

Engineers learning to become entrepreneurs, stimulations and barriers in Israel

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Abstract: This paper explores the processes by which Israeli engineers become entrepreneurs. We employed a qualitative approach, using ethnographic life history interviews with nine entrepreneurial engineers. We find that the uniqueness of the Israeli political, economic and security situations have impacted on the ways that engineers become entrepreneurial. In particular, we note how three generations of engineers have been variously affected since Israel was founded in 1948. Each era brought with it different needs and different socio-economic circumstances. Some pushed engineers into enterprise, but later, we show how pull factors have determined the Israeli entrepreneurial milieu. However, for all eras, we find that learning to become an entrepreneur was a lifelong process, an amalgam of experience moulded with formal learning. These elements fused self and circumstance to determine the career trajectories of our enterprising engineers. Although this study is based on Israeli data, the conditions for the third generation reflect global convergence. Accordingly, the learning process for new engineers can be anticipated as universal.

Keywords: entrepreneurship; engineers; israel; technology; generations.

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1 Introduction

The purpose of this paper is to explore the process whereby Israeli engineers become entrepreneurs. Our argument is that we can only fully understand this process by exploring the changing context within which engineers learn how to become entrepreneurial. Accordingly, the paper examines the socio-economic environment in Israel, noting how this has changed and then tries to relate these changes to the attitudes and experiences of our engineering respondents. We make a case for experiential learning and show how context and environment shape the choices, modes of learning and outcomes of entrepreneurial engineers.

Saxenian (2002) notes how engineers (immigrant, in this case) account for one-third of the skilled workforce in Silicon Valley and have emerged as 'visible' entrepreneurs. As Audretsch et al. (2002) point out, influencing knowledge workers, especially scientists and engineers to take advantage of commercialisation opportunities is a focal point of policy debate in Germany and France. Moreover, as Gans and Stern (2002) note, technology entrepreneurs may be able to develop competencies precisely because established firms may be ineffective at organising for and marketing new technologies.

Historically, the role of engineers, such as Brunel, is recognised both for their technological advances and their entrepreneurial ability. Yet, despite the acknowledged importance of entrepreneurial engineers, Audretsch and Erdem (2004) note the poverty of literature about the decision of engineers or scientists to start a firm. Arnold (2002) who is an engineer and also ran the Entrepreneurship Centre at the University of Arizona puts it thus,

“On the surface, engineers and entrepreneurs might appear to have little in common. Mention the word *entrepreneur* and it conjures visions of larger-than-life empire builders who create high-risk business ventures that promise either intoxicating wealth or wretched bankruptcy – and very little in between. The word *entrepreneur* is derived from a French word meaning *to undertake*, and is defined in Webster’s dictionary as *one who directs a business undertaking, assuming the risk for the sake of the profit*. Entrepreneurs seem to thrive in chaotic and uncertain climates far removed from the orderly and methodical world of engineers, where calculations and data are applied to design solutions that eliminate uncertainty and risk. Even our universities separate the engineering colleges from the business colleges”.

It is well established in the literature that the decision to start a business can be analysed at the macro economic level or the micro level of the individual. For example, Storey (1994) has documented the implications of policy. Similarly, De Koning and Snijders (1992) have noted the impact of the government. More generally, as Mazzarol et al. (1999) suggest the environment is seen as a pool of resources; accordingly the degree of resource abundance is environmental munificence (Castrogiovanni, 1991; Dess and Beard, 1984), and will significantly influence the start-up process. However, whilst such a macro approach allows us to see broad trends, it tells us very little about the individual decision to start up.

One approach to understanding the individual’s decision to become an entrepreneur is to see the problem in micro economic terms. Thus Janovic (2004) argues that individuals are confronted with the choice of whether they can apply their knowledge and skills more beneficially as wages with an existing organisation, or whether it would be better to start a new firm to capture new profits. Yet the decision to enterprise has to *Engineers learning to become entrepreneurs, stimulations and barriers* 323 confront the risk and uncertainty associated with a new business (Minniti and Bygrave, 1999; Parker, 1996). So, whilst the economic proposition is obviously rational, we wonder if such a calculative approach truly reflects the reality of the decision to become entrepreneurial. For example, as Verheul et al. (2001, p.24) point out, the total utility of each occupational alternative depends upon personal assessments of all financial and non-pecuniary risks and rewards. So, even the apparent objectivity of rational choice is affected by the individual’s subjective assessment. In the case of engineers, Casson (1995) had noted that the growth of technological advances has led to a more intense demand for entrepreneurship. It is easy to envisage how this general force could translate into a particular attractor for skilled engineers.

To place our study in context, we can see how early research in entrepreneurship focused on the entrepreneur. It sought to determine what personality characteristics distinguished entrepreneurs from non-entrepreneurs and examined the influence of these characteristics on organisation formation rates (Mazzarol et al., 1999). For example, such factors as the need for achievement (McClelland, 1961), risk-taking propensity (Brockhaus, 1980), locus of control (Brockhaus, 1982), tolerance of ambiguity (Schere, 1982) and desire for personal control (Greenberger and Sexton, 1988) have been identified and examined as possible traits associated with entrepreneurial behaviour. However, later research (Chell et al., 1991) repudiated this notion that we can explain entrepreneurship by looking solely at the characteristics of the entrepreneur. Bird (1988) argues that both personal characteristics and environmental factors define entrepreneurial intentionality.

We can conceptualise most of these issues as ‘pull’ factors. The literature often attempts to categorise motivation into pull and push factors – for example, Orhan and Scott (2001) and Robinson (2001) – these can also be described as positive and negative. For pull, we see independence and a need for achievement figuring strongly. Push factors are seen as elements of necessity – insufficient income, job dissatisfaction, no job and for women especially, the need to balance work and family responsibilities. Pull factors are intrinsic attractors to entrepreneurship – independence, need for achievement, attraction

of wealth or status. Push is often associated with necessity, whilst pull is linked to choice. For example, Bradley and Roberts (2004) report a much higher level of satisfaction amongst the self-employed compared to those in employment. In part this is explained by perceptions of self-efficacy. Similarly, Shapero and Sokol (1982) describe how dissatisfaction with a current job can trigger individuals into entrepreneurship as a way of resolving this dissatisfaction.

Some specific work about entrepreneurial engineers has been carried out in France by Fayolle (2000) and his earlier work (1994, in French). DeGeorge and Fayolle (2004) summarise this by noting that engineers seldom embrace entrepreneurial opportunities. They suggest that the propensity to become an entrepreneur is in fact directly, but inversely, related to the prestige of the diploma they received!

In addition to these 'personal' reasons to become entrepreneurial, the literature also draws out attention to the particularity of circumstances. Thus Birley and Westhead (1994) note the importance of capital availability. Blanchflower and Oswald (1998) and Evans and Leighton (1989) discuss the nature of opportunities available. As DeGeorge and Fayolle (2004) put it, even the objective reality of an opportunity is shaped by subjective interpretations. So, to understand the decision to start a business requires us to take a very broad approach by setting the individual, with all their characteristics, abilities and aspirations, firmly within the context of opportunity. For this paper our

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context is Israel, a milieu which is characterised by a change. The change permeates the business environment and is characterised by the particularities of the security position. The change is also manifest by the patterns of immigrants. To make some sense of these changes we felt it best to place our engineers' life histories in three distinctive periods of Israeli development. In a part, this is because it allows us to relate their entrepreneurial trajectories to the developments within Israel and in its part because these developments seem to have shaped their approach to both learning about and to doing entrepreneurship. Consequently, given that our topic is wide, our research methodology is correspondingly broad; we take an ethnographic approach to try to locate the entrepreneurial career trajectory of our respondents within the framework of Israeli socio-economic developments. We do this by collecting ethnographic life histories of entrepreneurial engineers. Our specific research questions are thus, "how does an Israeli engineer affect the decision to become an entrepreneur and how do they learn to become entrepreneurs?"

2 Methodology

Our primary data collection mechanism was an extended 'ethnographic' interview with each of the nine entrepreneurial engineers. These respondents were not chosen at random, but were purposefully selected on the basis that we believed that they would provide us with useful and relevant data to address our research question. In each case, one of the authors either knew the individual personally or knew about them from a personal contact. This closeness to the respondents had the advantage of speedy rapport, thus enabling us to collect quite personal data. The disadvantage of such closeness was, of course, the risk of bias in the data and in our analysis. Nonetheless, we believe that, for this fine grained study of individuals, this approach produced rich and relevant data. Naturally, we cannot make any claims for generalisability beyond our cases, though we hope that the patterns which emerge from the analysis will be sufficiently convincing in the abstract to be recognisable in other circumstances. We augmented our life history data with general reading about the Israeli situation. This served to triangulate the contextual material provided by our respondents and to inform us about the macro situation, so that we could relate their life histories and career trajectories into the unfolding situation in Israel.

The interviews were conducted in Israel towards the end of 2004. Each respondent was contacted by telephone before the interview and told about the study. We had an original list of 12 potential respondents whom we believed would provide useful data. However, for reasons of the respondents' time availability, we conducted only nine face to face extended interviews. Most of the interviews were in Hebrew but transcribed into English for ease of analysis. Our analyses employed the constant comparative method, looking for patterns and themes within the data. We then attempted to relate these emergent patterns into a more general explanatory framework. We recognise the potential for bias in the necessary subjectivity in both our respondents' interpretations

and our own interpretations. The problem is inherent in our methodology, but again we see a fair trade off between the depth of data, the richness of explanation, the naturalness of the enquiry and the risk of subjective bias. Table 1, below, gives details about our respondents.

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Table 1 Our respondents, their experience and background

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Table 1 Our respondents, their experience and background (continued)

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3 Entrepreneurial eras in Israel: three generations of entrepreneurs

As Table 1 indicates, most of our respondents were middle aged. Only one respondent, Eran is younger. Nonetheless, all our respondents emphasised the significance of Israeli history and how it had affected their career trajectories. Consequently, we felt it necessary to periodise our data and to contextualise it into the past and the prevailing socio-economic conditions. Thus for our respondents, the present and the future are profoundly predicated by the past. As Prof. Albert Einstein, President of the first Technion Society in Israel (The Technion is now the leading technical university in Israel) put it in 1924, "Israel can win the battle for survival only by developing expert knowledge in technology".

In 1948 many of the Jewish settlers were involved in farming or low tech jobs, high-technology opportunities simply did not exist. By the end of 1951, about 687,000 men, women and children had arrived, over 300,000 were refugees from Arab lands, thus doubling the Jewish population. Yet as the Technion website reports, "As Israel strives to maintain its economic independence, it recognizes, as do other nations, that a strong economy depends closely upon the education of its citizens". Towards the end of the first decade, the output of industry doubled, as did the number of employed persons, with industrial exports increasing fourfold. Vast expansion of areas under cultivation had brought about self-sufficiency in the supply of all basic food products except meat and grains, while 50,000 acres (20,000 hectares) mostly of barren land were afforested and trees were planted for about 500 miles (800 km) of highway. Now, about 50 years after its establishment, Israel has become an economic and technological powerhouse. It stands in the 21st place of the highest per-capita GDP in the world; a recently published United Nations report ranked it in the 23rd position in the worldwide standard of living, based on per capita income, life expectancy and educational standards. Much of the progress is due to innovative strategies in the applied sciences and technology. As a country almost bereft of natural resources, special emphasis was placed, from the beginning, on the need for advanced education. Today, the country enjoys a blooming high-tech entrepreneurship rivalling the most developed countries in the world. The country's 1800 high-tech companies are expected to generate exports of about \$15 billion this year, more than double the value that of 1990s, while the high-tech contributes about 75% of the Israeli GNP growth.

Business Week (3/2/97) reports on the unusually high concentration of skilled professionals. Israel has approximately 130 scientists and engineers for every 10,000 workers, according to Israel's Ministry of Industry & Trade, which compares with 80 and 75 in the US and Japan, respectively. Risk-taking is now viewed as a badge of honour and working into the night is de rigueur. Efraim Arazi, an Israeli who is the chairman of Electronics for Imaging Inc., a printer technology company in San Mateo, California, explains (Business Week, 3/2/97), "In Germany, if you have six engineers with a good idea, they will probably be put into a division or department. But in Israel or Silicon Valley, they will set up their own start-up".

Thus we see how the early settlers, the first generation, in Israel faced extreme conditions; how the pervasion of skill and talent and the very necessity to survive, forged a particular context which shaped the role of highly qualified engineers and created an economic requirement for enterprise. We also note how the political situation, the security problems, focused engineering skills towards developing technology and equipment which could allow Israel's continued existence. Moreover, we can envisage

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how the acceptance of risk, both social and personal, and its subjective interpretation, was likely to have been tempered by, in the early period; a need to provide necessities; in the second period by a need for security and in the third and current period by a need to

develop high-technology enterprise. These then are the conditions in which engineers have to learn how to become entrepreneurs.

The first generation of entrepreneurs immigrated before or shortly after the World War II to Israel. In those early days there was no technological industry and the little technological and scientific work that the country needed to survive was performed in the Scientific Corporation which later became Rafael (Armament Development Authority). This generation of engineers had to create something from nothing. The entrepreneurs had nothing to lose, hence were willing to take the high risks involved in creating the foundation of technological industry in an isolated country. Most of those companies were created in the first 20 years after the establishment of the independent state of Israel. The first generation can be described as the 'Pioneer' generation, the people who created the foundation of the Israeli industry.

The second generation, presently, the middle aged, persons were generally born in Israel or immigrated to Israel in its early stages. They are the descendants of the holocaust generation, who had suffered from instability and insecurity. These parents encouraged their children to study and to build a stable family reinforced by financial security. This generation grew up in a state which had an emerging technological industry. They sought a more stable life, but coupled with the desire to become free of their parents' horrors, while having to cope with military and reserve service in a country with significant security problems. This is the 'Grower' generation – maturing in a free country, but seeking stability while expanding the economy.

Table 2 The generations of engineering entrepreneurs

Generation Status Starting their enterprise

Category Risk perceptions

First Immigrated before or shortly after

World War II

1950s–1970s Pioneers – founders

Necessity is the mother of invention, risk is inherent

Second Mostly born in Israel

1980s – today Growers Security first, risk second

Third Israeli born or new immigrants from

Russia

Mid 1990s – today

Harvesters – opportunists

Relative security, risk is embraced

The third generation, those who are now in their 20s and 30s, are born in a new era and are deeply embedded in a different environment. It is an era of extraordinary technological developments in which the world has become a global village. Travelling is very common and the USA has a strong influence on the life style of the youngsters.

Their society has become much more materialistic and admires personal success stories, particularly when related to high-tech. The media transmits these success stories, thus stimulating the youngster to try an independent route to success. This young generation is self-confident and feels it has the financial support of family in case of failure. Indeed, entrepreneurial failure is positively accepted by the society. This generation can be dubbed the 'Harvesters' – raised in a stable country which is part of the developed

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western world. They grab the opportunity to imitate the American dream of achieving a successful career and to become wealthy at an early stage of their career. Table 2 gives a summary of the generations.

4 The first generation, the founder's stories

The following account is largely derived from two bibliographic sources (Levav, 1998; Maital and Shechtman, 1996) and from the authors personal acquaintance with

the people reported. An old rusty ship set sail from Konstanza in Romania to Istanbul in 1941 to what is now called Israel. Among the Jewish youngsters on board was 16 years old Uzia Galil. A few years earlier, Stef Wetheimer had immigrated with his parents from Germany to Tel Aviv. Stef, who was a poor student academically, left school at the age of 15 to work as an apprentice in an optical shop and quickly demonstrated practical, but advanced technical skills. In contrast, Uzia studied Electrical Engineering at the Technion (Technical University) and at the age of 28 spent four years studying and working in the USA. Stef joined the British army at the age of 17 but later enlisted in the Palmah (the 'Striking Force', which was the Jewish military force in Mandatory Palestine) before it became the Israeli Defence Forces. He became one of the first Israeli Defence Forces' pilots.

When Uzia returned from the USA, he commented that in the USA he saw the close cooperation between the university labs, research centers and technological companies. He noted the way that this identified technological breakthroughs and led to the development of state of the art products. Uzia thus decided to become an entrepreneur and became the founder of Elron and Elbit which turned to be the flagships of Israeli Electronic Industry. Uzia believes that the leader of a technological Start-up has to be someone that comes from an engineering or science background. This principal has to learn as fast as possible to understand the marketing and finance world and has to be the leader in charge of the entire business picture.

After the war of independence Stef began to work in the Science Corps (which became later RAFAEL – Armament Development Authority, the core of the Israeli defence industry). Stef was independent, creative, obstinate and rebellious and could not cope up with authority, so he quickly became unemployed. He received some money from his parents, bought a grindstone and started to sharpen knives to earn a livelihood. Even today as a billionaire, he says, 'Until today, I sharpen knives'. His motto from those early days was: 'everything I'll do, I do as well as I can. Israel will be an industrial country, I'll build an industry'. Stef became the founder of the Israeli Mechanical Industry.

Uzia and Stef represent the first generation of Israeli entrepreneurs. Those who immigrated as youngsters in the first half of the 20th century may have had an entrepreneurial character, but also did not have many choices. Uzia, the engineer who became the father of the Israeli private high-tech industry, was fascinated by the USA model which was already well entrenched in high-tech and set an example for high-tech entrepreneurs to follow. Stef, on the other hand, became the symbol and example for entrepreneurs who are not necessarily highly educated, but have a strong drive for entrepreneurship and success and do not insist upon high-tech.

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5 The second and third generation

Typical by, in the second generation we have Dr. Shlomo Barak, Yehuda Bronitzki and Eli Gamzun, who are among the leading figures of this generation. Some of the first and second generation entrepreneurs have followers in the family; Eli's Gamzun son Reuven and Oren Harpaz, (Stef's grandson) both manage their own start-up companies. Oren was interviewed for this study as representing the third generation, because most of the interviewees for this paper belong to the second generation. To establish some background of this generation we present a short description of the prominent figures mentioned above. The descriptions of the second generation entrepreneurs are informed by two sources, Maital and Shechtman (1996) and Levav (1998).

Dr. Barak initiated Optrotech (now known as Orbotech) in 1981, at the age of 43, after becoming frustrated from the way business was done in El Op, where he had worked as Chief Technical Officer. His primary goal was to achieve the highest level of intellectual fulfillment, but he was also looking for low technological risk. This seems typical of this generation. Indeed, Professor Fruman, former CEO of Intel in Israel claims that most of the large companies unintentionally suppress entrepreneurship, or do not encourage it sufficiently.

Bronitzki who initiated Ormat in the 1960s, noted that it was much easier to launch an initiative than it was before. You had to be more professional, but the environment was much more supportive and the awareness of enterprise was higher. He also points out how technology can assist you to reduce the size of your technological team, and if

needed, one can use experts who are located anywhere.

Eli Gamzun was a technical colonel in the air force and had studied engineering in the Technion. He also studied in the US and developed the first Unmanned Aerial Vehicle (UAV) for the Israeli Defence Forces. At the age of 42 he retired to launch a UAV company – Silver Arrow, as a department in Scitex. Scitex collapsed later, but the investor Michael Federman was persuaded by his consultant, Aharon Beit Halachmi, who knew Eli from military service, to invest in Silver Arrow. The Israeli motto of ‘one friend brings another’ proved itself again. The social network in a small and closed society is very strong and if one is well connected, he can easily reach the required resources. Eli’s son Reuven initiated his own start-up in his late 20s. Reuven said, ‘I am not going to wait till I am 42’. He likes Bill Gates’ principle – be successful and rich at an early age. Thus Reuven Gamzun belongs to this distinctively different third generation of Israeli entrepreneurs.

Oren Harpaz studied business in Babson (USA) and returned to Israel in 2001 when in his late 1920s. He then started a new company named Colibri, based on the ideas of a Russian immigrant. Harpaz says, “No doubt the new generation is very influenced by the media exposure. Also the environment and success stories, which are not always accurate, incite the young generation to start their own business”.

6 The interviews, data and analysis

It is notable that most of our informants had been employed by large organisations at the start of their careers. Four had worked at Rafael, one at Motorola, one at Elbit and two at Iscar. Yet, all of them had clearly demonstrated latent entrepreneurship which could not *Engineers learning to become entrepreneurs, stimulations and barriers* 331

be utilised in the organisations where they worked as employed engineers. This potential for entrepreneurship was demonstrated by their activities even as children. As examples, Reuven, who immigrated to Israel from Romania in 1964 (when he was 16 years old), sold cakes, made by his mother, to his neighbours and to coffee shops. He also gave private lessons to other children and the youths. Yoram worked in his father’s workshop and helped to improve the machines which his father renovated. Even as a child, Yishai was noted as an inventor. It seems that entrepreneurship was already in their blood and that working as an employee, even if they did not realise it at the time, was only a precursor to entrepreneurship. Interestingly, all of our informants suggested that entrepreneurship is a character phenomena, but that engineering is an occupation. Yet, they also noted that being an engineer often assisted in the starting of an entrepreneurial activity, particularly if this was connected to high-tech start-up.

If we consider the four informants who had worked for Rafael, a highly developed R&D organisation; each of them had experienced professional and engineering challenges during their careers. The high-technology environment within Rafael, combined with the intense promotion of technology for security reasons, provided an unmatched opportunity in Israel for innovative technology. Moreover, during their careers in Rafael, all were involved in a variety of roles and positions; some had been involved in the diversification of Rafael’s R&D activities. Belonging to a high status organisation such as Rafael was favourably regarded within the society and the organisation provided them with financial security. However, the organisation changed in the 1990s from being primarily R&D, to an organisation which behaved more as a commercial company with a new emphasis on marketing and management. All four became frustrated, dissatisfied with the emerging mismatch between their desire for promotion/change or for professional recognition and their need to have more influence and involvement and what was available in the changing organisation. Thus each of the respondents talked about a need for personal change and had begun to search for opportunities, but to balance this with their need for financial security. Reuven, who was the first to leave the company (before receiving pension entitlement), decided to move into consultancy. He felt that it would be difficult for him to pursue the rapidly changing technology and he decided to study MBA. “I decided that for my second career I will select a profession in which experience and white hair are a good promotion for the business”. Key considerations for Reuven, were low financial risk and being available to assist his family. So, Reuven established his home based consultancy firm which is now slowly diversifying into web based activities.

The other three interviewees decided that the unique opportunity to have an early

pension provided them with enough security to leave the organisation and thus make the move towards entrepreneurial activity. At this stage the informants had already demonstrated entrepreneurship at some level, or felt at least a desire for some change and diversification in their working life. It is difficult to see this as being exclusively pulled towards entrepreneurship. Restlessness and dissatisfaction also seem to be the significant trigger factors. For example, William had left the company for two years and worked as an immigration minister (agent) in South America. Ilan, during his time at Rafael, studied for a PhD in Austria. Reuven too, was always involved in some studying. He took his MBA when the organisation actually wanted him to involve in research and development. Reuven explains how he was prompted to think about high-tech entrepreneurship during his sabbatical in the USA. Yishai was always considered to be

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one of the leading inventors in the organisation; his room and lab were full of new ideas, subsystems and prototypes; however few were actually implemented within the company. Interestingly, Reuven and Yishai's sabbatical leave in the USA (and possibly the overseas PhD studies and massive worldwide travelling of Ilan) had stimulated their desire to become entrepreneurs. Thus we can see that exposure to different situations was employed as a part of their learning experiences. All the three were prompted by their international exposure and experience to take advantage of their technical background and to begin their high-tech start-up activity.

Michael worked for an SME, but was frustrated in his job because of the extent of his responsibilities and the relatively low reward. Michael's experience as a Russian migrant engineer was quite typical, in that the cultural barriers tended to limit employment opportunities. However, as one who had emigrated many years ago from Russia, he could also take advantage of the opportunity to utilise highly educated man power from the 1990s wave of Russian immigration. Michael shared their cultural identity and 'exploited' the relatively low salary the new immigrants commanded. Thus, he has been able to serve as the bridge between the old Israel and the new immigrants.

Avri had frequently changed his job, which was not at all apt to this generation. He worked for several years within several large organisations, but always felt restless and wished to become 'independent'. Again, we can see the emergence of what our respondents had referred to as the entrepreneurial character, the drive to become ones' own boss. In his various roles he attempted to acquire all the skills and knowledge which would allow him to start his own business.

Yoram had acquired an entrepreneurial mindset from home, where his father was in business. Nonetheless, in following the typical advice of the first generation to seek a secure professional career, he worked for large organisations such as Motorola and Elscint, but was always looking for a change. He started in Motorola in R&D, then seeking some overseas experience, he chose to become a service engineer. After returning from the USA, he sought out the opportunity for change. He then moved to Rose Village and became an entrepreneur. Rose Village is a unique Israeli institution started by Stef Wetheimer. In conjunction with the Tefen Industrial Park, an industrial location, Rose Village is the residential counterpart, where Stef wanted to create an entrepreneurial environment in which budding entrepreneurs could live and work in an atmosphere which encourages enterprise.

Micha spend some years in Elbit, a large organisation, but was always keen to be in a position where he could exert more personal influence. He thus became involved in the relocation of a relatively small family organisation, but quickly found that he missed the technological challenge. His next step was to join the newly established Silver Arrow UAV company. Here, he lead a major project and could combine his engineering skills with his knowledge of many years involvement in model airplanes at the Aero Club of Israel. He became ready for the change; he left for a new job, but scouted the market to find an opportunity to establish his own start-up until he found it.

Eran belongs to the younger generation who actually travels after army service. During his travels he worked as a body guard and spent some time in the USA working with horses. After two years of study in Israel, he returned to the USA to complete a BSc and an MSc and gain some working experience. He then returned to Israel and joined a large company, Iscar, but shortly began to seek an opportunity to become an entrepreneur. The incubator framework provided him the opportunity.

- All the engineers who became entrepreneurs demonstrated an early desire in their career to make changes. At first this was manifest as a sort of general restlessness, typified by dissatisfaction in their jobs. Only later, after considerable learning 'on the job' in large organisations and after some formal study of business did they turn to developing their own businesses. We can characterise this second generation as cautious and risk avoiding but almost destined, by their independent characters, to become entrepreneurial.
- The ones who had more technological challenges in their employment, waited longer to find a real entrepreneurial opportunity and to ensure that they had financial security.
- Most of them looked for external investment. Those who spent some of their own money did so only when it was accompanied by other investment and when they perceived this investment as a relatively low risk for their financial situation.
- Eran who represents the younger generation started at a young age (early 1930s) saw things very differently, security did not matter and risk was embraced.

Specific issues and circumstances in Israel:

- 1 Established in 1948 (although some Jewish industry, primarily the food industry started earlier). High-tech, as an industry, emerged in the 1950s/1960s.
- 2 The latter part of the 1990s demonstrated a strong economy (a robust global economy and relative stability in the region) and plenty of Angel, VC and Chief Scientist funds became available. The environment and trends became very supportive for the high-tech start-up initiative.
- 3 Enormous wave of Russian Immigration (during the 1990s).
- 4 Incubators emerged to exploit the opportunity of high-tech with highly skilled new immigrants (mid 1990s).
- 5 Early pension opportunities and sabbaticals were available in some large R&D organisations.

6.1 How then have the engineers learnt to become entrepreneurs?

In this section, we attempt to bring the wide ranging discussion into tighter focus. Our review of the literature indicated 'self', those characteristics and attributes of the individual, was a limited explanation of why and how people become entrepreneurs. Instead, an argument was made that the 'self' had to be fitted into circumstances, in that the outcomes of entrepreneurial characteristics were shaped by the environment in which they emerged. Our lifestory data confirmed the interplay between the unique, but changing circumstances in Israel, and the entrepreneurial drive of our engineers. We note that learning was indeed a life long process, that the amalgam of experiences moulded with formal learning about business shaped the entrepreneurial career trajectory. Figure 1 is our attempt to integrate these disparate elements into a conceptual model of process.

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Figure 1 The model representing three generations of entrepreneurs

Figure 1 deals with the three different generations in Israel of engineers becoming entrepreneurs. The first generation arrived on a bare land, with a very poor infrastructure and no industry. The country, surrounded by enemies, was isolated from the western world and travelling opportunities were limited and expensive. The inhabitants had to work in agriculture or in some low tech production companies. The entrepreneurs who wanted to establish a new venture with technological challenges had to create the ventures with their limited knowledge and without assistance. The risk was high but sometimes the only way to the future. Learning was by experience.

The first factor influencing the youngster is the atmosphere at home. If one of the parents was an entrepreneur (if so, it was usually the father, since very few females of the first generation worked, and even fewer were entrepreneurs), it stimulated his craving to become an entrepreneur. Thus the formation of an entrepreneurial character is primarily created at home. Its manifestation is to prefer independence than to be managed by others. Engineering studies are seen an acquired profession, different from a character trait, or attitude, but nonetheless can assist him in choosing the way towards entrepreneurship. Thus professional studies provide a guide to the direction of

enterprise.

On the other hand most engineers have a challenging and rewarding job and hence their desire to become independent is often subdued. Dissatisfaction at work is the major cause to seek a change. Other factors that are supportive of entrepreneurship are the high level of travelling and thus exposure to the developed world; growing professional and business education opportunities at the university and other professional organisations; government assistance and higher availability of Venture Capital. But the second generation has still felt the influence of his/her parents' generation to be cautious and ensure financial security. The second generation engineer tends to delay the decision to become 'independent' and establish his business until a point when he experiences financial security. The third generation will exercise the opportunity in an early stage without bothering too much about the financial circumstance (primarily due to the feeling that the parents serve as financial backup). The third generation has also a very favourable view about the supporting environment in term of media exposure and appreciation for high-tech entrepreneurs and funding availability. Thus there is a tendency to imitate the materialistic American culture which values entrepreneurship, wealth and success. Many engineers will seek the opportunity early in their career and will not hesitate to exercise it when it arrives. This is a self-confident generation where risk is not considered as an obstacle. Learning is still largely experiential but the range of experience and opportunity is broader.

Table 3 gives the capabilities, studies, experience and factors which influenced the engineer respondents towards entrepreneurship.

Most of our entrepreneurial engineers had a high level of professional expertise and wanted to continue to work in technology. By the time they become entrepreneurial at a relatively advanced age, they had already accumulated great knowledge and work experience in most necessary technical fields and hence did not focus on acquiring management knowledge. Learning for them, was largely experiential. Many high-tech organisations provided their experienced engineers with courses, such as project management, but only a very limited number encouraged formal business studies. So, although few of our engineers had broad management experience, that did not discourage them from becoming entrepreneurs.

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Table 3 The status and influencing factors of the respondents

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Most of the informants, who initiated a high-tech start-up, used the strategy of intensifying the team with permanent staff or consultants with expertise in their weaker knowledge areas. Only few strove to have their own business at an early stage and had been influenced from home or were among the third generation, for example, Eran. It is clear that frustration in the work and the feeling that their potential was not fully exploited was one of the main reasons to become independent. One entrepreneur, who started relatively early, when he was 35, has built a prosperous high-tech company. The others are at an early stage in their start-up ventures and the level of success has still to be determined. Reuven, who started a service based business, has had numerous ups and downs, and has now diversified into new areas. Two of the engineers who had not experienced the success they had anticipated changed their focus. Now instead of managing their own business, they coordinate other people's businesses. In this way, they can contribute with their experience and expertise, but avoid much of the problems by not managing the daily operation. Significantly, all of the engineers belonging to the second generation looked for a good level, some for a high level, of financial security before starting their business.

7 Conclusions

Our entrepreneurial engineers believe that being an entrepreneur is an outcome of character, whilst being an engineer is a profession. It is true that an engineer provides expertise that can be very useful in establishing an entrepreneurial activity particularly if it is high-tech oriented. We noted how we could characterise our respondents into the three generations. Each generation is very different from its previous generation. The first generation was forced to take risks to establish the foundation of Israeli industry. The second generation was first to holocaust and establishment Israel to live a normal life. Influenced by their parents, many went to study engineering but few implemented

entrepreneurship in their early careers. Most of the engineers who had the entrepreneurship 'bug', exercised it only after attaining financial security. If starting their company before having a high level of financial security, they took very careful measures, sometimes manipulating their professional engineering expertise to minimise the financial risk.

The third generation was born in a developed country with ample opportunities for study and work. This generation was exposed to the developed world by travelling and strongly influenced by media stories of success and the American culture. Many of the young engineers opted for a short engineering career to develop their expertise and gain some experience before deciding to try their own enterprise. Confidence was accumulated from their military service, sometimes in technological units and sometimes in fighting units, engineering studies and their short professional career. They know that even if they fail, society will still approve them as motivated bold youngsters and that their families will assist them if needed. The third generation includes highly skilled Russian immigrants who migrated to Israel in 1990s. They arrived, in a way that mirrored the Israeli's first generation, entrepreneurial by necessity, reflecting the Jewish way to survive and succeed within the tribulations of the Jewish Diaspora. The scientists and engineers among this group often fulfil their aspirations by establishing new start-up companies, often joining scientific incubators which are assisted by government funds.

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Many of the engineers continued their studies; some continued with their professional studies; some studied an MSc and then a PhD and others focused on business aspects and studied an MBA or other management diploma courses. There are some engineers who did both. The employers often support external studies at academic institutions or provide in house management course such as Project Management, Marketing, and other business aspects. The engineers who have an entrepreneurial character become frequently involved, before establishing their ventures, in management and marketing or other business related activities and hence opt to study business courses or even MBA studies.

When our engineers become entrepreneurs, they are aware of some missing skills and competencies needed to run their businesses successfully. In most of the cases the engineers sought out people who complemented their own skills and included them in the core team. External consultants were also used in areas such as law, accounting and marketing in addition to technological experts from universities or free lancers. The engineers were able to seek out information and to use their networks from school and university, military service, previous workplace or personal friends. They were determined to find the best people to add to their team or to use as consultants.

The model of engineering learning emphasises the three generations of entrepreneurs and the relationship with the establishment of Israel. What seems significant is how the third generation is currently most affected by the dynamic technological changes of recent decades. Modern media exposure and extensive travelling seem to bring this young generation into the 'global village'. So, creating a worldwide generation with quite similar aspirations and behaviour. Since engineers are technological leaders and initiators, this internationalised context provides great opportunities for engineers to explore new niches, especially those less attractive to established companies. Thus in Israel and elsewhere, these opportunities lead engineers to launch new high-tech start-ups. This suggests that governments and society should provide those young engineers who manifest any desire for entrepreneurial activity with the appropriate educational tools for entrepreneurship. In this way their countries, as well as the world economy, should benefit.

So, for our engineers, becoming an entrepreneur is truly a learning experience. Many were first motivated by family, some became dissatisfied with their engineering careers, but all used their experiences to build up the expertise necessary to launch a new venture. Learning by doing seems to be the leitmotif for engineers!

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