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## Evolution of demand and dynamics of knowledge-base in knowledge intensive sectors

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## Deliverable N° 5.2

**REPORT ON SCIENTIFIC REPORT TO POLICY**

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# 1 Policy implications

## 1.1 Introduction and objectives

In the Report concerning Deliverable 5.1, we described the main findings of empirical research on: (1) the dynamics of knowledge bases of biotechnology, telecommunications and pharmaceuticals; (2) the evolution of industry mix and relatedness among industries in Spanish regions, Swedish regions and the EU-27 countries. In this report, we will outline and discuss a number of policy implications.

In addition, a case study has been employed on the RAD group eco-system in Israel which has, intentionally, through the vision of the founder of RAD Bynet, given rise to 129 startups employing some 15,000 workers. This study highlights the need to include relatedness as a key policy input for successful diversification and to integrate private entrepreneurship and public policy to build up a successful high-tech cluster. Through a survey of the existing firms, the nature of this ecosystem has been explored. The main findings were: a) social and technological proximity encourages the tendency of the companies to maintain business relationships that contributed to knowledge exchange, while technological diversity drives innovation and startup formation; and b) firms will choose to cooperate on the basis of a shared past and personal proximity relations, as well as technological proximity at a certain level. A contributor to the RAD cloud was the existence of a strong venture capital industry which was fostered by a unique government policy. Massive immigration of human capital, especially from the former Soviet Union, enabled further expansion. Furthermore, the presence of world-class technological universities played a key role, as many of the RAD cloud founders graduated from these universities. And it is doubtful that the RAD cloud could have developed without the ambience of Greater Tel Aviv and its attractive environment for creative people.

## 1.2 Structure of the report

Section 2 wil present the policy implications of the main findings of 6 papers reported under Deliverable 5.1. Section 3 will present the Israeli study on private entrepreneurship and public policy which has been delivered by A. Frenkel, S. Maital and E. Israel (2013) entitled Jacobs externalities in the presence of viral entrepreneurship: The case of RAD.

# 2 Evolution of knowledge bases and industrial structures: policy implications

## 2.1 Introduction

In the Report concerning Deliverable 5.1, we described the main findings of empirical research on: (1) the dynamics of knowledge bases of biotechnology, telecommunications and pharmaceuticals; (2) the evolution of industry mix and relatedness among industries in Spanish regions, Swedish regions and the EU-27 countries. In this report, we will outline and discuss a number of policy implications.

## 2.2 Evolution of knowledge bases: policy implications

The report on Deliverable 5.1 concerning the dynamics of knowledge bases presented the main outcomes of the three following papers:

Krafft, J., F. Quatraro and P.P. Saviotti (2014) The dynamics of knowledge-intensive sectors' knowledge base: Evidence from Biotechnology, Telecommunication and Electronics, working paper.

Krafft, J., F. Quatraro and P.P. Saviotti (2013) Knowledge characteristics and the dynamics of technological alliances in Pharmaceuticals: Empirical evidence from Europe, US and Japan, working paper.

Quatraro, F. (2013) Co-evolutionary patterns in regional knowledge bases and economic structure: evidence from European regions, working paper.

### 2.2.1 Main findings of studies

The paper by Krafft, Quatraro and Saviotti (2014) dealt with knowledge heterogeneity at the sectoral level. The paper draws on work on recombinant knowledge, extending the approach to include: (1) the way that the dynamics of technological knowledge creation evolves according to a life cycle; (2) the characteristics of the search process in the phases of exploration and exploitation during this technology life cycle; and (3) the differences in sectoral evolution that can be explained by the properties of the knowledge base. European Patent Office data (1981-2005) have been used to propose some operational metrics for the knowledge base and its evolution in three knowledge-based sectors: biotechnology, telecommunications and electronics. The results showed that there are interesting and meaningful differences across sectors, which are linked to the different phases of the technology life cycles.

The paper by Krafft et al (2013) investigated the co-evolutionary patterns of the dynamics of technological alliances and the structure of the knowledge base in the pharmaceutical sector. The main hypothesis was that technological alliances represent a key resource for firms in knowledge intensive sectors to cope with dramatic changes in the knowledge base, marked by the introduction of discontinuities opening up new technological trajectories. Using patent information and data on technological alliances drawn from the CATI-MERIT database, they compared the evidence concerning the so-called triad regions, i.e. United States, Europe and Japan. The results confirmed the existence of a life cycle in biotechnology affecting the pharmaceutical industry. Furthermore, the dynamics of alliances was found to depend on (i) the phase of the biotechnology life cycle, (ii) the strength of the region in biotechnology, and (iii) the features of the economic environment of the region.

The paper by Quatraro (2013) presented an analysis of the co-evolutionary patterns of structural change in knowledge and economics. The former was made operational through an analysis of co-occurrences of technological classes in patent documents in order to derive indicators of coherence, variety and cognitive distance. The latter, on the other hand, was made operational in a synthetic way by implementing shift share analysis which decomposes labour productivity growth into effects caused by changes in the allocation of employment, those ascribed to intra-sector productivity growth and those caused by interaction of these two components. The results of the analysis conducted on a sample of 227 European regions showed that increasing variety is associated with the reallocation of workforce across sectors whereas within sector productivity is associated with high levels of both coherence and cognitive distance of the regional knowledge base.

### 2.2.2 Dynamics of knowledge bases and policy

The analyses carried out in these three papers bring about important policy implications concerning the role of government expenditure as an instrument to stimulate innovation-driven local development.

Actually, local development policies are too often focused on the design of measures targeted to restoring regional competitiveness by providing funding to incumbent activities. Although measures targeted to restore productivity in incumbent sectors are less complicated, these are more likely to yield only temporary outcomes. On the contrary, the results of our analyses suggest that policymakers should promote the entry of new activities grounded on new and profitable technological trajectories. Measures aiming at reshaping the structure of economic and technological activities at the local level are likely to yield enduring effects since they are based on structural interventions.

However, new activities cannot emerge out of the blue. In a context in which innovation becomes more and more central to the transition to low-carbon economies, our analysis suggests that the incentives to the local creation of new technology based activities such as nanotechnologies or ‘green technologies’, should be grounded on the accurate analysis of both the comparative advantages developed over time in a specific area and of the relative position of such technologies in the technological landscape. Stimulating local agents to jump to new activities far away from their cumulated competencies can be inefficient and unsuccessful.

These arguments, concerning both the rates of introduction of technological innovations and their rates of adoption, enable to elaborate a new approach to the demand pull hypothesis. The demand pull hypothesis can be effectively rejuvenated by the combination of the classical demand pull hypothesis à la Kaldor and Schmookler with the new advances of the economics of knowledge. The demand pull hypothesis has a new scope of application in this direction. It does not apply any longer to any undifferentiated increase of demand, as in the Kaldorian tradition. Nor is it limited to the demand for capital goods, as in the tradition that elaborates upon Schmookler's analysis. In our approach, the tradition Keynesian argument supporting the role of government expenditure as a contribution to the aggregate demand is further qualified so as to take into account the idiosyncratic features of the local environment in which agents benefiting from governmental demand are localized.

The most likely response in the short run to increases in the governmental demand targeted to specific technological activities in a specific place is indeed the entry of new firms in the market so as to take advantage of new profit opportunities, these new firms being brand new companies, or spin-offs from incumbent companies. The entrepreneurial process confirms to be in this respect a clear channel for the technological diversification of local economic systems.

Strategic demand pull emerges in this context as an ingredient to the strategic management of places, the goal of which should be the promotion of knowledge-based entrepreneurship as a vehicle for the employment growth and global competitiveness at the local level. Demand-driven innovation policies should therefore be particularly cautious in the identification of the key sectors to be promoted, above all when implemented at the European level, as this latter task cannot be performed without a careful screening of the patterns of local technological specialization in the different areas upon which the policy instrument impinges. These policy measures should be rather customized, so as to ensure effective implementation and the reduction of duplication of efforts and waste of resources.

## 2.3 Related diversification, agents and institutions: policy implications

The report on Deliverable 5.1 concerning the evolution of industry mix and relatedness among industries presented the main outcomes of the three following papers:

Boschma, R., Minondo, A., Navarro, M. (2013) The emergence of new industries at the regional level in Spain. A proximity approach based on product-relatedness, Economic Geography, 89 (1), 29-51

Neffke, F., M. Hartog, R. Boschma and M.Henning (2013), Agents of structural change. The role of firms and entrepreneurs in regional diversification, working paper, Utrecht University, Utrecht.

Boschma, R., G. Capone and R. Cappelli (2013) Relatedness, diversification and institutions in the EU-27, working paper, Utrecht University, Utrecht.

### 2.3.1 Main findings of studies

The insights we obtained from these three studies were manifold. The findings can be summarized as follows:

(1) countries and regions diversify into new industries that make use of capabilities in which regions are specialized;

(2) capabilities available at the regional level play a larger role than capabilities available at the country level for the development of new industries;

(3) the growth, decline and industrial reorientation of existing establishments tend to reinforce a region's existing capability base, while new establishments truly change it and hence induce structural change;

(4) entrepreneur-owned establishments induce most structural change in the short run, but in the long run, new establishments of existing firms increasingly acquire this role;

(5) founders from outside the region and, especially, expanding firms from outside the region induce more structural change than their local counterparts;

(6) national institutions matter for the nature of regional diversification, as countries with stronger general-purpose capabilities find it easier to jump to any new product, while countries characterized by weaker general-purpose capabilities rely more strongly on relatedness with their existing products when diversifying into new industries

(7) economic institutions are the least relevant for diversification, with the exception of having open trade networks which favours unrelated diversification

(8) political institutions play a very important role: democracy, especially if established since long, favors the diversification in distant products. Within the restricted set of developed countries, coordination in labor relations strengthens path-dependence, while coordination in the corporate governance domain is less important.

(9) educational institutions reduce the importance of the current productive structure only for products that have been already established in the past.

(10) long-term orientation of societies affects in a relevant and consistent way the process of diversification.

We will outline and discuss the policy implications for each of these conclusions. We will do so briefly, as the objective of this Work Package 5 was not to analyze the effect of public policy more in general or any direct policy interventions in particular, but to draw some general policy implications from the empirical studies.

### 2.3.2 Related diversification and policy

First, we discuss the policy implications from the first set of conclusions:

(1) countries and regions diversify into new industries that make use of capabilities in which regions are specialized;

(2) capabilities available at the regional level play a larger role than capabilities available at the country level for the development of new industries;

In all studies reported in Deliverable 5.1, there was a very strong message that countries and regions need to develop new economic activities to compensate for inevitable processes of stagnation and decline in their economies. In that respect, it is recommendable that local policy makers shift their focus from the industries that *are* present in the region to those that *could* be present.

Another clear message in all these studies is that new industries and new technologies do not start to develop from scratch. In fact, it turned out to be absolutely essential for the sake of economic renewal to connect industries that *are* present in the regions to those that *could* be present. In that sense, diversification can be understood as an emerging process through which new activities develop out of existing ones, and the scope and outcome of this process are fundamentally affected by technological and cognitive constraints at the national and regional scale. Any policy effort to promote and support new developments should take that as a basic point of departure.

Our studies learned that the ability of regions to develop new growth paths is not equally divided across all regions. Some countries and regions truned out to have more potential to recombine local resources and diversify into new directions, because of their accessibility, urban density, size, industrial specialisation, related variety, and institutional and governance structures. In this respect, it is a prerequisite that public policy avoids 'picking winners' that do not fit at all into the regional actual and potential industrial space, and it should at all costs refrain from supporting declining industries that occupy a peripheral position in the industry space of a region.

More fundamentally, emphasis on regional capability bases rightly shifts attention away from descriptions of regions in terms of their industry mix, toward an understanding of the region's strength and weaknesses at the deeper level of capabilities. This means that policy should be more keen to define their diversification opportunities in terms of their local capabilities rather than in terms of some desired or preferred industrial mix, as the underlying capabilities structure in regions provides a pool of opportunities but also sets limits to new developments that do not draw on this capability structure.

As the productive structure keeps exerting its influence many years later, and the position of countries and regions in the industry space is quite stable in the long run, policy interventions should be aware that policy effects display only over a long time period.

Policy focused on the creation of new growth paths in regions will always remain risky, as it is impossible to predict the most successful new recombinations in the near future. Having said that, and to cope realistically with this fundamental uncertainty, our studies have demonstrated that inter-industry relatedness provides a powerful framework to allows policy makers to identify regional potentials and to target and select activities as potential sources for diversification.

The relatedness concept provides a tool to identify regional (unused) potentials and a framework to target and select promising activities. Measuring the degree of technological relatedness between industries helps to identify opportunities for regions to diversify into new related activities. This requires substantial data collection to identify the degree of relatedness between industries in a region on the one hand, and with industries located outside the region that might be beneficial to connect with on the other hand. This implies that any smart policy design can only work when thoroughly informed by empirical studies that outline where policy actions might be most effective. Our studies have experimented with numerous sophisticated ways to measure technological relatedness between industries, like inter-industry relatedness based on SIC-codes, co-occurrence analysis of products (either within plants, within firms, or within countries), input-output linkages, and labour flows between industries. These empirical studies bear witness that defining such a local opportunity space for policy intervention can actually be very helpful for policy makers.

It is recommendable from a policy perspective not to aim for more specialisation, as our studies show that this is likely to increase the problem of overspecialisation and regional lock-in. It is also not recommendable to aim for diversification *per se*, as our studies show that this runs the risk of developing new economic activities like cathedrals in the desert that are not embedded in the region. Instead, it is recommendable to aim for specialised diversification into related technologies which generates new economic activities that are rooted in and can draw on local related resources.Such a policy has the objective to broaden and renew the industrial structure of regions by making them branch into new related activities. This is achieved by encouraging and enabling crossovers and recombinations between related industries that can provide complementary assets.

As said before, smart policy should be empirically informed. This not only applies to the identification of potential sources of diversification based on an assessment of the degree of relatedness between industries. It also requires collection of data to assess whether these related industries are actually connected or not. It might be the case that bottlenecks prevent related industries to connect and exchange knowledge, or that they are even not aware of potential complementarities. If so, it is absolutely a prerequisite to identify the bottlenecks that prevent related industries to connect and interact. After having done so, policy should be designed in such a way that it targets and aims to remove those bottlenecks that prevent knowledge to flow from one related activity to another. Making connections between related activities both within regions and across regions makes that regional potentials will be more fully exploited. Our studies have demonstated that this actually might work very well, as this brings in new knowledge and resources that are related to existing activities in the region which might lead to new recombinations and new industries that branch out of that.

Our studies show that it would not be wise to follow 'picking-the-winner-policies'. The objective of such policy is not about targeting activities that have been identified as promising for future growth more in general, and it is also not about making strong local sectors stronger either. On the other hand, policy prioritisation is still required, in the sense that related industries are targeted in regions where they have a strong presence and where potentials of new recombinations are high. Therefore, it might be wise to avoid targeting new industries that occupy a peripheral position in the industry space of the region, as these new industries will most likely fail to develop, and will disappear soon after its entrance, as they cannot draw on local capabilities from related industries in the region, like relevant local knowledge bases and particular institutions. Instead, our studies have learned that it might be wiser for policy to go for new industries that can more easily connect to and be embedded in the industrial structure of a region, because this increases its probability of survival and, thus, the probability of policy success.

A key policy implication that can be derived from our studies is that backing declining industries is not necessarily a bad thing to do, but this depends on the degree of relatedness of this declining industry with existing industries. As said before, to support declining industries that take a peripheral position in the industrial portfolio of a region is not a smart policy from a relatedness perspective, because these industries have already a high probability to exit the region. This is fundamentally different from local industries that have strong technological ties with other industries in the region. When such a related industry would be confronted with a (temporary) demand fall, its demise and loss could seriously damage the dynamics of other local industries to which it is technologically related, and thus policy might seriously consider to step in and avoid such a cascade effect which might erode the whole underlying capability base.

Policy should therefore avoid at all costs to follow a 'one-size-fits-all' policy. Instead, the related diversification approach outlined in our empirical studies favours tailor-made policy strategies that capitalise on region-specific assets that are linked to technologically related industries. This implies that the industrial history of regions provides opportunities but also sets limits to what can be achieved by policy.

Our studies learn that connections between related industries might boost regional diversification, and should therefore be encouraged. Policy could play an active role to enable and activate knowledge transfer mechanisms through which related industries can connect at the regional scale. This might be realized through entrepreneurship policy that focus explicitly on experienced entrepreneurs that come from related industries. This might also be achieved through labour market policy that focuses on mobility across industries, with an emphasis on mobility between related industries, because this leads to the formation of knowledge networks and the transfer of skills between industries that provide complementary resources. And policy could also focus on establishing collaborative research networks, with a focus on research collaborations between related partners within the same region or located in different regions. This latter underlines the importance of establishing linkages with partners outside the region, to get access to external knowledge, in particular related knowledge.

This key finding of the study on Spain suggests that some capabilities should be developed locally to raise the probability of developing new industries at the regional level. In that context, it would be wise to target policy intervention at the regional level, because it is at this level where the main assets to diversify successfully are present. This would bring us a step forward in the design of policy programs that are focused on regional diversification, despite all the unpredictability that is part and parcel of the development of new growth paths in regions.

This is not to say that all policy should be conducted exclusively at the regional level, as many relevant policy areas are actually designed and implemented at the national scale (like labour market policy, education policy) and the international scale (like research policy), but the effects of policy will certainly have different impacts in different regions.

### 2.3.3 Agents and diversification: policy implications

From the empirical studies, we obtained a second set of conclusions which concern more the agents that induce diversification and structural change in regions.

(3) the growth, decline and industrial reorientation of existing establishments tend to reinforce a region's existing capability base, while new establishments truly change it and hence induce structural change;

(4) entrepreneur-owned establishments induce most structural change in the short run, but in the long run, new establishments of existing firms increasingly acquire this role;

(5) founders from outside the region and, especially, expanding firms from outside the region induce more structural change than their local counterparts;

When thinking about effective policy making that focuses on regional diversification, one can think of which agents to target in particular. Earlier, we outlined the potential of experienced entrepreneurs that do not start from scratch but that come from related industries from which they can draw relevant knowledge. The Swedish study identified other agents that may also be important drivers of change in regional economies.

Our study on Sweden also revealed which agents contribute more to related diversification (i.e. new economic activities that largely build on the existing capability structure), and which agens are responsible for more structural change, which means more unrelated diversification in which the capability base is alo widened and renewed. Although related diversification is a more likely event to occur, and also more likely to be successful, it might be argued that regions need to make a jump in the evolution of their industrial structure on a regular basis, and to shift into more unrelated activities, to secure long-term regional development. New economic activities not only introduce new industries to a region but extend and renew in some cases the underlying capability base of a region. This latter means that real structural change occurs, and the paper on Sweden has demonstrated that new establishments are better in inducing structural change than existing establishments. If more unrelated diversification is needed to secure long-term economic development in regions, new establishments and non-local firms might be more attractive targets for policy makers than existing establishments.

### 2.3.4 Institutions and diversification: policy implications

The third set of conclusions concerns more the role of institutions in the diversification process, and how that affects the nature of diversification (related versus unrelated diversification) in countries (and possibly regions).

(6) national institutions matter for the nature of regional diversification, as countries with stronger general-purpose capabilities find it easier to jump to any new product, while countries characterized by weaker general-purpose capabilities rely more strongly on relatedness with their existing products when diversifying into new industries

(7) economic institutions are the least relevant for diversification, with the exception of having open trade networks which favours unrelated diversification

(8) political institutions play a very important role: democracy, especially if established since long, favors the diversification in distant products. Within the restricted set of developed countries, coordination in labor relations strengthens path-dependence, while coordination in the corporate governance domain is less important.

(9) educational institutions reduce the importance of the current productive structure only for products that have been already established in the past.

(10) long-term orientation of societies affects in a relevant and consistent way the process of diversification.

These findings on the effect of institutions on the nature of diversification are highly interesting and of high societal relevance. Together with the policy interventions focused on nearby industries set out earlier, policy makers might also consider taking actions aimed at improving the quality of the supporting institutions. Creating an environment where firms can emerge and grow more easily or returns from innovation can be better appropriated, might provide stronger incentives and opportunities for diversification even in very far products and therefore boost the future growth of countries.

Policy aimed at improving and speeding up the diversification process should consider that in countries with low institutional quality, this could be obtained mostly by favoring the development of nearby sectors. Directly favoring the creation of very distant industries might result in severe failures, since the lack of necessary supporting infrastructure and institutions may doom these initiatives before positive diffusion effects occur. Such policies might actually have a positive effect only in presence of a good education system that enables countries to keep producing also in sectors less related to its current productive structure.

Institutions have an important impact on the diversification process in general, but our study also revealed that some types of institutions matter more than others, in particular for unrelated diversification, and that policy should account for that. In particular, a major role is played by political, educational and technological dimensions of instituitions, and not so much by the immediate characteristics of the economic environment. This result is consistent with the idea that institutions less directly related to the economic system can have an important indirect effect on the economic performance of countries, as the speed and the direction of industrial diversification would represent an important mechanism through which their action actually takes place.

Quite surprisingly, economic institutions, that are recognized as fundamental elements to start and foster the growth process, are the least relevant dimension for the diversification process. Trade openness is the only element that plays a role, and it confirms that the entry in new areas of the product space that are far from the current productive structure of a country may be easier if the country is well embedded in the network of international trade. From here, it follows that policy can consider using the formation of international trade networks as a tool to diversify economies in more unrelated direction.

One of the main outcomes was that within the restricted set of developed countries, coordination in labor relations strengthen path-dependence. That is, so-called more coordinated economies, especially in the labor relations, tend to be more constrained in the diversification process jumping to more related sectors. This would imply that more flexible labour markets favour more unrelated diversification, and so, if countries strive for that, making labour markets more flexibe institutionally speaking would be very helpful in that respect. This is what the findings more or less suggest, and this is also in line with studies on the importance of related labour flows that have been part of this PICK-ME project, and which results have been reported under deliverable 6.1.

In a more international context, it seems to be of particular relevance to place more emphasis on the role of political institutions, as reforms of the political system aimed at increasing the degree of democracy could have an important impact on the development of new products, and thus economic renewal.

Educational institutions reduce the importance of the current productive structure only for products that have been already established in the past. In that respect, they reflect the education of the majority of the population rather than the frontier of the knowledge.

Finally, among the cultural dimensions of institutions we considered, only long-term orientation of societies seemed to affect in a relevant and consistent way the process of diversification. As stated earlier, this does not come as a surprise, as diversification (especially the unrelated diversification type) is a very lengthy and insecure process that requires strong and long-term commitment from many stakeholders. Traditions and cultures where it is common to set short-term goals will not work in this respect, and are likely to frustate any serious restructuring and diversification process. As policy is fully embedded in societies, societies with a more long-term orientation also enables policies that are more open and responsive to long-term diversification processes.

# 3 Private entrepreneurship and public policy

## 3.1 Introduction

Economic geographers have posited that “the more diversified a regional economy [i.e., Jacobs’s externalities], the more knowledge spillovers will occur because firms get new and better ideas through other local firms that are active in many different industries” (Boschma & Iammarino, 2009, p. 289; see also Frenken *et al*., 2007; Asheim *et al*. 2011).

The benefits derived from Jacobs’s externalities (which admittedly are rather ill-defined) are perceived to be growing, because increasingly, technological breakthroughs require combinations of technologies which often differ widely (for instance, innovations related to nanotechnology). The question then arises, what are the innovation policy implications that accrue from ‘industry mix’ and ‘regional relatedness and diversity’?

In the current paper, we discuss these implications through a unique Israeli case study – the case of RAD Bynet group. RAD is an Israeli startup founded in the 1981, specializing in network hardware and components. The uniqueness of this RAD and its founders stem from the fact that since its establishment large number of startup firms have emerged from the original core of RAD (Breznitz, 2009). The company fostered startups within its own group, and many ‘alumni/ae’ of RAD left to form their own startups, with technologies quite different at times from those of the “mother ship”. A vast ecosystem of some 100 firms exists and can be used as a case study for examining questions regarding external gains from diversity vs. external benefits of specialization. In this paper the Jacobs externalities effect will be examined empirically in the context of this RAD ecosystem and quantified.

Rapid innovation occurred in the RAD ecosystem, not because of government policy but possibly in spite of it -- the freedom to launch startups, and the culture that encouraged this action, made the RAD mother company into a powerful ‘university’ for successful entrepreneurship. This was the specific intention of the original RAD founder. There are other examples of such ecosystems that spawn entrepreneurship – for example, Finland’s Nokea and the startups that emerged from its ‘graduates’. As such the case of RAD can serve as a microeconomics laboratory to investigate policy implications of innovation driven by the ‘mother ship’ process.

Specifically, we seek to understand first the nature of such an ecosystem, or ‘cloud’ of startups, and to quantify the relationships that exist between the mother company and the enterprises that emerge from it. Several studies that focused on knowledge networks pointed to the importance that the exchange of technological knowledge has for firms’ innovation activities (Giuliani & Bell, 2005; Boschma & Ter Wal, 2007; Morrison, 2008; Sammarra & Biggiero, 2008; Broekel, & Boschma, 2012). Following the lead of these studies in the current paper, the interactions among the various companies that belong to the RAD ecosystem are studied and quantified. The paper examines the determinants that contribute to interaction and collaboration among the RAD companies, and with the mother ship RAD, that lead to knowledge exchange. The assumption is that an ecosystem like that of RAD benefited from different types of proximities – technological, social, personal, regional -- that raise the motivation to interact and cooperate with each other for mutual gain.

The role of proximities in the encouragement of knowledge sharing and innovation has been studied in recent years. The most investigated index of proximity is geographical proximity, based on the assumption that the exchange of tacit knowledge is greatly facilitated by face-to-face contacts and as such is sensitive to geographical distance (i.e. Audretsch & Feldman, 1996; Ponds *et al*., 1997; Torre, 2008). However, in the past few years researchers have claimed that geography proximity is only one of a number of proximity dimensions that might affect the ability and willingness of actors to cooperate and to interact (Boschma, 2005; Broekel & Binder, 2007; Boschma & Frenken, 2010). Boschma (2005) suggest three other proximity dimensions other than the geographical proximity that may have an impact on the likelihood of knowledge exchange between actors and their innovative performance. These are social, cognitive and organizational proximity that contribute much to knowledge exchange and innovation.

Recent studies (Boschma & Frenken, 2010; Balland, 2012; Broekel & Boschma, 2012) investigate the role that these proximity dimensions play in building technical knowledge network. These studies determine which proximity dimensions contribute to innovative performance among firms from different sectors. Nevertheless, the researchers point to the crucial need for further dynamic analyses that will examine knowledge network formation over time. In particular, they stress the need to understand how the dynamics of networks are affected by the various proximity dimensions and how these proximities change over time due to the evolution of networks.

We believe that an ecosystem like the one represented by the RAD cloud of enterprises creates basic conditions that encourage the existence of a variety of proximities. Therefore it can serve as laboratory for the examination of the effect of such proximity indices on the willingness to cooperate and to establish mutual business interaction among the actors.

The structure of the paper is as follows. Section 3.2 discusses the role of Jacobs' externalities, the industry mix, regional relatedness and diversity in the development of regional economic growth. This section also presents the various proximities dimensions and their potential contribution to knowledge exchange. Section 3.3 provides a short description of the RAD Bynet ecosystem, the data and the variables that we constructed. Section 3.4 presents the methods used in our analysis. Section 3.5 presents and discusses the results obtained from the analysis. In Section 3.6 we conclude and discuss policy implications.

## 3.2 The role of Jacobs' externalities for regional economic growth

### 3.2.1 Diversity versus specialization: Jacobs and/or Marshall

In general, technological innovation is driven by two key forces: Diversity and specialization. Both reflect externalities, or spill overs, i.e. benefits that flow from one firm to another. The concept of externalities – benefits or costs generated by one agent but enjoyed (or suffered) by another agent external to it – originates with Alfred Marshall (1890) and his star pupil at Cambridge, Arthur C. Pigou. Externalities play a key role in understanding innovative agglomerations in regional science. In *The Economics of Welfare* (Pigou, 1924) Pigou developed the notion of public goods – goods whose consumption by one agent does not diminish in any way the consumption of another agent. Public goods are an extreme example of externalities, and are in a sense a 'free lunch'. Such externalities can greatly facilitate innovation of all kinds.

Diversity is the creation of new products and services that spill over from existing firms, when innovation creates unique value in novel ways. Specialization is the creation of new products and services driven by a critical mass of expertise within a given technology, expertise that is strengthened within an agglomeration, or cluster of firms. Diversity as an innovation engine is stressed particularly in the work of Jane Jacobs (1961) and her work on the economics of cities. Specialization has its origins in the landmark textbook of Alfred Marshall (1890).

Clearly both types of externalities are present in any given city or geographical cluster of firms. Van der Panne (2004) and van der Panne and van Beers (2006) find that, in the regional Dutch context, "..regions endowed with specialized production structures accommodate more innovators than do diversified regions…innovators in diversified regions are less inclined to innovate in partnership and introduce less radical innovations. …However Jacobian diversification externalities prove relevant as well." (van der Panne and van Beers, 2006, p. 18).

Innovation indeed takes 'two to tango', as van der Panne and van Beers note in the subtitle of their paper. But which dancer takes the lead? In order to deepen our understanding of this key issue in regional economics and innovation, we undertook a study of a 'cloud' of Israeli technological startup companies whose architecture specifically was driven by, and created to exploit, Jacobs externalities, i.e. diversity. At the center of this remarkable cloud of 129 companies is a 'mother ship', RAD Bynet, founded in 1981, and described in the next section.

In a recent address to the MIT Enterprise Forum of Israel, MIT Professor Nicholas Negroponte asked a rhetorical difference: Where do new ideas come from? He provided a one-word answer: "Differences". Differences among people in ways of thinking, skills, background, and cognitive styles. It was this desire for diversity in thinking that drove Negroponte to establish the MIT Media Lab, a fountain of radical innovation driven by diversity. Cities and regions, like London, New York City and Silicon Valley, have a rainbow of diverse ethnic groups, skills, genders, age groups and professions. For any radical innovative idea, a group of people can be assembled who have the required skills and expertise to implement it.

Broekel & Boschma (2012) frame the research question as "both/and" rather than "either/or". They define a 'proximity paradox', i.e. "proximity may be a crucial driver for agents to connect and exchange knowledge, but too much proximity between agents on any of the dimensions might harm their innovative performance at the same time." (p. 409). In other words, there may be an optimal degree of proximity, sufficient to generate Marshallian specialization but not so narrow as to stifle innovation, which by definition requires some degree of diverse thinking. In other words, there can be too little "differences", in Negroponte's words, among innovators.

There have been several key studies of the role of diversity in innovation. Ejermo (2003) develops a measure of technological diversity and relatedness, based on patents, to measure the diversity or specialization of Swedish regions. He finds that "results strongly support that the likelihood of innovation is raised in regions with high technological diversity" (p. 1). With high intellectual integrity, however, Ejermo later challenges his own findings and notes that "the number of patent applications in Swedish regions is highly and positively dependent on regional technological specialization, quite the opposite of Jacobs' prediction." (2005, p. 167).

The literature on regional growth, policy and planning has numerous studies showing the importance of both specialization and diversity, i.e. Marshall and Jacobs externalities. Boschma & Iammarino (2009) indicate the existence of an optimal degree of 'cognitive proximity' (defined below), such that the links between the knowledge base of a region and the extra regional knowledge that spills in are neither too small (which makes them useless) nor too large (which makes them superfluous for innovation). Le Blanc (2004) examines the role of agglomeration externalities for information technology (IT) industries in the United States. He finds that the rise of IT clusters in the United States "is a particular case of Jacobs' dynamic diversity externalities" (p. 2); the regional co-location of distinct industries, such as telecoms, software, Internet, media) encourage employment growth. Boschma et al. (2012) study 50 Spanish regions, 1988-2007, and find that "territories diversify into industries that are related to the existing set of industries" (p. 31), a Marshallian externality and a "path-dependent process" in which old industries spawn new ones that are technologically adjacent to them.

### 3.2.2 Types of Proximities

As noted above, great importance attaches to the influence of various proximity measures on the tendency to engage in collaborative actions in the RAD ecosystem. In our study principally of Jacobs externalities, we will make extensive use of three types of proximity geographical, technological, and social. Before discussing the empirical findings concerning RAD ecosystem we present the essence of the proximity indices that appear in the relevant literature.

#### 3.2.2.1 Cognitive proximity

Cognitive proximity refers to the degree of overlap that exists in the information and knowledge base of two given agents. These agents are required to have various qualities, including the ability to absorb, assimilate, interpret, and exploit the information that other peer agents possess (Cohen & Levinthal, 1990). Interacting companies learn from each other; they generate knowledge and exchange it with each other (Argote et al., 2000; Nooteboom, 2000). Through interactive learning, agents reduce the cognitive distance between them on a voluntary basis. In this learning process, they exchange knowledge contents and supplement each other's knowledge (Cowan et al., 2006). Information links feeding inter-firm interaction increase the cognitive proximity. In this process, the ability to assimilate and mentally adapt the information coming from another company increases (Menzel, 2008; Denzau & North, 1994 ).

However, according to Nooteboom (2000), there are close relations between cognitive distance (which is desired so that innovation will appear) and cognitive proximity (which is desired so that a given agent will be able to interpret and absorb the information). If the bases of information and knowledge of two agents are quite similar, the probability of an innovative combination of pieces of information from the two databases may be low, as compared to a situation in which the difference between the bases is greater. In this way, the relationship between the cognitive distance and the appearance of innovation between two given agents is expected to assume an inverted U-shaped curve (Cohendet & Llerena, 1997). Namely, neither a state of excessive cognitive proximity nor one of excessive cognitive distance holds much chance that two agents who participate in technological-business activity will produce innovations. On the one hand, the optimum required of cognitive proximity is expressed by the need to maintain cognitive variance between two technological agents, in order to stimulate new ideas using a re-combination of technology products. On the other hand, it is defined by the need to ensure reasonable cognitive proximity in order to allow inter-firm and interpersonal communication for the transfer of knowledge. High cognitive proximity can indicate that two given companies are enjoying similar capabilities, and therefore, from their perspective, they are taking a high-level risk, which may weaken the comparative advantage of one versus the other. Therefore, it can be expected that great cognitive proximity may be potentially harmful to the company's performance (Nootebbom et al., 2007; Boschma et al. 2009; Boschma & Frenken, 2010 ).

Therefore, when discussing cognitive proximity, it seems that it is neither the quantity nor the quality that characterizes relationships of mutual knowledge transfer, which determines the success of companies, but rather the *type* of knowledge transferred, and how it *matches the existing knowledge bases* in the said firms. In this sense, cooperation is especially fertile when a network of partners communicates on the basis of bodies of knowledge that are not essentially similar. However, it appears that cognitive proximity is a very dynamic process, since knowledge bases change regularly and frequently (Dosi & Nelson, 1994). Knowledge bases are adapted and updated quite frequently, an update that results from interaction with others, often without a conscious basis that includes an explicit decision to change. For example, cognitive proximity can also deteriorate due to intra-firm R&D activities. Such activities increase the range of intra-firm information, so that they may increase the cognitive distance between a pair of companies/business partners (Cohen & Levinthal, 1990).

#### 3.2.2.2 Social proximity

Social proximity refers to the depth of the social relationship between agents, in terms of friendship, family kinship, and shared life experience (Boschma, 2005). The appropriate prism through which to view the concept of social proximity is the micro-level one. The perspective of social proximity should be studied as a dynamic process, which refers to human relations in which a process of knowledge assimilation takes place in a broad social context (Kossinets & Watts, 2006). An analysis of the dynamics of social proximity relates first to the establishment of interpersonal relationships between individuals belonging to different organizations (Granovetter, 1985). If two colleagues meet the mutual expectations they set for themselves during their work together, repetition of the relationship pattern connecting them is expected, up to the level of friendly relations and trust (Uzzi 1996; Gulati & Gargiolo 1999). The concept of trust is central to social proximity; the trust level is expected to grow when social proximity increases. Trust tends to increase the exchange of information and encourages it (Maskell & Malmberg, 1999). In the specific case of confidentiality, secrecy, or the fear of parasitism (free riding), relationships based on trust are the most important component in the establishment of social relations. Therefore, social proximity may serve as a significant predicting factor of the existence of a relationship between two agents. For example, a long term friendship among a group of people is likely to influence activities characterized also by sharing mutual information.

Social proximity that is based on knowledge networks that are consolidated on the basis of interpersonal relationship could be formed, for example, among colleagues who were employed by the same organization and remained friendly even after they left that organization (Breschi & Lissoni, 2009; Buenstorf & Fornahl, 2009), or even in the case where the organization itself ceased to exist (Broekel & Boschma, 2012). These social networks are initially formed within organizations (Allen, 1984). They tend to become permanent, and will be present in all spheres of life among these peers, on the basis of the constant movement between companies of engineers and scientists who change jobs during their career (Allison & Scott- Long, 1987; Almeida & Kogut, 1999; Agrawal et al., 2006; Breschi & Lissoni, 2009). The same argument can be made for a group of people with a shared history, such as those attending a similar type of school, university, or business firm. Shared history may increase the sense of communal belonging. Personal relationships emerge from a shared past in a given workplace. Indeed, one definition of ‘culture’ is shared experiences and values.

Social interaction is created not only within the firm, but also between companies. For example, inter-organizational cooperation in R&D laboratories may produce a social context, in which friendly relations are formed (Balland et al., 2013a). In this context, Saxenian (2006) described how immigrants who worked in the Silicon Valley in California and returned to their countries of origin use the social network they created in order to establish trade relations between the countries related to capital funding for technological innovation.

Other studies have shown that great social proximity may be a prerequisite, balancing rooted human relations (social cliques) and strategic-business relationships that are a product of the former (Rowley et al., 2000; Fleming et al., 2007). However, too strong a social proximity can also be harmful, for example, to innovative performance in technology, due to excessive loyalty or commitment to social relationships taking precedence over innovative-business relationships (Boschma, 2005). In this respect, excessive social proximity can lead to the opportunistic behavior of business agents being eroded. A high degree of social proximity could also block the entry of new agents into the network, and affect the network's rigidity (Uzzi 1997). To ensure an optimal balance of social proximity, flexible capability to expand the network at its margins should be ensured (Boschma 2005).

#### 3.2.2.3 Geographic proximity

None of the proximity types discussed thus far relates to shared spatial location. It could be argued that geographic proximity plays a major role in refining and deepening other types of proximity, because it facilitates their existence in the first place. Geographic proximity can also influence the chance that different agents will exchange information (Broekel & Binder, 2007). Through different mechanisms, geography influences motivation and the extent of the search for or location of individuals/persons. Proximity makes such a search and detection easier and tends to increase the consumption of information found within the nearest geographical distance. In this way, geographic proximity increases the likelihood that two agents will commit directly to sharing knowledge reciprocally (Healy & Morgan, 2012).

However, it seems that the concept of geographic proximity has, in recent years, been losing the ability to explain the possibility that two given agents who are also socially related will communicate during patent development (Breschi et al., 2003). Ponds et al. (2007) found, for example, that the predictive power of geographic proximity is small in relation to the possibility of research collaboration among academic organizations (incidentally, as opposed to cooperation that can exist between academic, non-academic, and not-for-profit organizations). Nevertheless, Ponds et al. suggest that geographic proximity can still help to overcome institutional barriers, when different types of organizations are concerned. Although geographic proximity may provide certain advantages for tasks that involve knowledge exchange, there is evidence showing that over-proximity also may erode the company's innovative performance (Broekel et al., 2010). For example, Giuliani & Bell (2005) showed that companies that are in the same industrial cluster and located in the same geographical distance tend to develop different patterns of interactions with regard to mutual information sharing. Some of the companies were characterized by contact with other companies, while other companies rarely develop relationships at all. Furthermore, certain companies will tend to interact with other companies outside the cluster, while others will not.

Overall, it seems that geographic proximity is perhaps the least dynamic of the various types of proximity. A given agent can learn at the same time from several other agents, and move toward them cognitively without significant geographic mobility. Sometimes geographic relocation comes at the expense of the connections formed in another place (Stam, 2007). For example, when human agents approach other agents they are in fact distancing themselves from agents to whom they had been close in the past. Giuliani (2007) claimed that in fact geographic proximity is not sufficient, and is even not necessary, for knowledge and information to be transferred between different agents. In this context, Ter Wal (2010) found evidence that in Germany, geographic proximity in biotechnology is becoming less relevant to the establishment of innovation/invention networks. He explained this by the increase of codification of knowledge in this field. Scherngell & Lata (2013) also found that knowledge networks that are funded over a long period of time by the European Commission have developed diminishing sensitivity to geographic proximity.

Empirical research suggests that the inclusion of other types of proximity in the analysis, in addition to the measure of geographic proximity, reduces to some extent the impact of the latter on agents that are linked together in an information network (Singh, 2005; Breschi & Lissoni, 2009). That is, different types of proximity tend to be associated with each other. Geographic proximity probably makes it easier to establish other types of proximity. However, while studies suggest that geographic proximity is losing some of its importance, the inclusion of all types of proximity in one analysis shows that geographic proximity still affects and impacts positively the formation of information networks and links (Balland, 2012; Hardeman et al., 2012; Balland et al., 2013b). Singh (2005) found that geographic proximity is especially important in establishing collaboration in interdisciplinary research, due to weak cognitive proximity between organizations. Balland et al. (2013b) found that geographic proximity is relevant and of increased importance in the video game industry, since it stimulates the creation of relations between companies, against the backdrop of the growing sophistication in the development of new video games (Sorenson et al., 2006). One of the slogans of globalization is ‘distance is dead’, as communications technology makes geography irrelevant. This is untrue, distance is far from dead; but clearly the nature of geographical proximity and its impacts have changed.

In summary, it appears that the types of proximity discussed here can influence the information networks that exist between different agents. Although in the past the study dealt mainly on the meaning of geographic proximity (see, for example: Jaffe, 1989; Audretsch and Feldman, 1996), in recent years an increasing amount of research has been devoted to the different meanings of the other types of proximity as related to corporate behavior (Fleming et al., 2007; Ter Wal & Boschma, 2009; Balland, 2012b). Most studies dealing today with different types of proximity in the context of technological innovation research consider at least two kinds of proximity. However, it often happens that they also ignore or miss the potential relevancy of other types of proximity that are not included in the research they conduct.

An example of research that combines different types of proximity is a study conducted by Cantner & Meder (2007). They found that cognitive and social proximity may be relevant for common business activity. In their study, they showed that a technological overlap between two agents (cognitive proximity) positively affects the probability that they will collaborate with each other. Moreover, it seems that the past experience of the agents might reduce social distance and affect positively the possibility of future cooperation. Mowery et al. (1998) found similar results, and therefore, they suggest that the pattern of the relationship between the probability of collaboration and cognitive proximity should be seen as an inverse U shape. Cassi & Plunket (2012) found that organizational, social, and geographic proximity leads to similar functions, so that they serve as substitutes in the establishment of collaborations pursuing innovative inventions. Hoekman et al. (2010) have shown that geographic proximity plays an increasingly important role in the creation of scientific networks, when institutional proximity is limited by national boundaries.

A study conducted by Broekel & Boschma (2012) found that cognitive, social, organizational, and geographic proximity has played an important role in the establishment of the knowledge network that underlies the Dutch aircraft industry. However, they found evidence that too much cognitive proximity may reduce the innovation instances of companies, and that organizational proximity does not affect this. Although they have shown that cognitive and organizational proximity are dominant factors in the consolidation of a relationship that is based on knowledge exchange, these types of proximity did not create an increased number of innovations. On the other hand, geographic and social proximity tended to increase the probability of creating knowledge networks, as well as greater innovation, among the same firms. Hardeman et al. (2012) compared, for example, the extent of variance that exists between the various proximity measures, and examined the impact of that variance on the scope of cooperation in Europe and in North America. Their findings indicate that geographic, organizational, and social proximity have a lesser influence in Europe than in North America. In contrast, cognitive and institutional proximity plays a similar role in these two parts of the world. The latter finding is surprising, since it is mostly claimed that the imaginary borders between universities, industry, and government tend to be more blurred in North America than in Europe (Balland et al., 2013a).

## 3.3 Data

### 3.3.1 RAD Bynet Ecosystems

The RAD Group today consists of 11 companies, of which four are traded on the NASDAQ exchange. The revenue of the group is approximately $1.5 b. Headquarters are in the northeastern quarter of the city of Tel Aviv ("Ramat HaHayal").

The RAD Group was founded by two brothers, Yehuda and Zohar Zisapel. Both are graduates in Electrical Engineering at Technion-Israel Institute of Technology. After a stint at Motorola Israel, Yehuda launched a business for importing and distributing computer networking equipment which later became Bynet. Bynet distributed equipment made by Codex, acquired by Motorola in 1977. In 1981, Motorola decided not to sell Codex equipment in Israel through Bynet but instead to sell it directly. Yehuda understood from this episode the importance of innovating Bynet's own products. He asked his brother Zohar to join him, and in a corner of the Bynet offices together launched RAD (an acronym for Research and Development) Data Communications. RAD's first successful product was a small computer modem. By 1985, RAD's revenues reached $5.5 m.

In 1985, just four years after its birth, RAD (and founder Yehuda Zisapel) offered initial funding and support to an entrepreneur to launch LANNET, which developed a pioneering Ethernet switch (the first to offer Ethernet switching over telephone cables rather than coaxial cables). Zisapel did this, in order to avoid two conflicting pitfalls: Losing focus by producing an excessively wide product range, and losing innovation, by having talented engineers depart the firm when their innovative ideas are rejected as "not in our product line". The success of LANNET (acquired in 1995, then again acquired by Lucent in 1998) showed Yehuda Zisapel that the model of LANNET could be extended to a large number of startup firms, with RAD at the center.

Over the years, Yehuda Zisapel has single-mindedly perfected this model. It has been described (Myser, 2005) as "the world's most successful incubator". In Zisapel's words, the model is simple. "We identify a niche, develop a business plan, hire a CEO and have them start R&D. There is no predetermined product." (Myser, p. 1). In some cases, links with RAD-originating startups are more informal, with RAD managers and engineers resigning from RAD to launch their own company, and receive varying degrees of advice, support and finance. In our study, we found that many of those now working for RAD-originating companies were simply unaware of the original link with RAD[1].

This RAD model is in some ways reminiscent of the structure of Thermo Electron, a Fortune 500 company now owned by Fisher Scientific with $11 b. in annual revenues. Thermo Electron was established in 1956 by an MIT thermodynamics professor George Hatsopoulos and his brother John. Each time they identified a social need, they matched it with a state-of-the-art technology and built a company. The ensuing 25-odd companies were flexible and independent, each highly focused, but had the umbrella of managerial expertise and finance provided by the Hatsopoulos Brothers. The RAD cloud and "incubator" has less formal structure than Thermo Electron but embodies a similar principle.

In general, the ecosystem generated by RAD includes at most some 129 firms. Some of these firms no longer exist, typical of high failure rates among technological startups. This is due either through bankruptcy or through their acquisition by larger firms.

[1] A good example is Radvision. In 1992 Yehuda Zisapel assigned one of his experts, Eli Doron, at RAD to find an unmet need in the burgeoning but new videoconferencing market. He did this, to avoid excess diversification within RAD. Within a year Doron had a business plan for a video-over-Internet-Protocol product. Outside funding was raised and Radvision was launched in 1983. The company was later acquired by Avaya and has several hundred employees.

However, the failure rate of RAD ecosystem companies is significantly lower than the overall failure rate of technological startups.

Most of the 129 firms belong to Internet, communications and cellular phone technologies. Another group in the ‘cloud’ are in the biotechnology and medical industries, while a third cluster are venture capital firms (Some entrepreneurs join venture firms later in life after their startup efforts). Firms that currently exist in the ‘cloud’ employ at least 15,000 workers. The vast majority of the 129 firms on which we have data are small, with two-thirds employing less than 100 workers. Only four firms in the cloud employ 1,000 workers or more, among them RAD Data Communications.

Close to half of the firms in the RAD ecosystem were founded during the 1990’s, mainly in the first half of this decade. In the second half of the 1990’s, there was a slowing in the rate of establishment of new firms in the cloud; the same applies to the decade of the1980’s, the decade at whose onset RAD itself was launched.

Geographically, the majority of firms in the RAD ecosystem are located in the metropolitan core of Tel Aviv city; as we move farther away from this core, there is a distinct drop in the concentration of firms. Nearly half (46.1 percent) of the firms in the cloud are sited in Tel Aviv, while another 18.5 per cent are located in surrounding nearby cities (Ramat Gan, Herzliyah, Petah Tikvah) comprising the inner ring of the Tel Aviv Metropolitan Region.

The RAD ecosystem itself comprises an important innovation – a novel business design for an interrelated group of companies. Some big companies launch new divisions when a radical innovation emerges from its R&D. On occasion, those divisions are spun off and sold. But such a sale can be difficult, costly and time-consuming. It is far easier to do an IPO (Initial Public Offering) for a startup, or an exit (acquisition by a larger firm). In the event of failure, the startup does not drag down the performance of the ‘mother ship’ because it is completely independent. Yet despite this independence, Zisapel can provide informal expertise and at times funding, not only from RAD but from all the other companies in the growing cloud of companies in the ecosystem.

It is significant that the RAD model for spawning new startups has become, in a sense, viral. According to Ellis & Drori (2012), the RAD Group has been the most fertile ground" for creating Israeli entrepreneurs, having produced 56 "serial entrepreneurs" who established more than one start-up each.

### 3.3.2 The firms’ survey

Data collection was conducted using an online survey. Out of 129 companies associated with RAD ecosystem, it was possible to review 119 firms[2]. With the survey, it was

[2] Some of the companies managers associated with RAD ecosystem couldn't be traced. Most of them relates to start-ups that ceased to exist in their initial stages of development.

possible to identify, inter alia, various relations taking place between companies in the cloud, the relationship of RAD with them, and its role in establishing the various companies. In addition the survey supply data that assists in measuring technological-cognitive proximity that exists between the companies and an array of social relationships that take place between their managers in formal and informal settings. The primary research tool in the survey was a questionnaire, transmitted via e-mail to firm managers. The managerial rank chosen to be interviewed were General Managers (CEOs) and technology managers (CTOs) in the firms. The online interview was found to be preferable to other possible alternatives. The priority of the email survey is reflected in its many advantages (low cost, ability to administer a relatively large questionnaire, easy and immediate distribution, as well as the possibility offered to the subjects to answer the questions any time and place they desire). Most of the questionnaire consists of closed questions and scales.

The survey was conducted over several months at the beginning of 2013. In the first phase, questionnaires were sent to the 119 companies included in the survey. There were several rounds of reminders, and about two months after the beginning of the survey, a round of calls was made to executives that had not yet returned the questionnaire even after the third reminder, in an effort to convince them to fill out the questionnaire and send it back. The final and direct phone call stage was found to be most effective, leading to a significant increase in the rate of response.

In total, filled questionnaires were received from 57 companies in RAD's ecosystem. This scope of samples indicates a good rate of response (48%). This is a relatively high rate, considering that company managers are in positions that leave little free time to respond voluntarily to research needs. In addition is the fact that many of the companies no longer exist and that some of respondents were actually past managers who did not always have a clear interest to respond.

Similarly to the overall study population, a significant proportion of the sampled companies were established during the 1990s (35%) and during the 2000s (37%). Thus, it is not surprising that 44% of the managers who answered the questionnaire were from companies in their consolidation stage (that is, the company has a distinct market share, and/or product after development), while 28% are at the germination stage (i.e., initial R&D, technology development, or prototype). 48% of the firms from which the questionnaire was received are located in the same area in Tel Aviv (Kiryat Atidim), where the parent company, RAD, is located. Another 14% percent of the companies included in the sample are in towns close to Tel Aviv, in the inner ring of the Tel Aviv metropolitan region. A minority of companies are located in outer ring of the Tel Aviv metropolitan region, while none of them is located in Israeli cities outside Tel Aviv metropolis (except one whose activity base is in the U.S ).

It is interesting to note that most of the companies included in the study are small with up to 50 employees (about 66% of the sample). Only four companies are large companies of over 500 employees. Another 14% are medium-sized companies, of between 100 and 400 employees. This property is common among technology intensive companies. In the U.S.

the Bureau of Labor Statistics (2013) reports firms with fewer than 500 employees accounted for 25 percent of the jobs in high-tech industries. And of course, Israeli firms tend to be an order of magnitude smaller, on average, than American ones.

Compared to those companies located in other parts of the metropolitan area, the companies located in Kiryat Atidim, close to RAD, tend to be larger in terms of number of employees in the firm (despite this tendency, this difference is not significant, since the dispersion around the average in each group is large). When considering the age of the companies in the ecosystem in terms of chronological position in the cloud development, no significant distinction between those companies located in Kiryat Atidim in north Tel Aviv, in close proximity to RAD, and the other companies, was found. It seems that the companies associated with RAD's cloud tend not to distance themselves spatially from the parent company as the ecosystem develops over time, so that the activity in this cloud tends to remain centralized. It seems that this is related to the interaction taking place between the companies. The scope of the interactions of companies located in Kiryat Atidim with other companies in the ecosystem is two times larger than that with companies located elsewhere in the region. This difference was significant, indicating the relationship that exists between geographic proximity and the ecosystem development, a development that will be discussed in detail below.

## 3.4 Method

### 3.4.1 The relation of the cloud members to RAD

The purpose of the first part of the data analysis as presented above was to examine the ongoing relationship of the companies in the cloud with RAD, the cloud founder. The intention was to gauge the extent of their relationships and the factors affecting the continued existence of such a relationship. To achieve this, several variables were developed, defining the relationships of the companies in the cloud, and specifically their relationships with RAD. The dependent variable, $RAD_{CONC}$, is a dichotomous one, indicating whether company i in the cloud reported the existence of some relationship with RAD (whether business-organizational, personal, or historical).

The independent variables included first the variable SNYRTY, which is a dichotomous variable that indicates whether the managers or their colleagues in the company management held a senior position in RAD in the past. Using this variable also allows us to determine the extent to which this has a direct effect on the continued relationships with RAD. In addition, another variable was used, COMRS, as a dichotomous variable indicating whether RAD played a role in founding company i, beyond the fact that its CEO fulfilled a senior role in the past at RAD.

Another variable is YEAR, which measures the number of years that passed since the establishment of RAD and the establishment of company i in the cloud. Using this continuous variable, it is possible to examine whether there is a loosening of the ties with RAD on the timeline. That is, whether the companies are becoming more independent as time goes on.

Two other variables represented the degree of technological and geographic proximity of the cloud members with the RAD Company. RADIST is a continuous variable that measures in kilometers the geographical distance between the locations of company i in the cloud and the location of RAD. It allows us to examine the effect that geographic proximity of the companies in the cloud to RAD has on the existence and strength of the ties between them. TECHNO is the variable through which the degree of the cloud members' reliance on technologies similar to those of RAD can be examined. Actually, the variable specifies a state in which technologies identical to those of RAD are being used. The assumption is that, if such technologies are employed, then it can be assumed that some of the revenues of these companies result from the use of these technologies. To create this dichotomous variable, we used the survey data that indicated the prevalence of the code words of the technology used in the development of their products, where 1 indicates a situation in which company i mentioned code words that appeared in part or in their entirety also in RAD (for the method of calculation, see section below).

Two other variables were used for descriptive statistical analysis only, indicating the nature of the existing relationship between the companies in the cloud and the founding company RAD. The first, INTENS, is a binary variable, indicating the intensity of the relationship of the senior executive of company i with RAD, where 1 indicates that an intensive relationship was reported, which takes place at several sites and has an orderly and steady character, such as professional and business meetings on a regular basis, meetings in conferences, and even meetings as a result of social and family ties; and 0 indicates otherwise. The second variable, BUSIN, is a binary variable that indicates the intensity of company i's business relationship with RAD (as the original company), where 1 is defined as a relationship of moderate or high intensity, and 0 is the non-existence of a relationship or a relationship of low level intensity.

### 3.4.2 Inter-firm contacts among companies comprising the RAD ecosystem

In the second part of our article, our objective is to examine the nature of the relationships that characterize the ecosystem created by RAD. The research questions that were examined are related to the existing ties, their nature, and their level of intensity, as well as to identifying the contributions of different proximity measures to the empowerment of these relationships. The assumption proven in many studies is that the existence of synergistic processes between technological companies contributes to the promotion of mutual and dynamic innovation processes (Lundvall, 1992; Nelson, 1993; Braczyk et al., 1998). The sharing processes that take place between firms in a given area, leading to knowledge exchange, have an effect on regional growth as claimed by Von Tunzelmann (2009).

In order to examine the structure of the relationships in RAD's cloud, several variables were developed through which it was possible to identify the presence and intensity of the relationship between the companies in the cloud. CONC_COMP1 was defined as a dependent variable that measures the intensity of the business relations existing between company i and the other companies in the cloud from which that company's founder arrived. We had no actual knowledge about the companies with which companies in the cloud maintain a business relationship that leads to cooperation and probably to knowledge exchange. The information reported in the field survey refers only to the existence of such relationships with companies in the cloud and their level of intensity. Therefore, we could not examine the intensity of an undirected network, consisting of a relationships matrix between any company i and company j in the cloud, similar to Broekel & Boschma (2012). Therefore, we had to settle for a more general measure indicating the existence of business relations among the companies in the cloud. In this way, the variable CONC_COMP1 yields 1, when the existence of business relations with high intensity that take place at several sites and have an orderly and steady character, such as regular professional and business meetings, meetings in conferences, and meetings resulting from social and family ties, were reported, and 0 otherwise. Of all the sampled companies, 38.6% reported high intensity relationships between them and other companies in the cloud.

As mentioned, one of the study objectives was to examine to what extent different proximity measures contribute to the intensification of these relationships in RAD's cloud. That is, the purpose was to assess the extent to which different proximity measures affect the chances companies will maintain relationships between them. To achieve this, we used three different proximity measures.

#### 3.4.2.1 Geographic proximity

The cloud of RAD BINAT was essentially formed when most of the companies that came out of RAD established themselves geographically at the center of the country and some in the close vicinity of RAD .

In order to assess the influence of the geographical proximity on the cooperation that exists within the cloud, the geographic proximity measure, DIS, was calculated according to the aerial distance (in kilometers) between two given companies in the cloud. According to Ejermo and Karlsson (2006), it is customary to measure geographic proximity according to travel time, not aerial distance. However, the structure of the company cloud connected to RAD apparently does not justify the use of travel time, since the distance range is short in many of the observations (similar to the use made by Broekel and Boschma (2012)). The distance is therefore measured as the log of the aerial distance (in kilometers) between each pair of companies in the cloud, in order to counteract its influence on the estimation findings of abnormal observations. Since it was impossible to examine the relationship on the basis of an undirected network, the measure of geographic proximity, DIS, was calculated as the average of the distances of company i from any other company j in the cloud.

#### 3.4.2.2 Cognitive proximity

Cognitive proximity represents the technological similarity that exists between the knowledge bases of the different companies in the RAD group. Because the companies included in the study belong mostly to the same technological-economic sector, it was not possible to distinguish between them by the sectorial databases that classify each company, according to a five digit numeric classification. Therefore, it was decided to characterize this proximity by the code words that describe the products and technologies that the company uses. To achieve this, the company executives were asked in the survey to specify up to ten main products that their company manufactures or develops, and for each product indicated, to list five code words that describe the technology that the company is using in its development. Thereby, we received a set of code words that describe the products and technologies used by each company. A total of 179 pairs of code words that represent the products and technologies of the sampled companies with co-occurrence were received and entered in our database.

The first step for identifying the degree of cognitive proximity that exists between the two companies focused on identifying the extent of the similarity that exists between pairs of words. According to Breschi et al. (2003) and Broekel and Boschma (2012), similarity between two words that represent technologies in our study is estimated on the basis of their co-occurrence at the particular company. Therefore, if a word representing technology A often appears in different companies that also presented a code word that represents technology B, it is likely that these two code words are interrelated. In addition to this direct relationship, they assumed the existence of an indirect link between words that represent two technologies. An indirect link occurs when code word A is presented frequently by the same companies that display the code word C, as is true for code words B and C, because then A and B also represent proportionately similar technologies, each being similar to C. In order to calculate the extent of direct and indirect proximity between technologies, we used the Cosine measure, as presented by Ejermo (2003) in the following equation:

$$r_{ab} = \frac{\sum_{c=1}^{t} w_{ac} w_{bc}}{\sqrt{\sum_{c=1}^{t} w_{ac}^2 \sum_{k=1}^{t} w_{bc}^2}} \qquad (1)$$

where t is the number of words, and b, c, a, are the code words that represent the technologies or products examined. $W_{ac}$ represents in the equation the number of times that the code words a and c were presented jointly by the companies.

When companies indicated multiple code words (represent different technologies and products), we have no information about the relative importance. For example, no information is given on the share of that technology or product in the company's total revenue, or, for instance, the number of employees that use this technology or produce the product that the code words represent. Therefore, we estimated proximity in two ways. First, we examined what is the most similar pair of words on the companies' word vector. That is, first we compared the word vector presented by two companies (i, j) as representing their products and technologies (Ti and Tj). Then, we identified for each code word a (a ε $t_i$) in company i the maximal $r^i_{ab}$ in the code words of company j. Similarly, the code words of company j were identified. The $r^i_{ab}$ were summarized and divided by the sum of the number of words which were presented by the two companies, i and j. This prevented bias in the proximity measure, which was calculated in this manner for the benefit of companies that presented more code words. The estimation is represented by equation 2:

$$S_{ij} = \frac{\sum_{a=1}^{t_i} \max_{b=1....t_j} (r_{ab}) + \sum_{b=1}^{t_j} \max_{a=1....t_i} (r_{ab})}{t_i + t_j} \qquad (2)$$

Since the Cosine index values, $r_{ab}$, range from 0 to 1, the cognitive proximity measure ranges also between 0 and 1, where 1 represents perfect technological proximity. In extreme cases, all of the technologies of company i are compared to one technology of company j. The underlying logic is related to the absence of information about the relative importance of a certain technology to the company, and for this reason, we assume that proximity, even to a particular technology, produces some proximity between the companies, since they have a common knowledge base that allows effective communication. Again, since we were unable to assess the relationships on the basis of an undirected network, the measure of cognitive proximity of each company $COG_i$ in the cloud was calculated as the average of the proximity distances between company i and any other company j in the cloud.

In addition, we used the square value of the proximity measures to test non-linear relationships. Since the two measures can be affected by multi-colinearity, we subtracted the average value of the variable before calculating the square value:

$$\mathrm{COG}_i^2 = (\mathrm{COG}_i - \overline{\mathrm{COG}_i})^2 \qquad (3)$$

making this measure similar to standard deviation. Therefore, the value of $COG_i^2$ is higher for both high and low values of the proximity measure.

#### 3.4.2.3 Social proximity

As mentioned above, social proximity can be considered a good predictor of the existence of a relationship between two companies. In order to trace the existence of social connections arising from membership in the cloud of RAD, we examined whether the corporate managers who were interviewed in our study had a personal connection to the company from which the founders of their company arrived. The hypothesis tested is that such personal relationships may contribute to collaborations and intensive cooperation and to their nature. In order to examine the relationship that exists between companies, we defined personal contact variable PERSON, as a binary variable that indicates the intensity of the personal relationship with one of the companies from which the founders arrived. In this variable 1 specifies that a rich personal relationship representing several types of personal ties that lead to regular professional meetings, joint participation in conferences, and family ties, was reported.

In addition, we used an indirect variable, PRC_EMPLY, a continuous variable that measures the percentage of employees who came from the same company as the founders. According to Broekel & Boschma (2012), shared history may produce communal proximity, which will affect the willingness to collaborate, so that this variable can express the intensity of possible relationships as a percentage of those employees is higher.

#### 3.4.2.4 Control variables

In addition to these, we also included other variables, which serve as control variables that may affect the likelihood of cloud members maintaining relationships. First, we defined the logarithmic value of the absolute size of company i in the cloud (SIZE) by the number of its employees. This continuous variable may control the variance factor of the companies' conduct, which is affected by their size (see Graf, 2011; Beise & Stahl, 1999).

Two functional control variables were defined in order to examine the effect that functional relations have on the companies in the cloud. COM_CONCT is a dichotomous variable, where 1 indicates that at least one member company from which the founders or executives of a company arrived played a role in the establishment of company i in the cloud, and 0 otherwise. The second variable, RAD_CONC, is a dichotomous variable, where 1 indicates that company i or one of its leaders communicates with RAD, and 0 otherwise (see e.g. Allen, 1984).

All the above variables are presented in Table 1, which includes a description of their characteristics. Table 1A in the Appendix presents the correlations between the variables. Most of the correlations between the variables are weak, hence the variables can be included in the regression model. However, some of the variables that measure that existence, intensity, and nature of the relationships have a high correlation, and therefore these variables were analyzed in separate models.

**Table 1: Variables related to RAD**

| Variables | Type | Shares of zero values | Mean |
|---|---|---|---|
| Senior position in RAD (SNYRTY) | Dichotomous | 70.2 | 0.30 |
| Business roll of RAD company in establishment of company surveyed (COMRS) | Dichotomous | 82.5 | 0.18 |
| # of years since Rad establishment (YEAR) | Continuous | 0 | 18.80 |
| Geographic distance from RAD (RADIST) | Continuous | 36.8 | 7.15 |
| Technological similarity with RAD (TECHNO) | Dichotomous | 59.6 | 0.40 |
| Strength of the relationship (INTENS) | Dichotomous | 47.4 | 0.82 |
| Intense of business connection with RAD as Origin Company (BUISN) | Dichotomous | 86.0 | 0.14 |
| Strong Intense of personal connection with companies from which the founders came from (PERSON) | Dichotomous | 75.4 | 0.25 |
| Percentage of employees from the company from which the founders came from (PRC_EMPLY) | Continuous | 33.3 | 14.50 |
| Cognitive proximity (COG) | Continuous | 7.0 | 0.13 |
| Cognitive proximity effect ($COG^2$) | Continuous | 7.0 | 0.01 |
| Geographic Distance (DIS) | Continuous | 0.0 | 2.16 |
| No. of Employees (SIZE) | Continuous | 0.0 | 115.80 |
| Business roll in establishment of the origin company/ies (COM_CONC) | Dichotomous | 49.1 | 0.52 |
| Senior in the company have relations with RAD (RD_CONC) | Dichotomous | 40.4 | 0.59 |

### 3.4.3 The Model

To test the research hypotheses, two basic models were estimated. One is the model that examines the influence of various factors on the extent of the continuous relationship that companies in the ecosystem maintain with the founding company, RAD. The other examined the influence of various factors on the existence of relations between the companies that belong to RAD's ecosystem. The dependent variable is then regressed with a standard logit model on the independent variables. The logit model was selected because both dependent variables are binary variables, 1/0. In the first model, 1 suggests an association between company i and RAD, while 0 suggests the absence of any connection. In the second model, 1 indicates the existence of high intensity business relationships between company i and other companies in the cloud, which take place at several sites in an orderly and regular manner.

## 3.5 Results

### 3.5.1 The relationship of the companies with RAD

The results of running the logit model on the variables related to RAD Company are presented in Table 2. The predictive level obtained by the model indicates that the model accounts well for the connections that were found. The results confirm the hypothesis that the presence in a company of executives who previously held a senior position in RAD affects the continued existence of relationships between that company and the parent RAD Company. The variable SNYRTY was found to be positively and statistically significantly related to the dependent variable, indicating the continued existence of a connection between the offspring company and RAD. These managers, as already mentioned, will tend to maintain long term relationships with their parent company. Companies in whose establishment RAD played a business role tend to preserve ties with RAD, as is indicated by the positive and statistically significant relation between the variable COMRS and the dependent variable. The third variable that was found to be statistically related to an offspring company maintaining ties with RAD is RADIST, the geographical distance, of the company i from RAD, although the statistical significance is moderate. The findings indicate that the geographic proximity effect has a positive influence on maintaining relations.

**Table 2: Logit regression on RAD connection to its ecosystem**

| Depended variables | | Estimate | Standard Error |
|---|---|---|---|
| Intercept | | 0.471 | 32.132 |
| SNYRTY | Senior position in RAD | 22.001 | 34.730*** |
| COMRS | Business roll of RAD company in establishment of company surveyed | 19.550 | 4.490*** |
| DIST | Geographic distance from RAD | -0.083 | 0.177* |
| YEAR | # of years since the establishment of RAD | -0.044 | 6.613 |
| TECHNO | Technological similarity | 0.972 | 4.094 |

Chi-squared test of fit improvement = 33.651 on 5 d.o.f., *P*-value =0.000

-2 Log likelihood = 42.187
Cox & Snell R Square = 0.452
Nagelkerke R Square = 0.609

* Significant at the 0.10 level ** Significant at the 0.05 level *** Significant at the 0.01 level

However, the model results do *not* indicate that technological proximity has an effect on the continued tendency of a company to maintain relations with RAD. From this, one might conclude that the continued relationship with RAD is based more on social proximity that stems from a shared history, and is *not* due to the existence of common ground based on knowledge related to the use of similar technologies. This finding is of great importance for the development of social networks that lead to the establishment of hi-tech firms by entrepreneurs with a shared history. Another finding of interest is the non-existence of a statistical relationship between the number of years since the founding of RAD and the year when the company was established, in the cloud. That is, the time variable has no effect in any direction on the probability of maintaining ties with the founding company in the cloud, a finding that reinforces the above conclusion.

In order to understand the intensity and nature of the relationships as influenced by a shared past, we applied a chi square model to the additional variables due to the ordinal nature of the scales. The results are shown in Table 3.

**Table 3: Type of relationships**

| | Does one of the managers in the company was in a senior position in RAD, in the past? (SNYRTY) | | | |
|---|---|---|---|---|
| Intense of the senior connection with RAD **(**INTENS) | No | Yes | Total | |
| No connection | 60.0% | 17.6% | 47.4% | $\chi^2$ =9.149; df=2; sig=0.010 |
| Weak connection | 15.0% | 41.2% | 22.8% | |
| Strong connection | 25.0% | 41.2% | 29.8% | |
| Total | 100.0% | 100.0% | 100.0% | |
| N | 40 | 17 | 57 | |
| Intense of business connection with RAD | | | | |
| Non or weak business connections | 92.5% | 70.6% | 86.0% | $\chi^2$ =4.747; df=1; sig=0.029 |
| moderate and strong business connections | 7.5% | 29.4% | 14.0% | |
| Total | 100.0% | 100.0% | 100.0% | |
| N | 40 | 17 | 57 | |

The findings clearly indicate that a common past probably leads to greater current intensity in the relationship. Over 80% of the companies whose managers filled senior positions at RAD in the past report the continued existence of a relationship in the present, sometimes many years later. About 50% of these companies define this relationship as an intensive, regular, and constant relationship (includes professional and business meetings on a regular basis, meetings in conferences, and even meetings held as a result of social and family relationships), as opposed to only 25% of the companies whose managers do not share such a common history.

Moreover, the shared history is also reflected in greater willingness to maintain relationships on a business basis with RAD, although the scale is not especially large. Only 14% of all companies reported a business relationship with RAD, but this percentage is almost double among companies with a shared history, but only 7.5% among the companies whose managers did *not* have a shared history.

### 3.5.2 The relationship of the companies in the ecosystem

The regression results with respect to the relationships within the cloud are shown in Table 4. The obtained explanatory level is high, indicating the model's ability to account for the relationship system in the ecosystem.

**Table 4: Logit regression on connections among companies in RAD ecosystem**

| Depended variables | | Estimate | Standard Error |
|---|---|---|---|
| Intercept | | -5.591 | 156.441** |
| PERSON | Strong Intense of personal connection with companies from which the founders came from | 4.239 | 298.191*** |
| PRC_EMPLY | Percentage of employees from the company from which the founders came from | 0.140 | 4.385 |
| DIS | Geographic Distance | 0.068 | 21.377 |
| ($DIS^2$) | | | |
| COG | Cognitive proximity | 9.824 | 776.478* |
| ($COG^2$) | Cognitive proximity effect | | |
| SIZE | No. of Employees | -0.030 | 0.271 |
| COM_CONC | Business roll in establishment of the origin company/ies | 1.916 | 229.262*** |
| RD_CONC | Senior in the company have relations with RAD | 2.139 | 40.717** |

Chi-squared test of fit improvement 34.202 on 7 d.o.f. *P*-value =0.000

-2 Log likelihood = 40.839
Cox & Snell R Square = 0.457
Nagelkerke R Square = 0.619

* Significant at the 0.10 level ** Significant at the 0.05 level *** Significant at the 0.01 level

Numbers in parentheses are based on models not reported estimations. Since the other variables' coefficients did not change significantly they are not listed.

The results arising from the model shown in Table 4, indicate that most of our hypotheses concerning the factors affecting the existence of intense business relations of company i with other companies in the cloud were supported. First, it was found that social proximity is particularly relevant to the existence of business relationships between the companies. The variable PERSON was found to be positively and statistically significantly related, at a high level, to the tendency to maintain intense business relationships. On the other hand, shared history, which is measured by the percentage of employees in the company who came from the company of the founders, PRC_EMPLY, was not found to influence the tendency to maintain relationships. This result is interesting, because it was found that in 66% of the companies in our sample, workers are employed who arrived from the same company as the founders, and on average the percentage stands at 14.1%.

Unlike many other studies, which found that geographic proximity has an impact on the creation of cooperation between companies, our research did not find such evidence. Geographic proximity hasn't an effect on the companies' tendency to maintain intensive business relationships within the RAD cloud. However, this result can be attributed to the relatively small distance between most of the companies in RAD's cloud. Apparently, the differences in the distance between the companies are insignificant in terms of their tendency to communicate with each other. To some extent, this finding supports the hypothesis that social proximity is of higher importance and has a significant effect. In fact, the geographic effect found in other studies was often due to the existence of social contacts that were not measured in these studies (see e.g., Ponds et al., 2007) and is strengthened in light of the findings of the current study.

As for cognitive proximity, a positive statistical association was found between technological proximity, as measured by the COG variable, and a company's tendency to maintain intensive business relations with the companies in the cloud. However, the relation is significant at a statistical level of 0.1 only, but still indicates the contribution that could be to technological proximity between the companies to their willingness to maintain contacts on this background, as found in other studies (e.g., Mowery et al., 1998; Canter & Meder, 2007; Sorenson & Singh, 2007; Broekel & Boschma, 2012). The square COG measure was found to be not statistically significant so that, as Canter and Meder (2007) and Broekel & Boschma (2012) found, it is impossible to verify an inverse U relationship between the tendency toward cooperation and technological proximity.

Supposedly, it could be deduced from these findings that social proximity considerably affects the tendency to maintain intensive business relationships, more so than technological or geographic proximity. The findings with respect to technological proximity were expected to indicate higher technological proximity (the average of technological proximity in the cloud stood at 0.13 on a scale of 0-1). This expectation is based on the fact that the source of the cloud is one founding company, which bred many other companies, some of which continued and bred other companies. For most companies, a significant cognitive proximity measure (over 0.7) was found with a few other companies (2-4 companies in the cloud). Only two companies showed such a high cognitive measure in relation to a significant number of companies (about 15 companies in the cloud). This is probably the result of a policy taken by the founder of the cloud, Yehuda Zisapel (see section 3.1 above), which led to high technological diversity in the cloud.

Similar to the findings of Broekel & Boschma (2012), firm size was not found to affect the existence of intense business relations between the companies. On the other hand, role proximity was found to have a positive effect on the intensity of business ties. As stated, this proximity was measured by two variables. The variable COM_CONCT, which indicates that the existence of a role in the founding of the company, which became the company from which the founders of the company arrived, has a positive influence on the tendency to maintain intensive business relationships in the cloud. The second variable indicates the influence of RAD, the founding company of the cloud, on business relations in the cloud. It was found that when a company, or one of the directors, is in communication with RAD, the company has an increasing tendency to maintain business relationships with companies in the cloud, as measured by the variable RD_CONC. These two variables are statistically significant, < 0.05, with RAD's impact being stronger than that of the other company from which the founders arrived.

## 3.6 Summary and policy implications

In this paper, we studied an unusual event associated with the germination of hi-tech companies, which grew out of the ideological idea of a high-tech entrepreneur who established the RAD BINAT company in the 1980's. Over the years, through a deliberate effort of the founder, companies were founded by entrepreneurs who had initially departed from the parent company, and during the following three decades, the companies that were thus born gave birth to other companies. This created a unique ecosystem, represented by RAD, which included at its peak expansion about 129 companies, some of which were closed over the years or were purchased by other companies and ceased to operate as independent entities. The field survey conducted among these companies yielded data from 57 companies that had agreed to answer a detailed questionnaire circulated among their senior managers.

The objective of the study was to examine the structure of the unique ecosystem that was generated and the existence of relationships between companies that are in the cloud. A central research question was the extent of the relationship measured between the companies in the cloud and the company that founded the cloud, 30 years later. The findings showed that the tendency to maintain such a continuous relationship is stronger among the companies in whose establishment RAD played a business role or where one of the company managers had held a senior position in RAD. These findings probably indicate the contribution of trust relations that were established among companies, which affect their willingness to conduct ongoing business relationships.

In addition, questions dealing with the essence of the relationships that characterize the ecosystem that was created by RAD were reviewed. We asked the subjects to identify the intensity of the relationships and their nature, and in particular to examine the contribution of various proximity measures to reinforce these relationships. The study findings provide compelling evidence about the effect of the different proximity measures on the tendency of the companies to maintain intensive business relations with other companies in this unique ecosystem. The study found that social and technological proximity encourages the tendency of the companies to maintain business relationships that probably contribute to knowledge exchange. An interesting finding was the relationship between geographic proximity and other proximity measures. Due to the tendency of most of the cloud companies to settle in close geographic proximity, no distance differences were created that affect the tendency of a business relationship to exist between the companies. This finding reinforces the hypothesis that geographic proximity in itself is not sufficient to create connections. Other conditions are necessary for the existence of cooperation, particularly proximity based on personal and trust relationships, which is even more important than technological proximity. From this, it can be concluded that firms will choose to cooperate when a basis for action is created on the background of a shared past and personal proximity relations, as well as technological proximity at a certain level. This finding is reinforced also in light of the positive and significant effect of functional proximity. Our findings indicating that companies in whose establishment other companies played a fundamental role, or who maintain a stable relationship with RAD Company, the founder of the cloud, tend to maintain business relationships with other companies in the ecosystem to a greater extent than do other companies.

However, the limitations of our study did not allow us to fully identify the mutual relationships, owing to the undirected network that was created in the ecosystem. Therefore the conclusions that can be reached given this limitation are more general and relate to the extent of the relations that exist within the ecosystem in general and not at the individual level between company i and company j. A refinement of the data requires further research that will allow an examination of the behavior of the network itself. In addition an analysis of the dynamics that characterizes these types of networks, in order to increase our knowledge about the development of such ecosystems and the factors that feed and preserve them over time. Also, continued research should examine the effects on the level of innovation of firms that belong to the cloud, an element that was not explored in this study. All these could have consequences for public policy that could encourage the emergence of similar systems. Still, there are several strong policy implications that flow from our study of the RAD ecosystem.

First, the inspiration for it was the vision of one man and the energy that propelled it was that of entrepreneurship and creativity. On the face of it, public policy played only a minor role. However, deeper analysis shows this conclusion is superficial.

It is straightforward to describe the Zisapel model for the RAD cloud. But clearly it is far from simple to implement it. This took single-minded vision and determination on the part of founder Zisapel. The key appears to us to be the personality and vision of Yehuda Zisapel himself. The architecture of the RAD cloud was clear to him from the outset. He was motivated not solely by financial gain but also by the desire to strengthen employment and wealth for his country, Israel. He understood that the driving force behind creative capitalism is not solely fierce competition but also constructive collaboration. In a sense, the RAD cloud embodies both ever-present Jacobs externalities (the creative constructive force of diversity in ideas and skills) and the existence of Marshallian specialization externalities, though it is clear that Jacobs externalities predominate.

A major contributor to the RAD cloud was the existence of a strong venture capital industry able to finance meritorious startups. While RAD provided some funding, most of the funding was external. Israel's VC industry was fostered by a unique government policy – a government VC fund known as Yozma. Yozma I was established by the Israeli government and offered matching funds to external VC investors. Within three years, ten more funds were established, with capitalization of over $20 m. each, and the VC industry took off, attracting many foreign-based VC funds who to this day predominate in Israel's VC industry. It is doubtful whether the RAD cloud could have grown so rapidly without strong venture backing.

Second, many of the RAD cloud companies were established in 1990-95. This period coincided with a massive immigration of human capital from the former Soviet Union to Israel. This in turn resulted from a fortuitous (for Israel) change in American legislation, which redefined Russian immigrants as economic, rather than political, emigres, thus subject to strict immigration quotas. One wonders whether America regrets this policy change, which could have brought enormous human capital to the U.S.

During the decade of the 1990's, some one million persons immigrated to Israel from former Russian nations, many of them highly educated. This influx of engineers and scientists provided the high-level manpower necessary to launch and grow startups. Without it, their growth and survival would have performed far more poorly. This serendipitous windfall of human capital played a key role. Failing such rare episodes of immigrant human capital, nations must have policies that create their own indigenous supply. It takes one, or perhaps two or three, entrepreneurs to launch a startup; but it takes tens and hundreds of engineers to grow them. Lack of adequate skilled manpower will make growing a RAD cloud unfeasible.

Third, it is hard to overestimate the importance of world-class technological universities. Israel has at least five such universities – Technion, Weizmann Institute, Hebrew University, Tel Aviv University and Ben Gurion University. Many of the RAD cloud founders graduated from these universities. They learned not only state-of-the-art technologies but also acquired a cultural value of launching their own businesses. Zisapel today complains that as the Russian émigré engineers are aging and retiring, Israel faces a serious shortage of engineers, as budget cuts hamper expansion of the number of graduates from leading universities.

Northern Finland provides a strong example of how a strong university can create an innovation cloud. University of Oulu is located in Oulu, a northern Finnish city of some 200,000 inhabitants, and one of the northernmost larger cities in the entire world. It has 15,000 students and graduates about 2,000 annually. Oulu Univ. of Applied Sciences is located in Oulu as well, with 9,000 students. Oulu has a sub-Arctic climate with an average temperature of 2 degrees C. In January the average temperature is minus 6 degrees. Despite this, graduates of Univ. of Oulu want to remain in the city and seek to start businesses. A thriving entrepreneurial culture has resulted, with focus on IT and medical technology. A leading technological university can be the core of a thriving entrepreneurial cloud, but of course this is not sufficient – other conditions must exist as well.

Boschma, et al. (2013) stress the importance of "policy intervention at the regional level", because "it is at this level where the main assets to diversify successfully are present."(p. 47). Their study shows that Spain is a prime example of such regional policies. If new industries are to emerge from old, as they must in a dynamic competitive global economy, new capabilities must build on existing old ones. This may require strategic government intervention; for example some of the RAD cloud companies benefited from R&D grants from Israel's Office of Chief Scientist, Ministry of Economy.

Within the RAD cloud, we have shown that networking, especially informal networking, played a crucial role. Asheim, et al. (2011) study the concept of CRA (constructed regional advantage), which is an effort to harness public policy to generate regional competitive advantage. They stress the importance of public-private partnerships, as well as "better anticipation and response" to system failures of "lack of connectivity in regional innovation systems" (p. 1133). While the networking and connectivity in the RAD cloud was largely based on acquaintanceship and common background, there are clearly ways that public policy can foster connectivity within regions.

The RAD cloud is a practical reality-based innovation. But is there theory underlying it, that can provide policy foundations? A first attempt at constructing such a theory is the study of Simmie (2012). Simmie concludes that "knowledgeable agents who are identifies as inventors and innovators may set in motion the creation of new technological pathways by consciously deviating from past practices and introducing and attempting to diffuse new technologies." (p. 770). This is precisely what Y. Zisapel fostered in the RAD cloud. Simmie suggests three policy paths: Displacement (subordinate technologies arise to displace existing dominant technologies; Layering (new technologies are added to those already existing) and conversion (old technologies are changed). (The author employs Denmark's wind power industry as a case study.) All three such effects exist within the RAD cloud.

Finally, an extensive survey of European innovation (the European Regional Innovation Survey, ERIS), revealed the crucial importance of network-building among firms and other actors in a regional innovation system (Koschatzky & Sternbeg, 2000). The authors stress the importance of linking networks within regions, with national and international knowledge sources. In a sense, the RAD mother ship facilitated such links, when the global RAD company became the 'eyes' of new startups, especially in identifying niche businesses and unmet needs in world markets.

Perhaps the main policy implication of our study relates to the creation of vibrant dynamic cities (for a study of Copenhagen, see Bayliss, 2007). Knowledge-based urban development is rapidly gaining momentum due its potential for inducing economic growth (e.g., Florida, 2002; Raspe & van Oort, 2006; Yigitcanlar, 2010) Creative people are drawn to such cities. And they are created by strong public policy, building physical, communication and educational infrastructure, with cultural events, great public schools, universities and pleasant environments. Tel Aviv is such a city. It is doubtful that the RAD cloud could have happened, without the ambience of Greater Tel Aviv and its attractive environment for creative people (Frenkel et al. 2013a,b). In the end, this was the main message of Jane Jacobs two decades ago. It remains highly relevant to this day.

In conclusion: Van der Panne (2004) frames 'agglomeration externalities' as Jacobs vs. Marshall. It may be more accurate to describe them as Jacobs *and* Marshall. At the same time, our study of the RAD cloud suggest that Jacobs externalities (diversity) are more powerful, if only because such diversity was the rationale for the existence of the cloud in the first place.

A key point – and the *raison d'etre* of the RAD cloud – is the benefits and costs of diversity, and the way Yehuda Zisapel from the outset found a way to maximize the benefits and minimize the costs. He maximized the benefits, by encouraging innovative engineers to launch their own startups when their radically new ideas did not fit within the focus of the mother ship RAD. He minimized the costs, by retaining highly creative people within the RAD cloud. The entire cloud was driven by Jacobs externalities – the desire to innovate in new diverse areas and the ability to do so within the existing ecosystem. But it also made generous use of Marshall externalities, by harnessing the ability to call upon existing local expertise and managerial ability, often informally, a crucial element in startup success.

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## 3.7 References


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## 3.8 Appendix

**Table A1:** Correlation Matrix

| | SNYRTY | COMRS | YEAR | RADIST | TECHNO | INTENS | BUISN | PERSON | PRC_EMPLY | COG | $COG^2$ | DIS | SIZE | COM_CONC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COMRS | .304* | | | | | | | | | | | | | |
| YEAR | -.041 | -.453** | | | | | | | | | | | | |
| RADIST | -.096 | -.314* | .035 | | | | | | | | | | | |
| TECHNO | -.224 | -.003 | -.163 | .037 | | | | | | | | | | |
| INTENS | .311* | .308* | -.262* | -.363** | .168 | | | | | | | | | |
| BUISN | .289* | .876** | -.357** | -.325* | .079 | .317* | | | | | | | | |
| PERSON | .298* | .167 | .073 | -.105 | .023 | .050 | .167 | | | | | | | |
| PRC_EMPLY | -.144 | -.065 | .348** | .060 | -.215 | .023 | -.037 | -.037 | | | | | | |
| COG | -.068 | .061 | -.273* | .010 | .546** | .275* | .220 | .120 | -.156 | | | | | |
| $COG^2$ | .010 | .335* | -.322* | -.220 | .147 | .295* | .246 | .034 | -.042 | .158 | | | | |
| DIS | -.011 | -.275* | .140 | .915** | -.078 | -.393** | -.289* | -.094 | .096 | -.140 | -.295* | | | |
| SIZE | .009 | .164 | -.427** | -.149 | .095 | .240 | .218 | -.056 | -.208 | .297* | .112 | -.151 | | |
| COM_CONC | .027 | .453** | -.086 | -.042 | .021 | .126 | .397** | .127 | .211 | -.044 | .040 | .021 | .073 | |
| RD_CONC | .536** | .379** | -.202 | -.271* | .020 | .788** | .332* | .122 | .133 | .131 | .155 | -.261 | .133 | .193 |

Notes: * Significant at the 0.05 level; ** Significant at the 0.01 level