Software Startup Ecosystems Evolution: A Maturity Model

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to S.N. Goenka, a great entrepreneur

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Resumo

CUKIER, D. **A Evolução dos Ecossistemas de Startups de Software: Um Modelo de Maturidade**. 2017. 98 f. Tese (Doutorado) - Instituto de Matemática e Estatística, Universidade de São Paulo, São Paulo, 2017.

Resultado da revolução tecnológica das últimas décadas, vários ecossistemas de startups de software surgiram ao redor do globo. Acelerados pela Internet, pela onipresença dos dispositivos móveis e pela abundância de serviços de nuvem, empresas de software com modelos de negócio escalável, conhecidas como startups, se tornaram o assunto da moda.

Com empreendedores de tecnologia como seus principais agentes, alguns desses ecossistemas já existem há mais de 50 anos, enquanto outros são apenas recém-nascidos. Essa diferença no grau de evolução e maturidade torna a comparação de aglomerados de tecnologia um desafio. Mais ainda, se alguns ecossistemas querem evoluir para um estágio próspero e sustentável, ecossitemas nascentes precisam de uma visão clara de como desenvolver suas comunidades.

Esta tese apresenta nossa pesquisa baseada em um estudo de caso múltiplo em três diferentes ecossistemas, e foi dividade em três fases. Durante a primeira fase, nós analisamos o ecossistema empreendedor de Israel e, utilizando teoria fundamentada em dados, criamos um arcabouço conceitual que provê uma versão generalizada para mapear ecossistemas. Desenvolvemos, também, uma metodologia e um protocolo sistemático para entrevistas a serem usadas na análise de ecossistemas específicos.

A segunda fase da pesquisa foi realizada em São Paulo, com o objetivo de refinar e validar a metodologia e o arcabouço conceitual. Esta fase resultou na descoberta de como é importante analisar a dinâmica e o processo de evolução dos ecossistemas, nos levando a criar um modelo de maturidade para ecossistemas de startups de software. O modelo de maturidade foi baseado no modelo conceitual que criamos, mapeando os fatores mais importantes que definem as características de um ecossistema.

Para validar e refinar o modelo de maturidade criado na segunda fase, realizamos um terceiro estudo de caso em Nova Iorque que contou com o feedback de mais de uma dezena de especialistas. Geramos um modelo de maturidade final, um guia prático para determinar o nível de maturidade de cada ecossistema. Com esse modelo, é possível não somente comparar diferentes ecossistemas, como também identificar lacunas e propor ações práticas e personalizadas que podem resultar em melhorias significativas e levar ecossistemas ao próximo nível de desenvolvimento.

Palavras-chave: Startups de Software, Ecossitemas de Startups, Ecossistemas, Modelo de Maturidade, Empreendedorismo, Inovação, Métodos Qualitativos, Teoria Fundamentada em Dados.

Abstract

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Resulting from the technological revolution over the last few decades, many software startup ecosystems have emerged around the globe. Boosted by the Internet, the omnipresence of mobile devices, and the abundance of cloud-based services, software companies with scalable business models, known as startups, became all the hype.

With tech entrepreneurs as their main agents, some of these ecosystems have existed for over 50 years, while others are newly born. This difference in evolution and maturity makes comparing tech hubs a challenge. Moreover, if they are to evolve towards fruitful and sustainable environments, nascent ecosystems need a clear vision of how to develop their community.

This thesis presents a multiple-case study research in three different ecosystems, and it was divided in three phases. During the first phase, we analyzed the Israeli entrepreneurship ecosystem and, using grounded theory, created a conceptual generalized framework to map ecosystems. We also developed a methodology and a systematic interview protocol to be used to analyze any ecosystem.

The second phase was performed in São Paulo, with the objective of refining and validating both the methodology and the conceptual framework. The second phase resulted in the discovery of how important it is to analyze ecosystem dynamics and evolution process, leading us to create a maturity model for software startup ecosystems. The maturity model was based on the conceptual model we created, mapping the most important factors that define an ecosystem.

To validate and refine the Maturity Model created in the second phase, we ran a third case-study iteration in New York City. Based on the feedback from over a dozen experts, we generated the final model and a practical guide to determine an ecosystem's maturity level. With this model, it is possible not only to compare different ecosystems, but also to identify gaps and propose customized practical actions that can yield meaningful improvements and lead ecosystems to the next level of development.

Keywords: Software Startups, Startup Ecosystems, Ecosystem, Maturity Model, Entrepreneurship, Innovation, Qualitative Methods, Grounded Theory.

"Here's to the crazy ones. The misfits. The rebels. The troublemakers.
The round pegs in the square holes. The ones who see things differently.
They're not fond of rules. And they have no respect for the status quo.
You can quote them, disagree with them, glorify or vilify them.
The only thing you can't do is ignore them.
Because they change things. They push the human race forward.
And while some may see them as the crazy ones, we see genius.
Because the people who are crazy enough to think
they can change the world, are the ones who do."

Rob Siltanen

Contents

Abbreviations list

CRUD	Create, read, update, delete
CS	Computer Science
CTO	Chief Technology Officer
IaaS	Infrastructure as a Service
IME	Institute of Mathematics and Statistics
FLOSS	Free/Libre and Open-Source Software
PaaS	Platform as a Service
SaaS	Software as a Service
SV	Silicon Valley
USP	University of São Paulo
VC	Venture Capital
XP	eXtreme Programming

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Prelude

In 1998, I started my undergraduate course in Computer Science at the University of São Paulo. At that time, I used to work as a software developer in the IT department of a socks factory. I was in the kindergarten of my professional life as a programmer (actually in that time the profession name was "programmer", not "developer"). We accessed Internet using dial-up connections in a 14.400kbps modem. We were not connected all the time, things used to happen in a slower pace than now. But they happened.

Some years later, in 2001, the year of the Agile Manifesto[1], I decided to go to Italy, to work for a small software startup (at that time it wasn't called startup). There I started to understand how much complexity and challenge there is in developing high-quality software. In that time, I was still immature to realize that the difficulties were not only on the engineering and technical side, but also on the product and business perspective. As a good computer science student, I was worried a lot more with the technical challenges of how to make great software. I did not care that the great software I created was not used by a single person.

I had a lot to learn about programming languages, object-oriented patterns, operating systems, software quality, etc. I was also very interested about development teams productivity. Because of that, I started to study agile methodologies. Agile was a pretty new concept in the industry, there were only a few professionals practicing it. Some professors at IME-USP began to get involved with Agile, giving classes about eXtreme Programming concepts [GKSY04]. Later on, in 2005, they found Agilcoop, a research group with professors and graduate students, with the objective of learning more about Agile and spreading the novel concept in the Brazilian industry. I had the honor to be part of that group and I learnt a lot with them. We organized the first agile events in Brazil, and we also created the first podcast on that theme[2]. Moreover, the group was responsible for many Masters and PhD thesis about agile, including my masters thesis about "Patterns for Introducing New Ideas in the Software Industry" [Cuk10].

It was a very exciting period. We were not only doing research, we were starting a national movement. Between 2006 and 2008, I worked at Locaweb, the largest Web hosting company in Brazil. At that time, the company had more that 80 engineers developing software. My master thesis was related to the process of implementing agile methods in that company.

In 2011, 10 years after the first visit of Kent Beck (the creator of the Extreme Programming Methodology) to São Paulo, I can clearly remember the day when I was having lunch with Fabio and he said: "We accomplished our objective of spreading agile methods. We are good at doing great software. Now it is time to create the right software. Now that we know how to build it, we need to learn which software to build so that it is actually used by real people.". We heard about

[1] http://agilemanifesto.org
[2] http://www.agilcoop.org.br/agilcast

people who were using agile methods concepts with business development techniques: we started to study Lean Startup [Rie11].

There were some students in our group who already had the experience of creating their own companies, some of them with experience in the Silicon Valley. Based on their experience and our research on the literature, in 2012, we organized the first Lean Startup summer course at our department. In the following year, Fabio decided to take a sabbatical semester to carry out research in a place we knew was one of the most vibrant and innovative startup ecosystems in the world: Israel.

At the same time, I was invited to become the CTO at Elo7, the largest crafts marketplace in Brazil (similar to Etsy in the USA). Elo7 had just received Series A investment from the Brazilian VC Monashees Capital and Accel Partners from Silicon Valley. It was a great experience for me, joining a company that had already found its business model, attained its product market fit, and was preparing to scale. By then, I had already started my PhD in the field of Cloud Computing. My plan was to find a good theme for my PhD research while working at Elo7 technologies. I could not find anything specific in cloud computing that motivated me. Entrepreneurship became popular, many new tech startups were popping up in São Paulo and other Brazilian ecosystems such as Rio, Florianópolis, and Belo Horizonte. Fabio was excited about his trip to Israel, so we decided to create a research group on digital entrepreneurship and I changed my research topic to software startups.

While working in a successful company as Elo7, I had the chance to talk to many other tech entrepreneurs from the Monashees portfolio. It was a unique opportunity to learn about startups, not only from books or theory, but also with real life experience. I was swallowed up by the entrepreneurship world. This practical learning was very useful later, when interviewing entrepreneurs for our research: it gave me the empathy to talk with them occupying the same place as theirs. Moreover, as someone from the Patterns Community[3], I could identify many patterns in the startup world, something that would become later part of the knowledge documented within this thesis research.

In 2013, I was living a frenetic life as CTO but, at the same time, I was very frustrated with the progress of my PhD research. Even if I were learning like never before, the hard work at Elo7 did not leave me too much energy or time to work on practical things of the PhD, such as reading (and writing) articles. For this reason, at the end of 2013, I left the company and decided to completely focus my efforts on the PhD research. Fabio had just returned from Israel. I travelled to Silicon Valley and attended the second edition of the Lean Startup Conference[4]. I participated in office hours with startup specialists and made a first "prototype interview" with an entrepreneur. This first interview was the beginning of our multiple-case study research on software startup ecosystems.

During 2 months, I could focus on the PhD research, especially reading the related literature and designing the case study. This period of full-time focus on the PhD did not last too long. In January 2014, I co-founded Playax, a startup in the music industry. Differently from Elo7, Playax was initially only an idea in my partner's mind. He invited me to develop the company, and I fell in love with his idea. I remember the day I went to his house and told him that I wanted to co-found the company with him under a single condition: he should accept the fact that I was also working on my PhD. I don't think he liked so much the idea, but since he had no other option at that moment, he had to take that.

[3] http://hillside.net
[4] http://leanstartup.co

When I joined Playax, I could fill the knowledge gap I had regarding early stage startups. It was the opportunity to understand how to bootstrap a company from idea to business plan, product and market development, acquire the first customers, pivot, change business model, raise seed funding, raise angel funding, and so on. The experience of working at Elo7, a late stage startup, summed with the experience at Playax, giving me background and real practical knowledge about how the world of startups function, not only from the perspective of an outside observer, but also from the entrepreneur's point of view. More than that, I became passionate about being an entrepreneur, specially because I was working with something I loved since I was a child: music. The best part was that, as my working experience contributed to my PhD research, also the PhD research presented me with many insights for my work as CTO and co-founder. Moreover, I had the right set of circumstances to build an extensive network of contacts, especially in São Paulo and New York.

One cannot deeply understand how a startup ecosystem functions without knowing how an entrepreneur mindset operates. Entrepreneurs are the center of any startup ecosystem, as Brad Feld reminds us in his book Startup Communities [Fel12]. By becoming an entrepreneur, I was able to have proper conditions to learn and write about this theme, not only from a theoretical perspective, but also from a practical one. Furthermore, my experience as entrepreneur was not about running an ordinary business like a barber shop or a restaurant. I spent my entrepreneurial years building innovative software for scalable business startups.

As we will show in this thesis, there are many agents and forces that operate within a startup ecosystem. We developed a maturity model to understand ecosystems evolution over time. This model was based on a conceptual framework that we created to map ecosystem's agents and relationships. All these agents have important roles, and must be analyzed and understood to improve the entire environment for everyone. However, we must begin the journey by understanding the entrepreneurs: their motivations, their difficulties, their lifestyle. For this reason, we decided to catalog some patterns about software startups, before we dive into the complexity of ecosystems maturity. Besides being a practical tool for entrepreneurs to apply in their own business, the patterns catalog bring us the atmosphere that surrounds startups. If we want to help entrepreneurs, then we must first understand them. Afterward, we comprehend the functioning of ecosystems where entrepreneurs are immersed.

Chapter 1

Introduction

After the popularization and wide use of the Internet in the 1990s and of mobile technologies in the 2000s, we saw an amazing growth on creation of new high-tech companies around the globe. Agile methodologies and Lean Startup concepts [Rie11, BD12, Bla13] brought tools that enabled testing innovative ideas with very low cost, specially when using cloud computing infrastructures. Innovative ideas can be developed, tested and adopted in one or two years and, in some extreme cases, in a matter of a few months [Ben06, GG05]. These super-fast growing innovative tech companies are known as startups.

A startup can be defined as a temporary organization in search of a scalable, repeatable, profitable business model [Bla13, BD12]. Many times, these startups have their business model supported bu some sort of software. The largest startup database, Crunchbase[1], has data about more than 200,000 founded startups in the last 10 years. Today, these ventures are concentrated around a few major startup hubs where a supporting ecosystem flourishes. What are the characteristics of startup ecosystems that became successful? Is it possible to replicate successful environments in places other than the one that these ecosystems were created? What can be replicated and what cannot? What changes and adaptations are needed to cope with specific characteristics of each region?

The **General Objective** of this doctoral research was to advance the understanding of how software startups work, what are the elements that influence their behavior and how startups relate with other players in their ecosystem. From this general objective, we derived our **Specific Objectives**: (1) achieving a better comprehension of existing startup ecosystems, with the development of a generic conceptual framework of software startup ecosystems; (2) instantiating the conceptual framework at, at least, 3 different ecosystems, in 3 different regions of the world, analysing their characteristics, strengths, and weaknesses; (3) developing a methodology to compare multiple ecosystems, highlighting their similarities and differences; (4) creating a model to map ecosystem evolution and dynamics; and (5) developing specific recommendations and guidelines for the ecosystems analysed in our research to improve their effectiveness.

We used two scientific methods to perform this research: grounded theory [SRF16, CS07] and multiple-case study [Sta13]. While studying a single case can be very insightful in the development of a theory, "the evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust" [HF83] apud [Yin13].

[1] http://www.crunchbase.com

In the last two decades, we observed the rise and maturation of many software startup ecosystems around the world. The technological revolution has driven society evolution, prompted by broader access to the Internet and the popularization of mobile devices; likewise, society's progress drives technological evolution in a co-embedded evolution phenomenon. The Global Entrepreneurship Monitor shows that human capital and social capital co-evolve [RHB+00, SAM15]. Given the hundreds of technological clusters present in different countries, it is difficult to identify each ecosystem's level of development. This thesis proposes a methodology to measure such maturity level with respect to multiple factors, enabling the ability to not only compare different ecosystems, but, more primarily, propose practical actions that can lead to meaningful improvements in the existing ecosystems.

This research began in 2013 in Tel Aviv, Israel. In our first study, we mapped [KCM+14, KCM+15] the complex social and organizational structure of a software startup ecosystem, where entrepreneurs and their tech ventures are the main actors. Some of these high-tech ventures will evolve into high-growth firms, which have a disproportionate impact on economic growth [MB14]. Based on all these complex relationships among agents in the startup ecosystem, we created a conceptual map.

As Daniel Isenberg argues that an entrepreneurial economy cannot be created based on an exact formula and that each ecosystem must find its own qualities [Ise10, Ise11]. Isenberg also proposes a conceptual model to map entrepreneurship ecosystems. Our model has some elements similar to Isenberg's version, but we go deeper on describing the relationships and dynamics of ecosystems.

Economic theory shows that entrepreneurs are the prime forces in modern economic development. Significant changes of economic systems is impossible without them [Sch34]. Besides creating new jobs and generating wealth in society, entrepreneurs and their startups generate technological innovation in industries. Kasturi states that they "foster technological innovations of industries, create new jobs, and generate new wealth for society. New venture creation has been statistically linked to both job creation and regional development" [KS14]. High rates of entrepreneurial activity are strongly related to local economies growth. Entrepreneurial market activity is mostly a decentralized and unplanned process [Lew11, Kop08], in which innovative companies must effectively interact with each other to achieve success [OB15]; thus, technological entrepreneurs act in the context of complex entrepreneurship ecosystems, which can be viewed as a new paradigm for economic policies [Ise11].

In our research, we focused on technology entrepreneurs and their software startups: companies with a potential for high-growth and scalable business models [BD12]. Startups usually have to pivot their strategy, especially in the first two years, until they find their product-market fit [TSKM15]. A supportive startup ecosystem can help entrepreneurs during this unstable period. We define a startup ecosystem as a *limited region within 50 kilometers (or one-hour travel) range, formed by people, their startups, and various types of supporting organizations, interacting as a complex system to create new startup companies and evolve the existing ones.*

Porter introduced the concept of clusters in 1990 [Por11], as a geographically close group of interconnected companies and associated institutions in a particular field. Differently from the cluster concept, which can be viewed as a static asset, ecosystems are dynamic complex structures in which stakeholders co-evolve [Moo93] based on both competition and cooperation [Pel04]. Thus, clusters are components within ecosystems. Besides, we define a startup ecosystem as a limited

geographic region, the boundaries of these regions are not perfectly clear, and the ecosystem is not dependent on the existence of these borders to exist. Boundaries are useful specially for the purpose of defining limits between different ecosystems that are geographically close. Therefore, for example, San Francisco and San Jose are far enough to be considered two different ecosystems, but at the same time, they are close enough to form a single larger ecosystem known as the Silicon Valley. Similarly, Tel Aviv, Haifa and Jerusalem are three distinct ecosystems, all of them within the broad Israeli ecosystem.

Any healthy entrepreneurial ecosystem directly impacts on entrepreneurs' lives [JR12]. Several studies try to identify gaps in innovation ecosystems and propose practical actions to improve their performance, with examples in Germany [VM09, Ste13], India [KS14], Portugal [VdGN14], and Israel [KCM+15]. Some industry initiatives such as the Startup Genome[2] try to map the characteristics of all startup ecosystems around the globe.

This thesis is based on a multiple-case study carried out in three different software startup ecosystems: Tel-Aviv (Israel), São Paulo (Brazil), and New York (USA). Rather than only mapping the innovation ecosystems characteristics and proposing actions and policies for those locations [FM14], the primary objective of this research was to understand their dynamics and explore how they evolved over time. Understanding each ecosystem's characteristics as a snapshot in time is very important, but evaluating their dynamics allowed us to understand the path that ecosystems followed to grow in a sustainable way. By mapping the road, we can show to ecosystem stakeholders the next steps they need to take to advance in the evolutionary process.

The literature includes many articles and books about general entrepreneurship and innovation, but very few works that focus on software startups and the ecosystems that produce them, a gap that this thesis helps to fill in. After a deep analysis of two ecosystems (Tel-Aviv and São Paulo), we published the first version of our maturity model for software startup ecosystems [CKK15b, CKK15a] to represent this evolutionary process. We then received a substantial amount of feedback from practitioners and researchers both in research workshops and in interviews with experts. Based on this feedback, we executed a third iteration of the research in New York to validate the final version of the model, which we present here.

After the refinement process, the final model ended up considering 21 evaluation factors, such as access to global markets, mentoring quality, accelerator's quality, human capital, entrepreneurship in universities, etc. It classified ecosystems in four levels of maturity: Nascent (M1), Evolving (M2), Mature (M3), and Self-sustainable (M4).

In our last iteration for validation, we found that the New York City startup ecosystem fits perfectly in the final model [CKT16]. In less than 15 years, this ecosystem evolved from the bottom level of maturity (Nascent/Evolving) to the top level (Mature/Self-sustainable). This case shows that it is not only possible for a particular region to develop a healthy entrepreneurial environment, but also that this development progresses through a path of multiple phases, in which each phase can be determined by different characteristics and requires specific management approaches. Moreover, this particular evolution is closely related to the moment when technology invaded mainstream businesses, and when traditional business centers started to become technology centers.

Changes in ecosystems are observed over time, and some differences can take years or even decades to be observed. Ecosystems are dynamic and evolutionary in nature, rather than a static

[2] https://startupgenome.co

phenomenon that can be captured by a snapshot at a given point in time [MB14]. The startup ecosystem report from 2012 [HMDH12] proposes a ranking of the top 20 ecosystems in the technology economy. It puts Silicon Valley as a benchmark and compares other ecosystems to it. Three years later, in another report by the same institution, the 2015 global startup ecosystem ranking [HGH+15], revises the 2012 version, presenting a new landscape of ecosystems that shows new technological hubs entering the ranking, as well as old startup agglomerations that did not evolved enough to enter in the new top 20. Questions that arise include: what happened to those ecosystems that fell out of the ranking? What did the ecosystems that entered the ranking do to scale up? Does ranking higher mean improving, and lower means degradation? Could the evolution across maturity levels stages be an evidence of a virtuous cycle [BK15]?

Preliminary partial results of this 5-year research were disseminated as technical reports [KCM+14, KCM+15, CKMF16]; the complete, final result of our research is presented for the first time in this thesis. It details the multiple-case study [Sta13, RH09, Yin13] and how it can be used to generalize a theory about startup ecosystems.

Before diving deep into the scientific approach we adopted, we present, in Chapter 2, the early stage software startup pattern language we documented. In this introductory chapter, we invite the reader to the world of the entrepreneur as these patterns were identified within our own experience as startup practitioners. This experience allowed us to analyse a startup ecosystem not only from an outsider perspective, but also as living beings within it. All the theory and scientific knowledge that comes after would not be complete without this special point of view that we could put ourselves during the research.

After presenting the startup patterns, Chapter 3 discusses existing literature and related theory about startup ecosystems. Chapter 4 explains the methodology used to collect the data and analyze the results. Chapter 5 presents our findings. Finally, Chapter 6 states our conclusions, suggestions for future work, and the research limitations.

Chapter 2

Early-Stage Software Startup Pattern Language

Preamble: Explaining Patterns

A pattern can be defined as a textual document that describes a relevant problem and a solution already tested in real-life scenarios. A pattern usually also describes the context in which this problem is observed, as well as a discussion of the advantages or disadvantages of applying the proposed solution in certain contexts. The presented solution is not necessarily unique and there is no guarantee that it is the best solution, but because it was already experienced many times with success, it can be considered a satisfactory solution.

The architect Christopher Alexander defined a pattern as "a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice" [Ale79]. It is a "three-part rule which expresses a relation between a certain context, a problem, and a solution" [AIS+77]. Richard P. Gabriel complements this definition to the software world, stating that "each pattern is a three-part rule that expresses a relation between a certain context, a certain system of forces that occurs repeatedly in that context, and a certain software configuration that allows these forces to resolve themselves" [Cru01]. Martin Fowler brings a simpler definition: "pattern is an idea that has been useful in one practical context and will probably be useful in others" [Fow97].

Patterns are not inventing something new, but rather documenting possibly implicit knowledge. They are just knowledge from practical experiences observed and written in a well-defined structure; they transform tacit knowledge into explicit knowledge [Cuk10]. They exist in different levels of abstraction and their study prevents us from reinventing the wheel. When a problem arises, and we know a solution for it in a similar context identified by a pattern, we simply use this solution. Therefore, patterns are reusable artifacts that communicate good designs and practices. Usually, they are cataloged and can be used together with other patterns to solve bigger problems. Each pattern is a way to capture experience.

The software community developed many works involving patterns. In 1994, happened the first PLoP Conference [1], an international conference created exclusively for the writing, refinement, and

[1] Annual Conference on Pattern Languages of Programs: http://www.hillside.net/plop

Figure 2.1: *Patterns and Pattern Languages Literature*

dissemination of patterns. During these conferences, the *Writer's Workshop* [Gab02] take place, a group dynamic to help authors to improve their writings. The patterns described in this Chapter were part of two of these workshops and were revised and commented by around 10 people from different backgrounds, from graduated students, industry specialists to Full Professors. Some examples of patterns in the literature are: Design Patterns [GHJV95], Pattern-Oriented Software Architecture [BMR+96], the series Pattern Languages of Program Design [VCK96, MRB97, HFR00, MVN06], Patterns of Enterprise Application Architecture [Fow03], XUnit Test Patterns [Mes07], Refactoring Databases Design Patterns [AS06], Patterns for Introducing New Ideas [RM05, CK11, MR15], Patterns for Pattern writing [MD98], and so on.

The patterns presented in this thesis 2.2 are organized in a pattern language, i.e., a set of inter-related patterns, all related to a single domain, in this case, software startups. They will help the reader not familiar with the daily activities of a software startup to grasp some of the major concerns a entrepreneur in this field should pay attention to. We proceed now to the Introduction to the pattern language, which we wrote itself in a pattern format.

2.1 Introduction

Search for known solutions to known startup problems in the Software Startup Patterns catalog.

In 2014, Daniel started a new company with a friend. He had some experience in working as CTO in another startup and also as technical manager in different companies. He also had a Masters in Computer Science, knowledge on how to build web systems, and had read several books on Entrepreneurship. Even with all this experience and technical expertise, they had a lot of difficulties to build their own company. Many times, Daniel found himself in situations where he did not have any idea of how to act or what decision to make. They had to learn a lot of new Startup concepts. Certainly, they were passing through experiences similar to those faced by many other entrepreneurs in the past (and to be faced in the future). They wish they had somewhere to look and learn known solutions to their problems.

A startup is an "organization formed to search for a repeatable and scalable business model" [BD12]. Altough Startups exist in many different industries, we focus this pattern catalog on Startups whose main product and revenue streams are based on software. These organizations are run by open-to-risk entrepreneurs who, along years of Startup creation, pass through many difficulties in fields where they are not specialists. The range of topics go from simple problems like "where the company's office will be?" to decisions of "how much equity do we give to employees?" or "which operating system do developers should adopt?"

Startups are usually located within a context of an Ecosystem [KCM+14]. There are many examples of ecosystems in different stages of development, such as Israel [SS11], New York [CP13], and many others [FM14]. By identifying opportunities in the market, an entrepreneur creates a Startup. The entrepreneur gets support from family (and friends), who are part of a society and culture that influences the entrepreneur behavior. Universities and research centers provide knowledge in technologies that enable the Startup, by preparing the entrepreneur and providing him/her with networking possibilities. Universities or established companies may run incubators or accelerators that train and instrument the startups with methodologies. Private funding bodies like angels and VCs mentor and invest on Startups, which can also get financial resources from governmental programs through R&D funding agencies or tax incentives. Within a complex environment, startup owners face a multitude of different challenges and problems.

Startups have a lot of problems to solve along their life and it is difficult for entrepreneurs to find answers to all questions by themselves.

Low budget, time pressure, few resources available and instability are every-day problems for Startup entrepreneurs. Moreover, since these organizations are very small in the beginning, there are not many people inside the organization who entrepreneurs can ask for help.

Therefore:

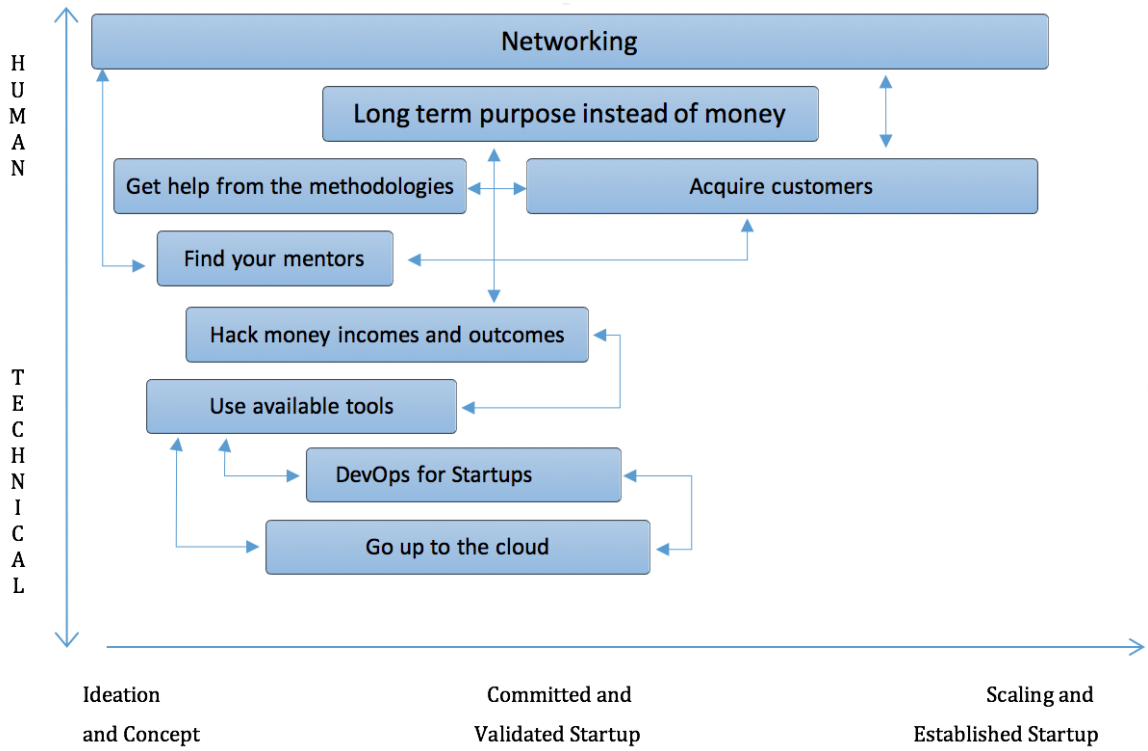

Figure 2.2: *Early Stage Software Startups Pattern Language*

Use the startup pattern language to look for known solutions for startup problems.

The Pattern Language organizes, in a structured catalog, common problems that entrepreneurs face and helps newcomers to apply known solutions to known problems in similar contexts. The pattern language also shows the relationships among the patterns and guides practitioners on which pattern to apply next. By using patterns to solve common problems, entrepreneurs can reduce the waste of time, since time is the most precious asset they have.

The entire Pattern Language can be visualized in Figure 2.2. Patterns more related to human aspects of Software Startups are located on the top, while other patterns more connected to technical characteristics lay at the bottom. The crosscutting patterns which tackle both human and technical aspects are in the middle of the vertical axis.

The horizontal axis is related to the startup lifecycle. Some patterns can be applied in the first days of the Startup **Ideation and Concept**. This is the initial phase when the team is not yet defined and the business model is not clear. A later moment in the Startup existence is when the team is already **committed** and the business model is **validated**, with some customers and confirmed revenue. Then, the Startup starts to show a clear and measurable grow, entering in a **Scaling** and **Establishment** phase to become a successful organization. Other patterns suit better on these later stage phases.

The present Pattern Language is not the first attempt to write patterns for Software Startups [Elo14, Hok15, GG05]. However, the patterns presented here are original in the literature until now. New patterns can be added to the catalog as entrepreneurs understand that their problems are not

[1]http://www.startupcommons.org/startup-key-stages.html

unique to their reality and that, by sharing their experiences in an accessible, systematic, and easy to use way, they can contribute to the evolution of the startup ecosystem they live in.

2.2 Patterns

2.2.1 Get help from the methodologies

Use existing methodologies that promote entrepreneurship best practices to make you less likely to commit the most obvious mistakes.

A successful Israeli startup in the field of Web analytics started their operations by focusing only on the algorithms they used. While the technology was doing well, the company was not growing until they decided to work systematically with the business aspects by adopting a more disciplined way of looking at their market. Then, business grew and they were forced to hire more programmers. At that moment, they realized that their way of developing software wouldn't scale and would produce very bad quality code. Then, they adopted Scrum to manage their development team and, in less than two months, they saw big improvements in their productivity.

In the past decades, practitioners have learned, in the hard way, that there are many recurrent mistakes made by entrepreneurs such as ignoring the product-market fit and focusing only on technology, forgetting to look at the business side of things. Some of these experienced practitioners became educators and consultants and started to write down their experience in the form of books defining methodologies that startups can follow to minimize mistakes.

While, absolutely no methodology or technology is failure-proof and we know there are no silver bullets [Bro87], they can help entrepreneurs avoid some of the common mistakes. As an entrepreneur, you should study and be aware of existing methodologies such as Customer Development by Steve Blank [BD12], Lean Startup [Rie11], Disciplined Entrepreneurship [Aul13]. Pick the one you like the most or a combination of them and follow it in your daily startup activities.

Specifically in the case of Software Startups, it is fundamental to adopt a software development method that can deal well with extreme uncertainty and requirements that can change in a daily basis. Agile Methods such as Extreme Programming [Bec00] and Scrum [Sch09] were designed for such situations and have been used successfully by thousands of companies world-wide.

Inexperienced entrepreneurs tend to make the same mistakes over and over again, repeating the same flaws that led to the failure of other startups that they are not even aware of.

Some young entrepreneurs tend to be a bit arrogant and believe that they know everything and don't need to learn from others. In rare cases, the same problem occurs with older professionals; although this is much more infrequent as more experienced professionals normally learned the hard way that everyone needs help from others. Studying existing methodologies sometimes can be boring and requires a lot of investment in reading multiple books, attending courses, and enrolling in acceleration programs. However, this investment is small when compared to the great benefits

Figure 2.3: *Startups working in the acceleration program in the University of São Paulo*

that arise from developing the business in a more systematic way.

Therefore:

Invest time and energy to study the well-known startup development and agile software development methodologies and follow, in your daily work, the best practices championed by these methods.

Everybody in a startup founding team should know very well at least one modern method for startup development, be it Customer Development, Lean Startup, Disciplined Entrepreneurship, etc. To acquire this knowledge, it is important not only to read books describing the methods and their consequences but also attending courses with practical activities and exercises. Finally, to really absorb the ideas it is fundamental to apply their concepts in real situations with real problems. By simply reading a book, we learn a little; but it is only when we actually apply the methods in real situations in our own context that we really incorporate the new knowledge. It also helps to interact with other people in similar situations via online forums, meet-ups, and study groups.

It is important to note that there are significant limitations on what this pattern can achieve, though. Learning from others' mistakes is helpful but won't make the entrepreneur failure-proof. Many times the entrepreneur faces new situations that he/she cannot relate to what is in the books. The context changes, the situations change, and the parallel with what the methodologies teach is not clear. Thus, even the most "well-educated" entrepreneur will make mistakes and fail many times. But the best learning comes exactly from one's own mistakes. Reading about a mistake in a book is one thing, but feeling on one's own skin the pain of making a wrong decision is something an entrepreneur will never forget in his/her entire life.

Agile software development requires a unique programming culture that is radically different from what used to be taught at universities in Computer Science and Computer Engineering courses up to the late 1990s. Unfortunately, this old culture is still common in thousands of software devel-

opment companies nowadays. Fortunately, a significant portion of the new generation of software developers is being educated with a more agile mindset based on strong collaboration with customers, test-driven development, incremental design and development, and continuous adaptation to changing conditions and requirements. A software startup is by definition an environment of high uncertainty where requirements change very rapidly, thus a robust agile development method is essential. Startup founders must embrace agile methods, hire programmers with this culture whenever possible and invest on training and education when the required level of adherence to agile practices is not observed. It is fundamental that a CTO proficient in agile methodologies guide the startup software development efforts.

The level of rigor and number of agile practices that must be applied vary largely across the lifetime of a software startup. In its very early stages, when there are only one or two developers, very little discipline is required; maybe only practices such as incremental development and customer collaboration are really helpful. When the startup grows to 4 to 6 developers, practices such as automated testing, pair programming, refactoring, stand-up meetings become more important. When the startup goes beyond 10 developers, a larger set of agile practices and a more disciplined organization become very important to manage properly the technical debt [BCG+10] [KNO12] of the product under development.

Also, entrepreneurs must remember that, many times, buying off-the-shelf software components and reusing available open source software is much more cost-effective and help reduce time-to-market. Thus, a startup should avoid developing software from scratch when there is no need for it because an existing solution can be reused.

A startup that applies these disciplined principles both for developing its business and for its software will make less mistakes over the course of its life and will be more likely to succeed. A systematic approach for finding the right markets and developing the software that really addresses a real pain of the customer will help the startup in finding the product-market fit more rapidly. This does not guarantee that the founders will not make mistakes and that, even if they don't, that the company will necessarily succeed. But, even in this case, if the business "need" to fail, it is better that it fails as soon as possible, preferably before spending large amounts of money and energy in investment.

2.2.2 Hack money incomes and outcomes

Find creative ways to avoid unnecessary costs and get as much free resources as you can.

In the beginning of our startup, we didn't have an office. My partner and I worked from our home, so we did not have to pay for an office space. But after some time, we were starting to grow the development team. We needed a place to meet with everybody. We rented a place at a very low cost. We tried to find co-working offices, but in our region it would cost more than having our own space. Then we needed to buy furniture. We discovered that new furniture prices were very expensive. We found a great alternative: asked some relatives for donation and also looked in auction websites. We could set up everything we needed for the office with less than US$500.

"In our company we have policy that you can spend company's money on whatever you like, but

Figure 2.4: *The day we bought furniture in an auction website*

you should treat it as it was yours. If you need something, it is ok to buy it, if you would pay for it yourself, too. It is kind of test that your really need that." – entrepreneur.

Startups usually have very little money. In the beginning, they do not have revenue streams and need to find ways to have money for their first month's costs. The challenge is to keep costs as low as possible and the incomes sufficient for these costs. Furthermore:

There is no revenue in the beginning of startups and costs are high. It is a challenge to know exactly where to spend the few resources a startup has.

Spending money wisely is as important and earning money as fast as possible. The best uses for money in a startup are those related to developing the product and marketing. Administrative costs must be as low as possible. Salaries also should be as low as possible (see Section 2.2.3). Even if the startup has received an investment, spending the money on the right things can be the difference between success and failure.

Therefore:

Eliminate unnecessary costs and get free or cheap resources as much as you can.

There are many ways to save money in your startups. Moreover, often there are great alternatives in your ecosystem to raise inexpensive resources. By focusing your expenses on essential things such as product development, customer development, and marketing, you maximize your resources and accelerate the business model implementation, anticipating revenue and increasing your chances of success. Furthermore, if you use "free" or "cheap" money offers, you are in advantage compared to your competitors.

Here are some ideas:

- If some people work from home, you don't need to have a big office (or even have an office).
- You also won't have to waste money with equipment and furniture.
- In some cities there are free co-working spaces for startups, use them!
- Save money by offering equity shares instead of high salaries (see Section 2.2.3).
- Buy used equipment and furniture at auctions websites
- Search for government or universities programs that foster startups development (ex: startup Chile, Startup Brazil, PIPE-FAPESP, USA NSF-ISBIR, Israel OCS, etc.)
- Use cloud providers programs for startups to save costs with infrastructure. Almost all providers such as Google, Rackspace, Microsoft, Amazon, and others offer free tier until US$100.000 for one year.

2.2.3 Long term purpose instead of money

Differentiate from big companies to attract talents.

When Daniel started the company with his partner Juliano, they did not have money to pay high salaries for tech talent in São Paulo, one of the most expensive cities in Brazil. Their startup was a high-tech innovative platform in the music industry, so they needed the best developers to create complicated algorithms. On a first try, they offered bellow average salaries, but even if some developers were interested in the company's challenges, they did not accept the job. When the founders started to offer equity, they attracted exactly the people they wanted to their team: people with passion and long-term commitment with the company. Moreover, people willing to give up high salaries in exchange of being part of the company's construction and purpose.

When working as CTO at Elo7, a successful Brazilian startup, Daniel organized a developer's retreat, a week when the engineers would work in a relaxed environment, out of the office. They had pool, sauna, video games and food at their disposal, as well as a working table and Internet access. Besides some communication problems with the main office, the workweek was very productive and the team members had a lot of fun, feeling very connected and engaged after this special and unforgettable moment.

Most startups, especially in the beginning of its existence, do not have resources to pay a salary compatible with market values. Startups need to have other ways to attract talent and motivate people to work on its project. Furthermore, hiring the right people in the early days is crucial for the Startup culture development. The criteria for hiring are very talented people with passion and commitment for the business.

It is very hard to hire talents when you are competing with big companies that are admired by people.

Figure 2.5: *Developers working at the swimming pool in a developer's retreat*

Big companies have dedicated staff for recruiting and they usually offer high salaries and many benefits to employees. Moreover, known high-tech companies are admired by people for their achievements. On the other hand, employees in big companies can feel themselves no one in the middle of thousands. They are restricted to companies existing rules and rigid processes.

The first substitute to money is purpose. Startups want to change the world for the better. Show your vision to candidates and let them dream with you. People want to feel pride of their work and like to be part of a big thing.

Another attractive in Startups is the growing potential. In big companies, employees do not have the chance to grow and evolve in their careers as fast as they can in a Startup. The first Startup employees have the chance to become managers or directors in a matter of a couple of years. They have not only the chance to grow, but also the freedom to dictate the rules and build the company from scratch following their own beliefs. In terms of professional growth, young Startups tends to be more attractive, despite being more risky.

Although Startups do not have money in the beginning, they can offer the opportunity to earn a lot of money in future, if the business succeed. Startup founders, especially those without investment, can reserve pool of the company stocks and give them to the first employees.

Therefore:

Offer company equity, freedom, and job with purpose instead of high salaries.

When you offer engagement on a common purpose instead of money, you attract the right people to work with. Workers will behave like founders and will give much more energy to the startup. D. Pink argues that people are mainly motivated by autonomy, mastery and purpose [Pin09]. You can offer all three in your Startup. If you are creating an innovative product that will change the world for the better, you have purpose. When you have a participative culture and flexible work environment, you offer autonomy. Startups with dynamic and learning environment permit people to master on their field. You can also offer flexible work schedules or home office days.

To convince candidates to accept equity and motivate them, you need to show the benefits of

this option in the interviews process. The interviews must be very engaging. You must show passion and belief on the project. Candidates must feel that you are reliable and strong. In these moments, your reputation counts a lot. Networking (see Section 2.2.5) is very useful not only to help you to build the reputation, but also to find potential talents in your local community.

If you want to attract people interested in Startups, post job announcements on forums or groups that you believe are aware of the Startup environment. Express your enthusiasm in the job post text. Make it clear that you are looking for people that want to work in startups, people who understand and like this environment. This will save you a lot of time, not only on explaining the Startup context in interviews but also by keeping away the wrong candidates.

2.2.4 Go up to the cloud

Prioritizing existing cloud solutions for features non-core to your business

When Daniel started to work in Elo7, the company website infrastructure was installed in two bare metal servers. A local SMTP server application was responsible for mail delivery. Server logs were stored in the local drive. Managing and scaling bare metal servers was difficult, so everything was migrated to cloud instances. The mail delivery was decoupled from the application server and migrated to a service provider. Server logs were also migrated to a cloud PaaS, so developers would not need to log in the application servers to search in log files. These and other changes to the cloud led to a lower cost and more flexible systems architecture, enabling the Startup to grow fast and solid.

Startups do not have time to build their own physical server infrastructure. They need to focus on their own product or service development. Nowadays, there are a lot of services that provide almost everything a Startup needs to setup its business online. There are hundreds of offerings on Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) layers. Moreover, most providers offer very low costs for low usage, as well as free tiers for beginners.

Today it is possible to build a technology company just by sticking together existing solutions. There are several of different Software as a Service (SaaS) platforms, most of them offering free tier for small companies to solve a wide range of problems a company has, from file sharing applications to accounting software and communications tools. Almost everything is available freely online.

Software running into production is much more complex than running on developers machines. There are many cloud providers that offer simple solutions to deploy software in a mater of a mouse click, without needing any knowledge on system administrations. These Platform as a Service (PaaS) environments save a lot of precious time for startups, which in the beginning don't have any specific requirement that justifies building its own infrastructure.

Building a physical server infrastructure is hard, time consuming, and expensive. Developing commodity software is also a waste of time. Startups do not have time to spend on tasks other than their core business.

Startups usually have few software developers to do the entire job. It is impossible for a small team to be competent in all technologies. In a software startup, its product codebase is the most

important place developers should spend they hours, learning about the business domain and creating nonexistent and innovative solution to the startup customers. Moreover, every line of code deployed into production increases the maintenance costs. If developers spend time maintaining software non-core for the business, they have less time to work on core functionalities. It is a matter of cost benefit between building and buying. Building software non-core to your business will make you loose focus from your customers.

Therefore:

Use ready-made infrastructures instead of building your own solution. Prefer SaaS to PaaS, prefer PaaS to IaaS, prefer IaaS to 'building your own infrastructure', except for features core to your business.

The more non-core software you delegate to the cloud, the more time your team will have to work on what really matters: your customer. When you spend more time on your business software, you deliver more value and learn faster from your clients. By continuously delivering software to your customers you are bound to become competitive and profitable.

If you need a communication tool to keep the startup remote team together, you can use HipChat or Slack. For documents and spreadsheets creation, there is Google Drive, Microsoft Office 360. Virtual machines infrastructure monitoring can be achieved with New Relic. Systems log processing and analysis can be done with Loggly or Splunk [Cuk13]. Do remote pair programming with Screen Hero.

Most of these SaaS, PaaS and IaaS solutions were a startup someday. Off course if your startup product is a cloud system, developing a cloud service is core to you, so you won't delegate these core functionalities to third party companies. But even cloud service providers use third party software. IaaS companies use SaaS. SaaS companies use IaaS, and so on. The DevOps for Startups pattern (see Section 2.2.8) can help you to choose the right balance between different cloud layers [LKO15]. A bad consequence of choosing the wrong cloud solution is that you can get stuck to a specific provider, so take care, preferring standard and replaceable solutions instead of proprietary hard to migrate architectures.

2.2.5 Networking

Cultivate your personal network every day by continuously creating opportunities to interact with your peers.

When Daniel left his functions as CTO at Elo7, he tried to make a good job on transitioning his responsibilities to the new CTO. Everything seemed to go fine, because the new tech manager remained for many years and the company advanced. Even far from the previous job, Daniel always kept warm the good relationship and friendship he developed with his previous partners, scheduling periodic lunches to talk about business and life events. In one of these lunches, they had a conversation about Daniel's new startup, how it was evolving, and what were the challenges. Nothing special, only a good and fun conversation between friends. Many months after this event, Daniel's friend

presented him to another friend, someone who had interest in the music industry, and would like to understand Daniel's business better. Six months later the friend of the friend became an Angel investor in Daniel's company.

Every day is a challenge in an entrepreneurs' life. When the startup is at its early stage, usually there are only a few collaborators in the company. Many problems occur every day and they are usually not related to the entrepreneur's expertise, like dealing with accounting rules, payroll, government bureaucracies, employment laws, international commerce, etc.

Entrepreneurs and their startups face problems that cannot be solved by their own. When they are isolated, important problems remain unsolved for a long period.

Building a company requires knowledge in many different areas. Friends and family cheer for the entrepreneurs success, so they will be ready to help with anything that is on their reach. Sometimes, a close friend knows someone who knows someone else with skills that solves your problems for a low or fair cost. It is impossible to solve all your problems alone.

Therefore:

Build a strong and diversified network. Keep in touch with people from different locations, distinct business expertise, various cultures, social status, and backgrounds

A strong network of partners will help the entrepreneurs in their long-term journey. To keep the network active and expanding, one should proactively dedicate time to build relationships by:

- Attending startups and community events
- Organizing formal and informal meetings with peers
- Offering himself/herself to mentor younger startups
- Connect with interesting people on professional social networks like LinkedIn
- Continuously acting on social networks writing blog posts, commenting and advertising other people's publications

With this proactive and continuous behaviour, the entrepreneur will be able to build a strong and genuine network of partners. You never know when you will need a lawyer, a specialist in BigData, a good writer or a video-maker. In the long term, a startup entrepreneur increases her chances of success by constantly nurturing her contacts, helping them on their issues, giving them opportunities to help on her problems, or sometimes just having inspiring conversations about life and business.

Networking is important on the long-term, but you should not forget that this is a secondary activity. The most important job is to run your business. Networking alone won't help your business to grow. It will be useless to spend your whole life in networking events, if you don't have the entrepreneurs daily life experience to share. Learning from others is great, but the best learning comes from your own experience.

2.2.6 Use available tools

Use on-line and offline services and tools and don't waste time with non-core work.

When Juliano and Daniel started their company, it was very easy to do the accounting and payments control. They did not have employees, most of the software they were using were free cloud based tools and the company did not have revenue. All expenses were divided equally by the two founders. After some time, when the company started to grow, it became more complicated to keep track of all expenses and revenue started to grow fast. Moreover, some investors got into the business and needed formal reports about company financial numbers. Instead of hiring someone to do the financial reports, or controlling everything with manual spreadsheets, they decided to test an on-line tool. After some days learning how to use the tool, they realized that the whole company financial control could be made using these tools consuming only 10 minutes per week. The tool served not only for internal control but also to automatically create financial and cash-flow reports for their investors.

When entrepreneurs start their new business, there are a lot of tasks that need to be accomplished to set up the company. Some of them are bureaucratic and happen only once, while others are monthly or weekly recurring. Common examples are organizing the company cash-flow, mailing customers, observing and analysing customers behaviours, testing product ideas, signing contracts, hiring people, paying salaries, etc. These activities are part of a startup daily life and need to be accomplished in a productive way.

Entrepreneurs and their startup staff need to focus their attention on primary tasks that are core to the business, such as talking to customers and learning from them, developing the best product that fits customers needs, assuring service quality. Founders need to be productive when doing non-core secondary activities like office cleaning, salaries payment, or cash-flow control. This does not mean that these activities are not important to the business. Actually, they are essential and need to be accomplished to keep the business running. Startup founders can't be experts in everything and these activities usually are not their core area of expertise.

Entrepreneurs do not have time to spend in many essential and required tasks that need to be accomplished but are not business related.

Startups don't have money to hire specialists in all areas, specially in the beginning. Besides that:

- most tools are free for small sized startups;
- startup community share knowledge about tools usage and can help;
- using productive tools, you have an advantage over the competition.

Therefore:

Use existing tools to accomplish non-core tasks instead of spending time and resources creating everything from scratch.

There are many on-line tools that solve common operational problems for startups. Most of these tools are SaaS (Software as a Service) that usually have a free tier for small companies or have very cheap entry options.

This pattern is similar to **Go up to the Cloud** (Section 2.2.4), but here the focus is not only on software infrastructure on-line services but also business support solutions. Do you need to send e-mails to your customers? Use the available tools for that instead of creating your own e-mail delivery service. Do you need to do A/B testing? Use an on-line tool for that. Do you have to organize payments and incomes? If possible, try to use an on-line service instead of hiring a secretary or other expensive accounting service.

Sometimes the learning curve for using those external tools can be steep, but after a few iterations, using them will become cost effective. Entrepreneurs will have more time to focus on strategy and business thinking instead of spending hours in operational or bureaucratic tasks. Moreover, remember that most of these tools are someone else's startup trying to evolve, thus using them will help to develop the entrepreneurial ecosystem. These tools are usually easy to configure and will save a lot of effort from your tech team, helping them to focus on your startup core features instead of creating supporting tools. Keep in mind, though, that most solutions were created for a large range of problems and could not fit well into your business. Even if it is not the case in present, this problem could also appear in the future of your company, e.g. business or legal changes.

The drawbacks of using external tools are:

- Vendor lock-in: it may be difficult to move to other providers if the tool you chose does not provide migration features.
- Data ownership: when you use external providers, the provider has access to your data. Be aware of the terms of use of your providers and make sure that your business data will not be shared with third parties or used for other purposes.
- Future costs: most online tools begin with very cheap options for small companies, but when you start to grow, the cost of these services can become too expensive for you.

When your company is just an idea, you don't need to hire developers to build landing pages and test business hypothesis. There are easy to use tools like Unbounce, Instapage, Leadsquared and many others to create quick landing pages and doing A/B tests. Optimizely is also a great tool to quickly create A/B tests for an existing website: business people can use it without need of development team effort. Mixpanel, Google Analytics, Heap Analytics are examples of must have software for measuring customer behaviour on your web or mobile application. In Brazil, there are some startups like Conta Azul, QuickBooks or Omie.com.br that offer on-line services for accounting and business finances.

2.2.7 Find your mentors

Choose one or two more experienced persons to share with you their life experience

and to convey credibility to your work.

Bill and Dave graduated from a young but already respected university from a less developed region of the country and decided to found a company to work with vacuum tube technology. They asked their university advisor, Fred, to be their mentor. Fred not only provided some helpful tips during the following years but, more importantly, served as a friendly shoulder for the difficult moments of the nascent company. He always had an open mind, ready to discuss new ideas, and opened many doors with the network he had built over the decades of his professional life. Later, the company grew and became known by the last names of the two founders, Hewellet and Packard and gave birth to the Silicon Valley.

Most startups are founded by young entrepreneurs, with ages 20 to 30, i.e., they are in the beginning of their professional lives and have relatively few professional connections. In addition, most of them are in their first, second, or third jobs or enterprises and did not have yet many opportunities to experience the large variety of situations, which business development entails. Even more experienced professionals can face difficulties when becoming entrepreneurs: handling legal issues, receiving investment, or even understanding their market. Technological, managerial, psychological, and other business related problems can hinder the capacity of startups to discover a repeatable and scalable business model and, many times, learning from past experiences or mistakes previously made can serve as powerful tool to surpass obstacles.

Experienced mentors such as executives from large companies or successful startups, serial entrepreneurs, or university professors have learned a lot from the dozens of mistakes they have done over the multiple decades of their lives. By collaborating with young entrepreneurs, they can share their practical knowledge, giving good suggestions to startup founders on how to approach the challenges of their business. Even more importantly, they can serve as an amiable collaborator, who is always ready to exchange some thoughts about your startup or someone you can use as devil's advocate to test your ideas.

Startup founders sometimes think they know everything about their business and do not need help. The smarter ones, are aware of their limited knowledge and can feel lonely, without a reliable person to exchange ideas about their business.

Young entrepreneurs have had very few professional experiences and, often, do not have a broad view of all the aspects of their business, all the things that can go wrong, and all the obstacles they will need to surpass. Very often, founder teams do not include all the skills required to run that business and they do not yet have funding necessary to hire high-quality professionals for that missing area of expertise.

Mentoring by experienced professionals can be useful not only in entrepreneurial activities but also in other fields such as technical aspects of software development. For example, pair programming with an experienced developer who acts as a mentor is a very effective way of learning best practices and elegant programming style.

Therefore:

Find one or two experienced professionals that will serve as mentors for your startup.

Start by thinking what are the weak links in your teams, what are the fundamental skills that your team lacks. For example, if you are founding a startup that will develop software to address the medical needs of elderly people, you need to ask yourself: do I have someone with good experience and knowledge in software development? What about Medicine? Gerontology? Business? So there are at least four fundamental aspects that must be covered by your team. If the founders are composed of one software engineer and one young medical doctor, you certainly would get a lot from adding to your team, at least, two mentors: one experienced in business in the Health sector and an experienced gerontologist. Giving some equity to the mentors is also a good idea to increase their commitment to the startup.

Try to find mentors that you get along with and have a personality that goes well with yours. Not only chat with them regularly, e.g., via phone, video-conference, text messages or email but also try to meet them in person, at least, once every one or two months. During these conversations, they can scrutinize your business and give you valuable feedback. Good mentors will give you lots of good and bad advices; it is your job to select the ones you will choose to follow. You should Get Help from the Methodologies (see Section 2.2.1) to test which are the good advices. Mentors don't need to have answers to all your questions. Sometimes they will be helpful only be asking you the right questions and making you think deeply about your business. You and your mentors may disagree and that can lead to conflicts. Keep in mind that they also want the best to the startup and try to avoid these situations.

Good mentors will use the professional networks they have built over their long careers to open important doors for you, connecting you to potential partners and introducing you to potential investors, customers or even competitors.

Last but not least, mentors also give credibility to your business. If you are in the health sector, showing the name of a well known physician from a major hospital in your company's profile can make a big difference. If you are on the software or hard sciences area, showing the support, via mentoring, of a renowned university professor in your startup's web site conveys the idea that your business has a solid scientific foundation.

HP was founded by Bill Hewlett and Dave Packard who received mentoring from Prof. Fred Terman, a story that inspired the example in the beginning of this pattern. Larry Page and Sergey Brin received mentoring, and a little bit of angel money, from Prof. Rajeev Motwani. Uri Levine, after failing in several startups and succeeding with Waze (selling it to Google for over 1 billion dollars), started to serve as a mentor for startups. [PP95]

2.2.8 DevOps for Startups

Use DevOps practices in your software startup to keep it lean and efficient

A growing startup had it business based on a marketplace platform. It had just received Series A investment, and hired a new CTO to help on scaling the business. Even if the existing software and company technical processes made a good job on taking the business to that stage, that infras-

tructure would not support the exponential growth for the next years. New versions of the software were difficult to be deployed, and sometimes many minutes of downtime were necessary to update the systems. One of the first things the CTO did to mitigate these problems was to move all the infrastructure to the cloud, and implement a DevOps process in the development team. He hired new developers and trained them to be able to deal with critical systems in production by themselves, without depending on external system administrators. After some months, the company's software kept evolving, with a mature software delivery process, sometimes with dozen of deploys in a single day with no downtime.

The faster a startup deploys software into production, the faster its business evolve. This continuous and rapid delivery cannot be done ignoring quality aspects, quite the opposite, high quality software can be a competitive advantage for many startups. "DevOps is a set of practices intended to reduce the time between committing a change to a system and the change being placed into normal production, while ensuring high quality" [BWZ15].

To deploy complex products, software startups depend a lot on Internet infrastructure. It is hard to find good sysadmins, and they are usually too expensive for the startup budget.

Today, simple blogs or CRUD web applications can be easily deployed using PaaS platforms. Scalable software startups usually have a much more complex software to deploy, and need to put effort on keeping its software delivery process clean and efficient. The startup software needs to be updated everyday, sometimes several times per day. System deploys need to be delivered with something as simple as a click of button. Moreover, the quality must remain, bugs must be avoided, the system up-time must be 24x7. All these requirements are essential to software startups who wish to be successful. Yet, early stage startups have only a few developers and no system administrator specialists. Sometimes developers have limited knowledge about running systems into production environments.

Therefore:

Use modern DevOps patterns in your startup. Join system operations and software development knowledge into a single unit and keep them side by side along the startup life

DevOps literature has been evolving in the past decade [Htt12], some of them focusing on describing patterns useful in a startup context [Cuk13]. DevOps patterns can be related to (1) technical issues, (2) organizational structure or processes. Some examples of technical DevOps patterns [Cuk13] are:

- Instead of administering a server for file storage, startup owners can **Store Big Files in Cloud Storages**, reducing costs and facilitating critical files management;
- Use a **Queue-based solution to process asynchronous jobs** to have a better control of background processes;

- Use an external **email delivery** service instead of building your own SMTP infrastructure.

Other examples of patterns from the organizational and processes point of view:

- Use a centralized **Logging** solution, to avoid manual management of logs;
- Implement a **Realtime User Monitoring (RUM)** solution, to easily understand your customers behaviour, avoid critical bugs impact;
- **Prefer PaaS over IaaS** when it is convenient, avoiding complex systems administration tasks for systems that are not core to your business (See section 2.2.4).

From the technical perspective, using many DevOps patterns together is a good starting point for scaling a business. This pattern is related to the **Go up to the cloud** (Section 2.2.4), because many DevOps tasks are related to having a broad understanding of Cloud Computing technologies.

Sometimes, DevOps practices are not so easy to understand or implement. If you already have a system administrator in your technical team, the tendency is that the developers leave this administrator with production related tasks, creating a separation between Dev and Ops on the long-term. Also, DevOps is another set of skills that your team needs to develop. Some developers may not be happy with learning something that eventually is not between their topics of interest, thus you need to motivate the team by showing them the big picture of how important it is to have a smooth and productive software delivery and maintenance process.

2.2.9 Acquire Customers

Understand your market and use multiple channels to bring in customers.

While Jorge was still in college, he created an website to advertise private classes for students. Since he was a good software developer and had just learned object-oriented programming and design patterns, he spent hundreds of hours creating exceptional high-quality code. However, when the website finally got published, Jorge was frustrated when he realized that not a single potential customer visited the site.

It is common that software startups are created by technology experts. If you are a developer, you enjoy programming and all the technical stuff. You can produce the most elegant code and solution. But, usually, you do not know how to sell your product. When launching your product, you should be aware that, to be profitable, it must be sold somehow. Even if you have a free website you will need to "sell it" to get more attention from users. In addition, Lean Startup teaches us that we must learn from the customers and users which product to build. You need users for several reasons:

- When you Get Help from the Methodologies like Lean Startup (see Section 2.2.1), it is expected that you bring users to test your hypothesis on them;
- You have to show your startup progress to your current investors or potential future investors, demonstrating that your business has traction;

- In most cases, users are the ones that pay or indirectly generate revenue to your startup. You will only have a sustainable business if this revenue is significant and grows.
- No one likes when their job is not fruitful. You and your startup team will certainly become very frustrated if no one is using your product.

Startups need customers to survive, to prove that they can grow, and to learn about their market.

There are several possibilities to advertise your brand-new product and reach to your potential customers. Some are cheaper like SEO (Search Engine Optimization) or newsletters and others can be more expensive like affiliate programs, but all of them demand some learning and hard work. As time will be short, you should understand your product and its target audience and figure out which sources will be the most cost-effective. For instance, if your product is B2B (business-to-business), investing in social media may not be a good idea.

Therefore:

Understand the options you have to disseminate your product and use them accordingly to your business model.

There are some dissemination channels in which you do not have to spend money directly or in which you can spend just a little money, like SEO, social media, newsletters, blogs, informational web sites, and press releases. Among paid options, we can cite search engine marketing, i.e., when you pay for your product to show at the top position in search engines, social media marketing, displays in related sites, and affiliate programs. Sometimes, what you will really need are salesmen with market experience. These options are not mutually exclusive, actually you should find the best combination of channels for your particular case; for that Find your Mentors and get advice from them.

For example, it is always helpful to be listed first in search engine results. One thing that should be avoided is dependence on a single channel, i.e., all your customers coming from the same source. If this source stops bringing new customers, your product may fail. Diversify strategies and be protected from this threat.

Finally, you should be aware that bringing customers is not the end. You should be worried about other metrics like engagement, i.e., if the users that know your product keep using it and churn, i.e., whether you loose customers. Otherwise, you will be spending money forever to bring customers in and your product will never be sustainable.

The drawbacks of Acquiring Customers are:

- You may spend too much money on advertising and do not get profitable users in return.
- You may forget that more important than bringing customers in is learning about the customer pains and needs so that you build the right product. If you do not have the right product, you will need to spend a lot more money to attract your users.

Jorge learned a little about SEO and got enough traffic for his site via search engines. The project ended but that learning was important to teach him about how important customers are and helped him in the enterprises he helped to create afterwards.

2.2.10 Pattern Language Wrap-up

The presented patterns can be used individually, but more effective results can be achieved when these patterns are used together. For example, you can use **Networking** to **Find your mentors** or **Acquire customers**. The reverse is also true, as you can use your mentors to build a strong network and also find new customers.

The **Long term purpose instead of money** can be one of the many ways to **Hack money incomes and outcomes**. **Use available tools** will also help you to **hack money outcomes**. It will be very difficult to use **DevOps for Startups** without **going up to the cloud**, since DevOps and cloud are closely related. **Get help from the methodologies** and you will be guided to **Acquired customers** more effectively, without spending so much resources.

Besides the presented pattern language are a good start, they are far from being a complete pattern language. We already drafted many other patterns that could be included to this language in future. For example, a pattern for valuating the startup, fund raising, pattern for reflecting about the business, pattern for doing the right pitch and so on.

The patterns describe good practices that any entrepreneur could use in his startup. In the next Chapters, we present our theory about startup ecosystems evolution. This research should not be seen as something detached from the entrepreneur daily life. Quite the contrary, entrepreneurs are inside the ecosystems. Everything that affects the ecosystem will affect the entrepreneur's life. Not only that, everything that affects the entrepreneur's life will have direct impact on the ecosystem structures.

Chapter 3

Literature Review

According to the classic Glaserian grounded theory guidelines [GS09], one of the methods we used in this thesis, researchers that use this method should not refer to existing literature to avoid being influenced by the existing knowledge. This grounded theory rule does not mean that one should not consider the existing knowledge at all. On the contrary, existing comprehensions and theories can be very useful to corroborate or refuse the created theory. However, they should be consulted in the right moment: not before, but after the research is already in a mature state.

For this reason, as you will see in the methodology chapter, part of the most specific literature on ecosystems was examined only after the research data collection and analysis phases. In the initial phase, only introductory research on entrepreneurship, startups, and innovation was studied. Although the publications review was not a fully comprehensive systematic review, it encompassed 269 readings, including books (53), reports (24), theses (4), and articles (188) published on conferences and academic journals on business, high-tech ventures, entrepreneurship, regional development, innovation, software, and management. The findings are divided in the following sections: Section 3.1 brings literature about **startups and their ecosystems**; Section 3.2 encompasses the **existing frameworks and models** about ecosystems; and finally Section 3.3 closes with publications about **maturity models**.

3.1 Startups and their ecosystems

We observed many factors and characteristics about startup ecosystems present in the existing literature in our first case study in Israel [KCM+14]. However, we did not find a deeper analysis comparing ecosystems, demonstrating how distinct factors found in different places can lead to the same result.

Startup ecosystems cannot be analyzed as static entities. Similar to biological ecosystems, they behave like living organisms and change over time. Some changes are planned or somehow controlled, while others are results from unexpected forces acting within and outside the ecosystem.

The groundwork for the startup ecosystem literature was laid years before both the terms "ecosystem" and "startup" began to be broadly used and understood in the context of company creation. Dating back to the 1980s and 1990s, scholars have studied geographic regions around the world where entrepreneurs have successfully emerged, seeking to understand the reasons behind that success [Fel94, RL84, Sax94, Mal97]. Others have focused on prescriptions for supportive environ-

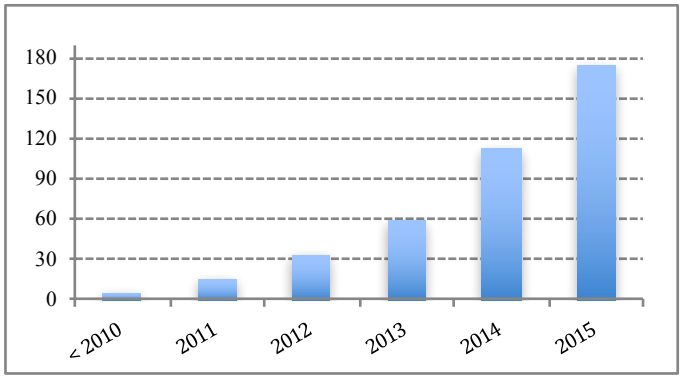

Figure 3.1: *Papers containing the term "startup ecosystem". Source: Google Scholar*

ments for emerging businesses that feature human development and other services [BM93, Joh93]. This literature made early contributions to the idea of a context supportive to both entrepreneurs and their enterprises, which was later fleshed out in the model of a "pipeline of entrepreneurs and enterprises" for managing a community's portfolio of businesses [LL01].

In 2001, Lichtenstein and Lyons presented their "entrepreneurial development system", which focused on the development of entrepreneurial skills through a community-wide or regional coaching and support system, as the main strategy for creating wealth and economic prosperity [LL01].

The term in wide currency at that time was "entrepreneurial community." Studies by both the Edward Lowe and W.K. Kellogg foundations contributed to the understanding of the elements of such a community, which included a supportive local culture; a helpful government; resilient and efficient hard and soft infrastructure; a varied collection of financial resources; support for youth entrepreneurship, and broad and strong networks [Fou02, DMM+03]. Building upon this work, Lichtenstein et al. [LLK04] and Markley et al. [MMF14, MLM15], offered prescriptions for fostering entrepreneurship among civic leaders and developing entrepreneurs and their businesses in entrepreneurial communities.

The theme "software startup" is not so new, even if there is still a wide research agenda for it [UAW+16]. Software startup ecosystems are a novel object of study, although we already have ample examples demonstrating that these ecosystems pass through different phases during their development, and that they can eventually degrade or die, as has been reported in Atlanta [BT14].

The term "startup ecosystem" appeared in the literature around 2005, and, according to Google Scholar, the occurrence of this term started to grow exponentially since 2010, as depicted in Figure 3.1. In fact, the notion of startup ecosystems emerged when technology (especially the Internet, and later, mobile systems) entered the mainstream and became a crucial aspect for innovation, transforming many traditional business centers into technology centers.

Nevertheless, very few works explore the ecosystem's dynamics and evolutionary nature. To analyze them, a snapshot from a given point in time is not enough [MB14]. Ecosystems must be evaluated over the course of years, in particular, a longer period over which we can observe the ecosystem maturation process.

As many of previous studies claim, culture is a deeply significant aspect that defines the ecosystem's characteristics. Thus, mapping its culture is one way to understand an ecosystem. Hofstede presented measurements for cultural aspects in many different countries [HHM10]. Places with significantly different cultural behaviors can have their own successful ecosystems, which shows

that specific cultural characteristics themselves are not a requirement for the existence of healthy ecosystems, but rather a base over which ecosystems evolve. Every region or country has a different entrepreneurial identity, which had in part been attributed to culture. "What we do know is that differences in entrepreneurial activity among countries, and regions within those countries, are persistent and cannot be fully explained by institutional and economic variables. A substantial part of these differences has been attributed to culture" [KLnN13]. Besides culture, the success of an innovation ecosystem highly depends on the level of inter-connectivity between its players [IL04]. Connectivity matters and improves as an ecosystem progresses [Ste08].

Regarding startup ecosystems, in the Secrets of Silicon Valley [Pis13], Piscione explores the characteristics of the first and most successful startup ecosystem in the world, which generated more than 6,000 innovative companies. For her, there is a shared set of attitudes, values, goals, and practices that turn the Valley into a unique place that is difficult to reproduce. Nevertheless, some of the Valley characteristics could be (and actually already are) reproduced in other places. Piscione points out the characteristics of a healthy startup ecosystem: (1) the presence of a high ranked University (e.g., Stanford), (2) the cultural mix of experienced and high-talented entrepreneurs, investors, and academics, (3) a wellness mindset and quality of life, with casual offices, healthy work culture, and disdain for hierarchical communication models, (4) people from many parts of the world and the Immigration and Nationality Act of 1990 that encouraged highly skilled immigrants to move to urban centers, (5) risk and failure being embraced as part of the entrepreneurial journey, (6) authentic entrepreneurs with passion to make a difference in humanity, (7) a well established patent industry, (8) passionate, authentic, driven by ideas, fearless in risk-taking, trustworthy, and resilient people, (9) no idea considered crazy, (10) the Venture Capital industry on virtuous cycle, where successful entrepreneurs take their exits earnings to invest in new startups, and (11) network culture of freely exchanging ideas.

In healthy ecosystems, entrepreneurs are embedded in the local area. Embeddedness is a widely studied entrepreneurship concept. It is considered the nature, depth and extent of an individual's ties into the environment [JA02]. It is a mechanism whereby an entrepreneur becomes part of the local structure.

In another approach trying to understand ecosystems, Feld presents the Boulder thesis with four essential characteristics in a successful startup community [Fel12]: (1) it must be led by entrepreneurs and not by other important players such as government, universities, service providers, big companies, etc., which Feld call feeders; (2) the leaders (entrepreneurs must have a long term commitment with the community (at least 20 years); (3) it has to be inclusive, which means that everybody who wants to participate must be welcome; and (4) it must offer high quality events to engage people, specially acceleration programs and mentoring sessions.

Hwang and Horowitt [HH12] claim that what explains the success of the Silicon Valley as a fruitful environment for innovation is not only the availability of qualified labor, capital, and technology but also, and most importantly, the unique differences in social behavior presented by people in the Valley. They proposed a Rainforest model of innovative ecosystems in opposition to a conventional plantation or agricultural model. The rainforest metaphor, with its diversity and inherent chaotic processes, reflects better what is important for innovation to emerge. They claim that the capacity of the ecosystem to promote innovation derives from its diversity of talents, trust across social barriers, motivations that rise above short-term rationality, and social norms that

promote rapid, "promiscuous" collaboration and experimentation among individuals.

Paul Graham considers high growth rate one of the most important characteristics of startups, and the secret for a great startup ecosystem is to have the right people working there. He claims that two kinds of people create a tech hub: investors and tech experts, but "a startup with the best people will beat one with funding from famous VCs". Graham also defends that a tech hub can only exist with the presence of a first-rate university close by, which is certainly the case of New York, Tel-Aviv, and, possibly, São Paulo in the fields of Computer Science and Engineering. For him, a high-tech city needs to be more liberal and tolerate odd ideas. A technology ecosystem grows organically and takes time [Gra06a, Gra06b].

Cometto and Piol [CP13] analyzes the story of the New York City entrepreneurship ecosystem, also known as Silicon Alley. In spite of having some history of successful startups, the numbers are lower than those in the Silicon Valley (the Valley is five to six times larger than New York in volume of invested capital). A recent (2013) partnership between Cornell University and Technion and an ambitious high-tech program created by Mayor Bloomberg aims to transform New York into the largest innovation center in the world. The advantages of NYC that Cometto and Piol cite are: (1) easy access to capital, as being close to the financial center of the world; (2) the new on-going, long-term project for Cornell NYC Tech University campus; (3) tolerance for high risk and failure; (4) a great sense of community, generosity and networking; (5) NY Tech Meetup, a non-profit organization with over 36,000 members supporting the New York technology community (nytm.org); (6) a big angel investors community based on the giving back culture; and (7) a large community with open access to the business world.

A network analysis of Canada's Technology Triangle emphasizes the importance of knowledge transfer, inter-firm networks and collective learning on the evolution process of high-tech ecosystems. Xu considers that knowledge transfer is a core force to drive the ecosystem evolution over time, pointing that knowledge transfer improves the relationship between individual firms, being responsible for establishing intra-firm and inter-firm technology networks [XM06] and build collective learning within the cluster.

Startup Nation [SS11] is the most famous account on the Israeli startup scene. In this best seller book, the authors claim that some factors led to the success of Israel as a startup ecosystem: (1) the military service (a compulsory duty for all 18 year old Jews) with its associated technical training; (2) the culture of doubt and argument, where leadership can always be questioned if it is reasonable; (3) assertiveness versus insolence; critical, independent thinking versus insubordination; ambition and vision versus arrogance; (4) the historical background, which makes Israel a place where people want to improve and succeed; (5) incentives for employing immigrants, specially highly-qualified scientists and knowledge workers; (6) Israel's smallness, which creates an opportunity to specialize in quality based on creativity. The book is written in a journalistic style and does not use a systematic approach to analyze Israel's ecosystem. In our research, we add to the anecdotal accounts of Startup Nation by using qualitative research procedures and techniques [CS07] to answer a set of well-defined research questions and develop a conceptual framework to help understand the elements that compose Israel's ecosystem as well as the relationships among them, all grouped in a unifying general view.

According to a ranking reported by Telefónica Digital, the Israeli startup ecosystem was considered in 2012 the second best startup hub in the world [HMDH12] and the third best in 2015

[HGH+15]. The report states that, differently from the Valley, Israelis care more about "building a great product" than "changing the world". They prefer smaller but faster, frequent exits. This can be explained by the fact that although Israel has the highest density of tech startups in the world, its local market is very small, so most of its startups are forced to grow internationally and/or be acquired early [dH11]. Thus, it seems that, currently, Israel's specialty is on creating a large number of short-lived startups that either fail or are sold to large foreign corporations after a few years.

Some academic works emphasize the role of intelligent policy-making in promoting innovation by aggressive pursuit of strategic objectives, fast adaptation to market conditions and combating market failures [Avi11]. Numerous policy design comparative studies [Rop00] aim to identify the "secret ingredient" of Israeli public policy for sustainable entrepreneurial capital formation and propose a generic model that can be replicated in other economies [Yuk09].

Dan Breznitz studied Mamram, the Computer Unit of the Israeli military, and concluded that it serves as a collaborative public space, acting as an originator and strengthener of innovation social networks, gathering, processing, and disseminating information [Bre05]. A number of innovation scholars consider military spending a major source of technological progress [TW12]. Piscione argues that Israel's success lies in the compulsory military service and in immigration, not recognizing other aspects of the Israeli ecosystem [Pis13]. Haan claims that besides the military industry, other two important aspects that helped Israel to be one of the most evolved places to start a tech company are the specific immigration of tens of thousands of highly educated Russian Jews from the former Soviet Union and the strong presence of high quality education. Haan also states that, in Israel, the ecosystem of universities, ventures, and incumbent companies facilitates exploration and exploitation, providing the five main components of capital that fuels growth: human, financial, social, knowledge, and entrepreneurship [dH11].

Patents are one of the most commonly used quantitative measure of innovation, as 'each patent represents an individual "quantum" of invention' [TW12]. Israel ranked 6th in the world in the number of patents per capita [LCM06]. This might be partially explained by a somewhat counter-intuitive fact: Israel is a very small country with very limited natural resources, and this can be considered an advantage for innovation, while some scholars argue that abundance in natural resources is an obstacle to innovation [TW12].

Some of the Israeli cultural characteristics are considered favorable for developing startups. Innovation is an act of revolt; a culture of individualism should aid it, while a culture of hierarchy, tradition, respect for status quo and authority should obstruct [Mok02]. Israel has one of the lowest "power distance" ranking, showing that hierarchies are very flat [HHM10]. High-levels of cultural individualism correlate with national innovation rates [TW12]. Israel is in the 19th position on the individualism ranking of 53 nations [HHM10]. Moreover, some types of collectivism present in Israel (e.g., patriotism and nationalism) also foster innovation at national level [TW12].

In a survey conducted in 2000, Meseri and Maital tried to identify problems in Israelis practices with regard to technology transfer from universities and research centers to the industry [MM01]. The authors report that while Israel is one of the world leaders in the productivity and intensity of its basic research in science and technology, its ability to transfer the fruits of this knowledge-creation to commercial applications is considered inadequate, ranking 41st in company-university cooperation and 40th in development and application of technology, according to the IMD's World Competitiveness 2000 Yearbook. The survey covered 8 technology transfer offices and units but was

inconclusive in terms of finding the reasons for this problem. One way to mitigate this problem might be through incubators interposed between research universities and the industry to support knowledge transfer. The incubator role is transforming theoretical knowledge into financial gains and this happens mainly via informal contacts and networks of innovation among the involved parties [RD05].

3.2 Existing frameworks and models

The triple helix model proposes that innovation ecosystems can be managed in a top-down approach from three perspectives: government, universities and industries [EL00]. Brännback et al. challenge this model by arguing that it fails to include the entrepreneur as the most important agent in the entrepreneurship ecosystem, and that the bottom-up approach is more effective [BCKE08].

Although there is a large amount of literature on startups and entrepreneurship in general, we could find only a few of them that try to develop conceptual frameworks or present a comprehensive view of startup ecosystems as a whole. Some of them focus on specific areas such as entrepreneurship education [O'C13] and the VC industry evolution framework [AT06]. Kang and Park [KP12], for example, present a specific framework that can be used to assess the mechanism of influence of government R&D support and inter-firm collaborations on innovation in biotechnology SMEs.

Daniel Isenberg argues, "There's no exact formula for creating an entrepreneurial economy; there are only practical, if imperfect, road maps". Instead of trying to imitate successful ecosystems, each region should identify its own qualities and develop them [Ise10, Ise11]. He also proposes a conceptual model for entrepreneurship ecosystems (Figure 3.2). The model maps different agents in the ecosystem and proposes that these agents must work together. Although this model contains almost all the important aspects in entrepreneurship ecosystems, it is not clear in the model how connections between agents are performed or established. The model is based on the OECD Indicators of Entrepreneurial Determinants that proposes indicators for measuring the ecosystem performance in 6 areas: (1) Regulatory Framework, (2) Market conditions, (3) Access to finance, (4) Creation and diffusion of knowledge, (5) Entrepreneurial capabilities and (6) Entrepreneurship culture. A limitation of this model that we try to capture is that it misses ecosystems' dynamics and the connectivity aspects.

Chorev and Anderson [CA06] proposed a model identifying critical factors for success. It divides these factors in two groups: internal (e.g., team, product, marketing) and external (e.g., politics, economy, education). Their study is based on experience and tacit knowledge of Israeli high-tech venture leaders. Similar to our study, they use interviews to collect data. Based on the experience collected from 13 high-tech leaders, they found that one of the major faults in many startups is a focus on technology, while the marketing departments are established very late. Moreover, funding has to be timed correctly (and sometimes investors do not add any value and may become an obstacle). The authors propose the top eight factors for high-tech startup success, in order of importance: (1) team commitment, (2) team expertise, (3) customer relationships, (4) core team expertise, (5) management, (6) strategy, (7) R&D, (8) the idea itself. External factors as politics, general environment and economy are shown as non-critical aspects for startup success. According to the authors, this study has still to be tested for causality and can be further adapted and expanded based on future research.

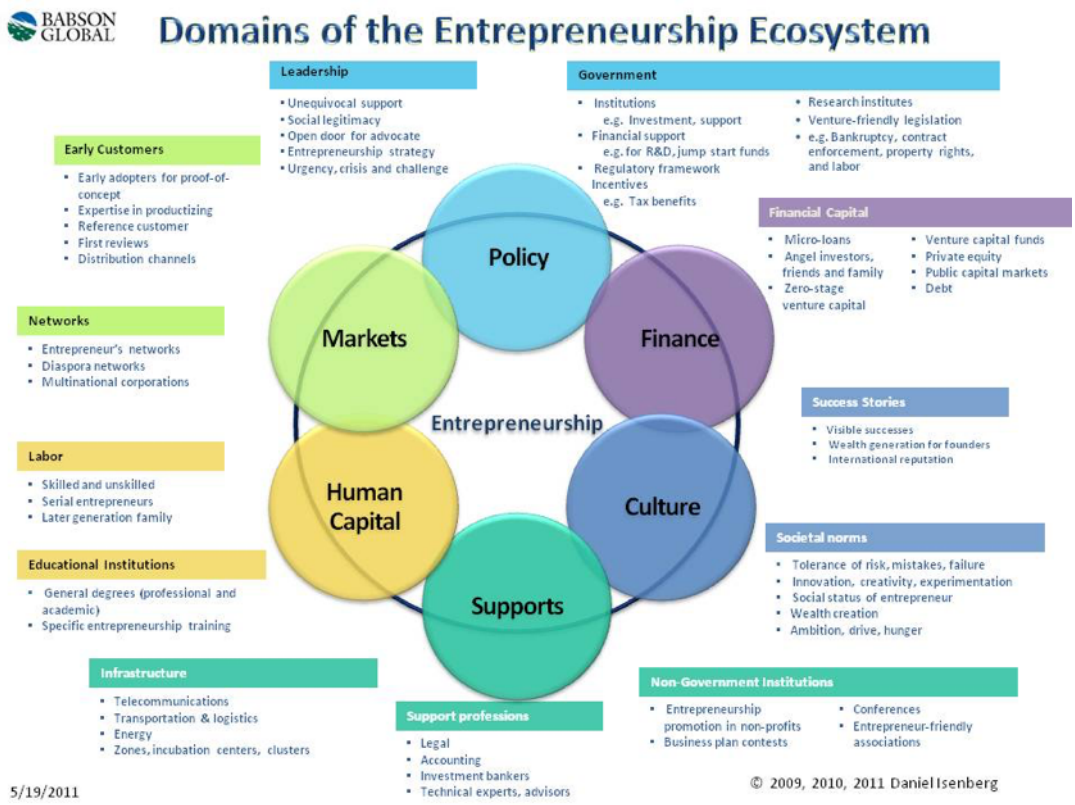

Figure 3.2: *Domains of the Entrepreneurship Ecosystem model by Daniel Isenberg*

Frenkel and Maital propose a methodology for mapping national innovation ecosystems [FM14] based on a workshop with ecosystem experts. Their methodology is based on a workshop with 15 to 30 experts in the field. These experts identify anchors and processes that characterize that particular ecosystem, leading to a visual innovation ecosystem map. Their methodology was applied to several countries and it resembles, in some aspects, the methods we used in part of our research in São Paulo. Our work differ from theirs in some factors: (1) we extend their approach by also incorporating meetings and interviews with ecosystem players, while Frenkel and Maital's methodology is based on a single workshop with experts; (2) our study focuses solely on software startups; (3) we consider the ecosystem evolution and dynamics, while their methodology depicts a snapshot of the ecosystem.

A framework for measuring innovation level in different countries is proposed by Zloczysti (2011). The framework measures levels of education, R&D, financing, networking, competition, implementation and demand as criteria to measure innovation. It also considers culture (social climate) as a factor that influences innovation levels. Most of the elements found in this framework are also present in our framework, with the difference that we explore the relationship between these criteria, not showing them as isolated or unrelated factors.

Lemos mapped entrepreneurship ecosystems based on the perspective of a research university [Lem11, Lem12]. His model has elements similar to Isenberg's, but primarily focuses on the research university elements, and not on the startup ecosystem as a whole (Figure 3.3). First class universities all around the world play a very important role in the development of the entrepreneurship ecosystem around them [Ste13], for example: Stanford in Silicon Valley [Pis13], Technion in Israel [KCM+14], and Cornell in New York [CP13]. Similarly, in São Paulo, USP serves as an unofficial hub for much of the entrepreneurial activity in the city of São Paulo, and has a number

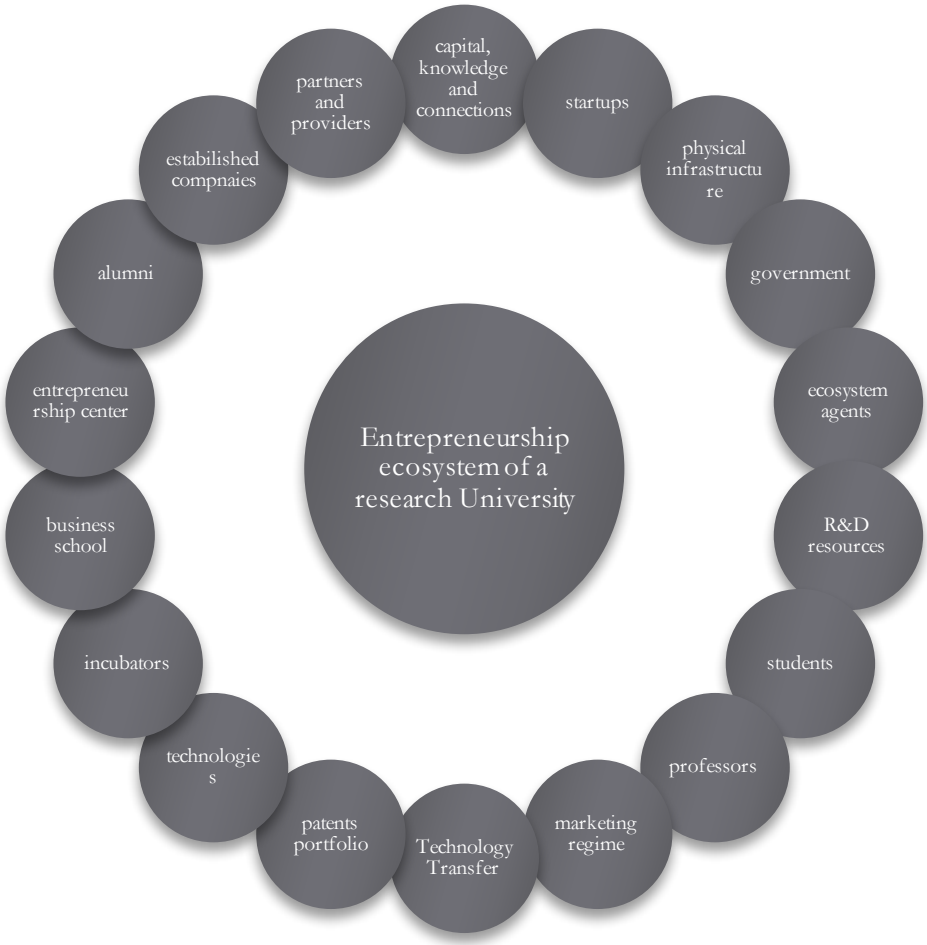

Figure 3.3: *Research University Entrepreneurship Ecosystem Model by Paulo Lemos*

of entrepreneurship initiatives on campus, including specific courses, an incubator, and student entrepreneurship groups. USP was also considered, in a recent ranking, the best entrepreneurial university in Brazil [NR16]. While research shows that the university plays a very important role on the development of a healthy ecosystem, the presence of a high-quality university is only one of many factors that characterize an innovation hub, as we can see in a report by Endeavor comparing the level of entrepreneurship in different Brazilian cities [End15].

The World Economic Forum mapped eight pillars of entrepreneurial ecosystems [FSC+13], namely: (1) accessible markets, (2) human capital workforce, (3) funding and finance, (4) mentors and advisors support system, (5) regulatory framework and infrastructure, (6) education and training, (7) major universities as catalysts, and (8) cultural support. All these eight elements are present in our proposed maturity model and conceptual framework. Our model goes further by not only mapping the ecosystems pillars, but also exploring the relationships and inter-dependencies between them.

Stangler and Bell-Masterson propose four indicators of entrepreneurial ecosystem vibrancy: density, fluidity, connectivity, and diversity [BMS15]. **Density** could be measured by the number of new and young firms per 1,000 people, share of employment in those young firms, and high tech sector density. Population flux, labor market reallocation, and number of high-growth firms measure **fluidity**. To evaluate **connectivity**, they propose the spin-off rate, deal-maker networks, and pro-

gram connectivity. For **diversity**, the measurements include mobility, number of immigrants, and multiple economic specializations. The authors emphasize the importance of the dynamics when analysing ecosystems, claiming that measures need to be continuously tracked. Besides being a good guidance for measuring ecosystems, differently from our model, Stangler and Bell-Masterson do not propose a practical method for evaluating the ecosystem maturity level.

Brad Feld's model also emphasizes the importance of the entrepreneur and claims that less fragmented ecosystems would score higher on all 4 elements required for success (led by entrepreneurs, long-term commitment, inclusiveness, and engaging events) [Fel12]. Recent studies show that policies that focus on bottom-up approaches are more efficient when developing startup ecosystems [Sta15], identifying the entrepreneur as the main change agent, while the traditional triple helix model tends to discard the entrepreneurs to focus only on governments, universities, and industries.

3.3 Maturity Models

Maturity models have been used in the software industry as a tool to assess people, culture, processes and technologies [Met11]. The most widely adopted instance, specially in large and complex organizations (such as the U.S. Air Force, IBM, Ericsson, etc.), is the Capability Maturity Model (CMM) [Pau95, Pau93, PCCW93] and its evolutionary version Capability Maturity Model Integration (CMMI) [CKS03, Tea06]. These models define a methodology to evaluate software development companies and IT management processes. They are not processes, but a description of the characteristics of effective processes. CMM defines five levels of maturity: (1) Initial, (2) Repeatable, (3) Defined, (4) Managed, and (5) Optimizing.

Other examples of maturity models are the following. The QualiPSo OpenSource Maturity Model is a CMM-like model created with the objective to improve the trust in Open Source software (FLOSS) [PNS09, DBLMT09]. MPS.br is a nationwide program for software process improvement in Brazilian organizations [MRW09]. Secundo et al. created a maturity model to measure university technology transfer efficiency [SDBP16]. Finally, the Project Management Process Maturity PM^2 Model [KI02] developed at UC Berkeley aims at evaluating the maturity of project management processes in an organization..

Maturity models can be developed using two different approaches: top-down and bottom-up. The top-down, as proposed by [BKP09] is characterized by pre-setting a fixed number of stages or levels in the model and, after that, elaborating the characteristics of each level. The bottom-up approach [LMM+11], on the other hand, is developed starting by defining the core characteristics or assessment items, and later clustering them to form the maturity levels. We used the bottom-up approach to create the model described later in this thesis. Differently from methods, which are systematic and have their root matter focused on specifying activities (how) to achieve a defined goal, models focus on state descriptions (what) [BWHW05].

The maturity models emerged out of software engineering, but their application had widened to more than 20 other domains during the last two decades. The scientific literature about this topic is still modest and most publications deal with the development of maturity models and empirical studies, with only a few publications of theoretical reflection, as Wendler suggests in a systematic review [Wen12] about the theme.

The concept of maturity models is not free from criticism. Pfeffer and Sutton [PS99] argued

that maturity models are a great tool to identify gaps, but not so effective on showing practical actions to cover these gaps. Moreover, critics claim that maturity models tend to focus on processes, tools, and bureaucracy, while the Agile software community prioritize individuals and the quality of interaction between them [1] to achieve success on software projects.

As practitioners in the software industry for many years, implicitly, CMM/CMMI may have some influence on our model, but we did not explicitly use these model. We believe that classifying a startup ecosystem in a city is very different from classifying software development processes in a company, so we did not created any one-to-one mapping of the concepts between software maturity and ecosystem maturity.

3.4 Literature Review conclusions

This thesis was built on top of the research described in this chapter, going further on (1) mapping and emphasizing the relationships among ecosystem agents, instead of only describing the elements as isolated entities (2) analysing not only the static characteristics of ecosystems but also their dynamics, something missing in the existing literature; (3) proposing a practical methodology for classifying the maturity level of ecosystems, something that, to the best of our knowledge, did not exist; and (4) mapping the key factors of each maturity level as well as the path to the next level. The next Chapters focus on explaining the research methodology, as well as the results obtained along the research.

[1] The Agile Manifesto: http://agilemanifesto.org

Chapter 4

Methodology

This thesis research was performed in three phases, each phase serving as the basis for the next one as depicted in the pyramid in Figure 4.1. The objective of Phase 1 was to map the components and factors that characterize software startup ecosystems as well as the relationships among them. This phase was based on Grounded Theory techniques [CS07].

In Phase 2, the objective was to validate and refine the Phase 1 map, as well as propose a maturity model for the evolutionary process that ecosystems undergo. During this phase, the method mixed literature review, workshops, and focus groups methodologies.

Phase 3 aimed to refine and validate the maturity model proposed in Phase 2. This last phase completes our multiple-case study.

Case study is a formal research process in which detailed consideration is given to the development of a particular person, group, or situation over a period of time. It is a research method focused on understanding the dynamics of research objects [RH09, Yin13]. Multiple case design is used to analyze complex research entities, and it permits induction of rich and reliable models [Yin13]. It consists in analyzing multiple instances of the research object. In our case, the research entity is the startup ecosystem. The next subsections explain in detail each research phase.

4.1 Phase 1: Startup Ecosystem Conceptual Framework

In the first phase, we used qualitative methods with elements from Grounded Theory (GT) [CS07] to identify the key factors that led to the emergence of a successful ecosystem. GT is a complex method fundamentally different from the traditional hypothetico-deductive research model. Grounded Theory-based studies have been growing in the computer science field in the last decade. The goal of GT is to generate a theory other than testing or validating an existing one [SRF16]. GT proposes an iterative method of collecting-coding-analysing data. Each iteration brings new insights and ideas. These new ideas are applied to the new iteration, changing the mechanisms of collecting-coding-analysing. This process repeats until we reach a theoretical saturation point, when all concepts, properties and relationships are already mapped, and new iterations do not bring anything new to the model.

Our goal was to develop a conceptual framework [MH94] of the software startup scene that might help analyze the current status of ecosystems, as well as locate opportunities for their improvement. At that time, we did not delve deeply into related work on frameworks and models of startup

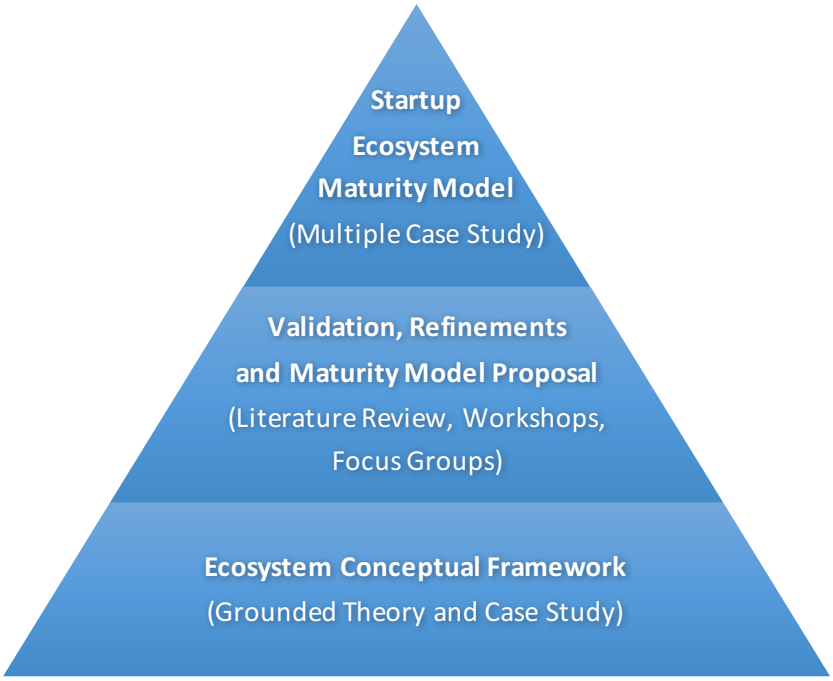

Figure 4.1: *Maturity Model Research Phases*

ecosystems, as we did not want to be biased in advance; rather, we wanted our framework to emerge from the data collected on the field. This approach is described by Corbin and Strauss [CS07] as a particular use of theoretical frameworks in qualitative studies: the researcher first develops a light theoretical body that provides a useful list of concepts, insights, and direction, allowing them to remain open to new concepts and ideas that emerge from field data as they carry out the study. We followed the GT approach that recommends to limit the exposure to the existing literature [SRF16], preventing the researcher from testing existing theory rather than being open-minded to new discoveries. We also followed other principles of the GT method:

- **Treat everything as data**, not only the formal interviews, but also the informal interactions;
- **Immediate and continuous data analysis** during all data collection period;
- **Theoretical sampling** by identifying new sources of data based on the continuous analysis;
- **Theoretical sensitivity** by identifying the relationships between startup ecosystem elements;
- **Memoing** by creating notes and recordings of all data collected, to be consulted later;
- **Constant comparison** between the raw collected data and the analyzed data / categorization;
- **Memo sorting** by oscillating between the memos and the emerging theory;

The objective of this first phase was to answer the following research questions:

- RQ1 - What are the sociocultural characteristics found in the startup ecosystems that foster the entrepreneurial spirit?

- RQ2 - What are the institutional mechanisms in place in startup ecosystems that promote entrepreneurship?
- RQ3 - What is the role of education in fostering entrepreneurship in startup ecosystems? What are the formal and informal, explicit and implicit pedagogical materials and mechanisms that nurtures the entrepreneurial spirit?
- RQ4 - What are the characteristics of successful innovative teams and entrepreneurs? What is the prime motivation of the software entrepreneur?
- RQ5 - Which technological aspects influence the success of software startups, and how? In particular, what is the role played by Object-Orientation, Languages, Frameworks, Patterns, Models, and Architectures? What is the role of Open Source Software?
- RQ6 - Which and how methodological aspects influence the success of software startups, and how? What is the level of adoption of well-known business and software development methods? Does this relation change during the course of the startup life cycle?
- RQ7 - What opportunities exist for the further development of the startup ecosystems? What could be a threat?

We began the first case study in Israel. To collect the data, we used meetings with experts, semi-structured interviews, observations, and a questionnaire. Our group had lengthy experience in software development (ranging from 15 to 25 years), both in the academia and in the industry. We brought to the research a comprehensive knowledge of the focused field (software) and also an outsider, non-Israeli perspective, which allowed us to see characteristics and facts sometimes not grasped by people who have been immersed in the culture for several decades. We partnered with Israeli researchers, Orit Hazzan and Harry Yuklea from Technion, the Israel Institute of Technology, who specialized in qualitative methods and software engineering education and entrepreneurship; they brought to the team a more in-depth knowledge of the local culture as well as complementary skills relevant to the research.

To select the people to interview and startups to visit, we began collecting suggestions from staff and faculty members from the Technion Bronica Entrepreneurship Center, from the Hebrew University of Jerusalem Yissum Technology Transfer company, and from the economic news website of the Israeli Ha'aretz newspaper, The Marker. We then followed a snowball approach, in which people that we met and interviewed recommended additional contacts. Overall, we approached 78 people via email or Linkedin messages, and were able to meet, in person, 48 of them.

From August to December, 2013, Fabio Kon carried out 48 meetings in several cities, primarily in Tel-Aviv, followed by Haifa and Jerusalem. 14 of these comprised informal conversations with experts in the high-tech and startup industry, on which the researcher took detailed notes. The core of the material was composed of 34 semi-structured interviews, the full audio of which was recorded in 25 cases, and on which detailed notes were taken in 9 cases. Most formal interviews lasted for about one hour; the shortest of all lasted for 15 minutes, while the longest lasted for 2 hours and 16 minutes. These interviews mostly covered startup founders, CEOs, and CTOs, but also a few angel investors, VCs, developers, and incubator and accelerator managers. During this process, 25 different startups and 6 accelerator/incubators were visited and observations were written down.

Fabio Kon also attended several events, lectures, seminars, and meet-ups, which are characteristic of the Israeli startup ecosystem.

As the interviews were carried out, the key elements of the startup ecosystem, as mentioned by the interviewees, were annotated and the conceptual framework [MH94] was iteratively constructed and refined by the author of this thesis and his advisor. To answer RQ7, a selected group of the 25 most experienced participants was asked to answer a SWOT questionnaire in an on-line form[1]; 20 of them did provide their input.

We created a protocol describing the full interaction process with interviewees. The protocol describes how to approach the contacts, as well as the interview process and follow-up. A first version of this protocol was used for interviews in Israel. Later, in the second (Section 4.2) and third (Section 4.3) phases of the research, we refined new versions of the protocol for interviews in São Paulo and New York City[2].

As qualitative studies are highly context-and-case-dependent, we observed four aspects to promote a trustworthy study: credibility, transferability, dependability, and confirmability [LG85]. To achieve credibility, we first developed the data collection instruments from practitioners and experts' opinion, either on innovation ecosystems or software development. Although we have used a purposive sampling of interviewees from top universities and startups, combined with a snowball approach, we tried to include participants by considering similarities, dissimilarities, redundancies, and varieties in order to acquire greater knowledge of the wider group. We collected and analyzed data in a systematic and iterative way, from a great number of participants, which improved both confirmability and dependability. To promote transferability, we described protocol details, the data collection and analysis process, and, finally, included quotations with our major findings.

4.2 Phase 2: Conceptual model validation, refinements and maturity model proposal

We performed an extensive review of the related literature after the first case study in Israel [KCM+15]. Important to notice that additional literature kept being added to the research after the second and third phases also. Article sources included: Google Scholar, recommendations from ecosystem research experts, and snowballing from references within the articles we read. The keywords used in the search were "startup ecosystem", "entrepreneurship ecosystem" and "maturity model". Though not a fully comprehensive systematic review, it encompassed 269 readings. The literature findings most relevant to our work were presented in Chapter 3.

After the literature review, we initiated a second case study in the São Paulo ecosystem. São Paulo is Brazil's largest city, 12th largest city in the world, with the 15th largest GDP (measured by purchasing power parity). It is Brazil's financial center and hosts the headquarters of many major companies and banks, including many foreign companies doing business in Brazil. São Paulo is home of Bovespa, Brazil's stock and bond exchange, the largest in Latin America, and has several leading science and technology universities. Foremost among them is University of São Paulo (USP), founded in 1934, one of the world's largest universities, with almost 95 thousand students (of whom about 1/4 are Masters and Doctoral students); four of its 11 campuses are located in the São Paulo

[1]SWOT analysis questions formhttp://bit.ly/swot-israel
[2]Interview protocol available for download at http://ccsl.ime.usp.br/startups/publications

Table 4.1: *Main differences across the Tel-Aviv, São Paulo, and New York startup ecosystem*

	Tel-Aviv	**São Paulo**	**New York**
Country size	Very Small	Continental	Continental
Country independence years	68	194	240
% GDP to R&D	4.2%[6]	1.61%[7]	2.7%[8]
Ranking position (2012 / 2015) [9]	2 / 5	13 / 12	5 / 2
Metropolitan GDP (Billion US$)	132	431	1,558
Startups	3.1k - 4.2k	1.5k - 2.7k	7.1k - 9.6k
Startup Density	0.85 - 1.15	0.05 - 0.15	0.35-0.5
Market Foreign Customers	74%	18%	35%
Startups with tech founders	100%	81%	100%
Ecosystem Maturity Level	Self-sustainable	Evolving	Self-sustainable

metropolis.

Besides having the potential to be a worldwide leading ecosystem in technological innovation and startups output, the city hub presented modest numbers in the last two decades. The 15th position in total GDP is not so amazing when compared to the 135th position in GDP per capita. The Crunchbase database shows 1690 startups[3] (representing 44.6% of all startups in Brazil). The dealbook[4] database contains 143 companies registered in São Paulo (38.2% of companies with location data) [5]. Only 163 deals (acquisitions or risk investment) for São Paulo startups (representing 41% of all Brazilian deals with location data).

Even if these are not official numbers, they represent a good snapshot of the reality, and the nonexistence of precise numbers itself is a sign of the low maturity of the ecosystem. In Brazil, few entrepreneurs have the opportunity to receive investments for their startups, and this can be one of the explanations why 50% of all firms shut down before 3 years [AMRS06]. In Germany, opening a firm requires 9 procedures, and this number is considered one of the worst compared to other developed nations. In Brazil, to open a firm, one needs 13 procedures [O+13].

Part of the São Paulo research was reported by Monna Cleide dos Santos, a member of our research group, in her Masters thesis [San15]. The interviews were performed between May 2014 and Jan 2015. Our team conducted 41 meetings with 32 startups, 3 accelerators, 4 venture capitalists, 1 angel investor, and 1 government agent. The list of interviewees was created using a process similar to the Israeli case-study.

The study of this particular ecosystem allowed us to identify new factors and characteristics that were neglected in the Israeli study. Table 4.1 presents some differences between the São Paulo and Tel-Aviv ecosystems. Although similarities exist in the two ecosystems, we emphasized the differences to show how collecting data from both enriches our model by making it more generalizable.

[3]Search by all variations of term São Paulo at http://crunchbase.com
[4]http://dealbook.co
[5]Appendix B contain the SQL queries we used to extract the dealbook data
[2]OECD Entrepreneurship at a Glance [OEC13]
[3]São Paulo state data. Source: FAPESP indicators for science, technology and innovation May/14
[4]World Bank Data for USA in 2013 - http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=US
[5]Global Startup Ecosystem Ranking [HGH+15]
[6]OECD Entrepreneurship at a Glance [OEC13]
[7]São Paulo state data. Source: FAPESP indicators for science, technology and innovation May/14
[8]World Bank Data for USA in 2013 - http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?locations=US
[9]Global Startup Ecosystem Ranking [HGH+15]

Whereas we applied a SWOT analysis to find opportunities for further development in the Israeli ecosystem, in São Paulo we used a different, somewhat more sophisticated approach. We applied a qualitative technique based on a systematic workshop / focus group that we executed in São Paulo [CKMF16] following a methodology proposed by Frenkel and Maital, using the local help from Prof. Shlomo Maital himself.

To investigate why São Paulo have such modest output given its potential, we gathered a number of ecosystem leaders and experts for a workshop. The results obtained from our exercise are simple enough to grasp but complex enough to capture their key elements as a common foundation or 'language' for an enlightened discussion of policy. The systemic approach this study adopted stands in contrast to partial approaches, in which emphasis is placed on specific aspects of the innovation ecosystem, without properly mapping or understanding the system as a whole and how its various parts interact with one another. Moreover, the most significant obstacles for innovation and entrepreneurship development are not related to technological aspects or capital availability, but depend on convergence and coordination between the various components in the entrepreneurship ecosystem [Moo96]. The purpose of our study was to understand all these components and the interactions between them, based on the idea that successful innovation ecosystems depend on a high level of inter-connectivity between its players [OEC97, IL04]. From the point of view of the university innovation ecosystem, the basic components are: people, companies, organizations, anchors, and processes [Lem12]. We gathered professionals from companies, government, academia, and NGOs to identify anchors and processes pertaining to their ecosystem.

The inputs for the innovation ecosystem map are based on a structured collaborative discussion (experts' workshop) conducted among experts from various realms and disciplines in São Paulo participating in this collaborative exercise. The methodology we used for mapping the national innovation ecosystem was developed and implemented in an earlier large-scale study [FM14]. As we saw in the literature Chapter, there are many authors emphasizing that successful innovation ecosystems have high-end research universities as one of its main assets [Lem12, Lem11, NR16, Pis13, CP13, dH11, Gra06a, Gra06b]. The objective of the experts' workshop was to identify fundamental "anchors" and "processes" that comprise the main elements of the innovation ecosystem around USP, São Paulo's largest research university.

We define these two key concepts as such:

- "Quality anchors" are ecosystem's strengths, or core competencies, on which innovation can be built, such as a high level of human capital, or the existence of strong world-class scientific and technological infrastructure.

- "Processes and trends" are processes, such as vocational training programs, tax incentives, R&D funding, etc., that can enable countries or regions to overcome strategic innovation weaknesses, or constraints that hamper innovative initiatives and policies.

The identification of anchors and processes was carried out in the Experts' Workshop, which took place in the University of São Paulo main campus on August 22th, 2014. To compile these results and elaborate this analysis, we put together a group of two local experts from the São Paulo ecosystem (the author of this thesis and his advisor) and two innovation scholars from abroad (Profs. Shlomo Maital and Amnon Frenkel from Technion), with no previous knowledge of this

local environment. Our goal was to achieve a good balance between insiders' and outsiders' views of the São Paulo culture and processes around innovation.

Experts representing all key sectors and disciplines relevant to innovation, i.e., stakeholders, service providers, policymakers, students and researchers from the academia, and professionals from the industry participated in the workshop and contributed inputs that were used to map the innovation ecosystem of São Paulo. The workshop was based on deep intimate knowledge of the experts and their familiarity with all aspects of the innovation ecosystem, including informal and ill-defined ones. The objective of the workshop was to formulate a creative systematic and inclusive list of key innovation variables that can be transformed into a visual innovation ecosystem map.

The Workshop was conducted through brainstorming and the nominal group technique [Osb63]. During the workshop, each expert was asked, in turn, to propose one anchor. After a first round of this process, there were additional rounds, until no more anchors remain to be listed. After the list of 'anchors' was completed, to the satisfaction of the experts, a similar process was employed to list comprehensively the 'processes and trends'. In addition, each expert was asked, in his/her turn, to indicate whether the suggested process belong to the 'demand-driven' or to the 'supply-side' of innovation or both.

The end result of this workshop included a comprehensive crude list of anchors and processes that reflect the views and insights of experts. The list of anchors and processes were refined, organized and compiled into a final, refined list that included 14 anchors and 10 processes. The list of processes was organized, to distinguish between 'demand-driven' and 'supply-side' innovation. This analysis enables us to show visually and clearly the key elements of demand-side innovation drivers, including consumers, businesses, labor markets, global markets and other channels, and indicate how these demand-side aspects of innovation interact with supply-side elements. Our focus is on identifying 'gaps' -– crucial ecosystem needs that have not been fully met, such that innovative technologies can be leveraged to match supply with demand and create business opportunities. At the same time, we seek to identify supply-driven processes reflecting innovation driven by supply (incentives, funding, etc.), through which resources are directed toward specific markets and products, "pushed" by supply factors rather than "pulled" by demand factors.

In the following step, a cross impact analysis was employed. We evaluated the relationship between the anchors and the processes that were identified in the earlier stage on a bipolar five-point Likert scale [J+04] ranging from strong negative link (1) to strong positive link (5). The evaluation matrix developed was processed through Exploratory Factor Analysis – EFA (data reduction technique), a statistical tool whose purpose is to reduce a large number of variables into a smaller, more compact set [KM78]. In the analysis, the anchors serve as observations in order to group the processes into major factors according to the similarities in their linkages with the anchors. Thus, the processes were grouped according to the results of the factor analysis. The classification of anchors into clusters did not involve a similar mathematical procedure and was based on logic. In order to compute the major linkages between each process factors and anchor clusters a mathematical procedure was employed (see Annexes).

After the experts workshop, we published a technical report describing the results. Until this moment we had three main outputs: (1) insights and practical actions regarding to the improvement of the São Paulo startup ecosystem; (2) insights to conclude our generalized conceptual framework about startup ecosystems; and (3) the strong recommendation from some experts to focus our

analysis not only on static characteristics of ecosystems, but also on their dynamics. At this moment, we began to developed a maturity model for startup ecosystems.

The maturity model was built iteratively. Since we already had a consistent list of the elements in an ecosystem (Startup, Entrepreneur, Funding bodies, etc.), we mapped, for each element, corresponding evaluation metrics. Table 4.2 shows the first version of this mapping.

Table 4.2: *Maturity Model Construction: mapping elements to metrics*

Element	Metrics
Startup	number of exit strategies, number of startups, established companies influence
Funding Bodies	Access to funding in US$ and # of deals, exit strategies
Established Companies	Exit strategies, high-tech company presence, established companies influence
Market	Global market penetration, tax burden, number of startups
University / Research Center	Entrepreneurship in universities, military influence on technologies, technology transfer processes, ecosystem data and research
Education	Entrepreneurship in universities, human capital quality, methodologies knowledge
Entrepreneur	Mentoring quality, human capital quality, ecosystem generations, number of startups, established companies influence
Legal Frame	Bureaucracy, tax burden, technology transfer processes
Incubator / Accelerator	Accelerators quality, # of incubators and tech parks, established companies influence
Culture	Culture values for entrepreneurship
Society	Culture values for entrepreneurship, ecosystem generations
Family	Culture values for entrepreneurship
Methodologies	Methodologies knowledge
Media	number of Specialized media players
Government	ecosystem data and research
Events	Established companies influence, quantity of events

For each metric, we set an evolution scale in three levels (L1, L2, and L3). Each level had a value or a value range for the metric. For example, the metric **Specialized media players** had values < 3 for level 1, values 3 to 5 for level 2 and values > 5 for level 3. These initial values were not completely arbitrary. For each metric, there was a reasonable valuation, trying to match the existing ecosystems we already analyzed, and also considering ecosystems rankings we found in the literature. In Chapter 5 we describe the first complete version of the model in details.

After exposing this initial version of the model to several experts and discussions with them, we concluded that we needed more data to refine and validate the model. We decided to do a third case study, adding a set of questions to the research protocol, now focusing on the discovery of the evolution process. The next phase was executed to refine and validate the created model.

4.3 Phase 3: Startup Ecosystem Maturity Model Validation

During this phase, we ran a case study in the New York City startup ecosystem. The main focus was not to identify how ecosystems operate or the agents involved (this was already accomplished in Phases 1 and 2), but rather to clarify how ecosystems evolve and mature over time and validate

the maturity model proposed in the end of Phase 2.

This part of the research was conducted in the New York City region, in a range of 15 miles from the Manhattan center, on October 2015. The qualitative research method included performing 25 semi-structured interviews with NYC startup ecosystem agents among entrepreneurs (14), investors (4), scholars (4), and other supporting players (3). The interviewees were selected by snowballing [Goo61] our network in both academia and industry. Only one participant was less than 30 years old; the average age was 42 with standard deviation of 11. They were 17 males and 8 females in roles including CEO, COO, CTO, lawyer, professor, manager, founding partner, and writer. All interviewees had at minimum an undergraduate degree: 38% had a master's or MBA, and 13% were PhDs.

The interview protocol was a refined and updated version of the one used in our previous research in both Israel and São Paulo. The protocol was designed to answer the following research questions:

- A. What are the minimum requirements for a startup ecosystem to exist in its nascent stage?
- B. What are the requirements for a startup ecosystem to exist as a mature self-sustainable ecosystem?
- C. What are the stages that ecosystems pass through? Can they regress or die?
- D. Can people proactively interfere in the evolution of ecosystems? Is it possible to develop ecosystems into mainstream ecosystems such as Silicon Valley, generating tens of high growth global startups? How many of these could exist in the world?

To reinforce the qualitative insights from the interviews, we explored quantitative data about startups from the Crunchbase database. Despite the fact that this database is not an official source of information about all existing startups, it is a good representation of the reality. Most relevant startups, especially those that received or want to receive investment, are listed in this database. Moreover, absolute and precisely correct numbers are not necessary for the conclusions we present.

One of the reasons we chose New York was because our literature review showed that this ecosystem experienced a tremendously fast evolution over the last two decades. Another reason we chose New York was that it is an ecosystem with different characteristics compared to the two ecosystems we analyzed before (see Table 4.1). Thus, by examining it, we could validate whether our maturity model proposal adhered to three different realities, making it more robust and generalizable, what is normally referred to as *triangulation*. Differently from statistical generalization, the analytic generalization is not defined by population that has been sampled, but to a theory of the phenomenon being studied, a theory that may have much wider applicability than the particular case studied[GRW08].

During this phase, we also talked with JF Gauthier, a specialist from Compass (formerly known as Startup Genome), a company that has as mission to help startups measuring their success based on standard metrics. JF was in charge of creating a similar model to evaluate ecosystems evolution process, similar to our proposal. The Compass model [Com15] is significantly different, since it is simpler and has fewer metrics. Nevertheless, the inputs from Gauthier were valuable in our process of refining our model.

Besides JF, we also talked to other specialists from Tel Aviv and São Paulo, showing them the model, at first hiding the metrics values and asking them to give us their own opinion about what

value should be in each level for each metric. During these discussions, we adapted the values, and also decided to completely remove some metrics that we concluded did not measure maturity.

After these discussions and changes, a refined version of the model was presented in an international Workshop [CKK15a] promoted by the Software Startups Global Research Network[10]. During the workshop, the model was praised, but also received constructive criticism in some aspects. We ran a few more iterations changing the existing model, considering the feedback we received from the specialists during the workshop, and also the new insights from the New York ecosystem case study. We presented a newer version of the model in a subsequent workshop [CKT16]. Based on another round of feedback from the workshop specialists, we created the last version of the model, which we present in the next Chapter (in Section 5.8), after presenting the results from all three phases of this research.

[10] https://softwarestartups.org

Chapter 5

Results and Discussion

5.1 Phase 1 Results: Startup Ecosystem Conceptual Framework

This first phase of the research resulted in the conceptual map of startup ecosystems key participants as well as the relationships among them. The resulting map was first published as a technical report in 2014 [KCM+14]. Figure 5.1 depicts the first version of the model, which was later refined on Phase 2. Since the figure is complex, we suggest examining it like a traveler looks at a map, navigating through it and not at first attempting to understand all details. While it may take some time to understand the whole topology, the map clearly shows that the elements that play a role in a startup ecosystem are numerous, and that there are a multitude of relationships among them.

The relationships in the map are graphically expressed in two forms: (1) continuous arrows, named as primary relationships, denote relations that were observed all, or almost all, of the times in our field research and (2) dotted arrows, named as secondary relationships, denote relationships that were identified only part of the times. The labels in the arrows characterize the type of relationship represented by them.

In the center of the diagram, we see the **Startup**, which is the major entity in which we are interested. It is created by one or more **Entrepreneurs**. Startups face multiple challenges to achieving market fit [GBWA15] and becoming successful. For this reason, the entrepreneur seeks support from **Family**, friends, and other personal connections, who are part of a **Society** and **Culture** that influence the entrepreneur's behavior. **Culture** is shaped by **Demographic** characteristics, such as national origin, race, religion, gender, language, and influenced by geography, politics, and conflicts with neighboring countries and populations. Geopolitical status also influences the culture and creates opportunities and barriers for the startup

Startups develop products based on available **Technologies**, with a high tendency to use of Open Source software as a foundation. Some startups, mostly the most advanced ones, rely on structured **Methodologies** such as agile methods [Abr02], lean startup [Rie11], customer development [Bla13], and disciplined entrepreneurship [Aul13]. Startups sell their products to the **Market**. **Legal framework**, including Labor, Tax, and Intellectual Property legislation, as well and patents and the level of bureaucracy required influence the decisions of which market to target and where to host the company.

Product and customer development, as well as marketing and production, require different levels of **Funding**. This is available both from the public sector, in the form of tax incentives and R&D

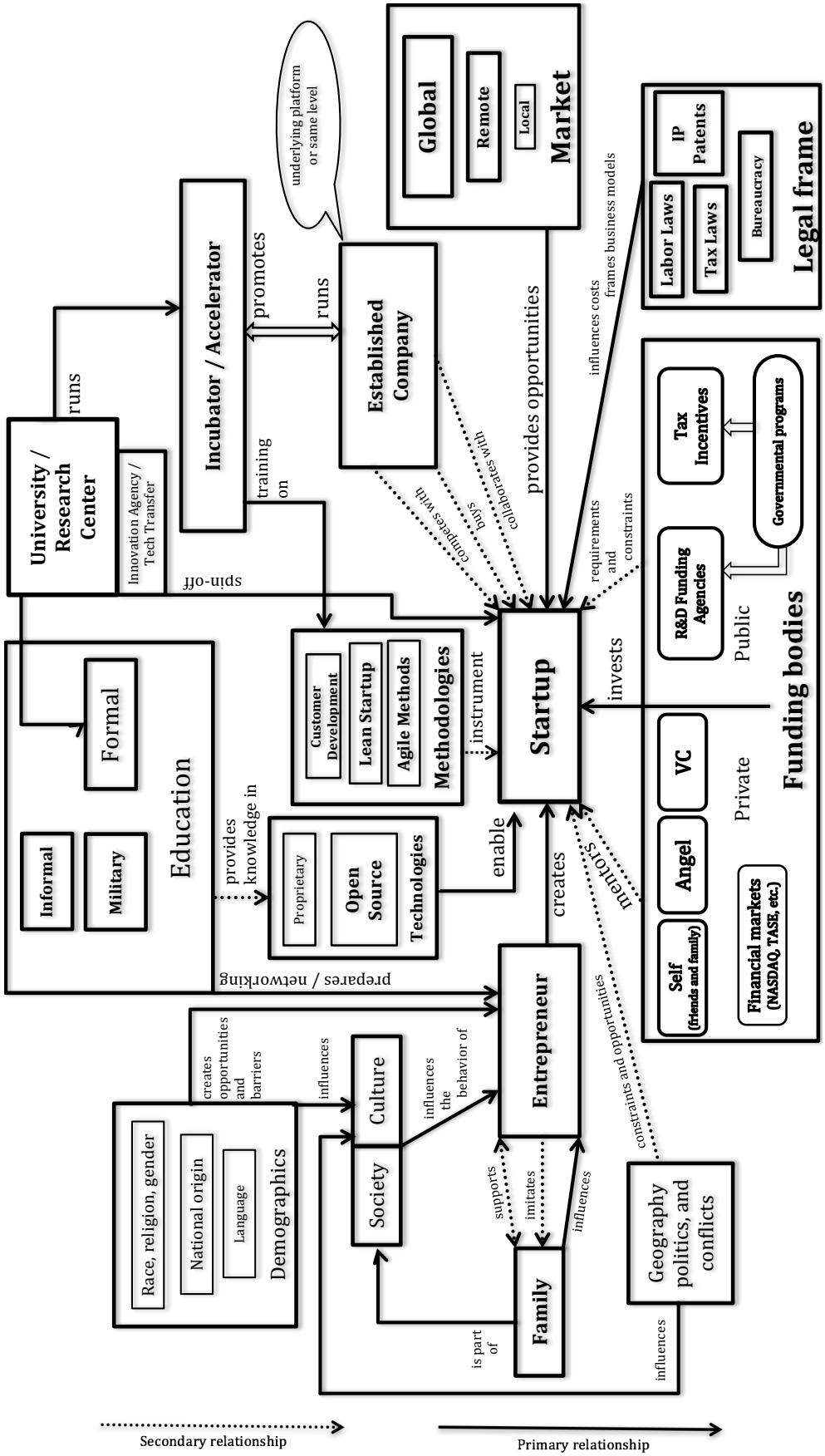

Figure 5.1: *Startup Ecosystem Conceptual Framework - First Version*

funding, and the private sector, from **Venture Capitalists**, **Angel Investors**, and **Financial Markets**. Governmental programs (e.g. Yozma in Israel, active from 1993 to 2003) can offer tax incentives, as well as R&D grants, have been essential for the healthy development ecosystems.

High-quality **Education** is a key factor for the success of any innovative environment [BCVH+11]. According to the 2013 Shanghai Jiao Tong Academic Ranking of World Universities in Computer Science, Israel hosts four top-50 Computer Science departments. Moreover, very good engineering programs are available at the Technion, Tel-Aviv University, and Ben Gurion University in Be'er Sheva. The Bezalel Academy of Arts and Design in Jerusalem produces highly skilled designers and creative artists who are essential for software startups. Other institutions such as the Interdisciplinary Center in Herzliya and the Academic College of Tel-Aviv Yaffo also make a contribution. Besides the academic training they receive in the university, entrepreneurs gain practical experience in real projects carried out during their compulsory military service, typically lasting 2 years for women and 3 years for men. People working in special technological units such as 8200 and Mamram typically serve from 4 to 6 years, being exposed to collaborative teamwork around advanced, state-of-the-art technologies.

Large **Established Companies** such as IBM, Microsoft, Google, HP, and Intel hold research centers and have initiatives to foster entrepreneurship. They produce and consume high-tech products and ideas cross-fertilizing the startup ecosystem. **Universities and research centers** also collaborate (or compete) with entrepreneurs in the technology transfer process [BMSC12], creating spin-off startup companies around products, usually hosted in **Tech Parks**.

Incubators are 1 to 2 years programs that help startup companies in their early stages. They provide a physical space, supporting administrative staff, as well as mentorship and networking with experts. Israel has about 20 incubators which are private enterprises highly financed by the government. Accelerators consist of short-term programs (typically 4 to 5 months) in which entrepreneurs are immersed on training and mentorship to develop their business model. Currently, there are a handful of accelerator programs ran by the Technion, the Academic College of Tel-Aviv, Microsoft, and VCs.

Even if not explicitly indicated in the diagram, we cannot forget that many elements in the ecosystem map play the role of *connectors*. Universities, for example, provide not only knowledge, but also a favorable environment for deep long lasting connections. Investors do not serve only to put money in business, but much more to connect growing companies with other players. Mentors, accelerators, families, and events also play a fundamental role on connecting people.

5.2 Phase 2 Results: Insights from the São Paulo Ecosystem

The objective of the second phase was to analyze the São Paulo startup ecosystem and use the insights about this ecosystem to validate and refine the conceptual model of Phase 1, as well as propose a model for the maturity process of ecosystems. During the São Paulo case study, we validated that many elements of the conceptual map from Phase 1 were indeed justifiable. We identified some gaps in the model and improved it. The main modifications in the model were:

- **The mentoring from entrepreneurs to entrepreneurs**;
- **Media and events attached to the society and culture**;

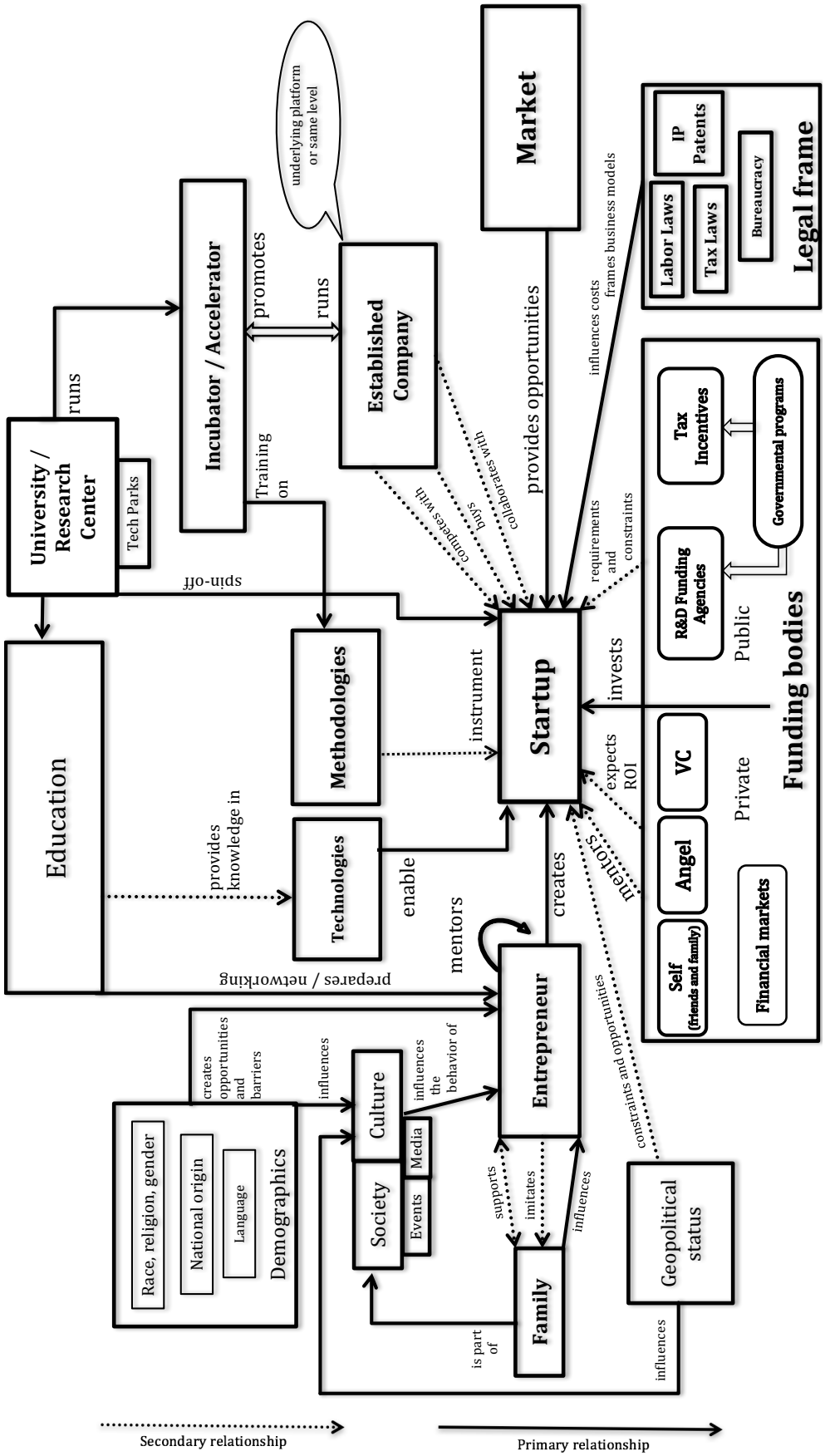

Figure 5.2: *Startup Ecosystem Conceptual Framework - Final Version*

- Abstracting the education core element, removing unnecessary details specific to Israeli ecosystem such as military;
- Abstracting the market core element, removing details specific to Israeli ecosystem;
- Abstracting the technologies core element, removing open source and proprietary details;
- Abstracting the methodologies, leaving it open to include any existing methodology;
- Innovation agency and tech transfer abstracted by tech parks;

In terms of ecosystem core elements, we consider the two first items in bold the most important discoveries for this phase. As we will see later in Phase 3 results, these two factors (1) media and (2) entrepreneurs mentoring (and funding) new entrepreneurs play a very important role in the ecosystems evolution process. Table 5.1 present the core elements of the model.

Table 5.1: *List of core elements of the startup ecosystem conceptual model*

No.	Element
1	Startup
2	Entrepreneur
3	Family
4	Geopolitical Status
5	Demographics
6	Society
7	Culture
8	Events
9	Media
10	Education
11	Technologies
12	Methodologies
13	University / Research Center
14	Tech Parks
15	Incubators / Accelerators
16	Established Companies
17	Market
18	Legal Frame
19	Funding Bodies

We also developed a simplified version of the framework (Figure 5.3). This version can be used as a lighter, easier to understand, introduction to the complete framework.

Different from Phase 1, when we used the SWOT analysis technique to better understand the Israeli ecosystem and generate practical recommendations, in São Paulo we applied a more sophisticated factor analysis workshop (as described in Section 4.2). The next section presents the results from this workshop.

5.2.1 Factor Analysis of São Paulo's Innovation Ecosystem

In this section we demonstrate the results of the São Paulo experts' workshop, and it is divided into four subsections: First we present the main **Inputs for the São Paulo's Innovation System**, following by an **Analysis of the Cross Impact Results**. Then we discuss the **Construction of**

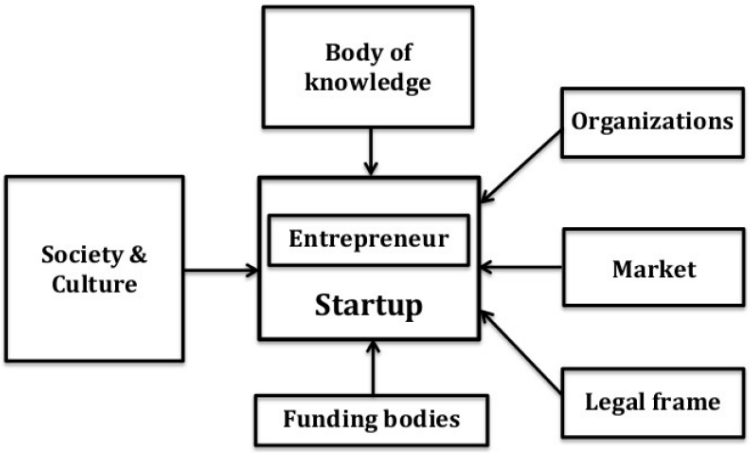

Figure 5.3: *Startup Ecosystem Conceptual Framework - Simplified Version*

the Innovation Ecosystem Map for São Paulo, and conclude with a final **Discussion and Recommendations for the São Paulo Ecosystem**.

Inputs for the São Paulo's Innovation System

This section provides a summary of raw inputs collected at the São Paulo experts' workshops. Table 5.2 lists 14 main anchors that were identified by the experts as the pillars of São Paulo Innovation system. Table 5.3 presents a list of 10 processes that were recognized by the experts as key elements driving and fostering innovation in São Paulo. 'Anchors' are essentially similar to what economists call 'stocks', or fixed assets, while processes are similar to what economists call 'flows' (changes related to various anchors, or stocks). The processes were ranked by the experts by their importance and classified according to which side of the market (supply or demand) they are assigned to.

Table 5.2: *List of São Paulo Innovation Anchors*

No.	Anchor Name
1	High quality human capital
2	Availability of finance
3	7 business incubators
4	(Lack of) an entrepreneurial culture
5	(Lack of) integration across USP schools and faculties
6	Attraction of low-risk employment in business (negative)
7	Scientific infrastructure
8	Strong faculty, good professors
9	USP's "brand name"
10	Entrepreneurship students organizations
11	Union mentality
12	USP legal framework
13	USP intellectual property framework
14	Evaluation of students by traditional tests

The essence of an ecosystem is the interaction among its various components [Moo96]. We used data on 'cross impact analysis' (the perceived links between various anchors and processes) to create

Table 5.3: *List of Identified Processes Fostering São Paulo Innovation, Ranked by Importance and Classified by Market Side*

Ranked number (by importance)	Process Name	Demand (D) Supply (S)
1	Incubation / Acceleration processes	S
2	Informal networking, activities promoting entrepreneurship	D, S
3	Seed money and venture capital	S
4	Alumnae sharing their stories	D, S
5	Collaboration with government and industry	D, S
6	Talents database	D
7	Scattered information, (lack of) a 'one stop shop' process	D
8	Technology transfer process	D, S
9	Mentoring	D, S
10	Evaluation of faculty by publications rather than innovativeness	D

a bipolar five-point Likert scale (ranging from a strong negative link, score 1, to a strong positive link, score 5, for each cell in a 14x10 cross impact matrix. The results of the cross impact analysis, conducted by the expert's teams are presented in 5.4.

Analysis of the Cross Impact Results

Identifying Key Processes Factor analysis was employed on the list of processes (variables). The anchors serve as observations in order to group the processes into major factors according to the similarities in their linkages with the anchors. Tests of sample adequacy constituted the necessary preliminary conditions for conducting factor analysis and obtaining meaningful results. The Spearman correlation matrix among the processes provided the input for both the tests and the factor analysis. The linkage-pattern items obtained in the São Paulo workshop demonstrate good sampling adequacy at the overall (KMO > 0.598). The result of the Bartlett's sphericity test rejects the null hypothesis that the correlation matrix is an identity matrix ($p = 0.000$).

The exploratory principal axis factor analysis with subsequent orthogonal rotation (Varimax rotation with Kaiser normalization) produced three factors. These factors together explain 85.7% of the variance. The factor loadings are presented in Figure 5.5. To facilitate factor labeling, the dominant items, marked in grey background in Figure 5.5, were defined as those with an absolute value of the loading greater than 0.50. Through the factor analysis we distilled the existing innovation process drivers down to three key factors:

Factor 1 – Human Capital / Talent: Talents database; Mentoring; Informal networking & activities promoting entrepreneurship; Incubation / Acceleration processes; scattered information, (lack of) a 'one stop shop' process. This factor explains 45.3% of the variance.

Factor 2 – Flow of Financial Capital: Seed money and venture capital; Collaboration with government and industry; Technology transfer process. This factor adds 26.2% to the explanation of the variance.

Factor 3 – Publish or Perish: Evaluation of faculty by publications rather than innovativeness. This factor adds 14.2% to the explanation of the variance. The first and the second factors represent both supply and demand side of innovation and the third factor is purely demand driven.

The first and the second factors represent both supply and demand side of innovation and the third factor is purely demand driven.

Anchors/Processes	Incubation/Acceleration processes	Informal networking & activities promoting entrepreneurship	Seed money and venture capital	Alumni/ae sharing their stories	Collaboration with government and industry	'Talents' database	Scattered information, (lack of) a 'one stop shop' process	Technology transfer process	Mentoring	Evaluation of faculty by publications rather than innovativeness
High quality human capital	5	5	4	5	4	4	3	3	4	2
Availability of finance	3	3	5	3	5	3	3	3	3	3
7 business incubators	4	4	4	4	4	4	2	4	4	3
(Lack of) an entrepreneurial culture	2	2	2	2	3	2	3	1	2	3
(lack of) integration across USP schools and faculties	3	2	3	2	3	2	4	2	2	3
Attraction of low-risk employment in business (negative)	3	2	3	2	2	2	3	2	2	3
Scientific infrastructure	4	3	3	3	3	4	3	5	4	4
Strong faculty, good professors	3	3	3	3	3	4	3	5	4	3
USP's "brand name"	4	4	4	4	4	4	3	4	4	3
Entrepreneurship students organization	4	5	3	5	3	4	2	3	5	3
Union mentality	2	2	2	3	2	3	3	2	2	4
USP legal framework	2	2	1	3	2	3	5	1	2	4
USP intellectual property framework	3	3	2	3	2	3	3	2	3	3
Evaluation of students by traditional tests	3	2	3	3	2	3	3	2	3	3

Figure 5.4: *Linkages between Anchors and Processes in São Paulo Innovation Ecosystem, Sorted by the Intensity of the Linkages*

1 = Strong negative link; 2 = Weak negative link; 3 = No linkage; 4 = Weak positive link; 5 = Strong positive link

Factor name	Items (Processes)	Component		
		1	2	3
1 - Human Capital / Talent	Talents database[4]	.918	.239	.218
	Mentoring	.910	.339	-.018
	Alumnae sharing their stories	.909	.062	-.279
	Informal networking & activities promoting entrepreneurship	.866	.280	-.354
	Incubation/Acceleration processes	.731	.443	-.309
	Scattered information, (lack of) a 'one stop shop' process	-.509	-.376	.204
2 - Flow of Financial Capital	Seed money and venture capital	.231	.901	-.278
	Collaboration with government and industry	.226	.841	-.222
	Technology transfer process	.597	.629	.399
3 - Publish or Perish	Evaluation of faculty by publications rather than innovativeness	-.176	-.341	.861
Percent of Variance		45.3	26.2	14.2
Cumulative percent		45.3	71.5	85.7
KMO = 0.598	Cronbach's Alpha = 0.837			

Figure 5.5: *Factor Analysis Results for the São Paulo Innovation Ecosystem*

Classification of Anchors

The classification of anchors into clusters did not involve a similar mathematical procedure as was done with the processes and was based on logic. The 14 anchors identified at the expert workshop (see Table 5.2) were grouped first into four basic dimensions of innovation [FM14]. These are:

- Culture (shared values)
- Context (scientific and technological infrastructure, structure of the economy)
- Markets (demand, preferences)
- Institutions (system of laws & regulations, written & unwritten 'rules of the game')

In addition, the anchors in each dimension were grouped into Key Anchors and presented in Figure 5.6.

The table shows that the major dimension in São Paulo's innovation ecosystem is the infrastructure dimension. Half of the anchors belong to this dimension that was divided into two major basic key anchors: University of São Paulo Infrastructure and Human Capital.

The five anchors capture the key infrastructure available at the University of São Paulo: laboratories; the USP brand name (regarded as a top science & technology university, not only in Brazil but worldwide); the 7 USP incubators; availability of finance for USP entrepreneurs; and the numerous organizations initiated and run by students that foster entrepreneurship.

No.	Anchor Name	Dimension	Key Anchor
2	Availability of finance	Infrastructure, Perception	University of São Paulo Infrastructure
3	7 business incubators		
9	USP's strong brand name		
10	Entrepreneurship students' Organization		
7	Scientific infrastructure		
1	High quality human capital	Infrastructure, Economy	Human Capital
8	Strong faculty, good professors		
4	Entrepreneurial culture (lack of)	Culture	Values & Attitudes
6	Attractive low-risk employment in business		
11	Union mentality		
14	Evaluation of students by traditional tests		
5	Integration across USP schools (lack)	Institutions	Formal Legal Arrangements
12	USP legal framework		
13	USP intellectual property framework		

Figure 5.6: *List of São Paulo's Key Innovation Anchors*

The second key anchor, Human Capital, refers to the infrastructure economy dimension. This key anchor includes three anchors. USP has strong human capital, both in its highly selected students and its research faculty.

The third key anchor Value and Attitudes are a key part of the Culture dimension. There is a 'union' mentality, with militant labor demands that can hurt productivity and generate strikes; and a question regarding the entrepreneurial culture, which is strong among a smaller part of the USP community and not strong among other parts; the value of creative thought is hampered by standard tests that require students to regurgitate existing knowledge rather than think creatively for themselves; and the prospects of secure well-paying employment with large established businesses compete with the entrepreneurial drive.

The forth key anchor, Formal legal arrangements, refers to the institution dimension. This anchor includes the IP legal framework at USP, and the legal framework in general governing property rights to ideas, establishment of startups, etc.; and the formal organizational structure, defined by the university charter, in which schools and faculties have considerable autonomy, which limits badly-needed integration and cooperation across faculty boundaries.

Construction of the Innovation Ecosystem Map for São Paulo

In the final step, an innovation linkages map was produced for São Paulo's ecosystem (see Figure 5.7). Most interactions between the anchor clusters and the process factors proved to be significant and positive describing the linkages between the two groups. The interactions between the group of anchors (clusters) and the group of processes (factors) was computed based on a mathematical procedure for determining and weighting the direction and strength of link between the factors and clusters (see Appendix). A summary of the relationships is presented in Table 5.4.

Table 5.4: *Linkage between Factors and Clusters*

Factors (Processes) / Clusters (Anchors)	Human Capital Talent	Flow of Financial Capital	Publish or Perish	
University of Sao Paulo Infrastructure	+	++	no linkage	
Human Capital	++	++	-	
Values & Attitudes	-	-	no linkage	
Formal Legal Arrangements	+/-	-	no linkage	

In general, the findings show that the second key anchor 'Human Capital' significantly supported (strong linkages) two of the key processes: 'Human Capital / Talent' and 'Flow of Financial Capital'. The University of São Paulo infrastructure key anchor also significantly supports the last, showing a large potential from the university to gather human and financial resources to promote innovation. In contrast 'Values & Attitudes' key anchors that refer to the culture dimension are negatively connected to both 'Human Capital / Talent' and 'Flow of Financial Capital' key processes. Probably, (1) the lack of entrepreneurial culture and tradition, (2) courses focusing on conventional lectures and exams, rather than learn-by-doing, as well as (3) some prejudice against applied research are the main reasons.

An interesting finding was encountered in regard to the 'Formal Legal Arrangements' key anchor. Mixed ties (positive and negative) exist between this key anchor and Human Capital / Talent key process, showing that there are already initiatives within the university to promote innovation but

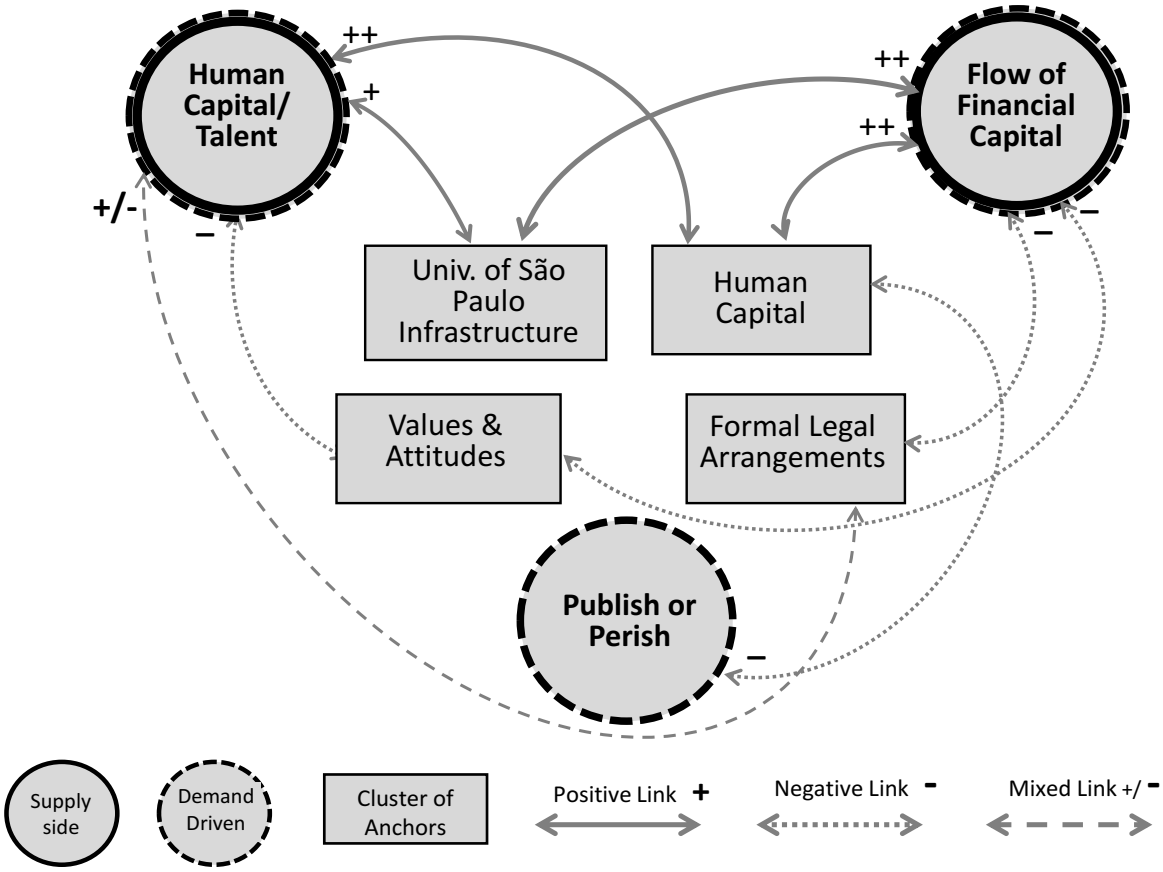

Figure 5.7: *São Paulo Innovation Ecosystem Linkages Map*

they still lack in breadth and effectiveness. In addition, it appears that this anchor has a negative effect on 'Flow of Financial Capital' key process, in particular due to the difficulties in technology transfer and in collaborations with the government and industry, which are hampered by university bureaucracy, legal obstacles, and a lack of motivation from the university supporting staff.

Finally, the 'Human Capital' key anchor has a negative effect on the Publish or Perish key process. This key process does not receive support from the other key anchors. The problem here is that the university, in general, does not value innovation activities — such as, technology transfer to large companies or government, and fostering the creation of startup companies — in the evaluation of its faculty. In a few schools, professors who concentrate on pure theoretical research with no application at all to the real problems of society are sometimes more valued than the ones that try to make a positive impact on society.

Discussion and Recommendations for the São Paulo Ecosystem

Examining the overview linkages present in the ecosystem map, first we see obvious positive link between the Human Capital assets and Human Capital processes. Also, as a world-class university, USP appears as an asset that has only positive links with both Human Capital and Flow of Financial Capital. Beside these positive links, analysing the elements of Human Capital processes, we can find improvements to be done, specially regarding to the ecosystem connectivity.

Breznitz & Taylor [BT14] argue that even in the presence of all factors for the good health of a technological hub, the entrepreneurial ecosystem will not flourish if social fragmentation is

observed. In other words, the local high-tech industry must develop rich multiple, locally centered social networks to enable growth of the ecosystem.

São Paulo is a huge city in area and population. There is a lack of good quality public transportation and people are always afraid to go far from their daily itinerary, because of heavy traffic and the large loss in time and stress involved. Moreover, the University of São Paulo main campus is located far from the city center, with few good public transportation options to get there, making a large number of the students and professors to use cars. These elements generate a virtual separation of the University from the rest of the city. Having a strong faculty and high quality human capital is not sufficient if these assets are not easily accessible to the other ecosystem players like established companies or startup entrepreneurs. The university administration must have a clear strategy to deal with this problem. In the past, the university took an opposite direction with that regard, for example, by denying the construction of a subway station at the center of its campus, promoting the isolation of the university from society.

Furthermore, the distance between buildings and institutes inside the campus is also a barrier for multidisciplinary interaction. As it was pointed in the workshop, there is no "one-stop shop", neither for the whole city nor inside the USP community. Thus, new entrepreneurs need to go to tens of different places to find the information and the right people to start creating a network to support new ventures.

The nonexistence of a "one-stop shop" is a factor that needs action. The first step could be to map the different informal networking activities promoting entrepreneurship and propose joint meetings and interaction between these networks. Within the USP community, more entrepreneurship activities involving different institutes could be a starting point. Another, bolder approach would be to create an 'Entrepreneurship Lounge' in the center of the campus where people from multiple disciplines would get together to discuss new ventures and work on their early-stage startups. This would be an open public space, the official USP port for entrepreneurs, promoting regular activities and offering free co-working space for startups and sharing of alumnae stories.

While the university has positive links to 'Human and Financial Capital', the 'Values and Attitudes' cultural factor has a negative link with both. This is a very important finding because this anchor should support the processes, not hinder them. The 'Formal and Legal Arrangements' also has negative impact on 'Human Capital' processes. Moreover, the technology transfer process is considered poor in terms of output, while theory shows that knowledge transfer is a key force that drives a technology hub evolution over time (J. Kim, Anderson, & Daim, 2008) (Pattnaik & Pandey, 2016) (Xu & McNaughton, 2006).

These are the aspects that need to change and some suggestions of how this can be achieved are the following:

- Lack of Entrepreneurial culture
  - Spreading the word of "entrepreneurship as a way of living" and the acceptance of failure
  - Early-stage startup competitions (hackathons, Startup Weekends, etc.)
  - More week-long and semester-long courses on Entrepreneurship for students and faculty
  - Sharing local cases of entrepreneurial successes in events, digital and printed media, as well as local and private communications

- Attractive low-risk employment in business. Lowering the risks for entrepreneurs with:
  - Differentiated tax policies for startup companies
  - Inexpensive and fast-track process for startups to open and close businesses
  - Financial incentives from funding agencies and private investment
  - Infrastructure availability: co-working spaces, Internet access
- Union mentality:
  - Create special labor rules for startups, with more flexibility and less bureaucracy
  - A small minority of union members are capable of stopping the university in very frequent strikes; they also criticize the approximation efforts between the university and the industry, causing huge losses to society. Seeking creative ways of stopping this waste would be beneficial
  - Fight the prejudice against commercial ventures born from the university; since the university is public, some people believe that everything that comes from it should be free and public. Instead, USP should be a birthplace for disruptive, innovative businesses, increasing the GDP
- Evaluation of students via traditional tests:
  - Implement new methods to evaluate students, promoting collaborative work, active participation, active learning, real-world project-based courses, and learn-by-doing
  - Give the option for students to create their own business and count the business performance as coursework credits

The overall conclusion was that, although the São Paulo region and its major university, USP, have enormous potential for Entrepreneurship and Innovation, mainly due to its human capital, the current status of the ecosystem is still weak. The region is not capable of generating significant disruptive innovation or produce startups with a global impact. This indicated that, looking from a global, international perspective, this ecosystem is currently in an early stage of maturity.

The major problems in the São Paulo ecosystem identified by our research were: (1) lack of connectivity / weak people networking, (2) lack of entrepreneurial culture and prejudice against businesses and applied research within the university, (3) high bureaucracy and lack of flexibility both within universities and in the market legal/tax frameworks, (4) no incentives for professors and students to pursue innovation and entrepreneurship, and (5) lack of high-tech startups (there are a few, but usually entrepreneurs in the city do not engage on searching scientific and high-end knowledge to apply in their business).

Our analyzes identified a few key recommendations for ecosystem leaders, entrepreneurs, university administrators, and policy makers that could significantly change this landscape within a few years:

- 1. In universities, create a vibrant "Entrepreneurship Lounge" to concentrate robust activities around entrepreneurship and innovation and gather students, alumnae, and professors from all university schools, while promoting local, smaller activities within the various institutes.

- 2. Spread the entrepreneurial culture with short and semester-long courses, events, and incentives for professors, students, and alumnae to engage in innovation activities. Entrepreneurial professors should be valued in their career progression, while students should receive credit for their innovative projects. Facilitate the participation of professors in innovative commercial ventures and the transfer of technology from the university to society.
- 3. Create new laws with tax incentives for innovative startups and simplify bureaucracy for these kind of nascent, tech-based companies.

5.2.2 Startup Ecosystem Maturity Model: First Version

The conceptual framework discovered in Phase 1 and refined in this Phase 2 contained core elements of every software startup ecosystem. The Phase 2 refinement led us to a theoretical saturation of the framework and no new core elements were discovered. These core elements are not isolated characteristics; rather, they relate to each other in different ways. For each core element, it is possible to analyze its level of development, as well as the quality of the relationship between them, to measure some degree of maturity in each aspect. Examples of maturity metrics in the core elements include: the funding bodies; the development level of the funding structure inside the ecosystem; the presence of technical talent provided by high quality educational institutions; and access to educational resources.

We transformed the core elements of the conceptual map created using Ground Theory into a list of metrics. We present a description of each metric and its relationship with the core elements in the conceptual map:

- **Exit strategies** - Entrepreneurs and investments are considered successful when one of the following happen: (a) profitable growth to the global market, (b) acquisition by a big company, (c) merge with another company, or (d) IPO. Especially for investors, the existence of exit options in the local ecosystem is an attractive factor. While mature ecosystems present all three strategies, there is a lack of exit options in new ecosystems. Zero options is considered weak, one option is medium and two or more options is a sign of maturity. Related framework elements: startup, funding bodies, and established companies.
- **Global market** - Percentage of startups that targeted the global market. A startup is considered to target the global market if it acts in markets outside its country, with existing customers or at least an official representation office. Related framework element: market.
- **Military influence on technologies** Related framework element: research center.
- **Entrepreneurship in universities** - Percentage of alumni that founded a startup within 5 years of graduation. Related framework elements: universities and research centers, education.
- **Mentoring quality** - the percentage of mentors that fit one of these criterion: (1) had a successful startup in the past, (2) founded and worked for more than 10 years in one or more startups. Related framework elements: entrepreneur.
- **Bureaucracy** - Based on the inefficient government bureaucracy index of the global competitiveness report [Sch13]. It represents the percentage of respondents that considered bureaucracy as a problematic factor for doing business. Related framework elements: legal frame.

- **Tax burden** - Based on the country's total tax rate ranking of the global competitiveness report [Sch13]. Related framework elements: legal frame, market.
- **Accelerators quality** - Percentage of startups in accelerators that reach the stage of receiving a next level investment, or reach the global market in a sustainable profitable stage. Related framework element: incubator / accelerator.
- **Access to funding in US$** - Total amount of investment in startups in US$ according to a trusted database. Related framework element: funding bodies.
- **Human capital quality** - Based on the ecosystem position in talent index of the global startup ecosystem report [HGH+15]. Related framework elements: entrepreneur, education.
- **Culture values for entrepreneurship** - Cultural support index in the global entrepreneurship and development index [ASA15]. Related framework elements: culture, society, family.
- **Technology transfer processes** - Based on innovation and sophistication factors of The Global Competitiveness Report 2013-2014, p. 22 [Sch13]. Related framework elements: University / Research Center, Legal Frame.
- **Methodologies knowledge** - Percentage of startups that have knowledge or are trained on methodologies[1]. Related framework elements: Methodologies.
- **Specialized media players** - Local media specializing in the startup industry plays an important role in spreading the word about what is happening in the ecosystem. The existence of at least six players is a sign of movement and engagement within the ecosystem. The specialized media must be recognized by the local community as a reference to be considered in this list. Related framework elements: media.
- **Ecosystem data and research** - The existence of database with data about the ecosystem is an indication of maturity. We cannot improve what we cannot measure, so ecosystems that do not have research institutions nor metrics are blind of the next steps to take. Related framework elements: research center, government.
- **Ecosystem generations** - the number of generations of prior entrepreneurs that are re-investing their earnings in the ecosystem. "0" means no prior entrepreneurs are investing in the ecosystem, "1" means a first generation of prior entrepreneurs re-investment their earnings in the ecosystem, "2" means that entrepreneurs that received investment from generation 1 are investing their earnings in new startups, and so on. Related framework elements: entrepreneur, society.
- **Number of startups** - Quantity of startups founded by year, according to a trusted database. Related framework elements: startup, market, entrepreneur.
- **Access to funding in # of deals / year** - Deal count, independently from value or startup stage. Related framework element: funding bodies.

[1] This was a factor we found difficult to measure, since there is no data about methodology adoption in ecosystems. Another proposal for classifying this would be the amount of local conferences about agile, lean startup or other methodologies.

Table 5.5: *Ecosystem Maturity Factor Classification (version 1)*

Factor	L1	L2	L3
Exit strategies	0	1	>= 2
Global market	< 10%	10 – 50%	> 50%
Military influence on technologies	< 10%	10 – 50%	>= 50%
Entrepreneurship in universities	< 2%	2 – 10%	> 10%
Number of startups	< 500k	500 – 3k	> 3k
Access to funding in USD / year	200M	200M-1B	> 1B
Access to funding in # of deals / year	200	200-1000	1000
Mentoring quality	< 10%	10-%50%	> 50%
Bureaucracy	> 40%	10 – 40%	< 10%
Tax burden	> 50%	30 – 50%	< 30%
Incubators / tech parks	2	2 – 10	> 10
Accelerators quality	< 10%	10 – 50% success	> 50% success
High-tech companies presence	< 10	10 – 50	> 50
Established companies influence	< 20	20 – 80	> 80
Human capital quality	> 20th	15 – 20th	< 15th
Culture values for entrepreneurship	< 0.5	0.5 – 0.75	> 0.75
Technology transfer processes	< 4.0	4.0 – 5.0 > 5.0 ?	
Methodologies knowledge	< 20%	20 – 60%	> 60%
Specialized media players	< 3	3-5	> 5
Ecosystem data and research	not available	partially available	fully available
Ecosystem generations	0	1	2

- **Access to funding in US$** - Total amount of investment in startups in US$ according to a trusted database. Related framework element: funding bodies.
- **Incubators / tech parks** - The number of incubators and tech parks active in the ecosystem. Related framework element: incubator / accelerator.
- **High-tech company presence** - How many high tech companies have tech teams located in the ecosystem region. Related framework elements: Established Companies.
- **Established companies influence** - How many big companies have activities that nurture the ecosystem? Activities include event organization, local community ambassadors and mentors, acceleration programs, or local investments in startups. Related framework elements: events, established companies, startup, accelerator, entrepreneur.

Thus, we proposed, a scale to evaluate each factor's state. The scale contains three levels of development: **L1**, **L2**, and **L3**. This scale was generated after a series of iterations with experts and confirmation of what they considered appropriate measurement of **L1**, **L2** and **L3** in each aspect. We then proposed a metric to classify ecosystems for each core element maturity, described in Table 5.5.

After generating the classification table for each factor, we filled the table with data about the ecosystems we analyzed, also using the help from two specialists from each ecosystem. The resulting Table 5.6 shows data collected from both the Tel Aviv and São Paulo Ecosystems.

Some factors in the ecosystem comparison table are crucial to consider when an ecosystem has reached a certain level of maturity. Not achieving a specific grade in any of these factors stalls the

Table 5.6: *Startup Ecosystem Comparison between Tel Aviv and São Paulo*

	Factor	Tel Aviv	São Paulo
*	Exit strategies	L3	L2
	Global market	L3	L2
	Military influence	L3	L1
	Entrepreneurship in universities	L2	L1
	Number of startups	L3	L2
	Access to funding	L3	L2
	Mentoring quality	L3	L1
	Bureaucracy	L2	L1
	Tax burden	L2	L1
	Incubators / tech parks	L3	L1
	Accelerators quality	L3	L1
	High-tech companies presence	L3	L2
	Established companies influence	L3	L2
	Human capital quality	L3	L2
	Culture values for entrepreneurship	L3	L2
	Technology transfer processes	L3	L1
	Methodologies knowledge	L2	L2
	Specialized media	L2	L2
	Ecosystem data and researches	L3	L2
	Ecosystem generations	L3	L2
*	Essential Factors	L3 (9)	L2 (9)
	Summing Factors	L2 (5), L3 (6)	L1 (8), L2 (3)
	Maturity Level	Mature (M3)	Evolving (M2)

ecosystem at a lower level of maturity. Thus, we divided the factors into two categories: **essential** and **complementary**. The complementary factors are important to "upgrade" the ecosystem to the next level.

Our proposed maturity model comprises four levels, as described below with a short description of each level:

- **Nascent (M1)**: usually an ecosystem is already recognized as a startup hub, with some already existing startups, a few investment deals, and perhaps government initiatives to stimulate or accelerate the ecosystem development, but no great output in terms of jobs generation or worldwide penetration.

- **Evolving (M2)**: ecosystems with a few successful companies, some regional impact, job generation, and a small local economic impact. To be at this level, the ecosystem must have all essential factors classified at least at L2, and 30% of complementary factors also on L2.

- **Mature (M3)**: ecosystems with hundreds of startups, where there is a considerable amount of investing deals, existing successful startups with worldwide impact, and a first generation of successful entrepreneurs who started to help the ecosystem to grow and be self-sustainable. To be in this level, the ecosystem must have all essential factors classified at least at L2, 50% of complementary factors also on L2, and at least 30% of all factors on L3.

- **Self-sustainable (M4)**: ecosystems with thousands of startups and financing deals, at least a second generation of entrepreneur mentors, especially angel investors, a strong network

of successful entrepreneurs engaged with the long term maintenance of the ecosystem, an inclusive environment with many startup events and high quality technical talent (as proposed in the Boulder Thesis by Brad Feld [Fel12]). To be at this level, the ecosystem must have all essential factors classified as L3, and 60% of complementary factors also on L3.

Important to notice that, even if the maturity levels are numbered in a linear scale, it is easy to see that the dimensions grow in an exponentially manner. Thereby, for example, assuming that the multiplication factor is 10, an ecosystem in level 3 is 100 times more evolved than another ecosystem in level 1.

5.2.3 Phase 2 Conclusions

More details about the results obtained in Phases 1 and 2 can be found in the associated technical reports [KCM+15, CKMF16] and also in Monna dos Santos' Masters thesis [San15].

After this second ecosystem observation, and with a more comprehensive understanding of how ecosystems operate and the associated theory, we identified the literature and theoretical gap in describing ecosystem dynamics. The main insight gained from the second iteration analysing a startup ecosystem was the need for a practical method for identifying where each ecosystem is located in its evolutionary process.

Based on the core elements discovered during the case study of Phases 1 and 2, we proposed a first version of a model for describing the maturity process of startup ecosystems. This initial model proposed to organize the evolution process of ecosystems in four levels of maturity: nascent (M1), evolving (M2), mature (M3) and self-sustainable (M4). The criterion for classifying each level was presented in a workshop [CKK15a]. Even if this initial model had adherence to the two ecosystems studied until then, we decided to triangulate, performing a third case study in New York City. The objective was to verify whether (1) this ecosystem fitted the model or (2) the model needed refinements.

5.3 Phase 3 Results: The NYC Case-study Adherence to the Maturity Model

The first high-growth technology software startups in New York City appeared in the late 1990s in the media industry. Then, the dot-com bubble burst, and New York lacked an established ecosystem, like the one in Silicon Valley, to support its technology startups. The few entrepreneurs who persevered formed the base of the first entrepreneurial generation who later led the ecosystem's development [CP13]. New York, the business capital of the world, as well as the center of advertising and the financial, food, and fashion industry, supported by a robust high-tech entrepreneurial policies system and a strong pool of human capital, blossomed into FinTech, FashionTech, FoodTech, AdTech, Marketing Tech, Real Estate Tech, and so on.

We heard from interviewed specialists that building a business is becoming cheaper and cheaper worldwide due to easy access to basic resources (computer infrastructure via cloud services, Software as a Service, Open Source software), and the mobile Internet connected world. The specialists also state that each ecosystem has expertise in a few specific industries. While Boston is a worldwide leader in areas like pharmacy and bio-tech [HGH+15], NYC is strong in media and financial

(FinTech) startups.

In the late 1990s, New York City was in its nascent maturity level and had already acquired much of the necessary support infrastructure to evolve quickly: the metropolitan region is home to top research universities like Cornell, Columbia, New York University, and the City University of New York, which all have special programs for entrepreneurs; many (sometimes free) co-working spaces like General Assembly and WeWork (which was valued $17 billion in 2016) started to emerge; the public transportation system is efficient; and big tech companies established offices in the city (for instance, Google's office in the Chelsea neighborhood).

The Boulder Thesis [Fel12] states that a prosperous ecosystem has four characteristics: (1) it is led by entrepreneurs; (2) it is inclusive, such that everyone is welcomed; (3) the people involved are committed long-term (at least 20 years) to the ecosystem; and (4) there are many opportunities for gathering, i.e., many events. New York is a perfect observational instance of the Boulder Thesis:

- Even if part of the NYC impetus for the ecosystem came from direct efforts of the Bloomberg Administration (i.e., the Mayor's Office) – supporting incubators, accelerators, and co-working spaces – entrepreneurs are still the central agents, as everything starts with them. An interviewed entrepreneurship professor remarked: "put two or three great entrepreneurs anywhere and they will create an ecosystem". The idea that entrepreneurs are the center of the ecosystem challenges the triple helix model [BCKE08], built on the idea that the regional innovation hubs emerge only from the collaboration among universities, industries, and governments.

- Events are made visible and discoverable, to bring people together and create a community. The largest tech meet-up in the world, the New York Tech meet-up has fifty thousand members. In 2014, the City officially launched Digital.NYC, an on-line hub for the startup ecosystem, bringing together every startup, investor, event, class, job opening, workspace, accelerator, news story, blog, video and startup resource. Small events happen every day, medium events happen every week, and large events every month.

- Inclusiveness: everyone is welcome in the cultural mix of NYC. When you look at startups, you find founders from dozens of different nationalities. Additionally, there are twice as many startups founded by women than in Silicon Valley [CP13]. The NYC Tech meet-up and other events involve people of all ages, with everyone from the elderly to children watching startup pitches.

- Long-term commitment: the first generation of entrepreneurs that led their startups to successful exits and helped to found the New York Angels, and many other investment groups, are a good example of persistent commitment, as is the Cornell Tech program, which was planned between 2009-2011. The Cornell Tech program's intent was to create high-tech and applied science entrepreneurship courses and build a new campus on Roosevelt Island. The construction project began in 2014, is expected to be open in 2017, and will be complete in 2037. It received donations from many Cornell alumni, including a very large one from Charles "Chuck" Feeney of US$350 million [PP11] and one of US$133 million from Joan and Irwin Jacobs to fund the Technion-Cornell Institute.

The combination of entrepreneurs' long-term commitments with the many inclusive startup events leads to a highly connected ecosystem. Theory shows that successful innovation ecosystems

depend on a high level of inter-connectivity between its players [BT14][OEC97][IL04]. NYC has several highly connected entrepreneurship networks, and successful business such as DoubleClick, which was bought by Google, have created a network effect. Howard Morgan, one of the founders of New York Angels explains why: "exits like that (US$ 1.1 billion) are essential to grow the high-tech ecosystem, because managers and engineers who have made some money (...) can then take some risks in other startups" [CP13].

A recent industry report for startup ecosystem rankings shows the New York City ecosystem evolving from the 5th place in 2012 [HMDH12] to the 2nd place in 2015 [HGH+15]. Another report put New York in the first place in 2015 [Cai15]. If these reports existed before, and considering the criterion they used, it is likely that New York would not be among the top ranked ecosystems before 2009.

Many theoretical models about entrepreneurship regions point to culture as a highly important dimension when analysing these ecosystems [HHM10][MMF14][LAAA12]. We observed a cultural shift in New York City after the 2009 crisis. Many interviewees commented that, before the crisis, highly-qualified engineers in the financial market were comfortable with the salaries their employers paid. When the market crashed, many tech talents lost their jobs and realized that they were not as safe as they believed. The opportunity cost of starting a new company seemed smaller, and taking the risk was no longer as big of an issue. Because of the traditional financial market crash, many investors began to look for new investment opportunities. Moreover, the financial district office spaces were completely empty and rental prices decreased. To promote the recovery of real estate, financial district owners offered free co-working space for new startups, with the hope that their growth in the future could bring more real estate business to the district.

The financial crisis in 2009 also impacted on people's decision to invest time in high-level education. In fact, "New York has more college students than there are people in Boston", affirmed one of the interviewed entrepreneurs. Another entrepreneur emphasized his decision to pursue a PhD because of the crisis: "when the market crashed, I didn't know what I was going to do, then an opportunity arose to do a PhD and then I thought that was great because there was nothing else to do".

By analysing raw data from Crunchbase, one of the largest and most complete startup databases in the world, we created two graphs that show the evolution of the New York Ecosystem. Looking at Figure 5.8, we observe an explosion of new startups being created in New York since 2009. The same degree of growth happened to the number of companies that got their first investment. Figure 5.9 shows that, even if the number of IPOs remained static within the ecosystem, the number of acquisitions grew at the same pace as the creation of new companies or investment deals.

In New York City, the very first technology startups appeared in the mid-1980s, but it wasn't until the mid-1990s that New York's first high-growth startups began to emerge in the media industry. The ecosystem experienced a modest growth during the 2000s, passing from a nascent stage to an evolving stage during these years. This first evolution was observed in the following metrics of the maturity model: a growing number of events, the first large startup exits, and the first specific university programs. In the beginning of the 2010s, it reached the mature stage (increased number of M&A and IPOs, a second generation of entrepreneurs, and growing angel investment groups) on its way to reaching a self-sustainable stage in the last couple of years.

We observe this evolution not only in the number of startups and investment deals, but also in

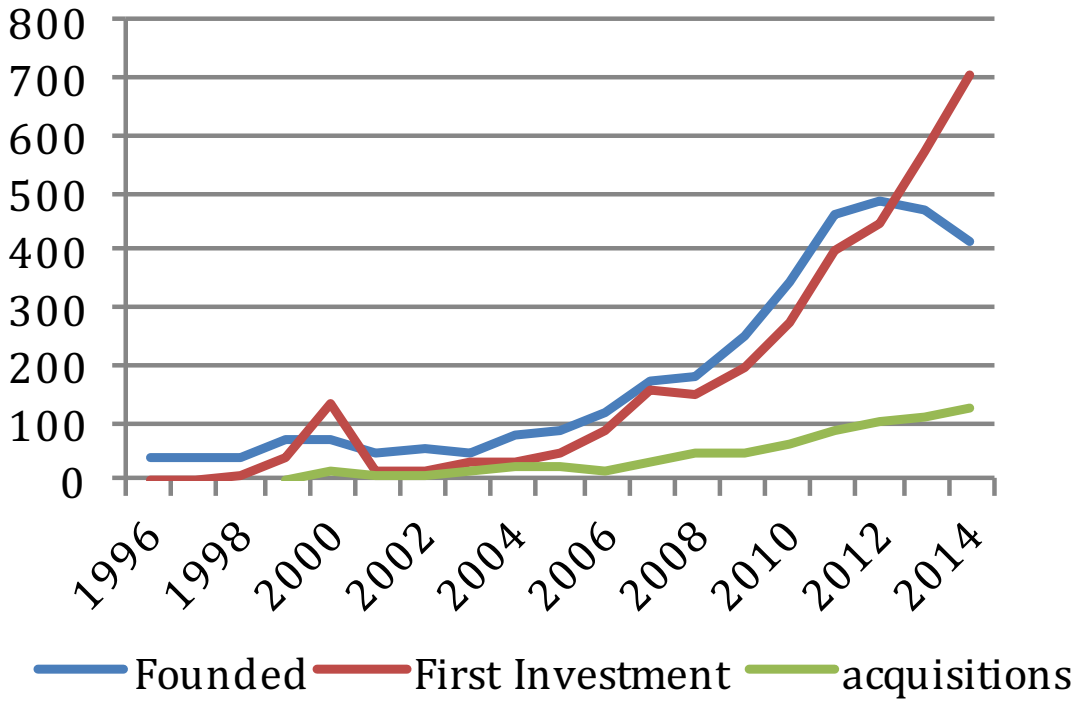

Figure 5.8: *Companies founded in New York and number of first investment deals per year. Source: Our graph from raw Crunchbase data.*

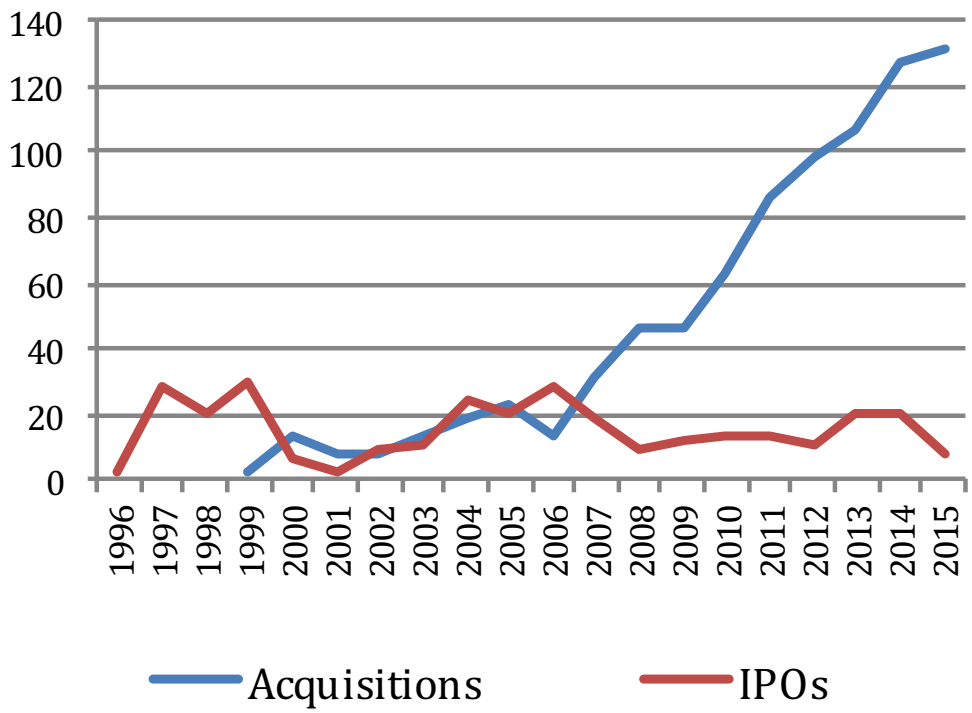

Figure 5.9: *New York startups acquisitions and IPOs. Source: Our graph from raw Crunchbase data.*

other factors, such as events frequency, support from big tech companies (like the first Cornell Tech course in Google's office), co-working spaces, etc. After 2010, the ecosystem started the path toward a virtuous cycle when the older generation of successful entrepreneurs became angel investors or serial entrepreneurs. In addition, after 2012, the number of startup acquisitions per year exploded (almost one every three days), indicating a prosperous environment for investors and entrepreneurs. Worth noting is that, since 2011, the number of new companies did not grow as much as the number of investment deals or acquisitions. This shows a tendency of abundance in access to funding in the last years, or a saturation of talent availability, suggesting that the ecosystem has space for more startups and needs more investment to attract and retain talent.

In summary, the answers to our four research questions, were the following:

A. What are the minimum requirements for a startup ecosystem to exist in its nascent stage?

Fred Wilson, co-founder and managing partner of Union Square ventures, claimed that "the story of NYC is a story of entrepreneurship (...), entrepreneurs re-investing their wealth back into the next generation of entrepreneurs. (...)" [CP13] – it follows that one of the first requirements for an ecosystem to exist is to have great entrepreneurs. It seems obvious that any entrepreneurial ecosystem needs entrepreneurs, but it is not so obvious that the entrepreneurs are the seed of everything. This means that talented entrepreneurs are necessary even at the first nascent stage of an ecosystem.

The existence of high-quality research universities in the region is an important attractor for these talents, especially when there are programs for tech-entrepreneurship. The presence of big tech companies can also be considered a talent attractor, but not necessarily the talents that will become entrepreneurs.

By analysing the three ecosystems in our case study, Tel Aviv, São Paulo and New York, it is clear that all of them surpassed the nascent stage.

B. What are the requirements for a startup ecosystem to exist as a mature self-sustainable ecosystem?

Startup ecosystems reach a mature self-sustainable level when there are at least three generations of successful entrepreneurs that start re-investing their wealth in the ecosystem by becoming angel investors and offering their mentorship. This is only possible when there are many opportunities for M&A and IPOs in the market, and, moreover, when the entrepreneurial culture is widely accepted and understood, supported by high-quality educational institutions, and startup events happen almost every day. When the ecosystem reaches the self-sustainable maturity level, the media also plays the role of maintaining the momentum and awareness of the public.

In our case study, both Tel Aviv and New York are considered to have reached the self-sustainable M4 maturity level. On the other hand, São Paulo has not reached this stage yet, since we do not observe there the required characteristics, such as an evolved IPO market or three generations of successful entrepreneurs. The classification Table 5.7 also emphasizes the maturity level for the ecosystems analyzed in our study.

C. What are the stages that ecosystems pass through? Can they regress or die?

Our interviews and observations led to the definition of four stages that ecosystems pass through:

[1]In the first version of the maturity model, Tel Aviv appeared in M3, but after the model changes, it passed to M4.

[2]In the first version of the maturity model, Tel Aviv appeared in M3, but after the model changes, it passed to M4.

Table 5.7: *Startup Ecosystem Comparison Table*

Factor	Tel Aviv	São Paulo	New York
Exit strategies *	L3	L2	L3
Global market *	L3	L2	L3
Entrepreneurship in universities *	L3	L2	L3
Mentoring quality	L3	L2	L3
Bureaucracy	L2	L1	L3
Tax burden	L2	L1	L3
Accelerators quality	L3	L1	L3
Access to funding	L3	L2	L3
Human capital quality	L3	L2	L3
Culture values for entrepreneurship *	L3	L2	L3
Technology transfer processes	L3	L1	L3
Methodologies knowledge	L2	L2	L2
Specialized media	L2	L2	L3
Startup Events *	L3	L2	L3
Ecosystem data and researches *	L3	L2	L3
Ecosystem generations *	L3	L2	L3
Number of startups *	L3	L2	L3
Access to funding # deals	L3	L1	L3
Angel funding # deals *	L3	L2	L3
Incubators / tech parks	L3	L2	L3
High-tech companies presence *	L3	L2	L3
Established companies influence	L3	L2	L3
Essential Factors *	L3(10)	L2(10)	L3(10)
complementary Factors	L2(4), L3(8)	L1(5), L2(7)	L2(1), L2(11)
Maturity Level	Self-sustainable (M4)[2]	Evolving (M2)	Self-sustainable (M4)

nascent, evolving, mature, and self-sustainable. The transition between stages is smooth and may take years. The classification is sometimes fuzzy, especially during the transition between phases.

It is possible that startup ecosystems can regress, but it is rare. An angel investor and serial entrepreneur explains: "the ecosystem evolution is a one-way street, because created conditions are self-reinforced". "Very drastic situations like wars or natural disasters can eventually lead the ecosystems extinction" – said another entrepreneur: "These are very rare situations, thus the natural path is evolution" [BT14]. We would add persistent economic crisis in the country in which the ecosystem emerges as a threat to this evolution.

In our analysis, Tel Aviv and New York passed through all four stages of evolution in the last 50 years, from nascent to self-sustainable, while São Paulo, a younger startup ecosystem, which had it first significant tech entrepreneurs' generation around the 2000's, is still in the evolving stage.

D. Can people proactively interfere in the evolution of ecosystems? Is it possible to exist other ecosystems as developed as mainstream ecosystems such as Silicon Valley, generating tens of high growth global startups? How many of these could exist in the world?

Fred Wilson adds, "what has happened in NYC can happen anywhere that has the entrepreneurial spirit and the freedom to innovate" [CP13] – and many interviewees agreed that it is possible for

self-sustainable ecosystems to exist if the local culture values the entrepreneurial behavior, confirming Brad Feld's claim that "You can create a vibrant long-term startup community anywhere in the world" [Fel12]. Two interviewees compared New York with Boston, claiming that Boston's ecosystem (the home of MIT) did not take off as fast as New York's, because Boston's culture is much more conservative, while New Yorkers are more open to risk. Thus, on the one hand, people can interfere to accelerate; but, on the other hand, culture, which is something very difficult to change in the short term, plays a very significant role.

Nevertheless, we learned from our research in São Paulo that culture can change, though it may take time. There, the first generation of tech entrepreneurs started timidly in 2000. At that time, young people were supposed to finish their university degrees and find a job. After 15 years, the scenario changed to a culture in which being an entrepreneur is a lifestyle. São Paulo is a city with many characteristics similar to New York: a large metropolis, with millions of people (mostly first, second and third generation immigrants); a financial, advertising, and business center; and a culture of hard work, where time is money. São Paulo has all the potential to evolve from the current Evolving (M2) level to Mature (M3) or even self-sustainable, but for that to happen, it must overcome important obstacles, like developing more policies for tech-talent attraction; reducing the tax burden; improving the law framework for company creation and closing; investing in mobility infrastructure to facilitate the access to high quality Universities; and advancing the investment market.

5.4 The Startup Ecosystem Maturity Model - Final Version

By analysing the ecosystem maturity model [CKK15b, CKK15a] proposed on Phase 2 with New York observations, as well as feedback from specialists at the PROFESS'2015 Software Startups Workshop, we refined some of its proposed factors. For example, we replaced the absolute number of startups in an ecosystem with the relative number of startups per million inhabitants. In fact, all factors that considered absolute numbers were revised to use values that are relative to the ecosystem size. Otherwise, ecosystems outside very large cities would never reach their maturity if the criterion of having high absolute values was required. We also received assistance and valuable feedback from one of the authors of the Startup Ecosystem life cycle model, a similar approach to design and map ecosystems evolution [GPSH15].

Two new essential factors were added to the maturity model:

1. Access to Angel Funding. "Startup communities feel like they are not complete until they have at least one angel investor group" [CP13]. Many interviewees mentioned the great importance of role models. For technology startups, it is important that these role models include not only successful business people, but also developers and tech leaders. One of the entrepreneurs interviewed said, "I think it is essential to give a lot of equity to engineers. When a company becomes successful and these guys become rich, they are the ones who will start new innovative companies". Successful tech founders will not only inspire new entrepreneurs, but will also become angel investors for the next generations.

2. Events: it is nearly unanimous among the New York City interviewees that social networking spaces and events are important to the ecosystem's maturity.

Another modification we made to the model was to remove access to funding from the essential factors list. Even if access to funding is very important, it is more a side effect than a cause of success for ecosystems. One investor said: "When you have amazing technology companies being created anywhere, investors will follow". We present the final version of the model proposal in Section 5.4. We removed the military metric, which was considered very specific to only a few ecosystems, and added new metrics to the model:

- **Startup Events** - How frequently local events focused on themes like high-tech entrepreneurship or startups occur. Related framework element: Society / events.
- **Angel funding in # of deals / year** - Deal count only by Angel investors. Mature ecosystems tend to have more angel investment support, since angels are usually successful entrepreneurs giving back their earnings to the community. Related framework element: funding bodies / angel.

The final version of the Startup Ecosystem Maturity Model factor classification and associated values for each level is depicted in Table 5.8.

After generating the classification table for each factor, we filled in the table with data about the three ecosystems we analyzed (Tel Aviv, São Paulo and New york), using the help of two specialists from each ecosystem. If we consider the New York ecosystem evolution from 2000 to 2015, the ecosystem passed through all four stages proposed in the maturity model. Moreover, some initiatives began by stakeholders when the ecosystem was considered nascent or evolving (such as the creation of the New York Tech meet-up), and other events that happened later when the ecosystem was already considered Mature (such as the Cornell Tech project [PP11]), all came at the right moment for the ecosystem, helping it to evolve quickly and robustly. Based on our research in Israel [KCM+14], we consider that the Tel Aviv ecosystem is in the same self-sustainable stage as New York, and observe that it took similar evolutionary steps. Our research in São Paulo concludes that this ecosystem already passed the nascent stage, but is still at the evolving stage. The characteristics and dynamics of all these three ecosystems fit the proposed maturity model. We chose Tel Aviv to analyze an evolved ecosystem outside the US market and avoid bias on US culture-specific characteristics. The choice of São Paulo, besides being the ecosystem two of the authors were immersed in, derived from the importance of investigating ecosystems in a more immature stage (from a global, international perspective), in a developing country, and understanding the specific needs in this context.

For ease of understanding, and to facilitate dissemination, we created a summarized version of the model depicted in Table 5.9. The level classification using the summarized version requires that the analyzed ecosystem must have at least seven (from eight) factors classified on that level.

It is worth noting that, depending on the ecosystem maturity level, the metrics have a different level of importance. Some metrics are more important to measure and develop during the first years of the ecosystem development, while others are more relevant when the ecosystem has already achieve an advanced level of maturity. Table 5.10 summarizes the metrics-importance classification. This table indicates where local agents should focus their efforts in the ecosystem development process.

The next chapter summarizes our contributions, presents our final conclusions, discusses the limitations of our research, and explores opportunities for future work.

Table 5.8: *Ecosystem Maturity Model Factor Classification: final version*

Factor	L1	L2	L3
Exit strategies *	0	1	>= 2
Global market *	< 10%	10 – 40%	> 40%
Entrepreneurship in universities *	< 2%	2 – 10%	> 10%
Culture values for entrepreneurship *	< 0.5	0.5 – 0.75	> 0.75
Startup events *	monthly	weekly	daily
Ecosystem data and research *	N/A	partial	full
Ecosystem generations *	0	1	2
Mentoring quality	< 10%	10-%50%	> 50%
Bureaucracy	> 40%	10 – 40%	< 10%
Tax burden	> 50%	30 – 50%	< 30%
Accelerators quality (% success)	< 10%	10 – 50%	> 50%
Access to funding in USD / year	$< 200M$	200M-1B	> 1B
Human capital quality	> 20th	15 – 20th	< 15th
Technology transfer processes	< 4.0	4.0 – 5.0	> 5.0
Methodologies knowledge	< 20%	20 – 60%	> 60%
Specialized media players	< 3	3-5	> 5
Relative measured factors (per 1 million inhabitants)			
Number of startups *	< 200	200 – 1k	> 1k
Angel funding in # of deals / year *	< 5	5 – 50	> 50
High-tech companies presence *	< 2	2 – 10	> 10
Access to funding in # of deals / year	< 50	50 – 300	> 300
Incubators / tech parks	1	2 – 5	> 5
Established companies influence	< 2	2 – 10	> 10
* essential factors			

Table 5.9: *Ecosystem Maturity Model: summarized version*

Maturity Factor	**M1 Nascent**	**M2 Evolving**	**M3 Mature**	**M4 Self-Sustainable**
Exit strategies	none	A few	several M&A few IPO	several M&A and IPO
Entrepreneurship in universities	< 2%	2-10%	10%	>= 10%
Angel Funding	irrelevant	irrelevant	some	many
Culture values for entrepreneurship	< 0.5	0.5 – 0.6	0.6 – 0.7	> 0.7
Specialized Media	no	a few	several	plenty
Ecosystem data and research	no	no	partial	full
Ecosystem generations	0	0	1-2	>= 3
Events	monthly	weekly	daily	> *daily*

Table 5.10: *Ecosystem Maturity Model: Metrics Importance*

Maturity Metric	M1	M2	M3	M4
Exit strategies	*	*	***	***
Entrepreneurship in universities	***	***	**	*
Angel Funding	*	*	**	***
Culture values for entrepreneurship	***	***	***	**
Specialized Media	*	**	***	***
Ecosystem data and research	*	*	**	***
Ecosystem generations	*	*	**	***
Events	***	***	**	*
Legend: very important***, important**, not so important*				

Chapter 6

Conclusions and Future Work

The evolution of the New York startup ecosystem from 2010 to 2015 is impressive. The 2009 financial crisis played a very important role, causing talent to migrate from traditional and established markets to startups. This isolated fact does not explain, alone, the rapid ecosystem growth, yet, when human talent is available to work in innovative startups, and these startups have all the infrastructure resources they need to develop, magic happens.

The New York case is a strong example of how startup ecosystems can evolve over time. In 2010, this ecosystem had a very modest impact in terms of startup creation and innovation generation compared to other ecosystems, such as Silicon Valley, Boston, or Tel Aviv. Less than 5 years later, the New York City ecosystem is considered a benchmark: the best place for startups according to the CITIE 2015 Report [Cai15], and the second best place in the Global Startup Ecosystem Ranking [HGH+15].

With the results obtained from this thesis research, we attained our general objective to advance the understanding of how software startups and their ecosystems function. We presented a conceptual framework that depicts software startup ecosystems, their agents, and the relationship between them, accomplishing specific objective (1). We iteratively evolved this framework until a final version that fitted in all three ecosystems we analyzed during our research (specific objective 2). We created a maturity model to map ecosystems evolution, achieving the specific objective (4). Stakeholders from any existing ecosystems can use the proposed model to evaluate its maturity and also compare to others (objective 4). As the last specific objective (5), we presented recommendations and conclusions about the Tel-Aviv startup ecosystem (SWOT) and the São Paulo ecosystem (Factor analysis).

In future work, we would like to collaborate with other researchers in using the maturity model to analyze new regions and derive concrete actions that should be taken to improve those ecosystems. Some questions that still remain are the following. Is there a limit to how many self-sustainable ecosystems can exist? To what extent does local culture influence the appearance of these ecosystems, since it is a limiting factor for all other aspects of the model? Since theory emphasizes the importance of the ecosystem connectivity, we also propose that new research should focus on ways to measure an ecosystem's connectivity based on on-line social network data.

This research could also be extended to other regions outside form big urban centers. It is a challenge to develop fruitful startup ecosystems in smaller cities such as São Carlos, São José dos Campos or Campina Grande in Brazil, or cities like Trondheim in Norway or Bolzano in Italy, or

maybe even cities in Africa and Middle East. On the long term, small and medium cities tend to loose talent and resources to the big centers. We consider that there is a vast field of research to be explored about startup ecosystems on small and medium cities.

Our maturity model was created under the context of software startups and their ecosystem. This does not mean that the model is useful only for startups based on software. Many conclusions could be applied also for startups around hardware or other technologies. Today, it is very difficult to find high-tech startups that do not have any software in its core. Even hardware companies need some kind of software to scale their business. However, we recommend further research over these startup segment to enhance to model.

Even though we achieved theoretical saturation in the conceptual framework, we believe that it is a moving target. Things are always changing over time, so the conceptual framework certainly needs to be revisited from time to time. After being applied in five or ten other ecosystems, we should consider new adaptations to the maturity model.

6.1 Threats to validity

Maxwell identified potential limitations of qualitative research [Max12]. **Descriptive validity** happens when the research is able to accurately collect the data. In our case, most of the interviews were tape recorded, so we could later listen to the audio. Even if most of interviews were recorded, some of them were not. Moreover, we had some informal conversations with ecosystem agents, so not all of our interactions were not under rigorous scientific control.

Interpretation validity is when the investigator has no influence over the interviewee answer, avoiding to guide the person to a desired response. In our case, questions already contained concepts and vocabulary such as “startup ecosystem”, “ecosystem agents”, “maturity model”, influencing the interviewee to believe that these paradigms were established. The interviewees responses can be biased by the few concepts about ecosystems presented to them during the interview.

Researcher bias happens when the investigator focus only on his own previous background to the research conclusions, avoiding to include in the research offenders of the preexisting beliefs. By using a Grounded Theory approach, we avoid part of this bias. However, while the first interviews are less biased by our previous knowledge, one limitation of this research is that the last interviewees are biased by the preconceptions we acquired on previous interviews. Moreover, people are somewhat biased by what they see on media about what is considered a successful path today for technology startups: founding a company, raising seed capital from angels, raising series investment from VCs, becoming a unicorn (US$1 billion company), going public, or being acquired. The media emphasizes only the successful cliché cases, and entrepreneurs are overwhelmed by these idealized models. Usually, the media ignores medium and small local companies that may also have an important impact on the startup ecosystem and on regional development. Their influence and role were not considered in our study, and need to be further investigated.

Theory validity is when the researcher does not force the data to match a previous theory. The Grounded Theory techniques we used help to avoid this threat during the elaboration of the startup ecosystem conceptual model. On the other hand, after research Phase 1, we deepened into the literature to support the next phases, so even if the conceptual framework for software startup ecosystems is unbiased by previous theory, the maturity model is not completely free of bias.

Reactivity is when the collected data and observations are happening just because the investigator is there. The first part of our interview protocol was built to avoid this kind of phenomena, specially when we do some "breaking the ice" questions, trying to make the interviewees comfortable. At a first moment, interviewees may get intimidated by the recording equipment, but after some minutes they forget that they are being recorded and begin to act more naturally. A small part (approximately 20%) of the interviewees already knew the researchers before the interviews and had a previous relationship with them. These interviewees may have their answers influenced, avoiding to offend the interviewer opinion. Besides that, we believe we performed a sufficient number of unbiased interviews, specially those with previously unknown interviewees.

One last threat of our research is that it was limited to western startup ecosystems. We believe it is necessary further efforts investigating Eastern Asian, Eastern European, African, and Australian ecosystems to understand if these cultures also fit into the proposed maturity model.

Finally, although not without its limitations, we believe that this thesis presents a significant contribution to entrepreneurship communities. Ecosystem agents must work together, at least with an overview of the complex structures they are embedded. We believe that this thesis can bring valuable insights for entrepreneurs, governments, investors, established companies, and other stakeholders in any innovation ecosystem. We believe in technological innovation with good intention as a road for improving human life, and hope this work to be a brick on this long and fascinating road.

Appendix A

Interview Protocol

Protocol to be used in the interviews at startups

A.1 Tips for the interviewer

- Speak the minimum possible
- Do not give your opinion
- Avoid / minimize bias
- Do not need to follow the script 100
- Focus on the person skills
- Avoid noisy places

A.2 Criterion for choosing interviewees

- Choose some from personal Networking
- Snowball strategy
- Try to mix different backgrounds based on different criterion
- company size
- role (entrep, univer, gov, etc)
- gender
- foreign x local
- cultural background, religion

A.3 Email invite (English)

```
Dear <<name>>,

[You have been recommended by <<name>>]

I am a Brazilian Entrepreneur and PhD student in the Computer Science Department
 at the University of Sao Paulo. Last year we created a research group on
Technology and Digital Entrepreneurship. Now we are performing a research in the
 New York Startup Ecosystem. With your experience as <role> in the city, we
consider you have a very important role and we will be very happy to interview
you for our research, which we expect to help many startups communities
worldwide

Can we schedule an informal conversation at <company>? Something between 45 or
60 minutes would be great.

Are you available in one of the time slots below?

MM/DD - HHam
MM/DD - HHam
MM/DD - HHam

Thank you very much,

Daniel
```

A.4 Email invite (Portuguese)

```
Caro <<nome>>,


Sou aluno de pós-graduação do IME-USP e faço parte do grupo de pesquisa de
Empreendedorismo Digital coordenado pelo Prof. Fabio Kon. Estamos realizando uma
 pesquisa sobre o Ecossistema de Startups de São Paulo e gostaríamos muito de
poder entrevistá-lo dado o <seu papel fundamental no ecossistema / a sua experiê
ncia no assunto, etc.


Poderíamos marcar um bate-papo informal na <nome da empresa>? Algo entre 60 e 90
 minutos seria ótimo.


Você teria disponibilidade em algum dos horários abaixo?


10/4 - entre 9:00 e 12:00
11/4 - entre 14:00 e 18:00
(quando tiver convidando alguém ocupado, dar muitas opções).
```

```
Muito obrigado,

Daniel
```

A.5 Quick into LinkedIn

```
Hi <name>
I am a Brazilian Entrepreneur and PhD student in the Computer Science Department
 running a research in the New York Startup Ecosystem. With your experience in
Vine, we consider you have a very important role and we would like to interview
you for our research. Best!
```

A.6 Preliminaries

When the interviewee and interviewer have a lot of time: in the 1st meeting, try to know the people, observe the startup environment, and try to schedule an interview with 2 or 3 members of the startup team for a few days later.

When both have some time: try to schedule a short videoconference call before to explain the research and the protocol.

Regular case in which people are busy: explain the research and the protocol in the beginning of the interview itself

A.7 Interview warm-up

- Explain the overall goal of the research in general terms:

  - GOAL: Study the Startup Ecosystem from a Computer Science perspective to obtain a better understanding of the current state-of-the-practice in Software Startups in «region», identifying best practices as well as problems / difficulties and opportunities for improvement in XX.

- Explain the default protocol and ask and if it's OK (if not, adapt to fit needs)

- Explain the reasons for recording and confidentiality

- Explain results will be sent first hand to them

- All results will be published in an anonymous form (except in particular cases in which it might be interesting to disclose the name of the person or company but only with explicit approval of the involved people)

- Optional: Interviewer show the 4 slides presentation introducing the group and the research

Benefits for the startup: Simply mention quickly: "We'd be open to further collaborations in the future (USP<->startup)".

A.8 During the interview

- Depending on the profile of the interviewee, some of the questions might be skipped or adapted (e.g., for a CEO with business background, we might adapt the questions about code quality; for a developer, we probably won't ask about investment).
- The researcher (interviewer) will make a few notes on paper or computer.
- The complete audio will be recorded

A.9 After the interview

- ask if it's OK to take a picture
- Interviewer will iteratively produce a working document (Research Question Notes) structured around the initial research questions. For each research question, he will write observations made by interviewees on related topics.
- ask suggestions of other startups/people to be interviewed.
- Ask for introductions.

Interview Duration: 30 to 90 minutes

A.10 Form on Background

Try to collect the following information before or after the interview but don't waste interview time with this; use linkedin, for example

Personal information (treated with confidentiality): name, email, age, degree of highest completed education, area, year degree was obtained, current job position,

Company (treated with confidentiality): name, URL, domain, number of company employees, how long ago was founded (age/months), stage of life (e.g., initial idea, self-funded startup, seed fund, VC funded, etc.)

A.11 Oral Questions

The questions below will serve as a guide to the researcher (interviewer) who will adapt the language and the direction of the interview based on the real-time feedback from the interviewee. This is not necessarily the order in which the questions will be asked. The interviewer must feel the person and adapt to what his intuition tells about it.

0. Can you tell me a little bit about your trajectory, how you started and how you got here?

    0.1. Have you participated in other startups before? Did any of these startups fail? How? Why? Did you make mistakes? Which? (Prime objective: find out the experience of the interviewee and serve as an ice breaker. Maybe find out partners/colleagues that may be interview later.)

1. What are the factors in XXX that foster/promote entrepreneurship?

   1.5. What are the factors in XXX that disencourage/create barriers for entrepreneurship?

2. What are the institutional mechanisms in place in XX that promote entrepreneurship? (legislation, educational, scientific and technological institutions, government (national, municipal and local) agencies/programs, seed funds, angel investment, VC NGOs)

3. Do you believe education has a significant role in entrepreneurship? At home? Fundamental school? Middle School? University? Self-education? Informal? Overall education or entrepreneurship-specific education? Can you think of explicit or implicit pedagogical material and mechanisms that nurtures the entrepreneurial spirit? Have you participated in any Entrepreneurship education activity (course, workshop, accelerator, incubator)? Do you believe there are elements that could be improved in Entrepreneurship education?

4. What are the characteristics of entrepreneurs? What are the characteristics of successful innovative teams? (mix of introverts and extroverts?) What are the roles of different kinds of people? Diversity is important? What is the prime motivation of the high-tech entrepreneur: wealth, fame, self-esteem, proof of technology, etc.?

5. Which and how technological aspects influence the success of software startups? In particular what is the role played by Object-Orientation, Languages, Frameworks, Patterns, Models, and Architectures? Does your team has a concern for code quality? How do you promote and control that? Do you have a large technical debt? Do you manage that in any way? (Prime objective: To discover if software practices are being used, if they help software development in startups of if they only serve to look like a "cool" enterprise)

6. Which and how methodological aspects influence the success of software startups? In particular what is the role played by Agile Methods, Lean Startup [Rie11], Customer Development [BD12]. Which Agile methods practices do you use? Is there something in agile methods that doesn't work very well for your company? Do you consider a systemic plan or the intuition being the dominant success trigger of start-ups? Is this relation changing along the start-up life?

   6.1. What you don't do very well and would like to do better? Have you identified any mistake you made in your current startup or something you should have done differently?

7. What's the relationship of your company with Open Source software? Do you use it? Do you contribute? Do you believe open source has a significant role in the startup ecosystem?

8. If you had to name 3 key elements for a healthy startup ecosystem in a country or region, what would them be?

9. For maturity model: According to your experience, do you believe it would be possible to exist other ecosystems as developed as Silicon Valley or New York, generating tens of high growth global startups? Do you know any place that has the chance to do so? How far it is from achieving this successful stage? What is missing? How many of these could exist in the world?

9.1. what would be in your opinion the minimum requirement for a place to be considered an nascent ecosystem? And the minimum requirements to be in the last stage of development?

9.2. do you think it is possible for an ecosystem to regress or die? How and why?

9.3. do you think people in the ecosystem can proactively make things to improve the ecosystem maturity or this is something that just happen independently from people's will?

10. (optional) Do you have any question to me or see any ways in which we can collaborate?

A.12 SWOT Analysis questionaire

Online questionnaire sent to people with >= 10 years of work experience and who have worked in >= 2 startups: http://bit.ly/swot-israel

Portuguese version: http://bit.ly/swot-sao-paulo

Appendix B

Dealbook SQL queries

This are the queries executed at 05/01/2017 on the dealbook database to extract this thesis data.

```
-- total companies with city data (374)
select count(distinct c.id) from companies c
join companies_locations cl on cl.company_id = c.id;

-- total companies in São Paulo (143)
select count(distinct c.id) from companies c
join companies_locations cl on cl.company_id = c.id
join locations l on l.id = cl.location_id
where region = 'SP' and l.city = 'São Paulo';

--total deals with city data (397)
select count(distinct d.id) from companies c
join companies_locations cl on cl.company_id = c.id
join deals d on d.company_id = c.id;


--total deals in São Paulo (163)
select count(distinct d.id) from companies c
join companies_locations cl on cl.company_id = c.id
join deals d on d.company_id = c.id
join locations l on l.id = cl.location_id
where region = 'SP' and l.city = 'São Paulo';
```

Appendix C

Weighted Linkage and Neutral Linkage Indicators

The cells in Figure 5.4 were transformed using the following key:

Old value	New Value
1	1
2	2
3	n/a
4	3
5	4

Two indicators were computed for each cluster-factor combination:

1. **Weighted linkage indicator**: (Sum of values in combination)/(number of non n/a cells in combination X 4). We receive a value ranging from 0.25 to 1:

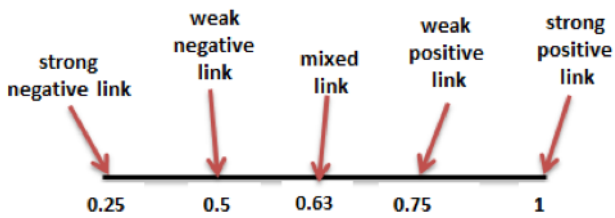

Figure C.1: *Linkage values*

2. **Neutral linkage indicator**: (Number of n/a cells in combination)/(total number of cells in combination).

Decision rule: If the number of cells in a particular factor (processes) - cluster (anchors) combination is greater than 50%, than there is no linkage (NL) between the factor and the cluster; otherwise, the weighted linkage indicator is used to determine the direction and strength of the linkage. The midpoint between each pair of values (0.25 and 0.5, 0.5 and 0.63, 0.63 and 0.75, and 0.75 and 1) was used as a basis for calculating the minimum and maximum threshold.

0.83-1: strong positive linkage (++); **0.69-0.82**: weak positive linkage; **0.57-0.68**: mixed link-

age (+-); **0.38-0.56**: weak negative linkage (-); **0.25-0.37**: strong negative linkage(–).

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