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Government policies towards Israel's high-tech powerhouse

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ABSTRACT

Israel's Silicon Wadi is second only to US Silicon Valley in terms of business start-ups. The government policies play an important role in promoting innovation and driving the country towards a high-tech powerhouse. In this study the analyses, carried out through the lens of cluster and national innovation system (NIS), have shown that the thriving high-tech clusters are the result of government-led policies in creating the venture capital (VC) industry with the impacts of Yozma program. Importantly, the government financing did not crowd out but crowd in private investments. Israel presents an interesting case of the most successful Silicon Valley-style economy. The lessons of Israel in successfully climbing the technological ladder to become a high-tech powerhouse would be useful for other countries to learn how to promote high-tech clusters.

1. Introduction

Silicon Valley is characterized as the high-tech region of the United States. Silicon Valley is the world's best known area of electronics and computer-related industries whereby its success is a result of effective linkages and cluster policies (Saxenian, 1990, 1994, 2006; Kaplan, 2000; Rosenberg, 2002). The success of US Silicon Valley has become a technology catching up model for countries around the world to follow. In this study, the term 'Silicon Valley' is based on the scholarly research of Saxenian (1990, 1994, 2006) using such a prevalent term to describe an area of high-tech industries with network-based structure and agglomeration.

The focus of this study is the country case of Israel, one of the most successful countries in replicating the success of US Silicon Valley. The research attempts to understand the government policies contributing to successful start-up nation of Israel. The reason to choose Israel as a case study is because it is the most successful country after the United States in establishing high-tech industries. The creation of Israel's high-tech Silicon Wadi is recognized as the most successful Silicon Valley-style economy outside the United States.

The government policies play an increasing important role in promoting innovation and economic growth. However, there are still considerable knowledge gaps in linking the government policies to innovation financing (Mani, 2004; Hyytinen and Toivanen, 2005). Therefore, this study attempts to fill the gap in the existing research literature. Specifically, the study attempts to answer the main research question – *How could Israel become a high-tech powerhouse?* The analyses of findings in this study are based on Porter's cluster model (Porter, 1990, 1998, 2001) and the national innovation system (NIS) concept (Lundvall, 1992, 1998, 1999, 2003). This research aims to provide practical contributions as well as reflections on government policies for promoting national innovative capacity and industrial competitiveness. The policy lessons and experiences drawn from the country case of Israel can be applied to other developing economies.

Israel is an innovation driven country having made the successful transition from an underdeveloped economy to a high-tech powerhouse. The country was ranked 24th in the 2014 International Institute for Management Development (IMD) World competitiveness ranking and 27th according to 2014 World Economic Forum (WEF) global competitiveness index. Israel was also ranked 19th in the category of very high human development according to the United Nations Development Program's Human Development Report Index in 2014. Israel was invited as a full member in the Organization for Economic Co-operation and Development (OECD), an economic group of developed countries since 2010. The competitiveness of Israel is a result of its entrepreneurial culture and the government-led technology policies in venture capital (VC) financing.

The structure of this paper is as follows. Following the introductory section, Section 2 provides a literature review on industrial innovation policies to promote entrepreneurial financing, the cluster model and the competitive advantage of nations as well as the national innovation system concept. Section 3 discusses the research design, methodology and provides the background of the study. Section 4 presents analyses of findings with emphasis on the government policies that help transform Israel into a high-tech powerhouse. There are two subsections providing

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analyses of Israeli high-tech industrial clusters based on the cluster model and Israeli innovation system based on the national innovation system (NIS) concept. Section 5 concludes the paper by drawing lessons and policy implications regarding the role of Israeli government in promoting high-tech clusters. The practical lessons and experiences from the case of Israel would be useful for other countries to learn the process of technological and economic catch-ups.

2. Literature review

2.1. Industrial innovation policies to promote entrepreneurial financing

The government policies to promote entrepreneurship are important in the national economic growth. In particular, the financial and investment policies are among the key operational priorities in developing countries to support investment by local firms, especially small and medium-sized enterprises (SMEs), and transnational corporations investing in these countries. In knowledge-based economies, economic growth is increasingly dependent upon innovation whereby access to finance is seen as a critical factor in this process (Bygrave and Timmons, 1992; Freeman and Soete, 1997; Pissarides, 1999; Wonglimpiyarat, 2007). Therefore, the government policies play an increasing important role in entrepreneurial, venture and economic development (David et al., 2000; Hall and van Reenen, 2000; Hyytinen and Toivanen, 2005).

Venture capital (VC) plays an important role in supporting entrepreneurial development. VC is a high-risk, potentially high-return investment to support business creation and growth. In other words, VC provides the opportunity for entrepreneurs to exploit technology and turn it into commercialized innovations. According to the study by Hellmann and Puri (2000), VC financing is related to the growth of start-ups. The importance of VC financing in the configuration of a geographical concentration is the regional capacity to engender economic advantages. In other words, the venture capital investment (clustering) plays a vital role in creating phenomenal economic growth.

The small and innovative companies are important to the economy. They have assumed a major influence in the economic development, employment and creation of new innovations (Laranja, 1998; Kingston, 2001; Gray and Gonsalves, 2002; Massa and Testa, 2008; Peters and Coles, 2010). The literature review on entrepreneurship reveals that the difficulties of firms lie in their early stages of business development and innovation process (Gompers and Lerner, 2001, 2004; Wonglimpiyarat, 2007). Many governments have tried to focus on introducing the innovation policies providing early stage financing to help SMEs reduce the risks underlying the process of entrepreneurial development. In developing countries, the government financing mechanisms play an important role in innovation system (Mani, 2004). The sets of institutions and public policies are used to support technology and innovation development so that the efforts of research and development (R&D) institutions and industries can lead to effective technology commercialization, bringing about business creation and economic growth.

One of the important public policies is venture capital (VC) policies to promote innovation and economic growth. Entrepreneurial financing plays a critical role in supporting SMEs, particularly in the early stage of venture development. The VC policies are considered to be instrumental in industrial development. Taking into account previous studies on public policies, Stiglitz and Weiss (1981) and Holmstrom and Tirole (1997) study the role of bank and financial intermediaries in providing finance to ease capital constraints (scarce capital) of firms in economic contexts of public policy. However, Gompers and Lerner (1998) as well as Da Rin et al. (2006) have focused their studies in the areas of VC financing which help evolve the context of public policy. While Gompers and Lerner (1998) employ multivariate regression analysis to study the impacts of venture variables on the industry fundraising, Da Rin et al. (2006) use the innovation ratios to evaluate the effectiveness of public policies on the development of VC market. Their study shows the three types of policies to enhance VC growth: the corporate capital gains taxation, the opening of new stock markets, and the reduction of barriers to entrepreneurship.

Considering the level of policy research, the studies by Gompers and Lerner (1998) as well as Da Rin et al. (2006) address the macro level policies. However, it is interesting to see that the work by Cullen and Gordon (2002) is devoted to the type of tax policy and its impacts on the demand and supply of venture funds. The studies by Jeng and Wells (2000) and Bottazzi et al. (2008) are focused on the determinants of VC. The results of their studies have shown the importance of initial public offerings (IPOs), institutional and legal environment, tax policy as well as human capital in driving the VC industry. More recently, Yu (2013) and Hsu et al. (2015) have extended their studies by integrating VC policies in a broader context of mechanisms for promoting the process of technology commercialization. Their studies also take into account the limitations of institutional/cultural differences of the VC industry.

2.2. Cluster model and the competitive advantage of nations

The literature on industrial clusters popularized during the 1990s. Porter (1990, 1998, 2001)'s Diamond model provides a framework of the industrial competitiveness in the form of clusters (Fig. 1). By definition, the cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities (Porter, 1990, 1998, 2001). Porter (1990) has developed a Diamond Model framework to analyze the industrial competitiveness in the form of clusters. Within an industrial cluster, the social community and the economic agents work together to drive product/process innovations to the marketplace (Gordon and McCann, 2000, Schmitz, 2000).

Porter (1998) argued that the nation's innovative capacity is built on the combined strength of common innovation infrastructure and vitality of the environment for innovation in particular clusters. According to Porter (1990, 1998, 2001), clusters are a source of strategic competitive advantage. The cluster approach provides an understanding of economic development processes. Clusters lead to increased levels of productivity, growth and employment. Within an industrial cluster, the social community and the economic agents work together to drive product/process innovations to the marketplace (Porter, 1990, 1998, 2001; Feldman, 2000; Steiner, 1998).

The cluster model focuses upon the conditions that support firm competitiveness at the national scale. It is an economic development model that promotes collaboration among institutions to facilitate the exchange of information and technology. Policy makers of the government worldwide have been challenged to implement the cluster concept as an economic development model. Industrial clusters are not confined to political boundaries and can be localized (like the clothing and garment industry of New York) or dispersed (like the North American auto industry). Within the context of industrial clusters, the four attributes contributing to the competitive advantage of nations are: (1) factor conditions, (2) demand conditions, (3) context for firm strategy and rivalry, and (4) related and supporting industries (Porter, 1990, 1998, 2001).

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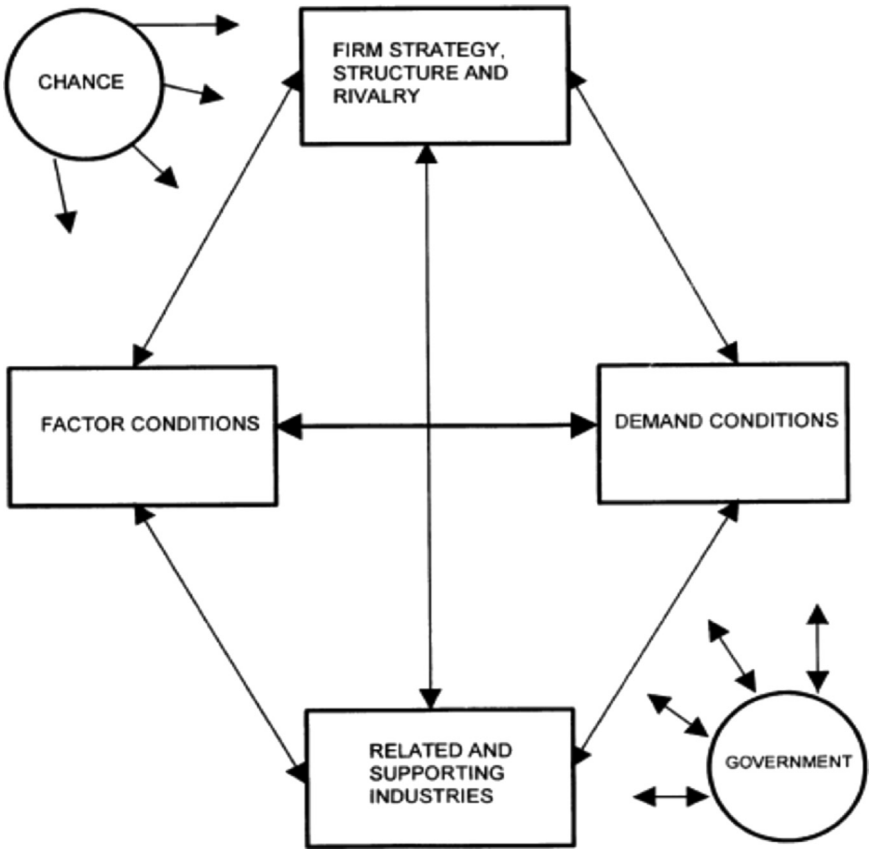

Fig. 1. Porter's Diamond model.
Source: Porter (1990, 1998, 2001).

The cluster can help reduce uncertainty in innovation and support technological development to increase the competitiveness of a region or a country (Saxenian, 1994; Beckeman and Skjöldebrand, 2007; Gnyawali and Srivastava, 2013). Concerning the cluster performance and the effects of clusters on societies, the economist – Schumpeter (1934, 1939) argued that the technological innovations pioneered by entrepreneurs have strong bandwagon effects. Geographic proximity (geographic concentration among firms, research institutions, suppliers and other organizations) can support information transfer within the clusters/networks which thereby help drive the innovation process. The knowledge spillovers from universities and research institutes can engender technology transfer among firms which help create jobs and economic growth. This condition reflects the highly successful model of Silicon Valley clusters where high-tech firms have been created (Wonglimpiyarat, 2005).

2.3. National innovation system concept

Over the past 30 years, the concept of national innovation system (NIS) has widely been recognized as a dynamic tool to investigate, formulate, plan and position the national economic and social development. The emergence of the NIS concept, particularly in the industrialized countries in the Northern hemisphere, can be traced back to the work of Professors Bent-Åke Lundvall, Christopher Freeman and Richard Nelson in the 1980s (Lundvall, 1992, 1998, 1999, 2003; Freeman, 1987; Nelson, 1988, 1993). The NIS framework stresses the importance of interactions and relationships among the actors and institutions to facilitate economic development and growth. The innovation system is composed of institutions, private and public firms (either large or small), universities and government agencies, aiming at the production, diffusion and exploitation of knowledge within national borders (Lundvall, 1992, 1998, 1999, 2003; Freeman, 1987; Nelson, 1988, 1993; Fagerberg and Srholec, 2008; Guan and Chen, 2012). Interactions can be achieved by both market mechanism and non-market mechanisms such as collaboration and long-term network arrangements.

The level of resources devoted by each nation to research and development (R&D) and innovative activities represents a basic characteristic of the NIS (Lundvall, 1992; Nelson, 1993; MjØset, 1992). Determinants of national economic performance and technological capabilities are the size of a country, R&D intensity and market structure (Freeman, 1987; Archibugi and Michie, 1997). The NIS concept is expanded further to the sectoral system of innovation emphasizing interactions and innovative activities at the level of sectoral production system (Breschi and Malerba, 1997; Malerba, 2002, 2004). The boundary of NIS is explained by the scope and interrelations between technological development and the institutional embeddedness of innovative organizations (Freeman, 1987; Lundvall, 1992, 1993, 1998, 1999, 2003; Nelson, 1988, 1993, Fagerberg and Srholec, 2008; Guan and Chen, 2012 among others). An understanding of NIS can help policy makers develop approaches to enhance the nation's innovative performance.

3. Research methodology and background of the study

3.1. Research methodology

To date, the role of government in the process of entrepreneurial development has been understudied. Even less is in the area of innovation financing. Therefore, this research attempts

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to fill the existing research gap by focusing on exploring the government policies towards Israel's high-tech powerhouse. This research employs a case study methodology (Eisenhardt, 1989; Yin, 2003) to understand in-depth the logical or causal drivers of phenomena (rather than statistical generalization). In particular, the case study research attempts to understand how the innovation financing policies/programs can help support the growth of high-tech industries, leading Israel to become a high-tech powerhouse.

The analysis in this study is based on the two main concepts underlying industrial development – the cluster model and the national innovation system (NIS) concept (the reasons are stated in the next paragraph). The results from carrying out the case study analysis provide insights in terms of content and mechanisms of the operating policies behind the successful high-tech industry – Silicon Wadi of Israel. The analyses of findings in the next section reveal that the rise of Silicon Wadi have confirmed the academic term of 'Silicon Valley' in the United States. To avoid confusion in using of the term 'Silicon Valley' as a buzzword, the study follows the scholarly work of Saxenian (1990, 1994, 2006) describing it as an area of high-tech industries with network-based structure and agglomeration. The analyses in Section 4 also reflect on the success of Israel's high-tech powerhouse with Silicon Valley style of management.

The analyses in this research study are carried out through the lens of cluster and national innovation system (NIS) (Porter, 1990, 1998, 2001; Lundvall, 1992, 1998, 1999, 2003). The reasons of integrating these frameworks are twofold. Firstly, the use of cluster model (Porter, 1990, 1998, 2001) offers an opportunity to explore the components (factor conditions, demand conditions, context for firm strategy and rivalry, related and supporting industries as well as chance and government policy) underlying the competitiveness of the nation. The analysis based on Porter's competitive Diamond model would provide a better understanding on the government policies behind the success of Israel as a start-up nation. Secondly, it is useful to view the combination of policies as well as the linkages and interactions among numerous actors/institutions in the overall landscape of Israeli innovation system through the NIS concept. This research is guided by the main question: how could Israel become a high-tech powerhouse?

The present study follows the traditional neo-classical economics, focusing on the macro variable – the national economy. The integrated frameworks of cluster and NIS would take into account institutional and policy factors underlying the development of high-tech Silicon Wadi. At the same time the research will offer recommendations to inform the long-term development of science, technology, and innovation policy. The findings based on this integrated framework would help fulfill an important gap in existing research of innovation financing policies and allow for a deeper understanding on the role of government and public policies in enhancing VC growth and development. The results from the study aim to draw attention of researchers in the policy arena to the structural approach for promoting innovation and industrial development (policy mechanisms driving the VC emergence as well as the innovation financing programs underlying the Israeli NIS).

The context-specific settings of Israel are an exceptional case and indeed interesting in policy practice. However, the use of a single case study has a limitation in that it cannot lead to generalization. Despite such limitation, an understanding of the dynamic process underlying the localized context of Israel's Silicon Wadi would provide important lessons and insights to learn the development processes behind a high-tech powerhouse. Specifically, the lessons of Israel in its growth process of industrialized economy would be useful for other countries to learn the stages of technological and economic catch-ups.

3.2. Background of the study

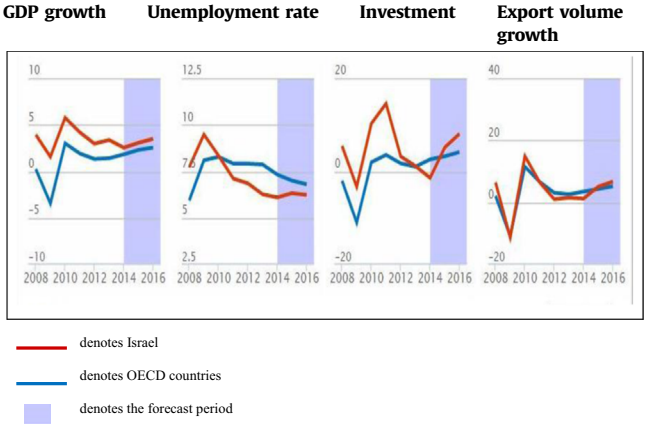
> "*How is it that Israel—a country of 7.1 million people, only sixty years old, surrounded by enemies, in a constant state of war since its founding, with no natural resources—produces more start-up companies than large, peaceful, and stable nations like Japan, China, India, Korea, Canada, and the United Kingdom?*"
> *– The Council on Foreign Relations, Start-up Nation Book –*

The above statements highlight the economic miracle and the technological leadership of the Israel. Israel represents the most successful country after the United States in creating high-tech industries. The rapid economic growth of Israel is attributable to its high-skilled labor force and outstanding academic resources (Trajtenberg, 2001, 2002; Avnimelech and Teubal, 2004, 2006).

Table 1 provides an overview of Israeli economy. It shows the competitiveness of Israel compared with the Organization for Economic Co-operation and Development (OECD) countries in various dimensions. The country was ranked 24th in the 2014 International Institute for Management Development (IMD) World competitiveness ranking and 27th according to 2014 World Economic Forum (WEF) global competitiveness index. Israel was also ranked 19th in the category of very high human development according to the United Nations Development Program's Human Development Report Index in 2014. Israel was invited as a full member in the Organization for Economic Co-operation and Development (OECD), an economic group of developed countries since 2010. The percentage of research and development (R&D) contribution to gross domestic product (GDP) is 3.93 in 2013 and 4.2 in 2014. The percentage of R&D investments to GDP of Israel is highest in the world, compared with 2.4% in the Organization for Economic Co-operation and Development (OECD) countries. The highest percentage of contribution to GDP among the OECD nations has shown that Israel is a leading country in industrial R&D. The GDP growth of Israel is 2.5% (compared to OECD of 1.8%) while the unemployment rate as a percentage of labor force of Israel is 6.1% (compared to OECD of 7.3%).

Table 1
Overview of Israel's economy.

	Year 2013	Year 2014
Competitiveness ranking by IMD	19	24
Competitiveness ranking by WEF	27	27
Human development index by UNDP	19	19
% of R&D to GDP	3.93	4.2
Unemployment rate (%)	5.6	5.6
Inflation rate (%)	1.55	0.54



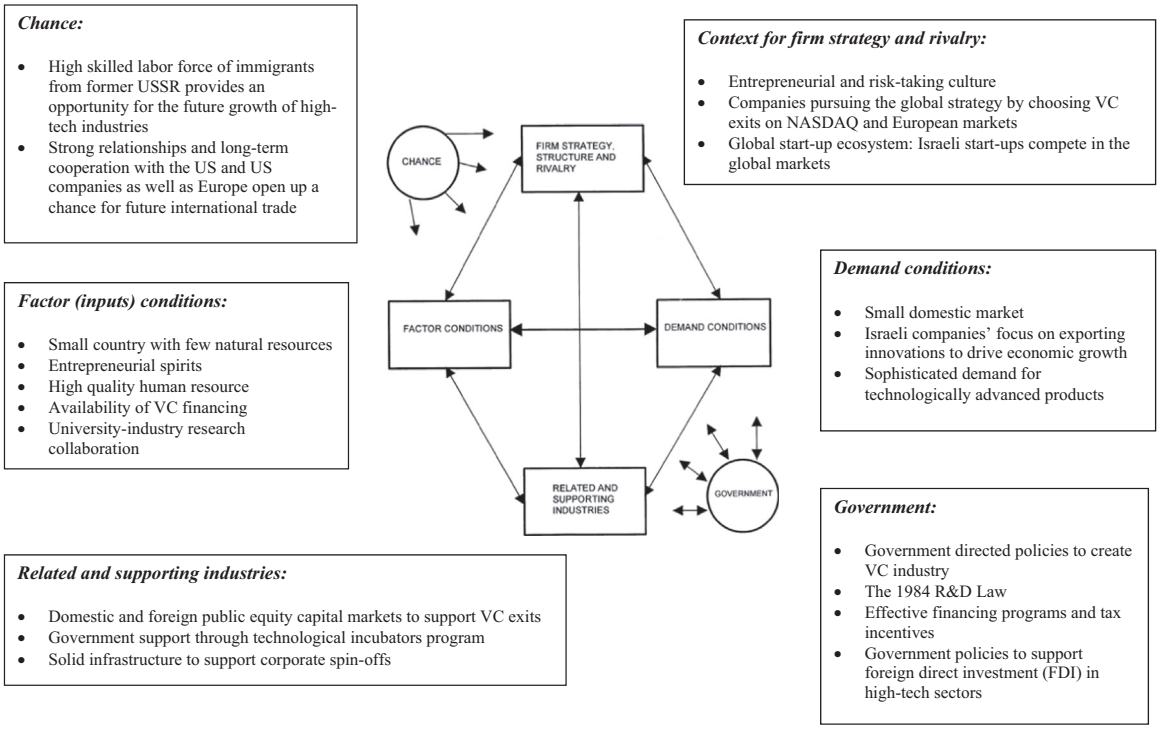


Fig. 2. Analysis of Israeli high-tech industrial clusters using Porter's competitive Diamond model.
Source: The author's design, based on the framework by Porter (1990, 1998, 2001).

4. Analyses of findings

4.1. Analysis of Israeli high-tech industrial clusters based on the cluster model

The analysis of Israeli high-tech cluster and strategy based on the cluster model (Porter, 1990, 1998, 2001) is shown in Fig. 2. The analysis was made on factors affecting the competitiveness of Israeli economy. The Porter's Diamond model can be seen as a basis for policy making since the model assists in understanding why and how the cluster and network conditions could support economic growth.

Israel's entrepreneurial clusters are one of the most successful high-tech industrial clusters outside the US. The government policies in the 1960s and 1970s are focused on R&D in defense industry but the policies are later directed towards creating high-tech industries in the late 1980s. The government has put a strong emphasis on R&D and provided financial supports to advance technologies. Among the government policies in innovation financing are the major programs of Inbal, Yozma and Magnet. These programs were introduced since the early 1990s through the Office of the Chief Scientist (OCS), Ministry of Economy with

***'Silicon Wadi'* - Israeli Silicon Valley**

- **Tel Aviv**
- **Herzliya-Pituach**
- **Haifa**
- **Jerusalem**
- **Rehovot**

Fig. 3. Israel's high-tech industrial clusters.
Source: The author's design.

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the aim to leverage the VC industry. Particularly, the government-led policy of Yozma program introduced in 1992 had helped transform the defense industry into high-tech clusters.

One of the main factors behind the growth of high-tech cluster development is the human capital since the immigrants from the former Soviet Union were scientists, engineers, technicians and skilled professionals. These immigrants are human capital characterized by entrepreneurial and risk-taking culture (Chorev and Anderson, 2006). The immigrants who were university graduates and highly skilled professionals at that time provided the valuable human resource that helped drive the high-tech clusters to become a successful Silicon Valley type of technology centers. In establishing entrepreneurial high-tech clusters, the government introduced the technological incubators program to support the projects proposed by these skilled immigrants. The universities also served as research incubators undertaking R&D activities in collaboration with the industries. The universities provided important sources of human capital (knowledge workers as intellectual capital). R&D undertakings were carried out in major universities like the Hebrew University of Jerusalem, Technion-Israel Institute of Technology, Weizmann Institute of Science, Ben–Gurion University of the Negev. The scientific research and technologies were commercialized through the universities' owned Technology Transfer Companies (TTCs). Today, many Israeli universities have entrepreneurship centers, for example, Bronica Entrepreneurship Center at Technion, StarTau at Tel Aviv University.

Israel had formed one of the world's most successful high-tech industrial clusters since the 1990s. The thriving VC industry has transformed Israel into Silicon Wadi – Israeli Silicon Valley (Fig. 3). Silicon Wadi is located around Tel-Aviv where it is second only to US Silicon Valley in terms of business start-ups. It is the technological hub generating innovations in the fields of information and communications technology (ICT), software, data communications, electro-optics, hardware design, internet, etc. The thriving VC industry has helped create cluster effects to support the growth of high-tech clusters. In other words, the successful cluster development was a result of effective interactions among the government (the OCS under the Ministry of Economy in particular), the universities and industries. The Yozma program effectively supported investments oriented in the ICT and life science sectors during 1993–2000. The Yozma funds and other Limited Partnership (LP) VCs have attracted follow-up funds to provide additional capital for further investments. Given that the Yozma VC fund required involvement of reputable foreign financial institutions (generally a foreign private equity or VC company), such requirement had triggered collective learning process via VC cooperation.

The Israeli government, through the OCS, provides grants and financing to support R&D in collaboration with universities and industries. With heavy R&D investments amounted to 4.5% of GDP, this has fueled the number of high-tech start-ups during 1993–2000. The number of high-tech start-ups in this period totaled

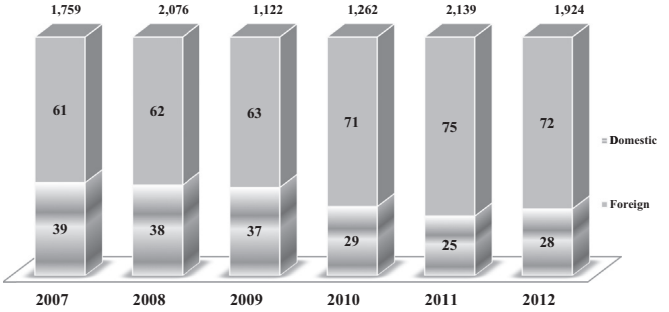

Fig. 4. Venture capital in high-tech companies (in USD million and %).
Source: Investment Promotion Center, IVC Research Center.

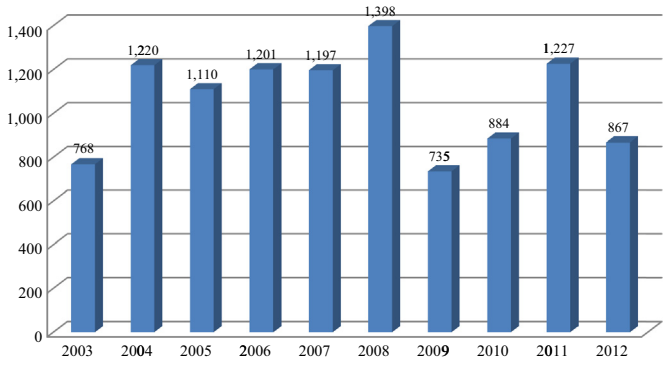

Fig. 5. Annual VC investments (in USD million).
Source: PwC Israel MoneyTree Report.

2436, comprised of 855 VC-backed companies. As a result of the OCS' policy to support R&D investments, the number of Israeli patenting in the US has grown very rapidly at the average rate over 10% per year, placing Israel as the 14th largest foreign recipient of US patents. The patents are mostly in the key technological areas of computers, communications and biotechnology.

Looking back to the early 1990s, there were virtually no VC investments in Israeli companies. Only 4 VC Limited Partnerships (LP) operated in Israel in 1992 but this number increased to 50 in the year 2000 (Avnimelech and Teubal, 2006). Venture capital (VC) is the main mechanism behind the successful creation of Israeli high-tech clusters. The emergence of Israel's VC market was triggered by the Yozma program, a government-targeted policy to support R&D activities. The launch of Yozma program mirrored the willingness of the Israeli government to take risks in VC investments. Yozma funds were private VC funds that invested directly in the business start-ups. These VC funds were part of the Yozma program, a government-targeted program launched during 1993–1998. Yozma funds had induced private VC investments by stimulating co-investments. The funds by far brought about 10 private VC funds in a few years of operation. The development of Yozma program has led Israel's VC industry to the highest growth in the 1990s. At present, the high-tech industry of Israel accounts for more than 54% of industrial exports, and over 26% of the country's exports. Fig. 4 shows the share of venture capital-backed investments in high-tech companies from the years 2007 to 2012. It can be seen that foreign investments account for 72% of total investments in 2012.

Interestingly, behind the growth of industrial clusters are strong linkages and effective interactions in the NIS. The

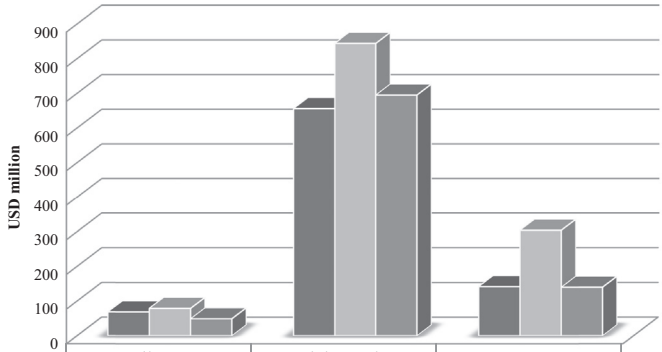

Fig. 6. VC investments by stages.
Source: PwC Israel MoneyTree Report.

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government's policies and OCS activities have created an enabling environment to support entrepreneurial firms in the clusters. Under these circumstances, the clusters have attracted R&D operations of major multinational companies that invest heavily in R&D. Examples of major multinational companies investing in Israel are Microsoft, Apple, Lucent, Intel, IBM, Oracle, Pfizer, Google, Motorola, Facebook, Siemens, AOL, Cisco, GE, HP, and Toshiba. The nation continues to develop high-tech clusters oriented in ICT areas.

Israel's Yozma program has triggered the emergence of a domestic VC industry. With a pool of human capital and VC supports from the OCS in sharing the risks of R&D projects, this led to the successful development of Silicon Wadi – the model of high-tech industrial clusters. Israel has become one of the most dynamic technological areas today. Fig. 5 provides the annual VC investments from the years 2003–2012. VC funds with most deal investments in 2012 include Carmel, Horizons Ventures, Gemini, Genesis, JVP, Magma, Pitango, OrbiMed Israel, Accel, Blumberg Capital, Bessemer among others.

Fig. 6 shows the stage of VC investments during 2010–2012 where most investments were made in early and expansion stages. The supports of SMEs by the OCS have helped facilitate the process of research commercialization. The OCS remains committed to advancing the VC industry to promote job creation and employment growth. According to Small- and Medium-size Business Authority data, there are 400,000 small businesses in Israel that employ more than 50% of Israel's workforce constituting about 96% of all businesses in Israel. Today, Israel is recognized as a model of high-tech clusters whereby the successful cluster development is seen as a result of government's policy in advancing VC landscape to support entrepreneurship.

4.2. *Analysis of the Israeli innovation system based on the national innovation system (NIS) concept*

The analysis of the Israeli innovation system (Fig. 7) is based on the national innovation system (NIS) framework (Lundvall, 1992, 1998, 1999, 2003). The Israeli government is the main actor of the innovation system playing an intervention role to enhance the supply of venture capital (VC). Specifically, the Israeli government designed the VC policies and implemented the innovation financing programs to support the development of VC industry which will be discussed further.

Taking into account the functioning of actors/institutions in the innovation system, the Israeli government through the Office of the Chief Scientist (OCS) created the technological business incubator program to leverage the strengths of immigrants from former USSR, many of whom were scientists, engineers, technicians and physicians. The OCS also worked cooperatively with other nations to establish bilateral R&D foundations providing finance for projects in areas of strategic importance to Israel's economy. The programs to support Israeli high-tech companies administered by the OCS include technological incubators as well as financial assistance to companies in pre-seed and seed stages such as TNUFA, HEZNEK, NOFAR, Magnet programs. From Fig. 7, one can also see that the Ministry of Economy assumes the strategic role in providing financial and developmental resources to entrepreneurs in supporting industrial R&D.

Underlying the Israeli innovation system, the OCS plays a dominant role in creating a solid base for the VC industry in Israel by introducing the Yozma program. Yozma is an important government program providing financial supports (Yozma funds) in enabling the creation of high-tech clusters. The implementation of Yozma program provided rapid VC supply to overcome the financial constraints of start-up firms. Supports of entrepreneurial start-ups and small- and medium-sized enterprises (SMEs) thereby helped foster job creation and economic growth.

The stock market is another important institution in the Israeli innovation system that helps reinforce the cluster development. The Tel-Aviv Stock Exchange (TASE), regulated by the Israel Securities Authority, provides an exit route for high-tech companies. Interestingly, the Dual Listing Law enacted in 2000 provides cross listing opportunities to broaden the investors' base. Most Israeli high-tech companies pursued a global strategy of exiting VC investments on the NASDAQ market. Approximately 50% of exits on NASDAQ are VC-backed companies. High-tech companies also exit through the New York Stock Exchange and the Alternative Investment Market (AIM) in London.

Table 2 shows the number of deals and total exits from the years 2004-2013. The listing on global exchanges has helped these

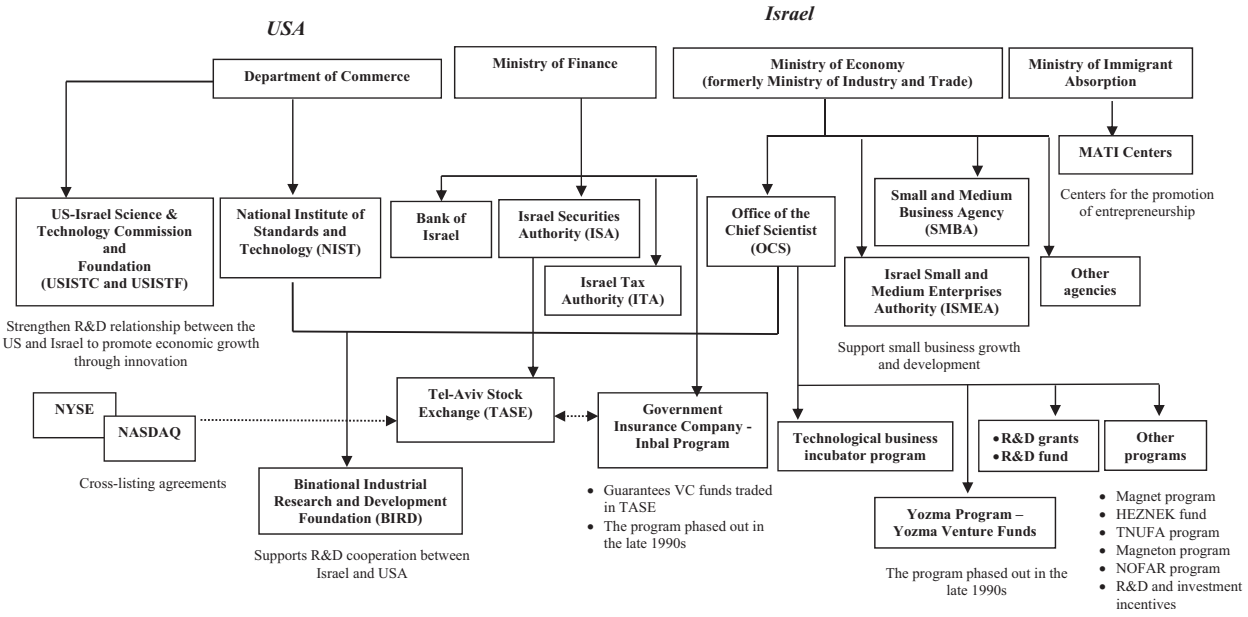

Fig. 7. The Israeli innovation system.
Source: The author's design.

Table 2
The number of deals and total exits of high-tech companies.
Source: IVC Research Center.

Year	Total capital raised (USD billion)	Total exits (USD billion)	Number of deals
2004	1.38	2.55	77
2005	1.38	3.56	96
2006	1.57	10.75	116
2007	2.08	4.38	115
2008	1.16	2.70	86
2009	1.01	2.59	78
2010	1.40	2.33	81
2011	1.37	5.23	100
2012	1.31	9.67	82
2013	1.26	6.98	81

high-tech companies establish linkages with the global markets. These linkages not only help bring more investments to Israel but also help Israeli companies grow their international trade. At present, Israel has the largest number of listed companies on the NASDAQ market than any country outside the US. The incumbent companies in NASDAQ are, for example, Scitex Corporation Ltd., Elbit Systems Ltd., Teva Pharmaceutical Industries Ltd. It is interesting to see that the VC policies and government financing programs, the spin-off of high technology companies (particularly in the ICT sector) as well as their linkages with the global capital market reflect effective linkages and interactions among actors/institutions that help facilitate the process of technology transfer and commercialization.

The OCS, Ministry of Economy plays a major role in introducing national innovation policies. In particular, the OCS is responsible for implementing the government policies with regard to industrial R&D supports. Table 3 summarizes the major innovation financing programs to support R&D undertakings in Israel. These innovation financing programs have contributed to the growth of Israeli economy and led the country to become the high-tech powerhouse.

The technological incubators program supports the translation of ideas into commercial innovations. From its inception in 1991, the program had already created over 1700 companies through the government investments of around USD 650 million. The successful companies graduated from the technological incubators program are, for example, Protalix – Meytav Incubator, D-Pharm – Orit (now Incentive) Incubator, Compugen – Am-Shav Incubator, Sightline – Eltam Incubator, Remon Medical – Naiot Incubator, Mazor – Technion Incubator, Contipi – L.N. Incubator, Imagine – Iris Incubator, Zoomix – JVP Incubator, Double Fusion – JVP Incubator, Lucid – Ma'ayan Incubator, Aeronautics – Orit (now Incentive) Incubator. To date, the program provides incubating supports to approximately 180 companies in various stages of R&D. The success of the program implementation can be seen from its ability to create approximately 70–80 new ventures each year.

Given the policy goal to portray the case of Israel in successfully climbing the technological ladder to become a high-tech powerhouse, the analyses in Sections 4.1 and 4.2 above highlight the theoretical and practical contributions as follows. Theoretically, the study has made an attempt to fill the gap in the body of knowledge with regard to the role of government policies in innovation financing. The analyses, based on the cluster model (Porter, 1990, 1998, 2001) and the national innovation system (NIS) concept (Lundvall, 1992, 1998, 1999, 2003) provide a better understanding of the government policies and innovation strategies (particularly the Yozma venture financing program) aimed at advancing the industrial clusters, making Israel a high-tech

Table 3
Major innovation financing programs in Israel.
Source: The author's design (compiled from various sources).

Programs	Description
Inbal	The Inbal program was established in 1992. The program objective was to stimulate publicly-traded VC funds by guaranteeing the downside of investments. A government owned insurance company (Inbal) gave partial guarantees (70%) of initial capital assets. The Inbal program placed restrictions on the investments of the VC companies which it covered. However, the implementation of the Inbal program was not successful and was later phased out.
Yozma	The Yozma program was launched in 1993. It was a USD 100 million government owned VC company to finance early stage VC funds. The aim of the Yozma program was to support the establishment of domestic Limited Partnership VC funds. Through inducing private sector investments, the Yozma program had triggered the creation of the VC industry in Israel. The program was phased out after the successful creation of Israeli VC industry.
Magnet	The Magnet program was established in 1992 to encourage pre-competitive generic research conducted by consortia of industrial companies. The program aims to support business R&D activities – cooperative R&D involving two or more firms and at least one university.
Mini-Magnet (Magneton)	The Mini-Magnet (Magneton) program encourages technology transfer from academia to industry via the mutual cooperation of individual companies and specific academic research programs. The program offers grants of up to 66% of the approved budget with no requirements on royalty repayment.
Technological incubators program	The technological incubators program was established in 1992. The incubators program has annual total program budget of USD 25–30 million to support business start-ups. The technological incubators program aims to support ventures in their first three years of operation. At present, the program is open to all Israeli start-ups to help them translate innovative ideas into commercial innovations.
R&D fund	The R&D fund is the main financing mechanism of the OCS to support all Israeli companies engaged in technological R&D activities. Grants are provided up to 50% of the total approved R&D expenditures. The R&D fund provides financial supports to various scientific fields such as communications, IT, biotechnology, etc.
TNUFA	TNUFA program supports technological entrepreneurship and innovation by assisting business start-ups in the pre-seed stage. The program also provides assistance in evaluating the concept's technological and economic potential, patent proposal preparation, prototype construction, business plan preparation, establishing business relationships with industry partners. Grants are provided up to 85% of approved expenses with a maximum of USD 50,000 for each project.
NOFAR	NOFAR program helps bridge the gap between basic and applied research in biotechnology. Grants are provided up to 90% of project expenditure with the remaining 10% coming from outside sources. The maximum grant is approximately USD 100,000 per project and no royalties or repayments are required.
HEZNEK	HEZNEK program is the government seed fund. It is a co-investment fund based on the government matching an investment in a start-up company, proportional to the investment of an investing entity. The investor is given an option to purchase the government shares in the start-up company at the initial price.
Binational Industrial Research and Development Foundation (BIRD)	The Israel–US Binational Industrial Research and Development (BIRD) program was founded in the early 1980s with the aim to promote and support joint, non-defense, industrial R&D activities of mutual benefit to the (private sectors of the) two countries. The program offers funding of up to 50% of each company's R&D expenses associated with the joint project.
Britain–Israel Industrial R&D Foundation (BRITECH)	The BRITECH fund was established in 1999. The program provides funding to support firms operating and headquartered in the UK and Israel on condition that at least 30% of the R&D work must be done in either country. The

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Table 3 (*continued*)

Programs	Description
	BRITECH fund also provides financial supports of up to 50% of the eligible R&D costs of joint projects.
Israeli life science funds	The Israeli life science funds aim to support the thriving industry of life sciences in Israel. The government provides an aggregate of USD 80 million to the funds as a limited partner of each fund. The government commitments are matched by commitments of private sector investors amounting to a multiple of the government commitments. The funds invest at least 3 times government commitment in the biopharmaceutical sector.
Eureka	EUREKA is the pan-European intergovernmental program established with the aim to coordinate efforts by the governments, research institutions and private sectors relating to innovation. Within the scope of this initiative, Israel provides funding equal to 50% of eligible projects. Matimop, the Israeli Industry Center for R&D, is the national agency acting on behalf of the OCS as the Israeli national program coordinator for Eureka. The program provides funding channels for Israeli companies to access R&D grants from the OCS.
Bridging aid program	Bridging aid program offers support for the transition between R&D and manufacturing and marketing. The program objective is to enable companies that have completed the R&D stage to manufacture a number of prototypes for installation on the premises of potential clients, especially abroad.
Katamon	Katamon program promotes water technology projects. The program encourages cooperation between industrial company, academic research group and water infrastructure company. The project provides grants up to 50% of project expenditure with no royalty payment requirements.
Sub-contracting industrial R&D program	The sub-contracting industrial R&D program supports the civilian R&D project undertakings for foreign companies, by Israeli enterprises acting as subcontractors. The program aims to initiate joint ventures with foreign partners in order to assist Israeli companies market their technologically advanced products abroad. The program provides grants of up to 20% of R&D costs.
Exploratory studies for industrial R&D projects program	The exploratory studies for industrial R&D projects program supports studies of the market potential for new technologies, prior to the investment of large sums in the R&D stage. The program aims to assist start-up firms or those with limited R&D experience. The program supports 50% of the approved project costs, up to USD 30,000.
Europe's R&D Framework Agreement (ISERD)	The EU's R&D Framework Program (ISERD) facilitates research funding in Europe, bringing together industrial and academic research. The program offers Israeli companies and research organizations an opportunity to participate in jointly implemented projects with European counterparts so as to help them better integrated into European business and scientific communities. The program aims to promote joint Israeli–EU R&D ventures. The program provides grants to cover 75% of the full cost with real overheads for SMEs and 50% of the full cost with real overheads for large industrial partners.

Table 4
Policy aspects to promote entrepreneurial financing of Israel.
Source: The author's design.

	Policy initiatives of Israel
Industrial innovation policies to promote entrepreneurial financing	• The competitiveness of Israel is a result of its entrepreneurial culture and the government-led technology policies in venture capital (VC) financing. • The government-targeted policies and financing programs effectively triggered crowding-in effects in terms of creating a quantum jump in VC investments and private VC supply in the market (unlike the process of crowding out private investments that took place in other countries).
The cluster model	• The rapid growth of innovative information and communications technology (ICT) cluster is a result of domestic VC support. • The thriving Israeli high-tech clusters are the result of government-led policies in creating VC industry with the financial support of Yozma program.
The national innovation system concept	• The government, through the Office of the Chief Scientist (OCS), Ministry of Economy, plays an important role in providing grants and financing to support R&D in collaboration with universities and industries to support the creation of Silicon Wadi – Israel's Silicon Valley. • Effective linkages and interactions among the various actors and institutions in the innovation system (under the lead of OCS, Ministry of Economy in policy implementation) facilitate the process of climbing the technological ladder to become a high-tech powerhouse.

miracle. Practically, the findings of this research provide a better understanding of the mechanisms to enhance innovative capacity of nations. The case analysis of Israel gives insights into policy measures and institutional interventions to harness the power of VC financing in national industrial development. Developing countries can learn and apply the policy initiatives from the case study of Israel to support entrepreneurial financing, national economic growth and competitiveness (Table 4).

5. Conclusions and policy implications

This study is concerned with the government policies for promoting innovation and driving Israel towards a high-tech powerhouse. The analyses are carried out through the lens of cluster (Porter, 1990, 1998, 2001) and national innovation system (NIS) (Lundvall, 1992, 1998, 1999, 2003). The analyses have shown that the success of Israeli economy is a result of strong government-led policies to create Silicon Wadi – a model similar to Silicon Valley in the United States. The high-tech clusters are driven by the government policies particularly Yozma and technological incubator programs which make Israel a global innovative hub, second only to the US Silicon Valley. The case analyses have shown effective linkages and interactions underlying the Israeli innovation system which help facilitate the process of technology transfer and commercialization. The government financing programs to support university-industry R&D projects have helped advance the industrial clusters, making Israel the high-tech miracle.

This study has made a theoretical contribution to the body of knowledge by filling the existing gap concerning scarcity of research linking the government policies to innovation financing. In respect of the practical contribution of this study, the case analyses provide a better understanding of the mechanisms for enhancing innovative capacity of nations that can be applied to other countries attempting to learn how to promote high-tech clusters. Although the use of a single case study may have limitations in terms of generalizability, the analysis provides important insights attracting the attention of researchers and policymakers around the world to learn the process of technological and economic catch-ups. Arguably, the case study of Israel is an exceptional one providing useful lessons for other countries to learn Silicon style of management and in particular how could Israel transform itself from an underdeveloped economy towards a high-tech economy. The present study offers interesting avenue for future research. The inclusion of multiple case studies would allow more useful

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generalization with regard to public policies as well as other indirect supports to promote competitiveness of nations.

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