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Global Clusters of Innovation: The Case of Israel and Silicon Valley

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Global Clusters of Innovation:
The Case of Israel and Silicon Valley

Jerome S. Engel
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Innovation is a global process. Innovation, especially among early stage start-up ventures, is generally understood to accelerate when such ventures are in close proximity groupings known as Clusters of Innovation (COI). Clusters are not isolated islands. The most successful are often the most globally connected, utilizing linkages with other like clusters to leverage resources, access markets and accelerate the innovation process. These linkages, and the networks they construct, allow participants to reap benefits beyond those derived from proximity groupings and achieve efficiencies and innovation on a global scale. In a previous article published in *Business Horizons*, we defined a framework for understanding the rapid emergence of new patterns of innovation and commercialization in existing or emerging COI and the global connections often established among them. We define a COI as an environment that favors the creation and development of high potential entrepreneurial ventures and is characterized by heightened mobility of resources, including people, capital and information.[1] The framework builds upon the cluster literature, allows for a deeper understanding of the mechanisms behind the formation of COI, and most importantly their symbiotic relationship to other COI. It explains how individuals and organizations in a COI benefit from cluster externalities but differentiates COI from pure agglomerations of interconnected organizations working in the same industries (industrial or Porterian clusters). It also explains how individuals, companies, universities and other players in COI are connected to other, sometimes globally distant COI, through diverse mechanisms including weak ties,[2] durable bonds and covalent bonds. These linkages lead to the creation of Networks of Clusters of Innovation (NCOI) with coincident efficiencies and benefits. In limited instances the elements of these networks intensify to the point of mutual dependence, giving rise to the emergence of Super-Clusters of Innovation (Super-COI). This paper uses a case study to illustrate how focusing internally on a region can neglect the importance of situating an emerging

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cluster in a global context, and how global resources, inputs and access can accelerate innovation and cluster development. It investigates the usefulness and adaptability of the Global Clusters of Innovation Framework for understanding innovation patterns of existing and emerging COI and their networks (NCOI and Super-COI).

To illustrate these points, this article focuses first on Israel and the attributes that characterize it as a COI. Second, it analyses how this COI in Israel exploits its global connections, specifically the relationship between the elements of the COI and Silicon Valley, giving rise to Israel/Silicon Valley Super-COI. The case study is based mainly on secondary data gathered from existing literature. Additionally, anecdotal evidence was obtained from key informant interviews in order to provide illustrative examples of the Framework's applicability for understanding the nature of global connections and innovation processes. In this case study, qualitative evidence is not used to build theory but rather to provide examples that reflect theories and industry-specific boundary conditions.[3] The interviewees are venture capitalists, entrepreneurs, and managers who represent fundamental connections between Silicon Valley and Israel: Arthur Berliner, co-founder of Walden VC, Walden International, and Walden Israel, one of the first Israeli venture capital funds dedicated to investing in early-stage start-ups; Kevin Brown, ex-CEO of Kidaro, a company headquartered in Silicon Valley based on technology developed by company founders in Israel and funded by an Israeli-born, Silicon-Valley-based venture capitalist; and John Woolard, CEO of BrightSource, which acquired a decades-old Israeli firm and, using a new U.S. management team and venture capital, accelerated the company to achieve explosive growth. The interviews were conducted between November 2008 and January 2009 and were focused on illuminating the nature of inter-connections (bonds) among elements in both COI and their characteristics in terms of business deal structures and the mobility of resources (principally capital), assets (most notably intellectual property/technology), and people. Specifically, we look at the Israel/Silicon Valley Super-COI and the interconnection between the COI to further explore the Framework and illustrate:

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- the underlying elements of COI, and differentiate them from the pure agglomeration of interconnected companies of an industrial cluster;
- the process in which some COI get connected to other geographically distant COI;
- the nature of the connections established among them, which we have characterized as weak ties, durable bonds, and covalent bonds; and
- how the resulting structures (NCOI and Super-COI) are articulated and how they operate in a mutually beneficial and interdependent fashion.

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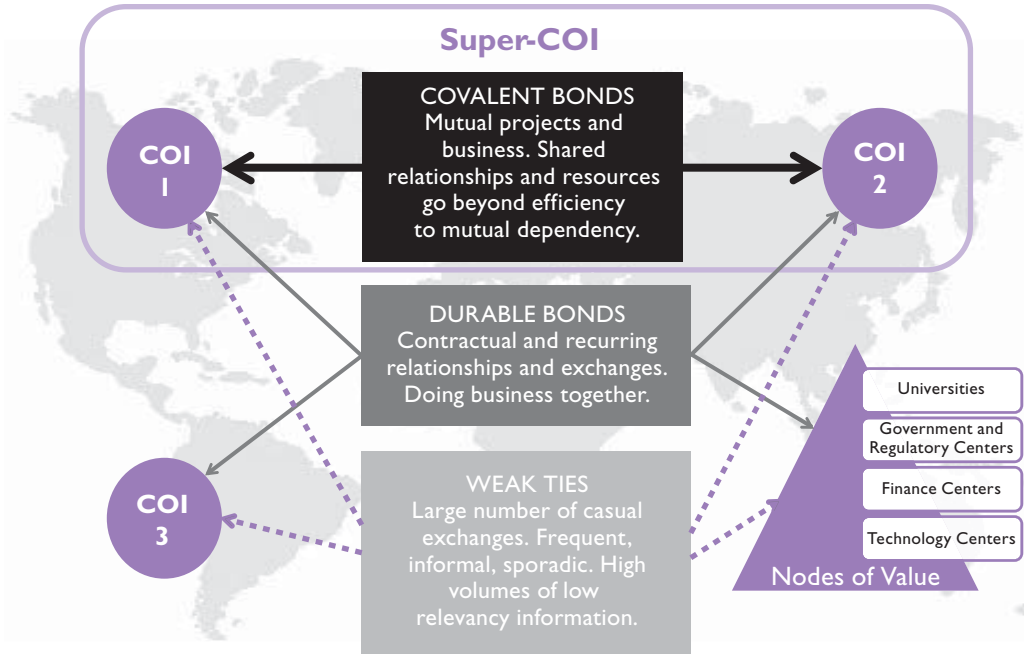
FIGURE 1. Global Networks of Clusters of Innovation



The description of the global network of clusters is a principal and novel contribution of the Framework and this article. In this respect, the Framework contributes to the global extension of cluster theory with a better understanding and characterization of the connections among COI and the resulting global networks of COI. For understanding this global perspective, the Framework adds to the cluster literature a comprehensive characterization of COI and integrates concepts, elements, and mechanisms otherwise dispersed in the literature. It also contributes to the global extension of cluster theory with a better understanding and characterization of the connections among COI and the resulting global networks of COI. Rather than focusing solely on the dynamics within the cluster, the Framework helps explicate rapid innovation and globalization patterns manifest in certain business clusters that leverage global inter-connections. Additionally, the Framework can be a useful tool for entrepreneurs, business managers, venture investors, and government policymakers, especially in an era where product and service innovations involve and often require collaboration and interdependency among entities in diverse geographies. For entrepreneurs, business managers, and venture investors the Framework can serve as a guide in designing strategies, transaction structures, business entities, and management roles that take advantage of the attributes and elements identified and defined in the Framework. For governments the Framework can assist in developing policies that support the evolution of innovation mechanisms that benefit from being engaged with the global innovation economy. It can help expand

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the focus of economic development policy beyond regional competitive advantage to embrace the benefits of global connectivity, and it can assist in strategically targeting and prioritizing specific regions for partnership. This last point is important as a great deal of regional economic development resources have been focused on creating industrial growth and innovation through the fostering of clusters modeled on Silicon Valley (such as Silicon Bog, Silicon Glen, Silicon Alley, Silicon Island, Silicon Wadi, and Silicon Hills). Such efforts have proven challenging. They require a sustained commitment as well as accomplishments that are beyond the control of governments. Our observations of the global interconnected opportunities of the innovation process, as expressed in the Framework, suggest that the significant benefits are derived from the integration of a local cluster into the value chain of a global NCOI, and that this objective is more likely to be achieved and to provide a higher return on investment for communities seeking to foster economic growth and innovation. To assist in the Framework's application we provide a comprehensive table as a quick reference and practical guide.

Why This Framework Is Important

The framework makes three principal contributions: it provides a novel definition of a Cluster of Innovation that illuminates heretofore overlooked attributes; it identifies that Clusters of Innovation should be understood in a global context, and defines their mechanisms of interaction; and it facilitates the practical implementation of effective economic development and business practices. We define a COI as composed of largely intangible processes (i.e., mobility of resources, alignment of incentives, and entrepreneurial practice) as opposed to the original Porterian orientation that relies on the physical proximity of entities in the same industry. While such proximity advantages persist, we have observed that the innovation processes we emphasize pollinate across industries and indeed across regions. The definition allows for and invites the investigation of the role of the global connections between COI. Previous literature has shown how some entrepreneurial regions are rapidly emerging and flourishing. Some of these regions have been referred to as innovation clusters and have been the subject of extensive analyses (i.e., Taiwan,[4] Israel,[5] and India and Ireland[6]). Among these clusters, Silicon Valley is the leading example of a high-technology entrepreneurial environment.[7] Studies have shown that many of these rapidly emerging COI have evolved by using Silicon Valley as a role model and point of reference.[8] Silicon Island in Singapore,[9] Silicon Wadi in Israel,[10] Silicon Bog in Ireland,[11] and Silicon Glen in Scotland,[12] for example, have some common factors with Silicon Valley. But what are those factors? Are these factors simply local, or do they have global network attributes? What makes them similar and different from each other? How can we distinguish pure agglomeration of companies from entrepreneurial and innovation intensive clusters (COI)? Are innovation processes common to companies in different environments? While some of these questions remain unanswered, it seems clear that certain clusters processes cannot be explained by traditional Porterian means, i.e., they are

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not a pure agglomerations of interconnected companies in a particular field or industry, linked by commonalities and complementarities, and benefiting from being geographically proximate to each other.[13] In these clusters, interactions between regions lead to differing advantages among otherwise similar industry clusters. The Global Clusters of Innovation Framework builds upon the concept of clusters of innovation[14] and helps us to understand what makes these innovation nodes different from traditional industrial clusters and, most importantly, how their interconnection can give rise to synergies and new capabilities.

The Global Clusters of Innovation Framework helps us to understand new patterns of innovation and commercialization in existing or emerging highly entrepreneurial agglomerations of businesses. It also helps us to understand how this innovation process, driven by mobility of resources[15] and alignment of incentives,[16] is remarkable, and how companies in these COI benefit from excelling in entrepreneurial processes rather than solely the benefits derived from industry concentration, thus demonstrating that the underlying processes at work go beyond Porter's historic cluster definition. As a result, we are able to explain why new and apparently unrelated industries emerge in existing specialized clusters.

The framework contributes to the global extension of cluster theory and literature.[17] Researchers have analyzed how companies that are "born global" leverage international opportunities.[18] Work has also been done to analyze the diffusion of entrepreneurial environments in order to understand how migration and fragmentation of industries have contributed to the creation of new innovation nodes worldwide.[19] The Global Clusters of Innovation Framework incorporates all these elements and mechanisms and helps us to understand how, in a field where geographic proximity is a presumed advantage, geographically distant individuals and companies create advantage through virtual proximity based on relationships and connections. The framework goes beyond the concept of the meta-clusters or the clusters of innovation networks[20] as it helps us also to characterize the linkages among entities based on the longevity and the frequency of the connections and the interdependency of the nodes. As a result, the Global Clusters of Innovation Framework helps to explain how entrepreneurial and other business practices are disseminated and thus how countries such as China and India use global entrepreneurial practices to emerge rapidly as international technology and innovation powers. Further, it helps explain previous findings such as how the socialized exchange of gifts in COI is based on reciprocal benefit rather than on power relationships and how only actors with complementary and equivalent resources useful for other members in a global community are permitted to enter the network.[21] We believe that the Framework provides a vehicle for putting this enhanced understanding to practical application and for encouraging explicit creation and overt management of these valuable bonds

For policymakers, the Global Clusters of Innovation Framework serves as a guide to formulate effective policies to promote the creation of local COI and enhance their productivity by integrating them into the global innovation

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economy utilizing global NCOI. Before 1990, most government incentives focused on R&D infrastructure provision, financial innovation support, and technology transfer, neglecting, in many cases, the absorption capacity of the firms.[22] Subsequently, the efforts shifted towards Regional Innovation Systems (RIS) and pointed to Local Knowledge Spillovers (LKS) to be the key actors in the process of knowledge creation and diffusion.[23] More recently the importance of including a global innovation perspective in governments' agendas has been recognized.[24] The Global Clusters of Innovation Framework contributes to this global perspective and aids governments and others to promote local strengths, to mobilize global resources and to integrate a local cluster into the value chain of a global NCOI.[25]

For business executives and entrepreneurs, the Global Clusters of Innovation Framework illuminates mechanisms that depend on collaborative engagement with other enterprises, such as *open innovation*.[26] It provides a roadmap for participation in the global NCOI. It can be transformative for small and early-stage companies that seek to overcome the limitation of their resource constraints through effective exploitation of the mobility of people, technology, and capital and to adopt mechanisms for aligning incentives and goals. The framework is a guide for managers who want to create mutually beneficial, and sometimes inter-dependent, collaborations with other enterprises around the world and helps them to understand how to leverage mobile resources to implement global strategies and collaborations.

In summary, we believe that the Global Clusters of Innovation Framework integrates critical concepts such as *clusters of innovation*, *entrepreneurial processes*, and *global connections* and illustrates their interaction in a global context. By highlighting the core elements that accelerate innovation in a cluster, the Framework can be used to deliberately encourage innovation and entrepreneurship.[27] It can help accelerate the systematic and robust analyses of clusters of innovation, the companies that constitute them, the business practices that define them, and the nature of the interrelationships that bind them. Further, it illustrates how individual and regional advantage can be gained by focusing on global interconnectedness.

Global Clusters of Innovation Framework

"We define a Cluster of Innovation as an environment that favors the creation and development of high potential entrepreneurial ventures, and is characterized by heightened mobility of resources, including people, capital and information."[28] It typically includes start-ups; small, medium, and large corporations; universities and research centers; entrepreneurs; investors; and service providers as well as other individuals and organizations that: use entrepreneurial intensive process as a mechanism for innovation and experimentation; have heightened mobility of resources, principally people, technology, and capital; create companies with an early international perspective; and have players who have shared identities and aligned goals.

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The presence of these factors explains the creation and rapid growth of companies in a region, even where they are in apparently unrelated industries. As in industrial clusters, firms in a COI benefit from external economies of scale[29] and from being located close to specialized suppliers and customers.[30] However, more important than agglomeration externalities is that the components of the community of a COI are well versed in entrepreneurial processes and in the needs of start-ups.[31] In these environments, many individuals have personally accumulated investable sums of capital by working for or investing in start-up ventures and they seek similar investment opportunities. It is part of the accepted behavior that recycles not only capital, but also know-how and expertise within the community. Entrepreneurs and start-ups in COI benefit from being co-located with other companies, suppliers, service providers, financial institutions, and investors specialized in or compatible with entrepreneurship. For example, law firms and other professional service providers with deep expertise in company formation and early-stage issues, such as shareholders agreements, IP rights, licensing, and employment practices, are prepared to serve new firms with flexible fee structures (including start-up discounts, fee deferrals, and/or accepting equity interests in payment of fees) and service approaches (such as the practice of attending Board of Directors meetings at no charge) that enable these unproven businesses to access top professional talent. Further, entrepreneurs have many opportunities to be educated about how to create and manage new ventures through formal training, practical experience, and informal networking. Specialized organizations exist to disseminate best practices, provide education for entrepreneurs and investors, and create events that foster networking, investing, and reinforcing a common set of values and practices.[32]

In COI, the entrepreneurial process is accelerated by high mobility of resources—principally people, technology/know-how, business practices, and capital. The mobility of people between and among ventures, both formally and informally, is key to the building of a common entrepreneurial business culture of shared values and business practices.[33] New technologies are rapidly developed, tested, commercialized and often acquired outright or shared with other companies that integrate them into their already existing products; capital is deployed and recycled for financing this rapid experimentation and innovation process; and there is a frequent flow of people who are employed in different scenarios, companies, and positions for relatively short periods of time. Continuous mobility intensifies linkages and networks among individuals and companies and creates a heightened affinity for collaboration.[34] Frequently, mobile resources in a COI cross regional and national boundaries and collaborations involve individuals and companies in geographically distant COI. Newly born companies in a COI are characterized by having relatively global perspective and for capitalizing on international opportunities earlier in the venture development cycle than is the historical norm.[35] The global perspective serves to enlarge economies of scale in COI.

Mobility and unbundled interactions have contributed to cross-fertilization and to the formation of unanticipated new markets within the COI and abroad.[36] International mobility of capital and people sharing common business

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practices has contributed to the emergence of new innovation hubs in geographically remote environments. The process is activated by selective migration forces[37] that attract entrepreneurial people to highly innovative clusters.[38] Many of them move to these COI to complete their education in leading research universities; others seek employment and help fuel the human potential available to both start-ups and mature corporations. Whatever the reason, these immigrants get embedded within the entrepreneurial culture and processes of the COI.[39] They experience and learn business practices of rapid innovation and experimentation; they align themselves with the incentives and goals of the companies. Companies in the COI benefit as these immigrants bring a broad perspective and contribute to the creation of global strategies. They have a personal knowledge of the markets in their countries of origin and are able to add value[40] by identifying opportunities and global networks of engineers, managers, suppliers, and customers to exploit them.

In many cases, these entrepreneurs return to their home countries and employ this knowledge to capitalize opportunities there. Despite geographical distance, returning entrepreneurs maintain weak ties[41] with entrepreneurs and engineers, managers, suppliers, and customers in their COI of origin. New start-ups then are born and grow based on global strategies that connect individuals and companies in geographically distant COI. Weak ties then evolve into more stable *durable bonds* that permit frequent and fluid mobility of assets and people with relatively low transaction costs. Those relationships are strengthened through non-economic exchanges rather than purely through power relationships.[42] Such relationships are dynamic and fluid, as is the nature of the interrelationships of their underlying units, the "born global" entrepreneurial ventures, which themselves are composed of relatively mobile resources. Individuals, "born global" companies, universities, research centers, associations, mature corporations, and other organizations that are globally connected and that excel in rapid innovation, experimentation, and commercialization form global NCOI. While distance may be considerable and individuals may differ significantly in their culture, language, and experience, the components in a NCOI have a business perspective that goes beyond their local cluster. It thus helps sustain common values and practices, including innovation through entrepreneurial business processes, most notably new firm creation. The network is reinforced by continuous human migrations.[43]

In these networks, durable bonds are often built and re-built and are accompanied and strengthened by a dense mass of weak ties which ensure the longevity of the relationships among remote COI, reducing transaction costs.[44] In some cases, those durable bonds become more permanent and solid to the extent that actors are mutually dependent; and, instead of single transactions, connections become vital continuing contributors to the stability and competitive advantage of the components. In these circumstances, actors in remote COI get connected through what we have characterized as *covalent bonds* and mutually benefit from exchanging "gifts" within a social network of connections.[45] Covalent bonds are created and nurtured by mobility of people and face-to-face, personal, and trust relationships, which connect businesses and individuals with

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different cultural identities but aligned goals in geographically distant COI. The ultimate expression of a covalent bond is when a single individual performs critical functions simultaneously for ventures in two different COI. The two communities are linked in a relatively permanent and bi-directional exchange and take on a mutually beneficial stability and trust relationship that allows further and additional exchanges. Even though two COI may be geographically disparate, when covalent bonds are multiple and are continuously created and re-created between individuals and entities in two or more geographically dispersed COI in such a way that they operate in a coordinated fashion, a subset of the NCOI may become a Super-COI. Within this NCOI and Super-COI, global mobility of resources and people is accelerated by mutual respect, shared entrepreneurial culture, and business management practices, know-how, and aligned incentives and goals. All the constituents units, from individuals in the COI, NCOI, or Super-COI are characterized by their ability to sustain innovation, commercialization, and productivity in an environment of relative mobility and even volatility. The simplicity of the Global Clusters of Innovation Framework provides clarity when analyzing these bonds and thus more opportunities to identify and encourage them.

Table 1 summarizes the main characteristics of the Global Clusters of Innovation Framework. This table contributes a guide for characterizing the elements of the network and for facilitating the practical application of the Framework. The Framework is divided in three different levels—COI, NCOI, and Super-COI—and each level is defined by: its components; the "rules of the game" that govern their behavior; and the relationships among them.

The Israel and Silicon Valley Interconnection: An Example of the Evolution of a COI, NCOI, and Super-COI

In this section, we examine the country of Israel as an example of a COI, and its global connections with individuals, companies, and other entities in Silicon Valley as examples of NCOI and Super-COI. We integrate the results of the literature review we performed with the interviews we conducted of entrepreneurs, investors, and managers that are part of the Israel/Silicon Valley Super-COI. We apply the Global Clusters of Innovation Framework defined previously to identify the main characteristics of the Israel/Silicon Valley Super-COI, and we link specific facts from the literature and our interviews with characteristics of the Framework on Table 1. In doing so we illustrate how the table may be used as a guide for practitioners to characterize and identify the elements of COI and their global interconnections that can be enhanced. Additionally, for our case study entities, Table 2 maps the dispersed multinational locations of core elements of these enterprises, illustrating the integration of two COI into a Super-COI.

In the last 50 years, the country of Israel has experienced extraordinary development. The emergence and growth of the country has attracted the attention of many academics and professionals, as evidenced by the success

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TABLE 1. Components and Characteristics of the Global Clusters of Innovation Framework as an Extension of the Industrial Clusters Concept *(continued on next page)*

	Industrial Clusters		Clusters of Innovation	
Ingredients	Co-Located: • Mature corporations • SMEs • Universities • R&D centers • Service providers • All entities and participants are related to a specific industry • Fill a position in the value chain • Specialize in that industry		Co-Located: • "Born Global" companies • Mature corporations • Entrepreneurs • Investors • Universities • R&D centers • Service providers	
Rules of the Game	• Limited cooperation principally on external threats	(c1)	• Entrepreneurial process • Mobility – within COI • Affinity to collaborate • International strategies • Recycling of capital and ideas • Short innovation cycles • Staged risk taking	(a2) (b2) (c2) (d2) (e2) (f2) (g2)
Relationships	• Local weak ties • Transaction based connections, i.e., proprietary vendor relationships • Strong competition	(h1) (I1) (m1)	• Weak ties within COI • Shared values within COI • Intra- and inter-firm aligned incentives	(h2) (I2) (m2)

Note: The letters and numbers in parenthesis are cross references to specific examples of these characteristics in the Israel-Silicon Valley Super-COI analyzed in this paper.

of the recently published book *The Start Up Nation: The Story of Israel's Economic Miracle*.[46] Here, we will focus on its development as a center of innovation and entrepreneurship, notably in high-technology venturing. According to the Central Bureau of Statistics, when this 20,000 sq. km. country gained its independence in 1948, it was the home of 1.17 million inhabitants with an agrarian economy.[47] Now Israel is home to 7.4 million people, most of them Jewish (76%), and has one of the most advanced economies in Southwest Asia; an economy with significant investments in the ICT industry. Economic development was promoted by strong public policies focused on fostering product R&D activities and on enabling labor mobility, allowing scientists and industry leaders to move back and forth between state and private industry.[48] In

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TABLE 1 *(continued from previous page)*

Network of Clusters of Innovation		Super-Clusters of Innovation	
Remote and Independent: • COI • Other nodes of value: – Financial centers – Technology centers – Governmental and regulatory centers		Remote but Interdependent COI • NCOI	
• Entrepreneurial process	(a3)	• Entrepreneurial process	(a4)
• Collaboration—episodic	(c3)	• Collaboration – permanent	(c4)
• Inter-COI (International)		• Inter-COI (International)	
– Mobility	(b3)	– Dependence	(d4)
– Connections	(d3)	– Recycling of capital, technology	(e4)
– Recycling of capital, technology	(e3)	– Mobility	(b4)
• Inter-COI weak ties	(h3)	• Inter-COI weak ties	(h4)
• Durable bonds	(i3)	• Durable bonds	(i34
• Shared values	(l3)	• Covalent bonds	(j4)
• Aligned incentives	(m3)	• Mutual dependency	(k4)
		• Unified values	(l4)
		• Aligned incentives	(m4)
		• Mutual respect	(n4)

2001, the ICT sector in Israel employed 148 thousand citizens and accounted for the 20% of the exports of the country.[49] The Israeli COI contributed significantly to the commercialization of many telecommunication and ITC innovations including Voicemail, the Internet Firewall, instant messaging, VoIP telephony, and modern cellular billing among others. Many Israeli ICT companies, compete with each other (see m1 in Table 1); however, as in other industrial (Porterian) clusters, all these Israeli ICT companies benefit from their proximity to other specialized firms, suppliers, and customers (h1): they have many local transaction based connections (l1) and can, in certain situations, collaborate, especially to address common external threats (c1). The clear proof that Israel is indeed a Cluster of Innovation lies outside the ICT concentration, where just as in

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TABLE 2. Location in the Israel/Silicon Valley Super-COI

	Founder	CEO	Capital	Mgmt	Market	Technology	Customers
Decru	SV*	SV	US	SV	SV	SV	Global
Kidaro	Israel	SV	US	SV	SV	Israel	US
Brightsource	Israel	SV	SV+Global	SV	SV	Israel	US
Walden Israel	SV	Israel	SV+Israel	Israel	Israel	—	Israel

* Israeli with US citizenship.

Silicon Valley, the practices mastered in growing ICT firms are being successfully deployed in the emergence of wholly new industries. Israel is today a technological powerhouse in the fields of biotechnology and medical devices. According to the Statistical Database of the Israel Patent Office, around 65% of the roughly 7,000 patent applications filed every year in Israel are in the combined fields of chemistry, medical devices, and biotech. In 2006, Israel had 139 biotech companies, making the country 6th in the ranking of Europe's biotech industry.[50] The emergence and rapid growth of companies independent from their industry alignment shows that Israel is not simply a set of industrial clusters where the innovation advantage is industry specific. Israel's innovation mechanism is more generalized and can be understood as an evolution and extension of a Porterian industry cluster, where "innovation and entrepreneurship are the norm; early adoption is the rule; and thinking "out of the box" is a daily phenomenon" (a2).[51] As of August 2008, Israel ranked third in companies listed on NASDAQ, following the United States and Canada, and the country attracts twice the number of venture-capital (VC) investments as the whole of Europe.[52] The percentage of Israelis engaged in science and technology, the number of scientific papers published, and the investment in R&D, in relation to its GDP, are among the highest in the world.[53] So, while competition is strong (m1), there is also the opportunity to easily learn from competition, and in certain instances, to collaborate (c2, h2, m2).

Israel is a "cluster of entrepreneurship and innovation like Silicon Valley";[54] further, "it is the most vital place for entrepreneurship" (a2).[55] As in other COI, entrepreneurship is a core competence and new firm creation is an effective mechanism for rapid innovation, technology commercialization, business model experimentation, and new market development.[56] According to the Israel Ministry of Foreign Affairs, approximately 1,000 new companies are added each year, and Israel has the second highest number, (in absolute terms) after the U.S., of start-up firms worldwide (a2). As suppliers and customers are preconditioned for entrepreneurship, the cluster has expanded beyond ICT into unrelated fields such as biotechnology and medical technologies.[57] As in other COI, business models and capital are recycled continuously (b2, e2). The *Doing Business*

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Report 2009 ranked Israel as the top country in the Middle East for ease of starting a business, getting business financing, and protecting investors.

The characteristics of the Israeli COI map well against the Global Clusters of Innovation Framework. The results of the analysis of the companies interviewed and summarized in following paragraphs demonstrate how in the Israeli COI resources are mobile within and outside the firm (b2); new firm creation is a rapid and frequent mechanism for innovation, technology commercialization, business model experimentation, and new market development (a2, f2); new start-ups have early global strategic perspective (d2); and incentives and goals within the company and among collaborating individuals and companies are aligned (l2, m2).[58] Mobility leads to an affinity for collaboration among individuals and companies (c2) and to creation of durable relationships in a Network of Clusters of Innovation (NCOI) (i3).[59] Further, with regards to the Israeli/Silicon Valley inter-relationship, the results of the interviews demonstrate how these durable bonds progress to form covalent bonds (j4) between tightly interrelated and mutually dependent businesses communities in remote COI and how Super-Clusters of Innovation (Super-COI) evolve (k4).[60]

The Israeli COI has a strong and dense pool of world-class scientists, entrepreneurial engineers, and technicians (a2),[61] in part due to a strong educational system, a fairly comprehensive compulsory military service,[62] and a somewhat homogeneous culture. The scientific community was further augmented by the more than a million highly educated Soviet immigrants and the government programs that accelerated their incorporation into the entrepreneurial and scientific sectors (b3),[63] the military service that includes intense training and team building,[64] and the excellent technical education provided by local leading universities.[65] The Israel Institute of Technology or Technion in Haifa and the Hebrew University in Jerusalem were created in the first half of the 20th century, and today, together with the Tel Aviv University, are ranked within the top 15 universities in Asia.[66] However, business schools were rare until the 1990s,[67] and thus new ventures in Israel have frequently suffered from "inexperienced management, lack of business, and immature systems."[68] Without management and business development skills, many Israeli companies had difficulty growing and sustaining themselves. Additionally, the domestic market is limited,[69] so natural market seeking motives encourage start-ups to be "born global" as they immediately look to foreign markets for growth opportunities (d2).[70] An example is EyeView, an Israeli company "which was a global citizen from its very first day" (d2).[71] The company commercializes videos and audios to engage consumers and turn them into customers. From the start, they targeted global markets with three international offices in Tel Aviv, Boston, and Sydney, and now "most of the customers are international, so the videos are produced in many different languages and watched the world over" (d2).[72]

Mobility of people was an early characteristic of the Israel COI (b2). Transnational mobility of people between Israel and other COI has occurred for decades (b3). Apart from Soviet immigrants, a significant number of Israelis have moved to the U.S. for advanced degrees. More recently, Israel's nascent

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COI has attracted engineers from Silicon Valley and from all over the United States.[73] These migrations foster a transnational web of relationships (c2, b3, d3),[74] which include weak ties (h3), durable bonds (i3), and in many cases also covalent bonds (j4). "Shai Agassi (founder of Better Place Inc.), an Israeli-American businessman based in Palo Alto, California, is promising to upend the car industry by going electric, in alliance with politicians, entrepreneurs, and companies in Israel, Denmark, Japan, and France" (c2, c4, d3).[75] This and other similar examples show that the Framework is useful in discovering, explaining, and tracking these relationships.

Mobility has been encouraged by public policies and institutions. In the 1970s, the Israel Armament Development Authority (RAFAEL) sponsored graduate academic education for a few hundred of its employees in top U.S. engineering schools such as MIT, Stanford, and UC Berkeley. These graduates returned regularly as visiting scholars (b3).[76] Researchers of RAFAEL formed bonds with other researchers, entrepreneurs, big and small companies, and investors in Silicon Valley (h3) and created a multidimensional web of weak ties that rapidly expanded and led to the creation of durable bonds (i3). The network supports the mobility of information and technology among individuals and organizations in both COI (b3, e3). Many technology companies from Silicon Valley (including Intel, Google, and Yahoo) set up R&D centers in Tel Aviv and Haifa in order to take advantage of the world-class scientists and engineers from Israel (b4, e4). "The Israeli high-tech scene is a well-spring of ideas, innovation, brains, and technology" (a2, f2),[77] and it attracts mobile capital from investors and multi-national companies (b3, b4) that either invested in Israeli companies, built subsidiaries in Israel, and/or sub-contracted work to high-level Israeli technology companies (d2, d3, j4).[78] Capital within Israel is mobile and, within the country, it is concentrated where high-tech activities provide the highest returns (b2).[79] Potential engineer/managers in Israel can now work in these multinational enterprises while in their home region, learn about world markets, and gain access to expert business and management practices from Silicon Valley and elsewhere (d3, l3, m4).[80]

Frequent collaborations and mobility of assets between Israel and Silicon Valley have contributed to the creation of a set of common business practices and entrepreneurial experiences (b4, l4).[81] The network of weak ties (f2, f4), durable bonds (i4), and covalent bonds has coalesced into the Israel/Silicon Valley Super-COI and both COI develop now in a coordinated manner (j4).[82] Connected individuals, universities, research centers, start-ups, and big companies have mutual respect and know how to work together for mutual benefit. They collaborate, share business know-how, knowledge creation processes, network structure, seek similar benefits, and have aligned incentives (c4, l4, m4, n4).[83] The institutional setting for start-ups and venture capital financing in Israel is also a strong imitation of and complementary to the American model (l4).[84] "The Israeli state has established relationships in which domestic firms focus on product R&D and their American partners focus on sales and marketing" (j4, k4).[85] "Although many Israeli firms moved their customer support, sales, and marketing function to the U.S.…core R&D functions remained in Israel" (d4).[86]

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These remote activities and divisions are linked through covalent bonds and benefit from the inter-dependent relationship (j4).

Examples of the Emergence of Covalent Relationships

Example 1: Kevin Brown, Decru, Opus Capital, and Kidaro

One example of the evolution of covalent relationships is Decru, a Silicon Valley based-storage security company founded by an Israeli team. Kevin Brown, a U.S. citizen and Silicon Valley native, became the VP of Decru shortly after getting his MBA from UC Berkeley (j4). When Decru was acquired by NetApp in 2005, Decru's CEO, Dan Avide, moved to OPUS Capital (b2), and shortly thereafter invested in a young entrepreneurial Israeli venture named Kidaro (b4). The Israeli team at Kidaro was actually an intact unit from the elite Israeli Defense Forces intelligence corps, which is an example of the previously noted benefits of the intense training and team building of the military service. Avide hired Brown as CEO. Brown added a team of 10 American business developers (d2). The covalent bonds connected capital and expert business management from Silicon Valley with a group of 25 superb scientists and engineers in Israel (j4). Kidaro then moved quickly to accomplish key milestones operating the international team in as a cohesive unit. According to Brown, "Kidaro completed the product to run on both VMware and Microsoft virtualization; created heavy partner engagement with Dell, Citrix, and Microsoft; closed deals with Dell, Fox, and Intel,....[thus creating a] great value proposition for Microsoft. In May 2008, Kidaro was sold to Microsoft and became a cornerstone of Microsoft's Windows virtualization strategy" (b4).

This strategy of Microsoft, using an open innovation approach to outsource elements for product development, is typical of the beneficial relationships between mature corporations and start-up ventures in COI (c2, l2, m2).

Example 2: John Woolard, Luz II, BrightSource Energy, and Vantage Point

Another example of an Israel/Silicon Valley covalent relationship is Brightsource Energy and its CEO John Woolard (j4). Woolard, a UC Berkeley MBA and an experienced and successful energy sector entrepreneur joined Brightsource in 2006 as CEO with the backing of VantagePoint Venture Partners, where he had been prospecting green energy investment opportunities as an Entrepreneur-in-Residence (EIR). The EIR role is an excellent example of how Silicon Valley reprocesses successful people in ways that diffuse management expertise, encourages excellence in entrepreneurial practice and builds strong linkages between firms, matching resources with opportunity (b2, c2, e2, f2, l2, m2). The EIR role is designed to be temporary. It provides venture capital firms a means to gain from the insights of experienced and trusted operating executives, exposing them to the culture and priorities of the venture firm and matching them with opportunities they can invest in.

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While working with VantagePoint as an EIR, Woolard formulated the strategy of aggregating existing proven solar thermal generating capacity as a fast way to establish a platform for utility grade generating capacity. He identified Luz II as a unique opportunity to build on the competency of a proven technical team and solution.

With Woolard's guidance, VantagePoint invested in Luz II and Woolard joined the Israeli engineering and knowledge talent as CEO (b2, b4, d2, d4). The new leadership team then changed the company name to BrightSource Energy, Luz II had been operating from Israel and had in the 1980s constructed the world's nine largest solar plants, all based in California (d2). A policy change in California energy law put the company out of business in the 1990s. In 2003, the team in Israel got back together, reformed their engineering team, developed a new design to maximize the efficiency of existing solar power plants, and started to look for the smartest way to build and grow the company.

The company has now implemented a transnational management structure; product and project engineering is done in Israel while marketing, commercialization, business development, project development and general business management is located in Silicon Valley (d4, k4, j4). Woolard continues as a Venture Partner at VantagePoint and a member of their Advisory Council. This covalent bond, where a single individual simultaneously plays contributing roles in two or more ventures, forms a more permanent and strong bond that is not based on single transactions or contractual obligations. Rather it is a wide bandwidth, strategically effective connection that enhances resource mobility to reduce the costs of innovation, sourcing, manufacturing, customer acquisition, and support (b4, j4). BrightSource is now experiencing great success and explosive growth. It recently was awarded the largest utility solar generation contract in history and is initiating construction of major new plants in California and internationally.

Example 3: Arthur Berliner, Walden Group, and Walden Israel

In the venture capital community, the first weak ties between the Silicon Valley and Israel were established in the 1970s when Dan Tolkowsky, a retired Israel military officer, joined Discount Investment and flew to Silicon Valley "to interest the still young U.S. venture capital industry to invest in Israel" (d2, h3).[87] His nascent efforts were notably successful in attracting some initial Silicon Valley investments in Israeli companies (d4).

The venture capital firm Walden Group was founded in 1974 by Arthur Berliner and George Sarlo and successfully invested in several Israeli opportunities (b2, d2). Headquartered in San Francisco, in the early 1990s Walden Group created a dedicated American-Israeli fund and invested in Terayon (b4). Located in Israel, Terayon used the capital for developing a high-speed cable modem technology and went public a few years after (b2). Walden Group also invested in Radcom, an Israel-based start-up specializing in testing solutions (b4). Radcom developed the technology in Israel and moved to the U.S. before going public in the late 1990s (j4, k4, b4), when Walden Group opened an office in Israel

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to support the linkages and ease the creation of new covalent bonds (b4). In the mid-1990s, Walden Israel became an independent entity. By that time, investors in Israel had learned the business practices that have made Silicon Valley an attractive environment for investors and had adapted them to their context (l4, m4, n4). Walden Israel is now independently managed by Israelis who learned business practices from their American partners. The covalent bonds have transformed into a dense international network of venture capitalists, entrepreneurs, and managers connected through personal and trust-based weak ties, and, eventually, also through durable bonds, all of which provide entrepreneurs with a diversified and global resource (h3, i3, l4, n4).

These three examples demonstrate the workings of the Framework. How mobility of people, resources, and technology; shared values and aligned incentives; and frequent collaborations among big and small companies within and among COI accelerate the development of ventures and the industrial communities within which they reside. Further, the examples show the benefits of establishing relationships—whether weak ties, durable bonds, or covalent bonds—and how they can evolve from an informal relationship to a more durable or even co-dependent collaboration. Although entrepreneurship is a fluid and constantly changing area of focus, models like those present in the Framework can help start-ups and their investors to best use and develop the resources available to them.

Both public and private initiatives have also contributed to the creation of the Israel/Silicon Valley Super-COI. Initially, the Israeli Government focused science and technology industrial policy primarily on developing capabilities to create new R&D-based products.[88] Subsequently, the government concluded several agreements that have been decisive in creating the Israel/Silicon Valley Super-COI. The Bi-national Industrial Research and Development Foundation (BIRD), for example, was created in 1976 in order to encourage cooperation between firms from the U.S. and Israel (c2, d2, c3). BIRD played an essential role in creating the first linkages between companies and employees in both locations as it provided a low-risk friendly framework to American companies to start R&D operations in Israel (c3, d3, l3).[89] Those linkages subsequently formed covalent bonds between companies and individuals in both territories (j4).

An example of private initiative is the California Israel Chamber of Commerce (CICC), a not-for-profit membership-supported organization that aims to strengthen business and trade relationships between California and Israel. This organization was created by American and Israel executives as a response to a perceived lack of sufficient structure for connecting both communities. The connections are promoted through networking events, mentorship programs, investments forums, and education seminars, which, in many cases, require companies, investors, and other professionals to take a tour in their partners' country. Today, the CICC consists of over 7,000 companies, business executives, and investors. According to Shuly Galili, Executive Director at CICC, Kidaro is one example of a business that arose from this network.

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Conclusions and Discussion

Clusters of Innovation have to date been understood fundamentally as geographic phenomena, and accordingly their analysis has mostly been internally focused. However, Clusters of Innovation, perhaps more than other industrial clusters, do not exist in isolation. Global interconnectedness is an increasingly essential attribute. This global interconnectedness is not surprising, but failure to understand the subtle, sometimes non-transactional, mechanisms of operation in and among COI have lead to them being overlooked by policy-makers, regional economic development professionals, and managers. Too often the allocation of development resources has placed a priority on replicating models such as Silicon Valley, without truly understanding what makes their innovative foundation of nascent and emerging firms so productive. Our purpose is to emphasize, analyze, identify, categorize, and illustrate these factors, especially the global interconnections. We use a case study approach. We purposely chose well-studied clusters to make clear what is novel in our approach. Our analysis focuses on Israel as an example of a Cluster of Innovation (COI) and as part of a global Super Cluster of Innovation (Super-COI). The analysis illustrates the application of the Global Clusters of Innovation Framework. The framework contributes a detailed and standardized definition of COI, the durable and covalent bonds created among them, the resultant Global Networks of Clusters of Innovation (NCOI), and the integrated multi-location clusters or Super-COI. We explain the importance of developing this framework. First, we noted that though many studies had analyzed the emergence of specific COI (such as Taiwan, China, and Singapore) these analyses lacked comparability due to the absence of a standardized schema and thus were limited in their usefulness and insight. Additionally, the global relationships among COI and their components have not been sufficiently explored. Using the illustrative case of Israel and the Israel/Silicon Valley Super-COI, we have shown how the Framework can assist practitioners catalogue the elements of COI and identify priorities for development with a vision that embraces the importance of global linkages and participating in NCOI. Secondly, for policymakers the Framework is a guide for developing and implementing effective innovation policies. We analyzed selected existing public policies and demonstrate that when public intervention ignores factors identified by the Framework, the resulting benefits may only be relative and a sustainable innovation process not achieved. Third, the Global Clusters of Innovation Framework can be a tool for managers of start-up entrepreneurial firms and mature corporations. At emerging entrepreneurial firms, with limited resources, entrepreneurs can leverage their capabilities and enhance their access to global resources and markets by becoming a valuable step in the NCOI value-chain. For managers at mature corporations, the Framework suggests policies, business practices, organizational structures, resources, and compensation methods to facilitate win-win constructive engagement with entrepreneurial firms and the culture of entrepreneurial innovation found in COI, NCOI, and Super-COI.

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Overall, the Global Clusters of Innovation Framework is an integrated and unified tool that helps to identify the components and processes operating in and among COI, emphasizing the elements that enable effective global innovation collaboration. It suggests business practices, informs government policy, and provides guidance for developing future research. Specifically, we have illustrated the usefulness and adaptability of the Framework by applying it to the case of Israel. We have anchored the analysis on the existing literature and complete it with anecdotal evidence collected by interviewing founders and managers of start-ups and venture capital firms with operations in Silicon Valley and Israel. The interviewees exemplify the action of the Framework's covalent bonds, integrating the productive capacities of these two distinct COI. They illustrate the four main characteristics of a COI: intensive entrepreneurial process; heightened mobility of resources; strategies that reflect a "born global" perspective; and a culture of goal alignment achieved through economic mechanisms that align economic interests. We have also illustrated examples of weak ties, durable bonds, and additional covalent bonds established between individuals and companies in Israel and in Silicon Valley. The results suggest that the ease with which COI get connected to other COI and form NCOI and Super-COI accelerates as the four elements of the COI become internally consolidated.

Certainly, Israel/Silicon Valley is not the only Super-COI. It is used here as an illustrative example. Previous literature has identified different emerging and rapidly growing innovation nodes (i.e., Taiwan was analyzed by Saxenian (2006) and Matthews (1997) and Singapore was analyzed by Matthews (1999)). Most likely, some or all of these COI have also global connections with other COI that accelerate innovation processes and help them flourish. The framework contributes with a characterization of these global linkages.

The Global Clusters of Innovation Framework can help expand the vision of regional economic development professionals and corporate managers to embrace strategies that provide benefits beyond those derived from proximity groupings and achieve efficiencies and innovation on a global scale. Our observations of the global interconnected opportunities of the innovation process, as expressed in the Framework, suggest an optimism that significant benefits can derived from the integration of a local cluster into the value chain of a global Network of Clusters of Innovation, and that this objective can provide a high return on investment for communities seeking to foster economic growth and innovation.

Notes

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25. There is much at stake here. Where public intervention has not been appropriately defined, results have been limited to relatively weak and local accomplishments. The German BioRegio Contest (BRC), for example, aimed to promote cooperative R&D projects among companies of biotechnology located in the same region. In spite of the positive reviews received by this initiative [e.g., D. Dohse, "Technology Policy and the Regions: The Case of the BioRegio Contest," *Research Policy,* 29 (2000): 1111-1133; P. Cooke, *Knowledge Economies: Clusters, Learning, and Cooperative Advantage* (London: Routledge, 2002)], the BRC has been also widely criticized for consuming extraordinary amount of administrative and support resources [A. Eickelpasch and M. Fritsch, "Contests for Cooperation—A New Approach in German Innovation Policy," *Research Policy*, 34/8 (October 2005): 1269–1282] and for not having solved fundamental information problems [Dohse (2000), op. cit.]. We believe this program failed to meet expectations of creating a globally connected COI because it did not sufficiently focus on promoting mobility of knowledge, capital, and people, and it did not create mechanisms for encouraging entrepreneurial business practices or aligning incentives and goals of individual participants. In addition, it neither encouraged nor contemplated the possibility of creating global collaborations. As in this case, when attempting transformative innovation processes, if the factors characterizing a COI are not promoted, opportunities for rapid innovation processes driven by entrepreneurship are overlooked, expenditures and efforts are likely to be wasted, partial policies may lead to little innovation and entrepreneurial development, and a global and sustainable competitive advantage is unlikely to be created.
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27. For example, a process that supports such developments is the Technology Entrepreneurship Challenge promoted by Intel and UC Berkeley. Begun as an independent series of competitions to support local start-up communities in dispersed locations around the world, this initiative has transformed into a more global program which aims not only to create active COI around geographically distant universities, but also to support the creation of a global network of collaborative communities and businesses based on shared practices, values, and understanding.
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32. As in Porterian clusters, the boundaries of a COI are related to the distance to which informational, transactional, incentive, and other efficiencies occur [Porter (2000), op. cit.].

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Geographic boundaries of clusters are therefore defined by inter-company relationships rather than by political boundaries [S.A. Rosenfeld, "Backing into Clusters: Retrofitting Public Policies," *Integration Pressures: Lessons from Around the World Conference Proceedings*, John F. Kennedy School Symposium, Harvard University, 2001]. A COI can be big or small and can include one of more towns, cities, regions, and countries or a combination of them.

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