contributions to the platform, specification of the platform itself, interactions between sides, and ecosystem objectives.

The Muegge et al. (2018) framework also swaps out value proposition for expected benefits. An example is provided to explain the distinction. Although Technovation employees *receive* a salary and personal satisfaction from their job, these benefits amount to a more holistic value proposition: “creating systems that empower girls and families”. Depending on the context in which the framework is being applied – an academic exercise versus designing a nascent ecosystem – the difference matters. As Anderson, Narus, & van Rossum state, simply listing all benefits is not an effective value proposition: “many, even most, of the benefits may be points of parity with those of the next best alternative, diluting the effect of the few genuine points of difference” (2006:

93). Users of these tools should consider their target audience when preparing ecosystem maps and select a framework that effectively communicates its value.

One challenge encountered with this representation is the fundamental assumption that all sides are connected through the platform (process). However, for Technovation Global not all sides directly interacted with the process, rather they were connected through a shared purpose. Therefore, application of the term “sides” was expanded to encompass all stakeholder groups involved in Technovation. This framework could be improved by placing these ancillary groups relative to the platform in a way that shows their contributions to a higher-level shared purpose, rather than the process itself.

5.1.3 Technovation as a multilevel system

Using the multilevel system framework revealed insights into Technovation that were not visible in other frameworks, but also had internal inconsistencies.

First, behaviour exhibited by Technovation that mapped to a specific property did not always align with its level of organization within the framework. For example, there are boundaries to participate in the competition: registering on the platform and meeting certain eligibility criteria. However, these boundaries involve members of the community and the platform itself, as opposed to economic actors, which is where the framework placed the “boundaries” property. Similarly, the regional Technovation communities are not subject to formal governance; instead, economic actors (the Board of Directors and CEO) perform governance activities. However the framework had placed this property at the community level. A possible explanation for this inconsistency is that the community design properties come from the open source software field. For a group focused on

delivering a program rather than developing a product, the need for formal policy and hierarchy may be less important. These discrepancies are summarized in Table 29.

Table 29: Discrepancies between property's level of organization

Property	Level of organization (framework)	Level of organization (observed)
Boundaries	Ecosystem	Community Platform
Governance	Community	Ecosystem

Regarding platform properties, it offers high option value. Participants can gain as much value from the ecosystem as they put in, without having to engage with all aspects of the process. Mentors frequently cited this as one of the strengths of Technovation – encouraging girls to try new things and discover new interests in a safe environment. Mentors also recognize that the diversity of topics covered in the curriculum is analogous to the variety of career options available in high-tech. As stated by one mentor in Ottawa:

You understand that if [coding] isn't exciting them, that's okay, because that's just not their thing. But if it is, leverage it. Just because it's not exciting them at that level, doesn't mean they can't, and should not, pursue technology. Don't forget you don't just have to build the thing, you can promote it, use it, market it, you can be a product manager.

Consistent with Baldwin & Clark's (2006) findings that option value increases voluntary participation, the fact that Technovation Girls is an extracurricular program is paramount to its success, as stated by the CEO:

Kids only spend 20% of their time in school. So I think that's why we chose this model. And many times we've done a study where we compare the same curriculum that we ran in school, and out of school with the parents – and the kids have higher scores for the program out of school, because they have so much fun.

The tiered approach to participation is another core tenet of option value embedded in the Technovation platform. For volunteers, the level of commitment on a

low-medium-high scale approximately maps to these roles: judge/instructor-mentor-regional ambassador. One does not need to fully commit to the most demanding role (Regional Ambassador) in order to receive value. Volunteering as a judge or instructor, even for a single event or workshop, is highly rewarding for those individuals. Mentors expressed even more personal satisfaction, particularly from witnessing the growth of their students over the course of several months. Lastly, for Regional Ambassadors the impact is even greater: contributing to positive, long-lasting changes in STEM fields.

In terms of modularity, the curriculum was designed as a fully modular system: independent, reconfigurable lessons (units) comprised of core concepts, theory, and ideas. Chapters following a different program structure or timeline could tailor the curriculum as-needed. However, one key property of the curriculum led to low modularity in-use: being written in English. Several chapters expended significant effort translating the curriculum in order to use it in their region.

5.1.4 Technovation as a structural ecosystem

Mapping Technovation using the ecosystem as structure framework presented a few challenges. First, the resulting map shown in Figure 5 clearly illustrates that all actors are connected to Technovation (the organization), suggesting it is a focal firm. This contradicts with Adner's structural definition of an ecosystem, which is anchored "around the focal value proposition, not a focal firm" (2017: 55). In this study, there was no evidence of a focal value proposition. Because of the variety of actors engaged with the ecosystem, they each had a unique value proposition. For example, corporate sponsors care about offering a meaningful and engaging volunteer experience to their employees.

Meanwhile, participants value the opportunity to solve a problem in their community while building teamwork skills and boosting their self-confidence. These are not mutually exclusive – they simply communicate different points of value to different “customers” of Technovation.

Based on the field setting of Adner’s article and the example provided, the delivery of a value proposition applies to a singular customer. This conflicts with the multi-sided platform perspective, because each side is comprised of several actors who inherently value different ideas, practices, and technologies.

Additionally, the structural framework refers to actors, while the other frameworks refer to sides and participants. For most cases, “sides” could be considered analogous to “actors”. However, in some cases this does not provide sufficient granularity. For example, in the Ottawa ecosystem there is a side for partners. Using a single box to capture this side hides important details about interactions *within* that side – for example, how some of these partners initiate new partnerships and lead key program initiatives. Further, this framework does not account for transfers that are mediated through the Technovation digital platform, such as registration in the competition and submission of the final project.

In summary, this framework depicted the complex configuration of actors in the ecosystem. However, not all underlying constructs mapped to observed data and behaviour. This could be due a few factors: lack of empirical examples that apply this framework to reference during the mapping exercise, misalignment in field settings, or misinterpretation of the structural diagram and its implications for the ecosystem.

5.1.5 Summary

Specifying Technovation as an ecosystem led to four key findings.

First, global and local Technovation ecosystems have a similar relationship as a keystone and niche players, but span the global-local dimension: one central keystone (Technovation Global) and several niche players (regional chapters). The behaviour of these entities was consistent with Iansiti & Levien (2004)'s description (Technovation Global contributes required resources; regional chapters develop specialized offers). The rival explanation is that this construct does *not* map to a multilevel ecosystem – it was originally conceived as a “one-to-many” dichotomous relationship, and does not account for middle layers (e.g. the national level observed in Mexico). Examining the intersection of the keystone-niche construct and glocalization – perhaps by studying multinational corporations (MNCs) and their local subsidiaries – could resolve this discrepancy. The relevance of keystone strategy and ecosystem health measures (productivity, robustness, niche creation) to MNCs could be an interesting area for future study.

The second finding is the presence of three anchors. The researcher could not find any cases of a multi-anchor business ecosystem described in the extant literature, nor did any of the frameworks account for this. The global anchor is a shared purpose comprised of universal values; the local anchor, a process platform, is a specific manifestation of this shared purpose. The keystone actor reconciles this by anchoring the global and local in a (quasi) tangible artifact – a not-for-profit organization. This structure reflects the “simultaneity and interdependence of particularizing and universalizing tendencies” (Drori et al., 2014: 6) central to glocalization.

Third is the tiered participation model employed in Technovation. This approach limits the barriers to entry for participants and encourages their growth by offering a clear pathway to increased contribution and involvement. While this model is not novel – it was central to the Eclipse Foundation platform (Muegge, 2011c) – its presence in Technovation shows that the approach can be useful in various field settings, beyond open source software.

Lastly, observation and articulation of the Technovation platform is an important finding because it provides empirical evidence that process platforms are applicable to other types of ecosystems than venture-creation. This validates Sunna's (2016) speculation, and suggests that the multi-sided platform structure is flexible enough to accommodate various ecosystem types. It should continue to be studied and adopted in the not-profit world, where change and impact are the desired outcomes, rather than products and services.

5.2 What are the similarities and differences between local Technovation chapters?

Between Technovation chapters, the main similarities are: the platform processes, platform components, and core platform sides. The main differences are: niche platform sides, participants comprising the platform sides, implementation of platform components, and interactions between sides. The similarities and differences are attributed to local factors, national factors, and the global platform, elaborated in the following sections.

5.2.1 Local factors

There are three local factors impacting Technovation chapters.

First, characteristics of the keystone actor contribute to differences between chapters. Each keystone has their own network – of potential sponsors, professional associations, and social groups – which influences the diversity of individuals and organizations involved in their chapter. For individuals, their professional background and prior experiences also shape the orientation of the program – be it more focused on coding, entrepreneurship, design, or an even balance of all elements.

Regional characteristics are the second contributing factor. Examples of these characteristics include the school board structure (which determines how simple or difficult it is to establish a formal partnership), strength of the local tech sector (as a key source of partners and volunteers), and the language(s) spoken in the region (as a determinant of whether the curriculum is translated or not).

Lastly, the institutional setting – that is, the type of institution that “houses” Technovation – significantly impacts the chapters. In the university setting, liability concerns constrain certain partnerships, events, and interactions. In the not-for-profit setting, complying with the rules of incorporation while optimizing funding and resources is a priority. Although not in scope of this study, the Global Ambassador spoke about a chapter in Kenya that is embedded within a local telecommunications company’s internship program. This impacts how they initially positioned Technovation, in order to highlight benefits for the company and secure valuable resources such as conference rooms.

5.2.2 National factors

At the national level, additional patterns in the similarities and differences between chapters emerged. The three driving factors are: culture (represented by the Hofstede cultural dimensions), infrastructure, and socioeconomic.

A notable difference between the two countries' Technovation programs is the national presence in Mexico. Dr. Makarova established the not-for-profit *Mentorialia* (<https://www.mentorialia.org/>) to support the program and raise its visibility across the country. In addition to her role as the Regional Ambassador for Guadalajara, she is also the National Ambassador for Mexico. She supports new chapters by providing them with resources and connecting them with the Regional Ambassador community. Technovation Mexico has a strong social media presence, which they use to highlight student and volunteer success stories, events, and opportunities from all chapters across the country.

In Canada, a national organization does not yet exist – although there is momentum. In 2020 an inaugural (virtual) “National Celebration Event” was held, bringing together over 300 people from across the country to celebrate the end of the Technovation season. Further, the Regional Ambassadors (in this study) expressed interest in establishing the Technovation Canada brand, raising visibility of the program, improving communication between chapters, and expanding to other cities, provinces, and territories.

The unity of regional chapters in Mexico may be related to the Hofstede *individualism* dimension – in which the country scores low (30) – meaning it is a collectivist society. Shared resources, support networks, and funding for the benefit of all

Technovation Mexico participants may be the manifestation of “long-term commitment to the member ‘group’” (Hofstede Insights, 2020). Meanwhile, with a higher score (80), Canada is an “individualist culture” (Hofstede Insights, 2020).

Across the three chapters in Mexico, Regional Ambassadors described a specific challenge that participants face with the curriculum structure. In Mexico, it is common for students to be closely guided through lessons by a teacher or parent, rather than performing self-guided study, which is the Technovation model. As suggested by one Regional Ambassador, this may be a result of the hierarchical society in Mexico. The Hofstede *power distance* dimension explains that in hierarchical societies “people accept a hierarchical order in which everybody has a place” (Hofstede Insights, 2020). Mexico has a score of 81 on this dimension, quite high relative to Canada’s score of 39.

Each chapter in Mexico emphasized the importance of recognition, both for participants and volunteers. Students may receive prizes for completing parts of the curriculum or actively participating in workshops. Depending on the school, teachers may receive credit for their involvement in the program. In addition to certificates provided by Technovation Global at the end of the season, mentors and other volunteers are recognized for their dedication on social media. This may be a reflection of the country’s rating on the *masculinity* cultural dimension. Scoring fairly high (69), Mexican society values “achievement and success” (Hofstede Insights, 2020).

In terms of infrastructure, reliable internet connection to access the curriculum was a challenge for many students in Mexico. This was exacerbated due to COVID-19, when all Technovation programming was moved online and students could no longer

access computer labs at their schools or workshops. In Canada, Regional Ambassadors did not identify this particular issue as a barrier for participants.

One similarity between the two countries was the ease of recruiting participants from private schools. Regional Ambassadors cited direct access to teachers, a simpler administrative structure, greater budget flexibility, and student/parent engagement on social media as key attributes that facilitated this process. Despite varying socioeconomic landscapes, the relative wealth of private schools compared to public schools appears to be a common factor in both Canada and Mexico.

Besides culture, infrastructure, and socioeconomic factors, other national attributes were not observed to impact Technovation. However, regulatory and political factors would likely be very important to other organizations. A possible explanation is that Technovation is an extra-curricular program, not a controlled product or service, therefore not subject to national jurisdiction.

5.2.3 Global platform

The process platform is defined by Technovation Global, and is a source of both similarity and difference. On one hand, design rules and alignment on the shared purpose promote homogeneity across chapters. Conversely, the modularity and option value of the platform enable differentiation. Certain sides, such as the Student Ambassador role, are adapted at the regional level and “plugged in” to the platform. Further, actors from the same stakeholder group (e.g. a teacher or University) may have a different role (i.e. be a part of another side) in each region. Option value can be invoked at the local or user level: the Regional Ambassador may choose to host certain workshops or events for the

entire chapter, but the users (i.e. students) may choose whether to attend or not. The Regional Ambassador may also choose to teach only one approved coding language in the workshops, but students may choose to develop their mobile application in another approved language.

5.2.4 Summary

Within Technovation, similarity emerged at the local level (between select cases), the national level (between cases in the same country), and then at the global level (between all cases). Differentiation was observed at the user, local, and national levels. Homogeneity at a global level and heterogeneity at a local level is simply the manifestation of the duality of form, expressed by Alexander: “As a unit it will fit into the hierarchy of larger components that fall above it; as a pattern it will specify the hierarchy of smaller components which it itself is made of” (1964: 131).

5.3 What are the design rules for local Technovation chapters?

21 design rules for local Technovation chapters were identified (see Table 27). In the following sections, the design rules are elaborated upon and linked to glocalization theory. Key findings from across the three research questions are also synthesized into a holistic framework.

5.3.1 Specifying Technovation design rules

The design rule construct mapped neatly to the ecosystem elements of Technovation. Architectural design rules define requirements for components of the platform process – for example:

- Recruit: Eligibility criteria for participants and volunteers

-
- Participate: Cost to participate, access to internet
 - Compete: Meeting the submission deadline

These rules are “architectural”, because they constrain *what* and *who* is part of the system. If individuals do not meet the eligibility criteria, they will not be able to participate in the process; if they do not have access to internet, they will not be able to submit their project; if they do not meet the submission deadline, their project will not be included in the international judging process. These constraints are consistent with Baldwin & Clark’s (2000) explanation of architectural design rules.

Interface design rules streamline communication between platform sides. Registration on the digital platform enables mentors and participants to match with each other. Using one of the approved coding languages facilitates the judging process by providing standard criteria to evaluate submissions against. Interface rules also establish common terminology, such as “junior” and “senior” team divisions, and the “Regional Pitch Event”. This helps streamline communication between chapters and Technovation Global. From interviews with individuals in both Canada and Mexico, they had adopted these terms in their regions. These various communication protocols fulfill the role that Baldwin & Clark envisioned, describing how modules “fit together, connect, [and] communicate” (2000: 77).

As a social system comprised of people and processes, one cannot simply run a system integration test to determine if Technovation meets its specifications. However, the integration rules do provide checks and balances to ensure that the system as a whole remains cohesive and functional. Post-season questionnaires sent to participants evaluate

the impact the program had on them, i.e. “how well it [the system] works” (Baldwin & Clark, 2000: 77). Guidelines for the project submission, chapter branding, and codes of conduct ensure consistency across the program.

Baldwin & Clark describe an approach to create and express design rules for a modular system, using a design structure matrix (DSM). Meanwhile, the 5-step process described in Section 4.6 for *identifying* design rules, and the use of natural language to express them, is a novel approach. This process could be validated and refined in future research. For example, not all systems may have an overview as accessible as the Technovation “FAQ” pages. Identifying design rules might require thorough examination of the interactions between lower-level and higher-level components. The interpretation of the three design rule types, as described above, should also be validated in other ecosystems.

5.3.2 Glocalization of Technovation

Implementation of local Technovation programs involves the three glocalization elements: what, who, and how.

The subject of glocalization – the “what” – in the Technovation setting is its process platform. Within the boundaries of the architectural design rules, many components are still able to be modified:

- Recruit:
 - Where to recruit participants from, and how many
 - Who to solicit as volunteers for the mentor, judge, and instructor roles
 - Which organizations to partner with and what their role will be

-
- Participate:
 - What language to deliver Technovation in
 - Where, and how frequently to hold workshops
 - Compete:
 - Whether to hold an RPE
 - Engage:
 - Whether to build a community that extends beyond a single season

Who

The “who” element refers to “mediating actors” (Meyer, J. W., 2014: 419), individuals leading the glocalization effort. In Technovation, these are the Ambassadors – both Global and Regional. As “agents of glocalization”, they advocate for both “local distinctiveness” and “global acceptability” (2014: 420).

The role of the Global Ambassador is helping to facilitate early adoption of Technovation in a region. As such, they position the program in a way that is both simple and enticing to local authorities or decision makers. The role of the Regional Ambassador is then to execute the glocalization processes – modifying the program to achieve fit with the local context.

J. W. Meyer (2014) proposes that mediating actors are highly educated and experienced in their profession. This is certainly true for Technovation: Regional Ambassadors are doctorates in engineering, former C-suite executives of high-tech companies, respected community leaders, and passionate social entrepreneurs.

How

There are several mechanisms through which global ideas or models are re-contextualized. A common mechanism discussed in the glocalization literature is discursive tools. One such tool is reframing, the reformulation of a concept “to make it reflect local values and beliefs” (Boxenbaum & Gond, 2014: 318). In Calgary, the University of Calgary hosted all workshops on their campus to create a feeling of unity. The Regional Ambassador spoke about how this in fact mirrors the city’s values:

[Calgary] is a very large city but feels very cohesive because of spaces like the library that actually do a really good job of bringing people together in a way that's both inviting and homey, but also big. And Technovation, we tried to foster that as best we can at the University by providing one place in the city where people can come together, regardless of where you are across the city, to still meet each other and interact with each other.

Another example of discursive re-contextualization was in Mexico City. Participants are encouraged to learn English throughout the duration of the program, rather than solely using the Spanish curriculum. Using a “bridging account” (Meyer, R. E., 2014: 82), the Regional Ambassador linked positive outcomes of learning English to opportunities within the Technovation program:

Here in Mexico City, we do not translate everything. And we do encourage those to learn English. Well, nowadays knowing English it's an added value. But now having solely English and Spanish it's not enough. Since we are working to continue to have these global opportunities and to work as a North American region, or be part of it, we need to know English. So this is why I do not do not encourage participants to get a translated version of the curriculum.

Another mechanism for modifying local programs is by adding or excluding certain elements of the global curriculum. For example: adding practice examples to increase students’ absorption of the material or hosting drop-in workshops to help

students troubleshoot issues with their mobile applications; conversely, omitting elements of the curriculum to fit within the local program time frame. The addition of components to the Technovation program is akin to layering, a process which introduces new components “on top of or alongside existing ones” (Christensen, 2014: 163). Meanwhile, excluding is similar to filtering, the process of removing “elements in the globalized construct that could be perceived as ‘incongruent’ with the new context” (Boxenbaum & Gond, 2014: 316).

Local actors often integrated existing pieces of institutional structures with the Technovation chapter through a process called “bricolage”. In Calgary, university regulation was impacting the program’s overall efficiency. However, by embracing and leveraging institutional protocols, they actually “[increased] the perceived usefulness and/or acceptability of the globalized construct” (Boxenbaum & Gond, 2014: 316):

Handling registration was a nightmare. But then we realized that, we could run [Technovation] sort of like a University-run summer camp ... And they have a ton of infrastructure for how to do sign ups for events, how to handle consent forms and signatures and authorizations. So legal has already agreed that that works for them. And so we were able to slip Technovation under that framework ... which was awesome.

5.3.3 Linking design rules and glocalization

Glocalization theory states that global ideas and processes are modified in local settings. However, the nature of design rules is that they are *enforced* parameters – that is, they “affect other parameter choices but they themselves cannot be changed” (Baldwin & Clark, 2000: 68). The findings from this study demonstrate that design rules create boundaries for glocalization. Fixed parameters, such as participant eligibility (limited to

girls⁶), has implications for local chapters in terms of where they recruit, how to approach schools, and safety measures for interactions between participants and volunteers. It also eliminates “cycles in the design process” (Baldwin & Clark, 2000: 68), because organizers do not need to deliberate on whether boys should be allowed to participate (among other possible decisions).

While design rules may not be modified, adapting the process platform is permitted, sometimes even necessary. As discussed in Sections 5.2.1, 5.2.2, and 5.3.2, the Regional Ambassadors – or “module designers” – determine how to modify the platform components. Their decisions are based on several factors, such as personal experience and the institutional setting of the Technovation program. The design rules are precise yet not overly prescriptive, leaving plenty of flexibility for Regional Ambassadors to select a suitable implementation. They specify high-level criteria – for example, a mentor must be over 18 years old and register on the digital platform. Identifying individuals best suited to the mentor role is entirely at the discretion of the Regional Ambassador. In Ottawa, mentors range from industry professionals to university students, reflecting the diversity of partners across academia, government, and industry. In Montréal, mentors are mostly industry professionals from the private sector, reflecting the important role of corporate partners in their chapter. In Yucatán, the Women Who Code Mérida club draws from an existing volunteer base within their organization.

The enactment of design decisions at a local level while adhering to global design

⁶The complete eligibility criteria includes “all students who identify as female, trans, nonbinary or gender nonconforming.” (<https://iridescent.support.zendesk.com/hc/en-us/articles/115002714613-Eligibility-for-participation-students->)

rules demonstrates J. W. Meyer's proposition that "glocalization supports local variations, but within legitimated boundaries" (2014: 418). Design rules being the legitimated boundaries, and design decisions contributing to local variations.

Just how glocalization processes transform an idea or model, modular operators translate "existing structures into new structures in well-defined ways" (Baldwin & Clark, 2000: 129). The examples provided in the previous section describe glocalization processes. However, some of the local modifications can also be described by modular operators. In Guadalajara, *inversion* was used to move the mentor parameter up a level, to become a design rule: male mentors must be partnered with a female mentor. In Calgary, Thinkable and App Inventor (the programming languages taught in the Technovation curriculum) were *substituted* with Java and Swift.

Table 30 extends the analytical framework from Drori et al. (2014) to include design rule constructs and their mapping to the glocalization dimensions.

Table 30: Glocalization and design rules analytical linking

Dimension	Glocalization	Design rules
	Theoretical constructs	
What	Ideas, structures, practices	Modules
Who	Mediating agents	Module designers
How	Processes and mechanisms	Modular operators

The analytical linking of these two domains is a novel contribution of this thesis. Extrapolating beyond a simple mapping, each domain also inherits a new set of vocabulary to describe their respective phenomena. From a design perspective, glocalization can be described as: A complex system (global organization) comprised of several modules (processes, products, people) operated upon by designers (managers,

employees) seeking to improve the system, within the boundaries of organizational policies. Conversely, from a glocalization perspective, design can be described as: A multilevel structure of functions and ideas (modules) which local actors (hidden module designers) align to their local context through translation and adaptation (modular operators). In this study, the former method was used – i.e. Technovation was described in terms of design rules, in order to understand how the global organization manifested into several local instances.

In addition to the intentional adaptation of platform components, the factors described in Sections 5.2.1 and 5.2.2 also impact the local chapter, but through a different means. They are not enacted by a design process, as they are often outside the control of the designer. These factors represent the “context” for which the chapter is the “form”, and they exert passive influence on the chapter. Thus, there are two forces acting on local Technovation chapters: design and influence. The complete glocalization model is depicted in Figure 7.

During the establishment of a Technovation chapter, selection of the institutional setting and keystone actor are design decisions. Considering them as binary variables, they would be set to 0, and would pass through the adaptation process shown in the diagram below. However, once these decisions have been made, they become part of the context and will impact the chapter (and their value would be set to 1).

Figure 7: Multilevel glocalization model

5.4 Recommendations for practice

Based on the empirical findings of this research and extensive dialogue with interviewees, the following recommendations are offered to five stakeholder groups.

5.4.1 Advocates for gender diversity in STEM

1. **Highlight the impacts of inaction.** Promoting the benefits of STEM education to girls and women should be complemented with an explanation of the impacts of choosing *not* to study STEM: Products and services built by one half of the population will simply not reflect the needs of the other half.
2. **Invite men to be a part of the solution.** Until gender parity is achieved in STEM, men should participate as champions. It is important to not conceal the reality of the STEM workforce to women entering the field – rather to show them that both women and men may be their role models and mentors.
3. **Use a tiered participation model for STEM outreach initiatives.** Both students

and volunteers benefit from its low barriers to entry and growth opportunities.

Particularly for students from underrepresented communities, starting with (sometimes taken for granted) first principles can make STEM less intimidating.

4. **Define the value proposition for all stakeholders.** Achieving gender equity in STEM must be a win-win for everyone. Whether they directly interact with the platform or not, all actors can derive value from an ecosystem. Anyone whose contributions are needed to achieve the shared purpose should have a reason to participate that resonates with their unique needs. This could include companies, managers, government, or parents.

5.4.2 Education institutions

1. **Start a new Technovation chapter or partner with an existing one in your region.** Existing resources can likely be repurposed to support Technovation, including personnel, materiel, or processes, to help girls foster an interest in STEM. A key benefit of course is the opportunity to promote your institution to potential future students.
2. **Offer multi-disciplinary learning anchored in meaningful projects.** Participants and volunteers preferred the multi-disciplinary approach of Technovation, combining technology *and* entrepreneurship, over coding camps and hackathons. Position theory relative to real-life problems that students can relate to and create a call-to-action to apply the concepts outside of the classroom.

5.4.3 Public policy makers

1. **Acknowledge the glocalization of the ed-tech industry.** Technovation is a US-

based organization that has expanded to over 50 countries worldwide and created a meaningful impact on thousands of young people. Public grants should be flexible enough to consider programs that may not originate in Canada, but still have a national presence, impact, and strategy, as eligible candidates.

2. **Support programs specifically dedicated to reaching underrepresented communities.** We cannot assume that everyone has the same baseline understanding of technology, business, and their impact on the world. Serving underrepresented communities requires a deep understanding of the challenges these individuals face, and a commitment to localizing the program accordingly.
3. **Position entrepreneurship as a legitimate career option.** Normalize the nontraditional by incorporating entrepreneurial theory and practice into school curricula. Invite successful founders – particularly local women entrepreneurs – to speak to students and demystify the entrepreneurial path.

5.4.4 Technovation practitioners

1. **If possible, seek representation from academia, industry, and government.**
Having volunteers from each strand of this triple helix not only offers students a diversity of role models, but also highlights the variety of career options available to them. On the partnership front, engagement from each institution creates a balanced program, and avoids bias towards a single organization or sector.
2. **Identify potential partners, then seek out champions with access to them.**
Champions are individuals who can influence decision making at partner or sponsor organizations. They may be friends, family members, spouses,

colleagues, or other professional connections. Importantly, they must be passionate about the Technovation mission and willing to advocate on its behalf.

3. **Have young professionals deliver workshops (and even recruit participants).**

Participants easily connect with these individuals – particularly women. They are relatable, given they are “not that much older”, are excellent examples of what a university student or young professional looks like, and can communicate the material in an engaging fashion.

4. **Connect with other chapters in your country or region** to share best practices, resources and funding opportunities, and even host joint events. The whole is greater than the sum of its parts – a regional network may lead to possibilities and initiatives beyond the scope of a single chapter.

5. **Acknowledge the limitations of volunteering.** Technovation is fueled by the passion of its volunteers who want to see the program grow and succeed.

Recognizing and thanking individuals for their time and effort can go a long way in ensuring the program is sustainable.

6. **Leverage the club model.** One benefit of an ecosystem approach is that there is room for everyone. Other organizations running similar activities as Technovation may already exist in your region. Reach out to see if they would be willing to recruit participants and host workshops on topics they specialize in.

7. **If just starting out, carefully consider the institution and keystone.** Once decided, these factors will greatly influence the regional chapter and may be difficult to change. For example, running Technovation through a university will

have drastically different outcomes than through a company.

5.4.5 Technovation Global

1. **Extend the platform to include a portal for instructors.** Instructors are key stakeholders who interface with the Technovation curriculum and process. Creating a space on the platform for them to familiarize themselves with the material and even connect with participants to answer domain-specific questions could be a valuable addition. This would also streamline recruitment for the Regional Ambassadors.
2. **Encourage ideation in the Technovation “pre-season”.** Across all regions, volunteers cited the ideation phase as too short. Extending it into the pre-season might allow participants to fully immerse themselves into their communities, in order to identify more tangible and meaningful problems. It also allows them to experience first-hand iteration, an important part of the design process.
3. **Multinational partner organizations should connect with regional offices** to extend their impact. Centralizing the partnership through headquarters can legitimize the program, and benefits from economies of scale for tasks such as recruitment, marketing, and funding requests. Nonetheless, site-specific champions should be empowered to make decisions based on their local context.

5.5 Research limitations

Examining Technovation from an ecosystem perspective had a major drawback: the lack of clarity and specification of the community. The community (the term used by interviewees) was frequently cited as one of the most important parts of the program: as

people's motivation for volunteering, as a support network during the launch of Technovation in a new city, or in helping recruit instructors to deliver workshops.

Another limitation was the lack of data collected on the three Mexican chapters. Due to COVID-19, travel to Mexico was not possible. Interviews and direct observation were moved online, which limited the researcher's access to data. This impacted the findings in the following way. First, information on mentors', participants', and partners' motivations and contributions was collected via second-hand interviews with Regional Ambassadors and social media testimonials. Therefore these may not be completely accurate. Additionally, there was insufficient data about economic actors and interactions among actors to complete the multilevel system and structural ecosystem maps. Therefore it was not possible to determine whether these chapters were indeed ecosystems. Lastly, influencing factors, particularly culture, were not able to be validated by first-hand observation. Therefore the Mexican culture was validated by the Hofstede cultural dimensions.

Along the lines of data collection, no Technovation participants (i.e. students) were interviewed for this study. This was primarily due to additional ethical considerations that were not factored into the initial research planning. Value propositions and benefits for the participants were also inferred from second-hand data. As students are the key beneficiaries and co-creators of the Technovation Girls program, future research should ensure their participation. Direct feedback from them may reveal meaningful insights about the design and delivery of the program.

Lastly, one limitation of the research design was that all six cases have been

operating for at least two years. Therefore the observations and findings do not consider the dynamics and decisions involved in establishing a new Technovation chapter.

5.6 Lessons learned

Conducting graduate-level research and writing a thesis is a serious undertaking. Reflecting on the last year and a half, I offer these lessons learned in hopes that they are valuable to others embarking on this path.

Although it may seem trivial, a clean and reusable data structure is key. An organizational system (digital and physical) for storing field notes, raw data, action items, and ideas will be invaluable in preparing the final report and piecing together various strings of information. Also, always include the date on written material.

Becoming comfortable with sketching is another highly useful skill that I picked up. In the writing of this thesis, I often struggled to articulate words that fully captured an idea in my head. Rough sketches and frameworks were an indispensable tool to convey abstract ideas. Plus, there is always a thesaurus to find just the right word.

Seeking feedback from key informants or peers (as early as possible) will ensure accurate interpretation of the data, and may even lead to new findings. In my case, review feedback was part of the overall experiential learning process. Specifically for ecosystem mapping, in the beginning it was not evident what constituted a “side” versus a “participant”. Only by iterating through the mapping process – based on feedback directly received from informants – did I come to understand the distinction.

For research involving human interaction, preparing the ethics application as early as possible offers two key benefits. First, it ensures that time-critical data collection is not

gated by outstanding reviews. Second, and most importantly, the ethics application is very thorough and forces researchers to consider, and make decisions on several parts of their research design. My completed CUREB protocol was actually an input to the overall case study design.

Lastly and most notably is to look for patterns everywhere. Interesting and necessary research topics do not exist in isolation – they often overlap with other domains. Do not ignore the fringe ideas; lean into them. Theories, constructs, or frameworks often have core components that can be reused in different settings.

5.7 Future research opportunities

Many interviewees spoke about the desire – and challenges – to reach a wider audience through Technovation. They speculated about factors that help chapters scale, such as dedicated staff, support from the local school board, and additional introductory modules. Researchers could examine whether the principles involved in scaling a venture (revenue) are applicable to scaling a not-for-profit (reach, impact), or if there are unique considerations. Given the specialization of the TIM program in scaling, and the social capital that Technovation has raised, this could be a particularly interesting study.

Researchers should continue to explore glocalization from a design lens. One possibility is to seek out new modular operators. Clear specification of the “modules” under study will be required in order to observe their evolution and adaptation. As Baldwin & Clark stated, “the best proof of the existence of an operator is to see it actually operate” (2000: 132). Another avenue is to expand on the framework developed in this research. Researchers could evaluate whether other levels are at play (e.g. state,

provincial), their contributing factors, and even if there are other forces that influence a local ecosystem. This research would contribute to both knowledge domains, as well as help scholars and practitioners accurately describe these multilevel systems.

The ecosystem mapping exercise revealed that extant frameworks are not sufficient to capture multilevel architecture. To describe structures of embedded ecosystems, new frameworks will be required. To maintain analytic precision, they must account for components that span several levels, components that only exist at certain levels, and components that are adapted across levels.

Lastly, as mentioned in Section 5.5, the Technovation community was not fully characterized in this study. Using the community design canvas (Weiss, 2017) to specify its components may lead to valuable insights about the overall design of Technovation.

6 Conclusion

This research was undertaken in order to examine the design of local ecosystems within a global technology entrepreneurship challenge for girls. Glocalization can be described as the combination of intentional design processes and environmental factors. Through the glocalization process, local ecosystems are shaped by active and passive forces. Because these forces vary at the local and national level, resultant ecosystems are different from each other, and are not merely translated versions of the global ecosystem. Building on the findings of this thesis, opportunities for future research are defining the scaling principles for Technovation, extending the multilevel glocalization model, developing a multilevel ecosystem framework, and specifying the Technovation community. Although this research examined six Technovation chapters in two countries, there are nearly 100 worldwide, reaching thousands of girls each year. By embracing glocalization, the Technovation program empowers students to create meaningful change in their local community while being a part of a global ecosystem of problem solvers. Managers, entrepreneurs, and policy makers facing grand challenges – such as increasing gender diversity in STEM – might do the same. The recommendations and framework presented in this thesis could be applied to a variety of problem areas that necessitate a holistic, multilevel approach.

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Appendix A: Calgary case report

Table 31: Calgary MSP representation (1)

Platform side	Participants comprising platform side	Value propositions for participants
Participants	Girls aged 10-18 located in Calgary, Alberta	Opportunity to interact with university students Understanding how to apply technology in fields of interest
Mentors	Industry professionals with entrepreneurship or technology experience Computer science students at the University of Calgary	Making STEM more accessible to women Opportunity to grow as a leader
Regional Ambassador	Computer Science professor at the University of Calgary	Career development opportunities Building a network of mentors Witnessing the growth of the participants and mentors
Partners	Suncor IBM Hunter Family Foundation Chic Geek Rainforest Alberta Cisco NSERC	-
Instructors	Graduate Teaching Assistants at the University of Calgary Creative Destruction Lab at the Haskayne School of Business Teachers	-
Influencers	Dr. Elizabeth Cannon, President, University of Calgary Dr. Leslie Rigg, Dean, Faculty of Science Computer science teachers at schools	-
Teachers	Computer science, or general math/science teacher at schools in Calgary	Teaching girls how to code and creating a tangible product Further learning opportunities for their students
Schools	Public, private, charter schools in Calgary School principals School board science consultants	-
Parents	Parents of participants	-
Organizing committee	Faculty of Science outreach office Legal department Dean's office	Offering an integrated, unique learning experience to students

Table 32: Calgary MSP representation (2) – Part 1

Feature	Explanation of features	Technovation Calgary
Sides	Number of sides	10
	Characteristics of each side	See Table 33
Platform	Processes	Recruitment Participation Competition
	Components/Sub-components	Program delivery Events Network Resources Organizational assets
Controls	Contractual terms of direct interaction between sides	Sponsors-University of Calgary Schools-University of Calgary
	Openness	Mentors-Participants Teacher-Participant Teacher-Mentor
	Membership rules for each side	Per Technovation Global design rules
Desired outcomes	System-level objectives	Collective learning and growth

Table 33: Calgary MSP representation (2) – Part 2

Platform side	Contribution to the platform	Expected benefits from the platform
Participants	Time Final project	Role models Network Exposure to technology
Mentors	Time Support	Experiences for their resume
Regional Ambassador	Time Visibility	Network Career development Personal satisfaction
Partners	Financial & in-kind support	-
Instructors	Time Expertise	Salary (Teaching Assistants)
Influencers	Advocacy Credibility	-
Teachers	Time Resources Coordination efforts	-
Schools	Access to participants Facilities	-
Parents	Permission to participate in program Support	-
Organizing committee	Resources Staff	-

Table 34: Calgary multilevel system representation

Level of organization	Property	Technovation Calgary
Organization of economic actors (<i>Ecosystem</i>)	Conceptual location	<ul style="list-style-type: none"> University of Calgary partnership with schools and technology firms
	Anchor	<ul style="list-style-type: none"> Keystone actor: University of Calgary
	Boundaries	<ul style="list-style-type: none"> University of Calgary's broader network in the technology industry
	Elements	<ul style="list-style-type: none"> Program delivery, resources, network, events, organizational assets
Organization of people (<i>Community</i>)	Production	<ul style="list-style-type: none"> University employees develop the material, events, resources, etc. for the Technovation Calgary program Voluntary dedication of time and knowledge from teachers and mentors
	Governance	<ul style="list-style-type: none"> The University of Calgary's Faculty of Science Outreach office oversees the program, including interactions between individuals
	Intellectual property	<ul style="list-style-type: none"> The University of Calgary makes no claims on the IP of the participants' projects, nor the instructors' workshop material
Organization of things (<i>Platform</i>)	Modularity	<ul style="list-style-type: none"> Low modularity in design: The Technovation Calgary program is dependent on teachers for much of the programming; interactions are limited to the school environment High modularity in use: Drop-in sessions are an additional module that allow participants to seek help on any problems they are facing; no curriculum tailoring is required
	Option value	-

Figure 8: Structural representation of Technovation Calgary

Appendix B: Montréal case report

Table 35: Montréal MSP representation (1)

Platform side	Participants comprising platform side	Value propositions for participants
Participants	Girls aged 10-18 located in Montréal, Quebec	Becoming a problem solver Developing new skills and perspectives
Mentors	Technology professionals Entrepreneurs	Giving back to the next generation Seeing the growth of the participants Gaining transferable skills Expanding their personal network
Regional Ambassador	Co-founder of Technovation Montréal	Being a part of a community of thriving women Creating opportunities for girls
Partners	Shopify GSoft Ubisoft EY Montréal Caisse de dépôt et de placement du Québec Microsoft IBM iX Espace cdpq District 3 Centre Zenika Montréal	Increased employee engagement Increasing diversity in STEM Inspiring youth about future job prospects
Instructors	Venture capital investor (Brightspark) Software developers (Zenika Montréal) – Coding workshops UX Designer (GSoft) – Leading the launch of the 2019-2020 cohort IBM iX Lead Team – Design thinking workshop CEO (ActualConversation) – Marketing & branding workshop CEO (Master Talk) – Pitch workshop Pitch video expert team	Leveraging their expertise to create a positive impact on youth
Influencers	School staff (teacher, principal, IT director) Potential mentors Employees within sponsor companies	Creating opportunities for youth Supporting a cause they are passionate about
Schools	Elementary and secondary schools in Montréal	Providing opportunities for students to learn and work on different projects
Parents	Parents of participants	Free extracurricular opportunity for their children
Organizing committee	Curriculum leads (business & coding) Community & volunteer leads Communications and marketing Partnerships Digital communications	Supporting the growth of the participants Contributing to a cause they are passionate about
Student Ambassadors	Alumni of the Technovation Montréal program	Support and promote Technovation Montréal by sharing their experiences Professional development opportunities
Board of Directors	A team of 5 highly accomplished women	-

Table 36: Montréal MSP representation (2) – Part 1

Feature	Explanation of features	Technovation Montréal
Sides	Number of sides	11
	Characteristics of each side	See Table 37
Platform	Processes	Recruitment Participation Competition
	Components/Sub-components	Workshops Events Network Resources Organizational assets
Controls	Contractual terms of direct interaction between sides	RA-Partners RA-Technovation Global RA-Schools
	Openness	Committee-Volunteers Volunteers-Participants
	Membership rules for each side	Per Technovation Global design rules
Desired outcomes	System-level objectives	Scale and expand the Technovation Montréal program Create a holistic learning experience Encouraging participants to reach their full potential

Table 37: Montréal MSP representation (2) – Part 2

Platform side	Contribution to the platform	Expected benefits from the platform
Participants	Time Final project	Learning how to code and solve problems Preparation for university Resume building Exposure to tech industry Exposure to role models
Mentors	Time Expertise Support	New skills Broader network
Regional Ambassador	Time Passion Energy	Involvement in a strong community Personal value derived from creating programs and opportunities for girls
Partners	Financial support Office space Access to volunteers	Increased employee engagement Promotion and visibility
Instructors	Time Knowledge	Personal value derived from supporting youth
Influencers	Legitimacy and credibility Passion	Personal value derived from creating opportunities for youth
Schools	Access to participants	Learning opportunity for students
Parents	Permission to participate in program	-
Organizing committee	Time Connections	Personal value derived from creating an impact on participants
Student Ambassadors	Support and promote program	Professional development opportunities
Board of Directors	Time Experience in strategic planning and governance	-

Table 38: Montréal multilevel system representation

Level of organization	Property	Technovation Montréal
Organization of economic actors (<i>Ecosystem</i>)	Conceptual location	<ul style="list-style-type: none"> A network of organizational partners (not-for-profit, firms, economic development agencies)
	Anchor	<ul style="list-style-type: none"> Keystone actor: Regional Ambassador
	Boundaries	<ul style="list-style-type: none"> All partners are publicly committed to diversity and inclusion in the workplace, and leverage diversity to drive innovation The Regional Ambassador's network is the lower boundary for new partners or volunteers
	Elements	<ul style="list-style-type: none"> Program delivery, resources, network, events, organizational assets
Organization of people (<i>Community</i>)	Production	<ul style="list-style-type: none"> Voluntary dedication of time and knowledge by the organizing committee, mentors, and instructors The production of the course curriculum is delegated to instructors and reviewed by an organizing committee member The "product" of the community is possibility, which is cultivated by all volunteers through positive reinforcement and influence
	Governance	<ul style="list-style-type: none"> The Board of Directors provides strategic direction Committee oversees all events for the current season
	Intellectual	<ul style="list-style-type: none"> Technovation Montréal makes no claims on the IP of

Level of organization	Property	Technovation Montréal
	property	<p>participants' projects</p> <ul style="list-style-type: none"> Technovation Girls curriculum is open source, and was translated to French by the Committee
Organization of things (Platform)	Modularity	<ul style="list-style-type: none"> Low modularity in design: Design of the competition timeframe (one weekend per month) makes it difficult to adapt to changes or external factors (e.g. adverse weather conditions) High modularity in use: Participants can pick any problem to solve and combine it with any program elements necessary to create their final project
	Option value	<ul style="list-style-type: none"> High option value in use: It is encouraged, but not mandatory, for teams to submit their final project in the official Technovation Girls competition High option value in use: Coding workshops are based on Thinkable, but teams may choose another coding language for their project High option value in use: Participants and mentors have the opportunity to get to know each other personally, but it is not required High option value in use: Participants have the option to immerse themselves in all or some aspects of Technovation. For example, if they are interested in coding they can focus on coding; if they are interested in design they can focus on design High option value in use: Volunteers have the option to participate with Technovation Montréal through multiple roles (mentor, Regional Ambassador, judge, instructor), and can advance to other roles

Figure 9: Structural representation of Technovation Montréal

Appendix C: Ottawa case report

Table 39: Ottawa MSP representation (1)

Platform side	Participants comprising platform side	Value propositions for participants
Participants	Girls aged 10-18 located in Ottawa, Ontario	Exposure and inspiration for career options in STEM Understanding the impact of lack of diversity on the world they live in and the products they use
Mentors	University students Technology professionals	Connecting with professionals in other industries Connecting with youth to have an impact on them Learning new skills Recognition of volunteer commitment
Regional Ambassador	Jennifer Francis of Women Powering Technology, founder of Technovation Ottawa	Creating positive impact on girls
Partners	Shopify Ericsson IBM Ciena Carleton University University of Ottawa La Cité Algonquin College	Promoting and celebrating women in technology Alignment with corporate priorities on gender equity Supporting existing company initiatives
Instructors	Employees from partner organizations with subject matter expertise on a particular topic	Giving back to the community Contributing to gender imbalance in STEM
Influencers	Professional development community groups Female CIO in the Canadian Government Treasury Board Connection with the school board of trustees Volunteers' friends and family	-
Education system	Ottawa school boards Schools Principals Teachers	-
Organizing committee	Regional Ambassador Representatives from select partner organizations (Shopify, IBM, Carleton University, University of Ottawa, La Cité) Mentor and instructor representative	Making a difference in girls' lives Creating experiences for younger generations that they did not have

Table 40: Ottawa MSP representation (2) – Part 1

Feature	Explanation of features	Technovation Ottawa
Sides	Number of sides	8
	Characteristics of each side	See Table 41
Platform	Processes	Recruitment Participation Competition
	Components/Sub-components	Workshops Events Network Resources Organizational assets
Controls	Contractual terms of direct interaction between sides	RA-Sponsors RA-Technovation Global RA-Schools
	Openness	Partners-Volunteers Volunteers-Participants Teachers-Participants Partners-Partners
	Membership rules for each side	Per Technovation Global design rules
Desired outcomes	System-level objectives	Creating a positive impact on participants Growth opportunities for volunteers Connecting different areas of the local tech sector

Table 41: Ottawa MSP representation (2) – Part 2

Platform side	Contribution to the platform	Expected benefits from the platform
Participants	Time Final project	Exposure to tech industry Exposure to role models
Mentors	Time Knowledge Support	Networking opportunities New skills Recognition
Regional Ambassador	Time Network	Personal reward from referring participants for job applications, university scholarships Seeing the impact of the program on participants
Partners	Resources Financial & in-kind support	Recognition (events & social media) Opportunity to promote career options Employee engagement via volunteerism
Instructors	Time Expertise	Personal value derived from sharing their knowledge with others
Influencers	Visibility Legitimacy	-
Education system	Credibility Promotion within schools Recruitment of participants	-
Organizing committee	Time Communication	Personal value derived from creating positive experiences for girls Alignment on program objectives Feedback on program

Table 42: Ottawa multilevel system representation

Level of organization	Property	Technovation Ottawa
Organization of economic actors (<i>Ecosystem</i>)	Conceptual location	<ul style="list-style-type: none"> A network of organizational partners (industry, academia, not-for-profit)
	Anchor	<ul style="list-style-type: none"> Keystone actor: Regional ambassador
	Boundaries	<ul style="list-style-type: none"> Affiliation with the local technology industry
	Elements	<ul style="list-style-type: none"> Program delivery, resources, network, events, organizational assets
Organization of people (<i>Community</i>)	Production	<ul style="list-style-type: none"> The Technovation curriculum is available online and modified by instructors Voluntary or paid contribution of time, knowledge, and resources by committee members and volunteers
	Governance	<ul style="list-style-type: none"> The Regional Ambassador has ownership of the overall program quality and delivery; the committee aligns partners and drives program initiatives
	Intellectual property	<ul style="list-style-type: none"> Technovation Ottawa makes no claims on the IP of the participants' projects
Organization of things (<i>Platform</i>)	Modularity	<ul style="list-style-type: none"> High modularity in design: Weekly in-person workshops coordinated by the RA seamlessly transitioned to a virtual format Low modularity in use: Volunteers of the English program do not participate in the French program

Level of organization	Property	Technovation Ottawa
	Option value	<ul style="list-style-type: none"> • High option value in use: Participants have the option to register in one of three program variants • High option value in use: Participants and volunteers have the option to attend workshops based on proximity to their workplace/school/etc • High option value in use: Coding workshops are based on <i>Thunkable</i>, but teams may choose another coding language for their project

Figure 10: Structural representation of Technovation Ottawa

Appendix D: Guadalajara case report

Table 43: Guadalajara MSP representation (1)

Platform side	Participants comprising platform side	Value propositions for participants
Participants	Girls aged 10-18 located in Guadalajara, Mexico	Increased capabilities in all aspects of life Meeting and learning from successful, local professionals
Mentors	Teachers Industry professionals University students	Supporting the growth of young leaders Learning transferable technical skills
Regional Ambassador	Dr. Maria Makarova, founder of Technovation Mexico	Supporting and fostering change agents Creating a supportive community
Partners	Intel Oracle IBM HP Universidad de Guadalajara: Centro Universitario de Ciencias Exactas e Ingenierías (CUCEI) Universidad de Artes Digitales Biblioteca Pública del Estado de Jalisco Juan José Arreola Meetroopers Epicentro Festival de Innovación	Increased engagement and development of employees Higher female enrollment in STEM careers
Instructors	Employees from partner organizations Teachers	-
Influencers	High school teachers Volunteers' friends and family University professors	Promoting a cause they are passionate about Being an agent of change
Education system	CUCEI and other academic institutions Public schools Private schools	-
Judges	Employees of partner firms	-

Table 44: Guadalajara MSP representation (2) – Part 1

Feature	Explanation of features	Technovation Guadalajara
Sides	Number of sides	8
	Characteristics of each side	See Table 45
Platform	Processes	Recruitment Participation Competition
	Components/Sub-components	Program delivery Events Network Resources Incentives
Controls	Contractual terms of direct interaction between sides	Male mentors-participants University-participants
	Openness	Industry mentors-participants

Feature	Explanation of features	Technovation Guadalajara
	Membership rules for each side	University clubs only have students as mentors Some school clubs only have teachers as mentors
Desired outcomes	System-level objectives	Skill development Increased ability of girls to solve problems

Table 45: Guadalajara MSP representation (2) – Part 2

Platform side	Contribution to the platform	Expected benefits from the platform
Participants	Time Final project	Increased self-confidence Exposure to role models Exposure to STEM career opportunities Learning the value of teamwork
Mentors	Time Expertise	New skills Rewarding experiences Recognition (teachers)
Regional Ambassador	Time Effort Personal network	Personal value derived from fostering a community of dedicated participants and volunteers
Partners	In-kind sponsorship Access to volunteers	Volunteer opportunity for employees
Instructors	Time Expertise	-
Influencers	Credibility Visibility	Personal value derived from being a change agent
Education system	Recruitment of participants Delivering workshops Dedicated resources	-
Judges	Time Feedback	-

Table 46: Guadalajara multilevel system representation

Level of organization	Property	Technovation Guadalajara
Organization of economic actors (<i>Ecosystem</i>)	Conceptual location	<ul style="list-style-type: none"> A network of organizational partners (not-for-profit, technology firms, academic institutions)
	Anchor	<ul style="list-style-type: none"> Keystone: Regional Ambassador
	Boundaries	<ul style="list-style-type: none"> No boundaries for partners
	Elements	<ul style="list-style-type: none"> Program delivery, events, network, resources, and incentives
Organization of people (<i>Community</i>)	Production	<ul style="list-style-type: none"> Voluntary contribution of time to organize events and prepare resources (by the Mentoralia team, mentors, and instructors)
	Governance	<ul style="list-style-type: none"> Mentoralia team oversees entire chapter, and coordinates between clubs Each clubs oversees planning and volunteers for their own workshops Regional Ambassador performs “quality control” on the various clubs to ensure alignment with Technovation guidelines
	Intellectual property	<ul style="list-style-type: none"> Technovation Girls curriculum is open source, and was translated to Spanish by Oracle volunteers

Level of organization	Property	Technovation Guadalajara
Organization of things (Platform)	Modularity Option value	<ul style="list-style-type: none"> High option value in use: It is encouraged, but not mandatory, for teams to submit their final project in the official Technovation Girls competition High option value in use: There are several local clubs that students can participate in, depending on their school

Figure 11: Structural representation of Technovation Guadalajara

Appendix E: Mexico City case report

Table 47: Mexico City MSP representation (1)

Platform side	Participants comprising platform side	Value propositions for participants
Participants	Girls aged 10-18 located in Mexico City	Seeing their own progress and accomplishments Lived experiences involving technology
Mentors	University professors High-tech professionals Researchers Entrepreneurs Parents Teachers	Learning experiences Developing entrepreneurial and leadership mindset in participants Contributing to participants' development
Regional Ambassador	Yanira Hernández, founder of Technovation Mexico City	Being a part of the participants' transformative experience
Partners	Universidad Autónoma Metropolitana (Unidad Cuajimalpa) Aplicadas y en Sistemas Uber Oracle Thales Dev Day 4 Women Biblioteca Benjamín Franklin	Developing future leaders Building a community Having a social impact by improving the environment and education
Instructors	Professionals with subject matter expertise on a particular topic Mentors	-
Schools	Public and private schools	
Parents	Parents of participants	Opportunity for their child to have increased responsibility and skills
Judges	Engineers Marketing & communication specialists Professors	-

Table 48: Mexico City MSP representation (2) – Part 1

Feature	Explanation of features	Technovation Mexico City
Sides	Number of sides	8
	Characteristics of each side	See Table 49
Platform	Processes	Recruitment Participation Competition
	Components/Sub-components	Program delivery Events Network Resources
Controls	Contractual terms of direct interaction between sides	-
	Openness	RA-Other Regional Ambassadors Participants-teachers Participants-mentors
	Membership rules for each side	Per Technovation Global design rules

Feature	Explanation of features	Technovation Mexico City
Desired outcomes	System-level objectives	Reinforcement of participants' capability to tackle problems Positive learning experiences

Table 49: Mexico City MSP representation (2) – Part 2

Platform side	Contribution to the platform	Expected benefits from the platform
Participants	Time Final project	Skill development Knowledge acquisition Environment knowledge Validation Positive experiences Personal and professional growth
Mentors	Time Encouragement Knowledge Planning, monitoring, & guidance of teams' projects Insight into future opportunities and market trends	Opportunity to share experiences and knowledge Witnessing participants' transformation Personal and professional growth New skills
Regional Ambassador	Time Resources Planning and execution of activities Monitoring program progress Providing guidance	Witnessing the participants' transformation
Partners	Time Space or venue resources Volunteers Refreshers or food	Possibility within Mexico and globally for girls to consider them for future education or career opportunities Recognition at events and promotion of activities
Instructors	Time Subject matter expertise	-
Schools	Facilities (computers and internet access)	-
Parents	Time Permission	Opportunity for their child
Judges	Time Feedback Reflection	-

Figure 12: Structural representation of Technovation Mexico City

Appendix F: Yucatán case report

Table 50: Yucatán MSP representation (1)

Platform side	Participants comprising platform side	Value propositions for participants
Participants	Girls aged 10-18 located in Yucatán, Mexico	New and challenging experiences Creating future opportunities for themselves Learning from accomplished professionals
Mentors	Computer scientists/developers Marketing specialists QA engineers Project managers Entrepreneurs Teachers Professors Parents	Growth and learning opportunities Helping the participants become better professionals
Regional Ambassador	Karla Levya Patino, founder of Technovation Yucatán	The opportunity to create and be a part of an integral learning experience for the participants
Partners	Universidad Modelo Mérida Escuela Secundaria Modelo Autonomous University of Yucatán	Promoting their institution to potential students
Instructors	YOCO Entrepreneurs from companies: Adhoc Finanzas JPG Creativo Change Is Wild Zero Waste Yucatán Vanguardia VM Curvy Zone Mumas Mandelbrôt	Sharing experiences about entrepreneurship and encouraging the future generation
Influencers	Ministry of Education of the Government of the State of Yucatán (SEGEY) Impact Mayab Metropolitan University of Technology (UTM)	-
Parents	Parents of participants	Ensuring their child has competitive skills
Judges	Social entrepreneurs Engineers Managers Researcher	Using their expertise to shape participants' experience
Clubs	Women Who Code Mérida Escuela Secundaria CTM Escuela Secundaria Pilar Victoria y Victoria	Leveraging their communities to create future female leaders

Table 51: Yucatán MSP representation (2) – Part 1

Feature	Explanation of features	Technovation Yucatán
Sides	Number of sides	9
	Characteristics of each side	See Table 52
Platform	Processes	Recruitment Participation Competition
	Components/Sub-components	Workshops Events Network Resources
Controls	Contractual terms of direct interaction between sides	RA-Schools and NGOs Sponsors Mentors
	Openness	Clubs-Mentors Clubs-Partners Clubs-Sponsors
	Membership rules for each side	Per Technovation Global design rules
Desired outcomes	System-level objectives	Changing the lives of participants Awareness of diverse career options

Table 52: Yucatán MSP representation (2) – Part 2

Platform side	Contribution to the platform	Expected benefits from the platform
Participants	Time Final project	Role models Networking Learning about technology and business from experts New abilities Personal reward from developing the mobile application and project
Mentors	Time Support	Growth and learning opportunities Practical opportunities (jobs, networking, attending events) Personal value derived from witnessing the growth of participants
Regional Ambassador	Time Resources Network	Personal value derived from creating positive experiences for participants Professional and personal opportunities
Partners	Safe facilities (computer labs) In-kind sponsorship	Publicity and acknowledgement as a sponsor Opportunity for students to learn about their facilities
Instructors	Specialized talks (coding, business) Inspiration	Publicity as an entrepreneur for their business Personal value derived from sharing their experiences and knowledge
Influencers	Visibility and promotion of campaigns, achievements, mentor recruitment and other communications	-
Parents	Encouragement Permission	Learning opportunity for their child
Judges	Time Feedback	Personal value derived from having their feedback taken into account
Clubs	Mentors Training & workshops Facilities	Volunteer opportunity for their community Participation in Technovation Yucatán Regional Events

Figure 13: Structural representation of Technovation Yucatán

Appendix G: Regional characteristics

Table 53: Overview of Canadian Technovation regions

Technovation feature	Calgary	Montréal	Ottawa
Website	https://science.ucalgary.ca/connections/outreach/technovation	https://www.technovationMontreal.com/	https://technovationottawa.org/
Regional Ambassador	Dr. Lora Oehlberg	Name hidden	Jennifer Francis
Associated organization	University of Calgary Faculty of Science Outreach	N/A	Women Powering Technology
Year founded	2014	2014	2015
Number of participants (Total)	N/A	N/A	1200
Number of participants (2020)	N/A	55	200
2020 Completion rate (Submitted projects)	N/A	90%	85%
Regional feature	Calgary	Montréal	Ottawa
Population (M)	1.3	1.8	1
Post-secondary institutions	University of Calgary Mount Royal University	University of Montréal McGill University Concordia University Université du Québec à Montréal	Carleton University University of Ottawa La Cite collégiale Saint Paul University Algonquin College
Entrepreneurship-focused institutions	Creative Destruction Lab, Rockies	FounderFuel District 3 Innovation Center Institut d'entrepreneuriat Banque Nationale – HEC Montréal	Invest Ottawa L-SPARK Bayview Yards Lead to Win STARTUP GARAGE

Table 54: Overview of Mexican Technovation regions

Technovation feature	Guadalajara	Mexico City	Yucatán
Website	https://www.mentorialia.org/capitulos/jalisco	https://twitter.com/TechnovatioCDMX	https://www.facebook.com/TechnovationYucatán
Regional Ambassador	Dr. Maria Makarova	Yanira Hernández	Karla Patiño Leyva
Associated organization	Mentorialia	N/A	N/A
Year founded	2013	2015	2018
Number of participants (Total)	1200	823	160
Number of participants (2020)	283	297	93
2020 Completion rate (Submitted projects)	52%	18%	22%
Regional feature	Guadalajara	Mexico City	Yucatán
Population (M)	5	8.8	0.78
Post-secondary institutions	Universidad de Guadalajara Universidad Autónoma de Guadalajara Universidad de Especialidades Universidad Metropolitana Latin Campus	Universidad Nacional Autónoma de México (UNAM) Universidad Anáhuac Universidad Panamericana (UP) Instituto Politécnico Nacional (IPN) Instituto Tecnológico Autonomo de México (ITAM) Universidad Iberoamericana (UIA) Universidad Autónoma Metropolitana (UAM) Universidad Autónoma del Estado de México (UAEMex)	Universidad Autónoma de Yucatán Universidad Anáhuac Mayab Instituto Tecnológico de Mérida Universidad Marista de Mérida Universidad Modelo Universidad Mesoamericana de San Agustín
Entrepreneurship-focused institutions	Startup GDL Hackers and Founders iTuesday MakersGDL Reto Zapopan HF CoopMX Tec Lean Accelerator	Startup Mexico Instituto Nacional del Emprendedor (INADEM)	Yucatecan Institute of Entrepreneurs IYEM

Appendix H: Case study database

Quick Access

- Files
- Memos
- Nodes

Data

- Files
 - Archival Data
 - Direct Observation
 - Interviews
- File Classifications
- Externals

Codes

- Nodes
- Sentiment
- Relationships
- Relationship Types

Cases

- Cases
- Case Classifications

Cases Search Project

Name	Files	References
Calgary	6	278
Global	6	175
Guadalajara	2	40
Mexico City	4	23
Montreal	9	168
Ottawa	17	301
Yucatan	2	86

Figure 14: Case study database folder structure

Nodes Search Project

Name	Files	References
Design rule	20	43
Ecosystem structure	27	130
Evolution	16	39
Platform	30	176
Practitioner tip	21	51
Program components	12	31
Regional difference	25	91
Unique factors	14	21

Figure 15: Nodes used to codify data