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Knowledge flow in Technological Business Incubators: Evidence from Australia and Israel

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ABSTRACT

The study of the contribution of incubators to economic growth started to gain momentum in the 1980s, following the growth of the incubation phenomenon. While acknowledging the challenge of evaluating incubators' outcomes, we shift the focus from incubators' performance to their internal processes, in particular, the interrelationships through which the incubator stakeholders share knowledge. The literature suggests that small new ventures tend to fail because they lack managerial experience and ability to raise capital in an early stage. Incubators are expected to overcome these obstacles by offering experienced monitoring skills and by enhancing access to capital at a firm's early stage. However, empirical results of incubators' ability to perform their role are often contradictory, making policy makers question their effectiveness. We provide evidence from Australian and Israeli incubators. Our findings suggest that collaborations between incubatees, graduated incubatees, and incubator management increase the incubatees' knowledge of technology and market in both countries. Collaboration between incubatees and incubator management also increase incubatees' financial knowledge and their likelihood of raising capital. We also found that universities played a modest role as a source of new ideas for incubatees, but a more important role in later stages of incubatees' new product development processes.

1. Introduction

The study of the contribution of Technological Business Incubators (BIs) to economic growth started to gain momentum in the 1980s, following the growth of the business incubation phenomenon (Smilor and Gill, 1986; Temali and Campbell, 1984). In the 1990s the majority of studies analyzed data from the US, where technology clusters and technopoles evolved around technology generators such as universities, national laboratories, private research and development (R&D) laboratories and other high-tech enterprises (Markley and McNamara, 1995; Sherman and Chappell, 1998). In recent years an increasing number of studies have been conducted outside the US. For example Bøllingtoft (2012), Carayannis and von Zedtwitz (2005), Clausen and Korneliussen (2012), Kim and Ames (2006), Malek et al. (2014), Peña (2004), Ratinho and Henriques (2010), Sofouli and Vonortas (2007), Totterman and Sten (2005) and VonZedwitz and Grimaldi (2006) provide evidence from Canada, Denmark, Greece, Italy, Korea, Norway and Portugal.

In a broad sense, the literature suggests that firstly, small new ventures tend to fail because they lack managerial experience and ability to raise capital at an early stage (Allen and Rahman, 1985; Smilor and Gill, 1986). BIs stimulate the innovation process by creating a bridge between these market failures and improving access to capital at a firm's early stage, (Allen and McCluskey, 1990; Smilor and Gill, 1986; Tornatzky et al. 1996). Secondly, although the literature acknowledges the existence of knowledge transfer barriers (e.g., Hall et al., 2001; Siegel et al., 2003a), it also acknowledges the knowledge spillover from government funded research institutions to absorptive entities – high tech firms that reside in proximity to universities, some of whom are associated with BIs.

In part because universities have transformed from being conventional research and education hubs to being innovation promoting knowledge hubs (Youtie and Shapira, 2008), most of the readily available BI research arguably put the university in the center of their studies, and focus on the University–Industry Technology Transfer (UITT) where knowledge is transferred from universities to the individual firms inside incubators (hereafter called incubatees) (Debackere and Veugelers, 2005; Lumpkin and Ireland, 1988). However, as argued by Rothschild and Darr (2005) this research approach is insufficient because a university is only one of several

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potential knowledge sources for incubatees. Other external sources such as consultancy firms, customers and graduated incubatees may also have the potential to serve as significant knowledge sources. A growing body of literature acknowledges this variety of knowledge sources (Malek et al., 2014), and the networking behavior and collaboration practices of incubatees are increasingly often suggested to explain their success (Bøllingtoft, 2012; Ebbers, 2014). At the same time the importance of BIs' ability to provide incubatees with valuable networks is increasingly acknowledged (Peters et al., 2004; Schwartz and Hornych, 2008).

However, there is a lack of in-depth studies examining the different knowledge agents that surround the incubators, and the nature of knowledge that flows between these knowledge agents and incubatees (Bøllingtoft, 2012; McAdam and McAdam, 2006). The existing studies in this area typically rely on survey data and have a narrow focus on technological knowledge flows, particularly from universities (McAdam and McAdam, 2006). In this article, we aim to contribute in filling this gap in the literature by acknowledging that a university is only one potential source of knowledge for incubatees, and also by exploring the nature of other types of knowledge flows experienced by incubatees. As a consequence we ask the following explorative research question:

RQ: What is the nature of the knowledge that flows through the endogenous and exogenous interrelationships experienced by incubatees?

To explore this question we analyze BIs in Israel and Australia. These two OECD countries differ in their public/private knowledge sectors and in their incubation working models and government support. Consequently, Israeli and Australian BIs work in quite different environments. The Israeli high-tech industry is the most successful instance of the Silicon Valley diffusion model outside of North America (De-Fontenay and Carmell, 2004). It is ranked first among OECD countries in its business expenditure on R&D per GDP and it has higher ratio of VC investment to GDP than any other OECD country (Baygan, 2003). However, it has a declining R&D funding for its higher education sector. Australia is lacking in private investment in R&D. However, its higher education sector is a major R&D funding sector (Collier, 2007; Garrett-Jones et al., 2005), and it is ranked 5th among OECD countries, which makes this sector a major source of research activities (Australian Bureau of Statistics, 2008).

Regarding the differences in incubator models and government policies to promote incubators, Israel has the Technology Incubation Program (TIP) that was established in 1991 and has expanded significantly since, while Australia has no coordinated technology incubation program. In these two countries different incubation models are applied. Israeli incubator managements typically invest in their firms and provide very close monitoring services (even after the incubatee graduates), while Australian incubator managements are mostly providing a portfolio of services and charge the tenants for the services. They typically hold little or no equity in their firms.

The rest of this article is arranged in the following manner: we first provide the theoretical background for our empirical inquiry, by reviewing the relevant research literature. Following the review, we describe our research method, including the selected cases. In the following section we present our empirical findings. Our findings are then discussed in light of existing literature and based on this discussion we offer five propositions and an incubator interrelationship model that should be the basis for future research.

2. Literature review

Studies that analyze incubators can be grouped into two general areas. The first is studies of incubator performance and the second is studies of the internal processes within incubators. The first area is more common and it is often used by policy makers to evaluate incubators' impact in terms of knowledge and job creation. However, the second method is favoured by the authors, in part due the challenges of measuring incubator performance (Bergek and Norrman, 2008), but primarily due to the literature gap related to the incubation process itself (Hackett and Dilts, 2004b). In particular empirical research focusing on both technological and non-technological knowledge flows between incubators, incubatees and other entities is lacking (Bøllingtoft, 2012). We now review the parts of the literature that are relevant in relation to our research question.

2.1. Characteristics of BIs

It is agreed that a BI's major goal is to stimulate entrepreneurship and help incubatees in their early stages. The National Business Incubation Association (NBIA) defines BIs as a catalyst tool for economic development which provides entrepreneurs with a range of business resources and services (NBIA, 2007). Services provided by BIs are typically access to co-located premises at a low-priced rent (e.g., Hackett and Dilts, 2004b), access to networks (e.g., Peters et al., 2004), assistance in developing business and marketing plans (e.g., Grimaldi and Grandi, 2005), management assistance (e.g., Peters et al., 2004), administrative services (e.g., Grimaldi and Grandi, 2005), as well as financial services (e.g., Bøllingtoft, 2012). However, the services provided by incubators vary. Bruneel et al. (2012), for example, showed that old generation incubators tend to provide fewer services to their incubatees than new generation incubators.

This heterogeneity of incubator services gives rise to different incubator model classifications (Grimaldi and Grandi, 2005). Examples of how incubators have been categorized include:

- NBIA (2007) categorized incubators in five categories: for-profit property development ventures, non-profit development corporations, academic institutions, venture capital firms, and hybrids of the above.
- VonZedwitz and Grimaldi (2006) classified the incubators by looking at the services they provide namely: university, regional business, company-internal, independent commercial and virtual incubators.
- McKinnon and Hayhow (1998) classified business incubators into four categories that relate both to the services they provide and the incubatees' field of work: manufacturing incubators, technology incubators, targeted incubators (which assists start-ups from a specific industry), and mixed-use incubators that does not focus on a particular industrial sector.
- Grimaldi and Grandi (2005) classified incubators into four categories: business innovation centers; university business incubators; independent private incubators; and corporate private incubators.
- Etzkowitz (2001) divided incubators into university incubators and network incubators (with inter-networking and extra-networking).

The literature also suggests that the objectives of incubators vary. Bøllingtoft and Ulhoi (2005), for example, focused on the 'networked incubator', which was a for-profit collaborative incubator type, and suggested that the main objective of this incubator type was job creation. Another example is Allen and McCluskey (1990) who focus on not-for-profit incubators and suggest that the objective of these incubators is mainly related to regional development.

Typically BIs also have specific regional adaptations, in terms of organizational structures, operation policies and institutional affiliations, in order to fit into local needs (Kuratko and LaFollette, 1987). For example, in Belgium and Spain, the incubators' objective is often to attract branches of multinational firms, in Germany, incubators

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are often targeted towards establishing innovative start-ups, and in France and the Netherlands, the university incubator model is often promoted to commercialize research knowledge (Aernoudt, 2004). In summary, grouping BIs with different organizational structures, services provided, objectives and institutional affiliations creates some difficulties in generalizing knowledge about the incubator phenomenon and also creates difficulties in ascertaining the actual size of the incubator population (Hackett and Dilts, 2004b).

2.2. The relationship between universities and incubators

The university role has evolved from performing conventional research and education functions to serving as an innovation-promoting knowledge hub and generating economic development (Mian, 1997; Youtie and Shapira, 2008; Haoour and Mieville, 2011). By shifting the focus from traditional education to include R&D and resources allocation to knowledge commercialization, universities have become an important entity in generating technological development (Etzkowitz, 2004; Klofsten and Jones-Evans, 2000). Rothaermel and Thursby (2005a) suggest that incubatees may transform university knowledge into competitive advantage if they have the sufficient absorptive capacity. Incubators that reside in proximity to universities and research institutions are increasingly important and the university and the incubator relations may be used as a vehicle for technology and knowledge transfer (Rothaermel and Thursby, 2005b).

Proximity to universities or research institutions is valuable to knowledge-based firms (Smilor et al., 1988). The literature uses interchangeable terms to describe the areas around the universities (Swierczek, 1992), and frequently used terms to describe these areas include 'science parks' (McAdam and McAdam, 2008), 'technology parks' (Felsenstein, 1994) or 'technopoles' (Castells and Hall, 1994). The incubators working in this environment may for example be referred to as 'university science park incubators' (McAdam and McAdam, 2008). All university science park incubators share the characteristics of spatial proximity, in which tacit knowledge is shared between actors (Maskell and Malmberg, 1999). However, how incubators interact with universities varies. Some are focused on acquiring or sourcing knowledge from universities, while others are more interested in creating new firms, and some are simply real-estate focused (Hackett and Dilts, 2004b).

Several authors (e.g., Peterson, 1985; Smilor and Gill, 1986; Mian, 2006) have found a positive correlation between the presence of universities and performance of incubatees. On a more detailed level the findings of McAdam and McAdam (2008) suggested that the effective use of the resources of a university science park incubator '*increases as the lifecycle stage of the company increases*' (p. 277). It is also notable that some studies question the quality of knowledge that has been generated in universities. For example, using patent count and patent citation, Henderson et al. (1998) found that between 1965 and 1988, universities as a source of commercial technology reduced their rate of quality patenting in comparison to their patenting rate. Thus, the empirical evidence points in different directions, perhaps in part due to the heterogeneous nature of incubator objectives.

2.3. Networking and knowledge flows in incubators

Cooperation with external entities can give firms access to valuable information, knowledge and resources that would have been difficult or more expensive to build internally (Chesbrough, 2003). Thus, in general the importance of networks, cooperation and knowledge sharing with external entities is increasingly acknowledged both in the entrepreneurship literature (e.g., Bøllingtoft, 2012; Johannisson, 2000) and in the innovation literature (e.g., West and Bogers, 2014).

Incubators ability to provide opportunity for networking is often highlighted as one of the most important services provided by modern incubators (e.g., Bøllingtoft, 2012; Peters et al., 2004). This ability is suggested to be particularly relevant to Israel, where Rothschild and Darr (2005) describe the importance of informal incubators' networks. Similar to the triple helix literature (e.g., Etzkowitz and Leydesdorff, 2000), the incubator literature often addresses the network between incubators, government and universities. Etzkowitz (2002) for example argues that incubators are not an isolated entity, but rather a networked entity supported by regulatory environment and by government funding programs. Lofsten and Lindelof (2001) suggest that entrepreneurial firms located in incubators are more likely to have relationship with universities than other entrepreneurial firms.

Some authors also highlight the role of incubators in developing networks among incubatees (e.g., Bøllingtoft and Ulhøy, 2005; Bøllingtoft, 2012), typically an informal nature of networking (Lyons, 2000; Birley, 2000). Vanderstraeten and Matthyssens (2012) argue that by utilizing external and internal alignments an incubator can achieve service differentiation that can enhance the value of the incubatees, while Campbell and Allen (1987) suggest that internal networking among the incubatees inside an incubator is equally important as external networking and emphasise the synergy between incubatees.

But what is the nature of the knowledge flow in these incubator networks? Answering this question is not an easy task, in part, due to its association with tacit knowledge that is very hard to trace (Dosi, 1988; Pavitt, 1985, 1986). The traditional model to be used when describing BIs' knowledge flows is the linear model, in which new technologies originate from R&D activities in public funded research institutions, typically universities. These R&D results are then used to create a new product and/or service that is development and commercialization by incubatees (Hansson et al., 2005; Siegel et al., 2003a, 2003b; Massey et al., 1992).

Bullock (1983) offered an extension to the traditional linear model by distinguishing between firms providing 'soft' and 'hard' (typically production) services and by suggesting that the knowledge flow typically goes from the firms providing 'soft' services to the firms providing more 'hard' services. However, Westhead et al. (2000) failed to apply this model to UK science parks. In a more recent attempt Rothschild and Darr (2005) proposed a cyclical model in which knowledge flows in a loop through social networks between the entities. In their model, the university plays a dynamic role in knowledge transfer. They also suggested that incubatees may have other knowledge sources than universities, but they only tested the university linkage in their study.

Most attention in the literature is drawn to technology related knowledge. Only a few exceptions discussing business related knowledge exist. Hansen et al. (2000), for example, argue that those incubators that offer value through an extensive network of powerful business connections will provide its incubatees with a clear advantage that enables them to establish themselves in the market ahead of their competitors. Another example is a conceptual article by Howells (2002) where he points out that the advantage for an incubatee is its management network, which can be intrinsic networks between the incubatees (or even graduated firms), extrinsic networks with available investment resources, potential market opportunities and any other means that promote the incubatee in its development. However, there is a lack of empirical studies addressing the nature of the knowledge that flows through the endogenous and exogenous interrelationships experienced by incubatees (Bøllingtoft, 2012), and the aim of this paper is to contribute in filling this gap in the literature.

3. Method

Our approach in this study is to systematically identify the interrelationships in BIs, and try to understand how knowledge flows through these interrelationships, directly and indirectly

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through the BI's management. While a more common approach is looking at a linear process – primarily technological knowledge coming from the university – our approach looks at other knowledge agents that provide the incubatees with not only technological knowledge, but also other types of knowledge. All of which, can help incubatees to overcome the early stage common obstacles.

3.1. Research design

In order to answer the research question we conducted a qualitative research study based on eleven in-depth case studies. A qualitative approach was chosen since qualitative research arguably has advantages when the phenomenon to be studied is not well understood prior to the study, and when the development of new theory is a desired outcome of the research process (Yin, 2008; Johnson and Harris, 2003).

We purposely chose to focus on BIs in Israel (eight cases) and Australia (three cases). The comparison of Israeli and Australian BIs provides some economic commonality. Both countries are members of the OECD, both look to larger markets for export sales and both have strong R&D investments, albeit generated through different sectors. However, there are also some fundamental differences between incubators in Israel and Australia. The two countries have different policies to promote BIs and their incubators are based on different models. Israel has a strong business expenditure on R&D, while in Australia the government is the main source for R&D expenditure. Although 85 percent of the incubatees in Israel are funded by the government, the incubator management is typically a significant shareholder. The Australian incubator management typically provides a range of services such as office and laboratory facilities services, training and consultancy services to their incubatees. The incubators are largely supported by indirect government funds or by private investors, but the incubator management typically holds little or no equity in its incubatees.

Although the literature proposes other incubation models than those we chose to study (e.g. Carayannis and von Zedtwitz, 2005), we argue that the Israeli incubation model and the Australian incubation model represent the extremes in terms of equity and control over the incubatees. By studying these extremes, we expect that the findings would offer opportunities to learn and build generalizable theory about the nature of knowledge flows in different types of BIs (Eisenhardt, 1989; Eisenhardt and Graebner, 2007).

Out of the 25 BIs currently working in Israel, we selected eight incubators in different geographic areas (rural and urban) in all available industry fields (Cleantech/Environment, Machinery, Pharma including Bio-Technology and Medical Devices, Electronics/Software, Communications and Substances). Some incubators specialized in one industry field and some had a mixture of incubatees in different fields. In Australia, we identified five active BIs focusing technology businesses only. These incubators were technology focused, two of them were owned by universities. Since all the identified active BIs had incubatees in a mixture of fields, we chose three of the incubators that had the longest record and a high number of incubatees.

Our sample represents 30 percent and 60 percent of the current working BIs in Israel and Australia respectively. Over a period of four months in 2010, we conducted in-depth interviews with the CEOs of the eight Israeli incubators and with the CEOs of the three Australian incubators. The interviews were conducted in a semi-formal manner with a pre-defined set of questions (see Annex A). These questions related to the different incubators' stakeholders and the types of interactions at different stages in the incubate lifecycle. These stages – started from engagement with external sources to bring ideas to the incubators, from individual or universities/hospitals, to the stage of following the progress of the incubatee, some of which had graduated from the incubator.

Due to the inductive nature of this research, the questions had an open character, as the ambition was to get the interviewees to talk openly and freely about the subject, rather than confirming some pre-defined ideas. The question set was developed in English and was used for all interviews. Some of the interviews in Israel were conducted in Hebrew and were transcribed by the first author of this article, who is a native Hebrew speaker. All interviews in Australia were conducted in English and a full transcription was made.

In the following sections, we review the environment of BIs in Australia and Israel and we provide some descriptive statistics relating the incubatees' R&D fields in both countries, before we report our findings from the empirical investigation in Section 4.

3.2. BIs in Australia

Little research has been conducted about Australian BIs. The available research is focused on a general concept of technological parks (Phillimore, 1999) and on knowledge transfer from universities and public research organizations (Australian Government Productivity Commission, 2009; KCA-Knowledge Commercialization Australia, 2008). General purpose incubators were established in Australia more than 20 years ago. However, the focus has been on general business incubators, which are not necessarily related to technology. Australian technological parks evolved from its various states' interest in industry development, while the vision was more of a knowledge flow from universities that would be commercialized by park-based companies (Phillimore, 1999).

In the late 1990s, the states' pushed to extend the technology park model into urban redevelopment, transforming older industries sites into technology parks. The technological incubators reside in these technological parks and are more associated with links to universities, as geographically their development inclines towards the British science park, model which is centered on a university or other government funded research institution (Garrett-Jones, 2004). Nevertheless, technological parks may include government funded seed programs, mature technological firms and also technological incubators; thus the generalized nature of the technology park makes it difficult to measure performance and apply long run government policy to foster technology development (Joseph, 1994). Australian technology business incubators, in most cases, have a private model in which the incubator management offers services to its incubator firms and holds little or no equity in its firms. Thus the incubators' revenue is mostly generated from tenants' payment for their services.

Over the years, many programs have been created in Australia by state and federal governments, targeting knowledge intensive businesses, all of which were not directly established to support incubators, but rather to stimulate research activities in Australian businesses. The exception is the Australian Federal Government program, Building on Information Technology Strengths (BITS), which was established in 1999 to support technology business incubators. This program allocated AU$158 million over five years to promote innovation in the information industry, to establish information and communication technology (ICT) incubators and to address venture capital market failure.

Although the BITS incubator program was originally scheduled for completion in 2003–04, an evaluation report concluded that further funding was required to help with the long-term sustainability of the incubators and their incubatees. In 2004, the Australian Government extended funding to the better-performing BITS incubators until 2007–08 with a further AU$36 million under the ICT Incubators Program (ICTIP). Eight out of the eleven incubators received funding till 2008; however, in 2008 the Australian Government stopped

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funding the ICTIP program. Lerner (2009) provides some reasoning by criticizing the management of these incubators, claiming that by forcing young firms to purchase the incubators' own overpriced services, the incubator captured majority share that should have gone to the entrepreneurs.

In Australia almost 42 percent of incubatees are in Software/IT, 33 percent are in Engineering and 25 percent are in Life science. These proportions of R&D fields were represented in this study as it will be discussed in Section 3.4.

3.3. BIs in Israel

As discussed in the Introduction, the main reason for the initiation of business incubator programs is the recognition of a common failure of new ventures which is due to capital scarcity and lack of management and marketing experience. However, in Israel, in the 1990s, the reason for establishing the Technology Incubator Program (TIP) was driven by the labor supply side, because although Israel had a growing high-tech industry, it could not provide enough jobs for the rising number of educated Scientists & Engineers (S&E), in particular S&E arriving in the migration cohort from the former Soviet Union. The first objective of the Israeli technological incubator program was thus to assimilate these S&E in the labor market in an environment in which their knowledge could be leveraged (Avnimelech et al., 2007).

Today, even though employment is still a major objective for the technological incubator program, in many cases incubatees that are in the incubator program (thus supported by government funds) have only 2–4 employees and projects are outsourced ad-hoc to subcontractors. Unlike other incubator programs, the Israeli government absorbs a large proportion of these firms' risk while allocating significant financial assistant vested over two to three years for firms working in the technology incubator program. Avnimelech and Teubal (2006) claim that without the Israeli government's initial investment in these projects, the incubator program would not have been ignited and the private investments that they have successfully attracted, would have been directed elsewhere; however, this is in contrast to the findings of studies from other countries. For example when studying incubatees in Norway Clausen and Korneliussen (2012) did not find any significant correlation between incubatees' financial capital and their ability to get their products and services faster to the market.

The total budget for the two year term ranges between US $520,000 and US$900,000 for each incubatee. The budget for Biotech incubators may reach up to US$2,100,000 for three years, of which 85 percent is a grant or a soft loan under the government's TIP program (Israeli Ministry of Industry Trade and Labor: Office of the Chief Scientist, 2013). A top-up of at least 15 percent is provided by the incubator management which is also responsible for office and laboratory space, professional guidance and administrative assistance. Most Israeli incubators are privatized, which means that although the government is a major source of funding, it does not hold equity in any incubatees, and the incubator's management shares the incubatees' equity with the incubatees' entrepreneurs.

Fig. 1 presents the distribution of the Israeli incubatees by R&D fields according to the available information in the Israeli Ministry of Industry Trade and Labor: Office of the Chief Scientist (2007). As it is shown in Fig. 1 almost 40 percent of the incubatees are in medical devices, 19 percent are in bio-technology and 19 percent are in software, while other fields of R&D are less dominant. These proportions of R&D fields were represented in this study as it will be discussed in the following section.

Since the program was established in 1991, the total government investment was over US$600 million for incubatees across 25 centers operating throughout the country. 65 percent of graduated incubatees managed to raise over US$3 billion (Israeli Ministry of Industry Trade and Labor: Office of the Chief Scientist, 2013). After more than 20 years of an active technological incubator program, it establishes over 70 new start-ups each year and is positioned as the first 'manufacturer' of start-ups in Israel (Avnimelech and Teubal, 2006). By the end of 2006, over 1000 incubatees had graduated from the incubators. Of these graduates, 57 percent have successfully attracted private investments. Since the beginning of the program, 41 percent of the graduate incubatees are still in business (Center of Incubators for Technological Initiative, 2006).

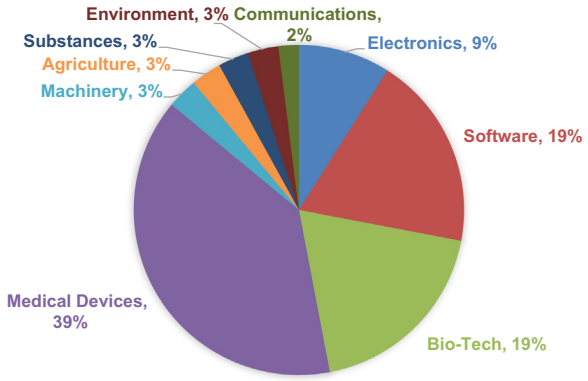

Fig. 1. Israeli incubatees, by R&D fields. Source: Israeli Ministry of Industry Trade and Labor, 2007.

Table 1
Australian incubators characteristics.

Incubator's number	Geographical proximity to university (less than 20 km)	Specialization (according to the incubators' web site)	Years of operation
1	Yes	Life science, IT and engineering	10
2	Yes	IT	5
3	Yes	IT/Software	10

3.4. Australian and Israeli incubators – incubatees characteristics

In this study, we interviewed eight technological incubator managers in Israel and three technological incubator managers in Australia. In the Australian sample there are 66 incubatees working under the three incubators. Table 1 provides the Australian incubators' R&D field and some of their characteristics. We can see that Australian technological incubators are relatively young organizations, in the sphere of general incubators in Australia that were established more than 20 years ago.

Fig. 2 shows that the main focus of these incubators is in software development, followed by engineering and life science. Although not all the incubators have similar incubatee portfolio fields, all incubators have a strong IT/software field. We attribute the strength of the IT/software field to the relatively low initial costs required to develop a prototype in that field before joining the incubator.

Table 2 provides the Israeli incubators' R&D field and a few of their characteristics. It is apparent that most incubators in our sample do not reside in proximity to a university. However there are 25 incubators and only 7 research universities in Israel, a small country in its geographical size, therefore some incubators would be co-located and some are further away. Most incubators have a long history, around 20 years of working records experience under the same incubation program, therefore they provide substantial management ability to help incubatees.

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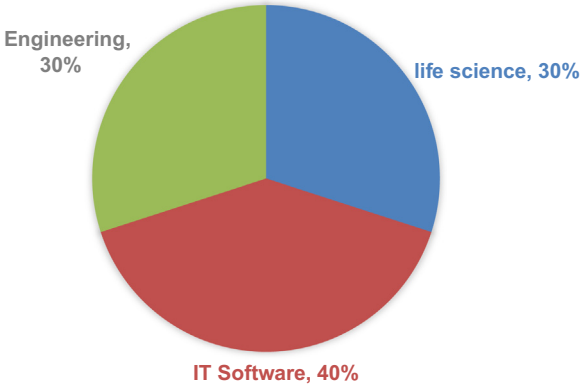

Fig. 2. The Australian Sample, by incubatees' R&D Fields.

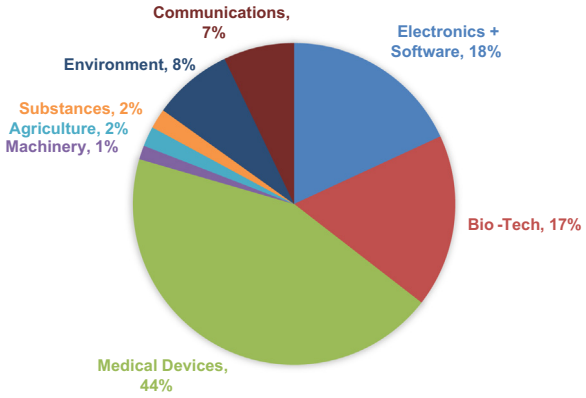

Fig. 3. The Israeli sample, by incubatees' R&D fields.

Table 2
Israeli incubators characteristics.

Incubator's number	Geographical proximity to university (less than 20 km)	Specialization (according to the incubators' web site)	Years of operation
1	Yes	Electronics, medical devices and Biotech.	21
2	No	Life science, healthcare and cleantech	21
3	Yes	Biotech	8
4	No	IT and Medical Devices	9
5	No	Medical Devices and biomaterial applications	19
6	No	Information Communication Technology (ICT)	9
7	No	Medical devices and biotech	20
8	No	Medical devices and life science	21

In Fig. 3 we present the Israeli incubatees in our sample, the incubators' specialization represents the general population of incubators. It is apparent that the leading R&D field is medical devices where incubatees would tend to use hospital and university facilities in the development process. Comparing to Fig. 1, the general incubatees' population and Fig. 3 the incubatees' fields of research in our sample, one can see that the sample is close to representing the actual incubatees' fields as provided by the Israeli Ministry of Industry Trade and Labor in 2007.

The data of incubatees' fields (Figs. 2 and 3) portrait two different strengths. Australian incubatees tend to be in fields that typically require low seed investment, such as software/IT and engineering (75 percent of Australian technological incubators are in these fields). In Israel, the dominant field is medical devices, a field that typically requires a high investment with high risk. As the Israeli government provides 85 percent for each incubatee's funding, it allowed this field to grow over the years. The fact that each country inclines to different fields of R&D means that they may require different knowledge sources. For example, we expect that an Australian incubatee would rely less on the universities as a source of technological knowledge than an Israeli incubatee, while as for financial and market knowledge, we expect both countries' incubatees to rely on similar knowledge sources.

4. Findings

We started this article by asking what is the nature of the knowledge that flows through the endogenous and exogenous interrelationships experienced by incubatees? On the whole our findings suggest that incubatees' endogenous and exogenous interrelationships take different forms depending on whether it is technological knowledge, market knowledge or knowledge about financial resources that is being transferred or shared with other entities. Thus, based on this empirical observation we call the different types of interrelationships for 'knowledge bearers', and we divide the knowledge bearers into three types: (1) technological knowledge bearers, (2) market knowledge bearers and (3) financial resources bearers. In the rest of the findings section we report the detailed findings related to the nature of knowledge that flows through these three types of knowledge bearers.

4.1. Technological knowledge bearer

Our findings suggest that technological knowledge is critical for an individual incubatee and for the incubator. In our cases technological knowledge was needed to search for ideas, and to carry out the new product development (NPD) and new service development (NSD) processes. In this knowledge bearer, we identified two knowledge sources: university knowledge sources and know-how knowledge sources.

4.1.1. University knowledge sources

We found that using the universities as a source of ideas involved clear evidence of organizational conflicts facing incubator management both in Israel and Australia. In the Israeli instance when interviewing incubator managers from incubators located in proximity to universities, it was noted that although they regularly scheduled meetings with Technology Transfer Office (TTO) officers and were actively looking for knowledge generated by nearby universities, the process of bringing ideas to the incubator required a long process of negotiations and legal correspondences. One CEO related to this problem in the following way:

> *"We have regular contact with local university and hospital staff but the number of licenses signed is declining. The conflict between our needs as an incubator and the universities attitude toward Intellectual Property (IP) is the main issue. Although we would like to be able to work more closely with them, applications from individual entrepreneurs are more than enough, with 100–150 presented each year and 5–6 selected."*

Another CEO highlighted the flux of ideas coming from individual entrepreneurs rather than from Publicly Funded Organization (PROs):

> *"On average we receive 150–200 applications each year and select 5. Our most effective marketing tool is our website which attracts the majority of the applications. However we still think it is*

important to participate in conferences and maintain contact with universities."

Thus, since each incubator received hundreds of new venture applications per year from individual entrepreneurs, and because of the long process of IP negotiations, the university became an insignificant source of ideas for the Israeli incubators in our sample.

In the Australian instance, out of the three Australian incubators in our sample, one incubator CEO argued that his incubator did not aim to commercialize ideas from universities. Only ideas coming from independent entrepreneurs were screened:

"Our state universities have already internal 'incubator like' entities, thus our incubator does not provide any competitive advantage to attract universities' knowledge."

Another Australian incubator manager provided similar reasons, referring to long legal negotiations that limit the number of start-ups emerging from universities, as was also pointed out by the Israeli incubators' managers.

"Independent entrepreneurs generate more business ideas, more often, with much less effort than trying to extract them out of universities."

The CEO of the university owned incubator in our sample stressed that in his incubator they saw the link with the university as a source of support for individual entrepreneurs' development processes. The role of the incubator management was to provide the mediation between the incubatees and the university, rather than bringing out ideas from universities to the incubator:

"We are focused on providing independent entrepreneurs with the link with to the university's experts to leverage the university's knowledge in specific fields of interests, rather than commercializing the university knowledge, which is handled by the university's TTO office."

These evidences suggest that the universities were non-preferable sources of new ideas, both for Israeli and Australian incubators. However, it is notable that the universities were regarded as a significant knowledge sources during the incubatees' NPD and NSD processes. In this stage our findings suggest that universities offered valuable R&D support, provided laboratories facilities, as well as consultancies services by universities' experts. One Israeli CEO for example described their regular use of universities facilities as follows:

"We do have here some dentistry equipment for example, but if needed heavy equipment is needed, our firms rent hours in universities' laboratories by the hour. The same is done for with other R&D processes, if a firm doesn't think it need a full time engineer, it can outsource the development process to an independent engineer or a university consultant. Most of our R&D is conducted outside; you cannot really do much in house with our budget per firm."

Another Israeli CEO indicated the importance they saw in the ongoing involvements of university experts:

"We use consultants from universities for evaluating new tenants when the technology is not in our area of expertise. At times they become involved in the firm once they enter the incubator, sometimes even chairing them."

Also in Australia, all our interviewees reported that universities were a knowledge source, either as a result of simple access to facilities, or by providing experts, as was noted by one of the interviewees:

'One of our selling points for independent entrepreneurs is having access to university experts. Our strong relationships with universities allow us to provide this advantage to our firms.'

4.1.2. Know-how knowledge source

The other knowledge source identified in our sample is the 'know-how knowledge source'. This knowledge source may be described as the way in which informal knowledge is shared between incubator stakeholders. One Israeli CEO described it as follows:

"Almost all the firms that have graduated from our incubator have found office space close to the incubator. This makes it easy for us to keep an eye on them and conduct meetings. More importantly I think they like to be close to access continued support."

All Israeli interviewees noted that they encourage informal interactions between incubatee employees, in order to expose them to their peers' work. One CEO gave an example of how tenants view the spatial proximity:

"A firm that recently joined us had staff living some distance away. They wanted to rent an office closer to home, but we insisted they work in the incubator. It was hard initially to convince them of the benefits of being located with other firms. However, after a year they realised the huge advantage of sharing challenges and problems with fellow tenants, in the corridor or over lunch in the shared kitchen, to help formulate new ideas and solutions."

Another CEO described the incubator management's active and passive roles in helping the information to flow between tenants.

"It is important that the firms working alongside each other understand the business and the individuals involved. There is great advantage to be gained from mixing together and looking for synergies. We encourage this by trying to create the feeling of one big firm rather than multiple small ones, through sharing facilities and conducting networking events. In addition we facilitate the direct connections, A recent example was one of the firms staff approached me with a question and I was able to direct him to one of the other firms that had solved a similar problem last quarter. My involvement was modest, but it was a significant benefit to the firm."

This example illustrates how one incubatee can provide a valuable advice to another incubatee through informal connection between the tenants with minor mediation by the incubator's management.

In Australia, more tangible know-how was shared between incubatees. Such collaborations were made only because the tenants know about their peers' expertise, which allows them to collaborate in order to address customers' needs. One interviewee explains:

"Each year around 30 percent of our clients work together to create new products for their customers. Recently we had two of our firms collaborate on a joint tender bid. The combination of their expertise, one in medical device design and the other in wireless technology, meant they could satisfy the technical requirements of a leading Australian life sciences business. In addition, one of the firms was larger and listed on the Australian Stock Exchange, offering additional credibility to the bid. The combination of the strengths of both firms meant a successful outcome."

Technological expertise can be shared between incubatees even after graduating from the incubator; for example, an Australian interviewee related to collaboration between two graduated tenants who formed a third firm and came back to the incubator. This example illustrates not only how the incubator provides the pool of knowledge that can be utilized even after graduation, but

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also how it provides a platform for firms to return and create a new joint venture.

"Over the years we have seen new businesses built with staff from alumni firms. During their time here in the incubator they get to know the capabilities and experience of other firms staff members. Because the skills required for the initial stages of product development are often different than those required at a later stage in a business, these specialists are often available after a period. Recently a new firm has recruited several engineers from an alumni firm who had expertise in wireless product design. Their familiarity with the product launch phase and relationships with each other has made a significant contribution to the new firm."

Another source of know-how is the shared information about recommended subcontractors. In many cases, while the incubatee does not have enough resources to conduct most of its initial R&D activities, many small projects are outsourced. Peers in the incubatees share valuable information about potential subcontractors. For example one interviewee in Israel had noted that:

"With our budget we cannot conduct all the work in-house, we rely on outsourcing our R&D projects, we have our people that we work with outside the incubator, it's easy, fast and saves a lot of efforts to our firms."

An Australian interviewee talked about using a mechanical prototype manufacturer whose services are often used by the incubator firms, saying:

"Working with a contractor that the incubator has worked with before makes the process easier to manage as they understand the needs of incubator firms."

4.2. Market knowledge bearers

In the Israeli cases, because the incubator management owns a significant portion of equity in its incubatees, the incubator management's goal for each incubatee is to reach a 'fundable milestone' in order to be able to find new financial resources following the joint government and incubator financial support. This fundable milestone can be either a product or an accomplishment of a significant trial, depending on the industry in which the incubatee is working. One interviewee explained:

"Achieving a milestone that allows us to raise further capital before leaving the incubator is critical to our continued growth. The milestone must both raise the value of the firm so the initial investors see their stake multiple several times and attract investment from angel investors or a firm in the field."

Another CEO specified that there is no one milestone for an incubatee:

"In the medical field the fundable milestone we typically aim for is animal trials. Even if we are able to secure a third year of funding though the incubator, we target completion of the clinical pilot in two years or less. The results are then used to approach potential partners to interest them in collaboration."

One Israeli incubator even had an independent consultancy business unit that supported the incubatees from their early stage in the incubator.

"We provide a business advisor, technology support and capital raising advice. We see our primary role as incubator manager, to "force" the firm's managers to "think business".

Other Israeli incubators provided less intense consultancy; however they nominated an external chair person with a specific experience in the relevant field for each incubatee and had regular meetings to review their incubatees' progress.

"We have two programs that monitor our firms on a monthly basis. The first program is undertaken by a technology consultant that checks on the R&D progress against plan to identify problems early. The second program reviews the progress of the business. It consists of the incubator's CEO, the business development manager, the operations manager and the technology manager. The outcome is a list of actions for the next month and individuals are assigned to each."

Unlike in Israel, an incubatee in Australia typically enters the incubator in different stages in the market and R&D progress. Some will a have strong and established prototype with a less robust business plan, whereas others may enter with an established understanding of their market, but in an early stage in their R&D, or any other combination between these market and technology vectors. Australian incubators are expected to support the incubatees in their different stages. All Australian interviewees noted that accepting a firm to their incubator required having a business plan. However, as a result of their work in the incubator, the business plan may be modified following ongoing consultancy with the incubator's management. One interviewee explained:

"In general, companies entering our incubator must have a prototype of the product and a deep understanding of the market. Those that approach us with only a business plan are required to complete an extensive application form. If they are accepted then we will spend up to six months helping them do market research, in which we will identify target markets, find the first set of potential customers and validate the product idea."

The market knowledge bearer also incorporated informal knowledge, typically shared between incubatees that work in similar fields. Most Israeli interviewees noted that their incubatees' board of directors had regular board meetings, every one to two weeks, to maintain close managerial monitoring. Unlike the Israeli incubatees that are obliged to develop a particular product or service, for which they received government and incubator funding, the Australian incubatees may shift their core development to a different product or service. Such change or branching of a product line was given as example by one Australia CEO who described the following scenario:

"We had one firm that collaborated with another firm in our incubator to create a solution for a customer. The collaboration was for a software product applied on a hand held device. While one incubatee provided the software for the potential client, the other incubatee provided its skills in hardware design. They collaborate because they knew each other and that a link was made instantly."

4.3. Financial resources bearer

Our findings suggest that one of the key support mechanisms provided by incubators is the provision of assistance to secure financial resources. The incubator management provided better estimation of novel technology's success by screening the procedures of the firms that are joining the incubator and by compensating for the lack of incubatees' managerial experience by using its networks and experience to link its incubatees with potential financial resources.

In parallel to securing financial resources is assisting incubatees in financial planning and management One example from an Israeli CEO was that even though the government funding is for at least two years, the business plan is written for a fundable milestone after the first year in order to leave some time in the second year to raise money:

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"Although we work with our firms in most cases for two years, we only invest in firms that can reach a point of development within one year that could justify raising further funding. The capital raising process takes time, so from day one we are working towards that milestone. Our inputs include creating an updated business plan, undertaking market validation, implementing a R&D plan, recruiting a chairman and scientific advisory board, helping the firms with the process of filing patents and creating the initial brand and website."

In both countries, the interviewees noted that they used their networks on a regular basis to introduce their incubatees' products or services to potential investors. One Australian CEO noted for example that he regularly meets with VCs and angel investors to discuss new and follow-on investment opportunities:

"In the incubator we have a member of staff dedicated to raising capital for our firms. He will visit angel investors and venture capital companies on a regular basis to provide them with introductions and updates on our current firms and those entering our pipeline. The global financial crisis has reduced the amount of venture capital investment, so we have relied more on grants and angel investors."

"The relationships between our firms continue after they graduated. Knowing each other's capabilities results in alumni being a good source for introducing potential customers and investors. That is not a rare occasion and it is of great benefit to our active firms."

For an Israeli graduated firm, although it leaves the incubator premises, in many occurrences the incubator management is still very involved because it still holds the firm's shares, thus the graduated firm still benefits from the incubator's financial networks for its further development. In fact, all Israeli interviewees noted that they would see no difference between an active incubatee and a graduated incubatee in terms of the incubator involvement in their management and support. Even when the firms graduate from the incubator the incubator management will put its effort into helping the firm to reach a desirable exit strategy if they have not been sold to a third party. One CEO commented that counting only the active incubatees is not a true reflection of the circumstances:

"We are often asked how many firms are currently in the incubator. This is less relevant than asking how many firms are we involved with. We remain shareholders and board members long after they leave the incubator space and thus our interest in all our firms is ongoing."

The incubator management is not the sole source of knowledge concerning financial opportunities. Because incubatees are clustered, the available information about potential funding is often shared directly between the incubator tenants or through the mediation of the incubator management. This information is very valuable for incubatees because it saves, in most cases, unavailable resources for searching for new funds, thus provides the incubatee with a clear advantage. For example, as was described by one interviewee:

"People meet and talk, eat lunch together and exchange knowledge. They will notify each other if there is a European fund that they may be able to access or if there have found a very good regulatory consultant others can use. The information gathered by each tenant can be very important to the others."

5. Discussion

Due to the inductive and explorative nature of this study we are not able to test theoretical relationships based on our findings. However, our empirical findings do provide a solid basis for discussing and developing a new theory, in the form of theoretical propositions. These propositions, that should also serve as tentative managerial prescriptions, and in turn should lay the foundation for future research on incubator interrelationships, are now discussed.

5.1. Technological knowledge bearer

Aligned with McAdam and McAdam (2008) our findings demonstrate that incubators have several sources of technological knowledge and utilize different ones at different stages in their incubatees' lifecycle. Based on our findings we have categorized the technological knowledge bearers in two sources, university knowledge sources and know-how knowledge sources.

5.1.1. University knowledge sources

On the whole, our findings confirm and deepen the findings of prior research by differentiating between two stages of which incubators and incubatees collaborate with universities: firstly an early stage of idea generation; and secondly a later stage of NPD and NSD. Our findings suggest that the universities play a very important role in the NPD and NSD processes by providing facilities, expert consultancy and even employees to the incubatees. However, in the early stages of idea generation our findings suggest that universities play a modest role.

This observation may be explained by organizational conflicts between universities and incubators. Siegel et al. (2003a) suggest that knowledge transfer barriers are based on cultural organizational differences and incentive structures. Universities are typically large risk averse organizations with large budgets, whereas incubatees are small organizations willing to take risks (Haoour and Mieville, 2011; Markman et al., 2005). Lewis (2008), (2001) argued that while a public research organization's goal is to maximize their revenues from knowledge commercialization generated in their organization, the incubator's goal may be different, namely, to produce successful firms that will leave the incubation program freestanding. It is likely that these differences hamper knowledge transfer, especially in the early stages of idea generation.

Based on this discussion we offer Proposition 1 and 2:

P1: *Universities play a modest role as a source of new ideas for incubators and incubatees.*
P2: *Universities play an important role in the later stages of incubatees' NPD and NSD processes.*

5.1.2. Know-how knowledge source

We describe the know-how knowledge source as the way in which informal technological knowledge is shared between incubator stakeholders. The literature often distinguishes between explicit and tacit knowledge, where explicit knowledge can be codified and transmitted in a formal, systematic language and does not require direct experience of the knowledge that is being acquired, while tacit knowledge cannot be communicated in any direct or codified way (Howells, 2002). Our findings suggest that know-how knowledge is mostly of the tacit type. The way to acquire tacit knowledge is to take a non-structural method, like experience, that can wear a form of learning by doing (Arrow, 1962), learning by using (Rossenberg, 1982), and learning by hiring (Song et al., 2003). As was noted by Maskell and Malmberg (1999), the more tacit the knowledge used, the more important is the spatial proximity between the stakeholders taking part in the knowledge exchange.

The importance of tacit know-how for incubatees may explain why graduated firms in most of our cases continued to stay in proximity to the incubator after graduation. Our findings confirm that geographical proximity is critical for incubatees both during

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their period in the incubator and after graduation, because they keep using their familiar knowledge sources to find technological solutions and experts during the NPD and NSD processes.

Based on this finding we conclude that the know-how shared between incubatees, directly and indirectly through the incubator management mediation, provides the incubatees with an immediate source of knowledge that is rarely to be found when working as a standalone company. This know-how is very valuable to a firm in its early stage; it saves time and financial resources in order to allocate an appropriate technological expert or a company to enter into agreement with. By so doing, the incubatee can reduce its costs and get to market faster, which can provide them with a competitive advantage compared to other start-ups that do not have the interrelationship mechanism. Hence, we offer P3:

P3: *The technical tacit know-how shared between incubatees, and between incubatees and graduated incubatees, is valuable both for incubatees and graduated incubatees.*

5.2. Market knowledge bearers

Success in technology markets does not come easily and relatively few small firms survive (Hicks and Hegde, 2005). Although the literature often reports a high survival rate for incubatees, the evidence is anecdotal and difficult to compare. One of the reported obstacles that an incubatee faces is its misunderstanding of its market which can be attributed to the entrepreneurs being technology averse (Vohora et al., 2004).

All incubator managers in our sample emphasized the fact that their purpose was to make the incubatees freestanding before leaving the incubators. In the Israeli cases, they did that by monitoring the incubatees' compliance with the predefined business plan and timeline as defined in the incubatees' roadmap. In the Australian cases this was done by close monitoring and by providing management advice during the incubation period. In the Australian cases, our findings also suggested collaboration between two incubatees could allow both firms to 'tailor' a product to a client by utilizing both firms' expertise.

Based on our findings we argue that the market knowledge bearer is very important for incubatees. Understanding the market needs in a firm's early stages seems to be critical for the firm's survival and can be achieved either by collaborations conducted between incubatees or by the marketing consultation provided by the incubator management team. Our findings confirmed the findings of Monck et al. (1988) that external managerial advice and support for a business are crucial in its formative years. We conclude that although the incubator models in both countries were different, the close monitoring support for incubatees in an early stage allowed them to gain market knowledge. We suggest P4:

P4: *Collaboration between incubatees and between incubatees and incubator management increase incubatees' market knowledge.*

5.3. Financial resources bearer

The literature stresses that one of the most significant obstacles an incubatee faces is a lack of access to financial resources. This occurs for two reasons: firstly, it is difficult to forecast novel technology success (technologically and market-wise); and secondly, in most cases technological entrepreneurs lack managerial experience (Westhead and Storey, 1994). These two reasons result in a high risk venture for investors.

Although it is out of this article's scope to discuss the venture capital (VC) industries in both countries such as capital market structure and regulations as enablers of VC industry development (Black and Gilson, 1998), it is impossible to ignore the specific VC programs and key players in the VC industry in these countries.

During 1993–97 in Israel, a successful government VC program named Yozma triggered the creation of a domestic VC industry (Avnimelech and Teubal, 2008). Yozma created a solid base for a competitive domestic VC industry that invested in Israeli early stage high-tech start-ups, which together with the incubator program had a significant impact on its high-tech industry (Avnimelech et al., 2007). During the 1990s, the Israeli VC industry became the largest VC industry in the world in relative terms (VC expressed as percentage of GDP) and only second in absolute terms after the United States (Avnimelech and Teubal, 2006). According to OECD reports, it has the highest level of venture capital as a share of GDP of any other OECD country (Baygan, 2003).

As for Australia, there were over 30 active VC firms in 2010 that had funded over 400 high-tech firms. These funds have increased their investment each year during the last decade. In 2010, Australian VC had around AU$2.5 billion under management, which is 0.2 percent of the Australian GDP (Australian Private Equity & Venture Capital Association Limited – AVCAL, 2010).

In this VC industry, incubatees need to stand out in order to attract funding. One difference between the Australian and Israeli incubators from the financial perspective is that while the Israeli incubatees enjoy guaranteed government financial support and complementary funding from the incubator investment group for at least the first two years, Australian incubatees rely mostly on angel investors, general government programs that support innovation or entrepreneurs self-funding projects. Therefore the search for funding is conducted at different stages for each incubator type.

Having said that, our findings suggest that all interviewed incubator managers in both countries noted that the search for the next funding source begins at a very early stage of the incubatee's lifecycle, by preparing the firm to reach the next 'fundable milestone' in order to be able to attract further funding. In practice business incubator management screens firms that apply joining the incubator, and this screening process signals a prospect success to investors. The incubator management also uses their networks and experience to link their incubatees with potential financial resources. The 'fundable milestone' term was often used to highlight the fact that the objective of each incubatee is to be able to graduate with either sufficient revenue or to be venture backed. We see great similarity between the coined term 'fundable milestone' and Hackett and Dilts (2004a) 'inspection points' where they propose that processes of incubators' activities can affect their outcomes by managerial development of 'inspection points'.

We conclude that through the financial resources bearer the incubatees not only benefit from the incubators' management networks to improve their chances for initial investment or for further investments, allowing more exposure to investors, but also benefit from the shared financial information between incubatees in both incubation models. Hence, P5 is offered:

P5: *The screening process of incubatees and the collaboration between incubatees and between incubatees and incubator management increase incubatees' financial knowledge and their likelihood of obtaining financial resources.*

The following table summarizes the similarities and differences between the countries for each knowledge bearer Table 3.

5.4. Incubator knowledge flow model

To conclude and summarize our findings and associated propositions we now present a new incubator knowledge flow model.

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This model is based on our findings and also inspired by Porter's (1985) Horizontal Strategy theory. The Horizontal Strategy relates to the synergy between decentralized business units in the organization, which create the organization's competitive advantage. The purpose of the Horizontal Strategy is to enhance differentiation in virtually any activity in the value chain, improve the time to market and reduce costs (Porter, 1985).

Although Porters model relates to the interrelationships between different business units in the same organization, we argue that our findings demonstrate that the model may also be relevant to incubators if we perceive the incubator as an organization and its incubatees as its business units. According to the Horizontal Strategy the objective of the business should encourage collaborations between its business units in order to improve the organization's competitive advantage. Hence, this approach helps us to demonstrate how the interrelationships between the incubatees may help the incubator to improve its performance.

In our proposed model (Fig. 4) we call the interrelationships between incubator stakeholders 'knowledge bearers', and as a consequence of our empirical findings we distinguish three knowledge bearer types: technological knowledge bearer; Market knowledge bearer; and Financial resources bearer. These three types of knowledge bearers are illustrated as three blocks in the outer part of the model (Fig. 4), and in each block we have entered the corresponding propositions (P1–P5). In the model (Fig. 4) we denote the direct knowledge bearers between incubatees and graduated firms by thick arrows and the indirect knowledge bearers between incubatees, graduated firms and incubator management by thin arrows.

This proposed model expand the narrow focus on technology knowledge in prior research, and suggests that also other knowledge bearers are relevant and may help incubatees to be more competitive and faster to market with their products and services.

6. Concluding remarks

In this article we shift the focus in the existing incubator research from incubator outcome to the processes and interrelationships within incubators. Based on our empirical findings in eleven case studies, eight in Israel and three in Australia, the interrelationships were classified into three knowledge bearers used by the incubator stakeholders: (1) technological knowledge bearer, (2) market knowledge bearer and (3) financial resources bearer.

We found that the technological knowledge bearer was not limited to the universities as often is suggested in the extant literature that addresses the university-incubator technology transfer in a linear model. Our findings suggested the technological knowledge bearer to be a more comprehensive source of knowledge that incorporates not only the universities but also other sources of knowledge such as other incubatees and graduated incubatees.

We found that the shared technological knowledge between incubatees generates collaborations that create new products and services in some incubators, and in others enriches the know-how of incubatees, helping them to overcome technological obstacles. We also found that because of organizational conflicts between the university and the incubator, the university becomes a modest source of ideas for the incubator but an important source for experts, infrastructure, consultants and employees.

On the market aspect, we found that through the market knowledge bearer, the incubator management and other incubatees share their market experience which is commonly absent in

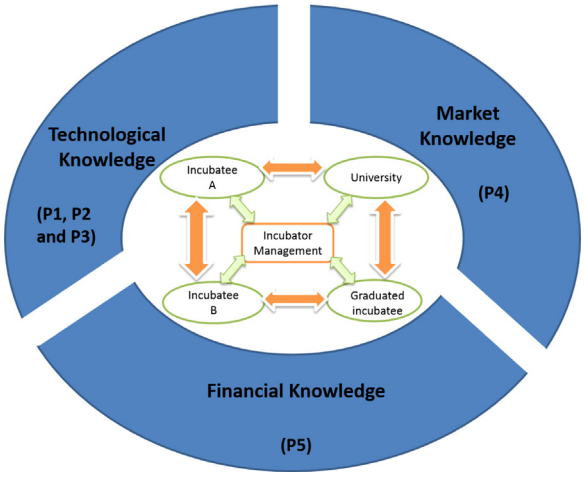

Fig. 4. Incubator interrelationship model.

Table 3
Comparing knowledge bearers finding between countries.

Technological knowledge bearer	Countries	
	Israel	Australia
University knowledge sources		
Conflict of interest between incubator management and universities' TTOs	√	
Ideas tend to come from independent entrepreneurs	√	√
Introducing university's experts to entrepreneurs		√
Using the universities facilities, consulting with universities experts	√	√
Know-how knowledge source		
Geographical proximity of graduated incubatees, following their graduation	√	
Informal networking	√	√
Problem solving by other incubatees by 'popping up' technical questions	√	√
Employing staff from graduated incubatees		√
Sharing knowledge between graduated incubators' employees and incubatees' current employees	√	√
Incubatees collaborate on NPD/NSD		√
Market knowledge bearers		
Guiding the incubatees to achieve a 'significant milestone' in a very early stage	√	√
Close monitoring of the incubatee's progress according to its business plan	√	√
Financial resources bearer		
Careful monitoring of the incubatees' funding progress	√	√
Dedicated incubator staff to raise capital for incubatees	√	
Continuing consulting the incubatees following their graduation	√	
Sharing knowledge between incubatees about relevant grants and international funds	√	

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new technological ventures. We found that the close monitoring by the incubator management and the incubatee collaborations are both very valuable for the incubatees.

In the financial knowledge bearer our findings suggested that incubatees benefit from both the incubator's managerial business connections with potential investors and from their peers in the incubator that work in similar fields and share information about available research grants. By utilizing incubator's management connections with potential investors and having valuable information about potential funds, the incubatee will not necessarily get funding, however the odds are improved.

We also found that graduated incubatees are a very active source of knowledge in all bearers, and in most cases these firms continue to reside in proximity to their incubator premises, in particular in the Israeli model, where the incubator's management has its equity in the graduated firms. Even after graduating from the incubator, the graduated firms continue to benefit from the incubator; in fact, in the Israeli model, the management does not relate to the incubatees as 'real-estate' assets, but rather tries to see them as an investment that needs to be nurtured for the long run. In Australia, although the graduation from the incubator is more clear-cut, collaborations often happen and the graduated firms use some of the incubator's services and conduct informal relationships with their peers from the active incubatees.

Based on these findings we offered an incubator interrelationship model and five propositions in Section 5. Despite the fact that our study is based on case studies from two countries, Israel and Australia, that have implemented a very different incubator models, we found commonality between the knowledge flows in these two incubators' models: firstly, that incubators are not actively contributing to university technology transfer but rather use the universities' resources; Secondly that incubatees and graduated incubatees interact positively. And thirdly both models of incubation show similar service provision to tenants. We believe that our findings are generalizable to other countries, but nevertheless, it may be argued that this model should be tested in other countries before being generalized. Therefore we suggest that future research should investigate the propositions and the knowledge flow model that we offer in this paper.

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Annex A. Interview script (English)

1. Please tell us about your background and your current role.
2. Please tell us about the history of this incubator, including if and how the focus have changed along the years?
3. Can you, based on examples, please describe the process of receiving a new incubatee, including who initiates the contact.
4. Once an incubatee has started its work, can you, based on examples, please describe the process it goes through, including where new ideas come from.
5. Based on examples, can you please explain who the incubatees interact with in different stages (e.g. incubator management, other incubatees, university, R&D institutions, consultancy firms, authorities, suppliers, customers etc.), and on which matters they interact (e.g., technology, financials, markets, etc.).
6. Can you please explain what happens after an incubatee has matured (e.g., does it leave the incubator – the physical premises, and are they still in touch with the incubator (including other incubatees and the management) in any way?)
7. According to your view, what is the advantage that the incubator provides to the incubatee?

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