

**Scaling up and Sustaining Innovation Policies and Projects:
Schumpeterian Development Agencies in Small Open Economies**

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Abstract

This paper examines how two historically low-technology economies, Finland and Israel, assumed leadership in new, rapid innovation-based industries. The paper argues that ‘Schumpeterian development agencies,’ the Finnish Fund for Research and Development and the Israeli Office of the Chief Scientist in the Ministry of Trade and Industry played a transformative role, introducing new science and technology policies and facilitating industrial restructuring. In contrast to literature on the developmental state, however, argues that these agencies were located the periphery of the public sector, with few hard resources. The paper describes how their peripheral location facilitated successful experimentation. It also explains how ostensibly marginal agencies could successfully scale and monitor new initiatives. More specifically, it argues that reform-oriented policy-makers in small states could leverage extensive inter-personal networks to facilitate scaling and international openness to facilitate monitoring. In identifying specific mechanisms by which policy-makers introduced, scaled and monitored policies, it also explains why these two historically innovative economies have struggled to support experimentation in recent years.

Recent debate over how to promote economic development bifurcates into streams. One school of thought, common to international development organizations, seeks to identify and diffuse ‘best practice,’ universal and invariant programs designed to promote economic growth. For example, recent scholarship has emphasized macroeconomic stabilization, private property rights and domestic and international economic competition for stimulating innovation and growth. This ‘Washington consensus’ (Williamson 1990) has been widely applied across a wide range of institutional and economic contexts in from Latin American to Eastern Europe and East Asia (Sachs 1993; Wade 2000; Williamson 1990). While the Washington consensus has been broadened to incorporate a greater role for government intervention, from financial regulation to social policy and poverty alleviation, this school of thought nonetheless continue to search for, codify and diffuse a specific set of policies across a diverse range of societal and economic contexts (Rodrik 2007).

An alternative school of thought contends that any efforts to codify best practice are futile as countries develop in unique and irreproducible ways. The aforementioned Washington consensus, for example, has proven problematic in at least two respects. First, policy-makers rarely implement policies as academics and international sponsors would intend, but instead “translate” them into a form that is politically feasible for and intuitively appealing to local stakeholders (Kjaer and Pedersen 2001). Second, even if policy-makers could, and would, directly copy international best practices, policies might not address context-specific barriers to growth within individual countries (Hausmann et al. 2008). As a result, literature on successful innovators such as Denmark, Finland, Ireland, Israel and Taiwan has identified a range of distinctive, even divergent and policies (Breznitz 2007b; Lundvall 2002; O’Riain 2004; Ornston 2006). Taken to its extreme, this reaction to the codification and diffusion of best practice might

suggest that no general lessons are possible. Economic development is a product of serendipity, a combination of good governance and the uncertain acquisition of qualified managers and public servants.

This tension is most acute at the technological frontier, where firms rely on rapid-innovation-based (RIB) competition. RIB competition, an important source of growth in many late developers (Breznitz 2007b; Hommen and Edquist 2008; O'Riain 2004), exemplifies the challenges associated with policy-making described above. The rapid introduction of disruptive new standards, technologies and business practices makes it difficult to identify best practice. Traditional industrial policies based on planning have struggled in this space (Breznitz 2007b; Katz 1998; O'Riain 2004). Delegation to private sector actors via market-friendly reform is no less problematic, however, as entrepreneurs are equally uncertain about future products, activities and industries (Breznitz 2007b; Breznitz and Zehavi 2010). For example, entrepreneurs may also be unwilling to make risky, long-term investments in product and service development, particularly if they require complementary investments or demand by other actors (Edquist 1997; Lundvall 1992). Recent literature suggests that policy-makers can respond to these challenges by relying on “experimentalist” governance, launching and monitoring a range of developmental initiatives (Breznitz and Zehavi 2010; Rodrik 2007; Sabel and Zeitlin 2010; Schulze-Cleven et al. 2007), but the specific process by which policy-makers do so remains unclear.

This paper seeks to illuminate this process, shifting attention from policy programs to the processes that generate them. It adopts the perspective of a reform-minded policy-maker seeking to promote RIB growth with a portfolio of developmental projects. To add more empirical substance to this theoretical framework we analyze the experience of reform-minded policy-makers in Finland and Israel. These small states are widely perceived to operate at a

disadvantage in high-technology markets because they lack the resources and institutions to conduct capital-intensive research and the market size to establish industry-defining standards (Dalum 1992; Katzenstein 1985; Kristensen and Levinsen 1983; Lundvall 2002). At the same time, they have proven remarkably successful in this space, competing in RIB industries as diverse as biotechnology, software and telecommunications equipment. While each country leveraged different institutions and instruments to pursue unique objectives, they relied on strikingly similar mechanisms to introduce, scale and monitor portfolios of private-public programs.

More specifically, the paper advances two claims. First, it argues that ‘Schumpeterian development agencies’ or SDAs, public organizations with a mandate to facilitate innovation in new industries, played a critical role in precipitating industrial adjustment. In contrast to literature on the developmental state, however, we argue that successful SDAs occupied a *peripheral* position within the public sector. Limited access to resources exposed these agencies to new ideas and limited political interference. At the same time, it generated formidable two challenges. Most obviously, their peripheral status left them with few ‘hard’ resources to scale-up science, technology and innovation (STI) policies that proved successful. Furthermore, to the extent that they did scale new projects, their success increased their profile and inhibited their capacity to monitor and adapt new STI policies.

Consequently, this paper advances a second, two-part argument, explaining how SDAs in small states successfully scaled and monitored portfolios. First, it argues that agencies with limited ‘hard’ resources were able to leverage close, often informal, ties among elite actors to publicize and implement new programs. Second, agencies in small states could rely on international, market competition to resist the political and cognitive lock-in that stemmed from

both consensual political and social systems and success (Breznitz and Zehavi 2010; Schrank and Kurtz 2005). In other words, the paper supports contentions that small states are uniquely advantaged in their capacity to construct and monitor portfolios of private-public projects, because of their ability to combine internal communication with external vulnerability (Doner et al. 2005; Katzenstein 1985). In identifying the specific mechanisms by which they do so, however, the paper explains why some small states may be less innovative than others and even the most ‘successful’ cases fail to innovate, particularly during good times.

The paper develops the preceding arguments in four steps. Section one introduces the concept of the Schumpeterian development agency, explaining its importance in introducing experimental STI programs and the challenges that it faces in scaling and monitoring those policies. Section two describes how policy-makers in small states have navigated these twin challenges, leveraging their exposure to domestic networks and international competition. Sections three and four support the argument by reviewing developments in Finland and Israel. While policy-makers relied on agencies and instruments, each relied on inter-personal networks and international competition to scale and monitor developmental projects. Section five concludes by discussing how their successes, and failures, yield concrete lessons for policy-makers in larger and less developed states. Analysis is based on 215 interviews with policy-makers and industry representatives conducted in Israel and Finland between 2000-2007.

1. Schumpeterian Development Agencies and Rapid-Innovation-Based Competition

In each of the countries under consideration, RIB growth can be traced back to Schumpeterian development agencies with an explicit mandate to promote innovation in new industries, such as the Office of the Chief Scientist (OCS) in the Israeli Ministry of Trade and

Industry or the Finnish National Fund for Research and Development (Sitra).¹ These agencies have evolved to become the institutionalized loci of experimentation, continuously developing and implementing new sets of STI policies that proved to be the kernel of national economic transformation. These programs were developed as a part of a co-evolutionary process between policy and industry. Crucial was the ability of these agencies to supply the needed spark that moved their respective RIB through stages of maturation until they reached success.

In contrast to literature on the developmental state (Amsden 1989; Ansell 2000; Chibber 2002; Evans 1995; Johnson 1982; O'Riain 2004; Wade 1990), however, we contend that these agencies initially occupied a peripheral position in the political system. RIB industries were marginal, innovation policy was not very salient and the agencies that advanced these objectives, contrary to popular perception, possessed limited resources. Far from constraining experimentation, their peripheral location facilitated innovation for two reasons. First, their location at the periphery of the public sector and the political and economic system more generally increased their exposure to new, often radically different ideas, about how to organize political and economic activity. The following sections demonstrate that the agencies actively identified and imported new policies from foreign countries and international agencies, because they were barred from participating in traditional activities. Second and just as importantly, their low profile enabled them to introduce, monitor, adapt and abandon new policies with minimal interference from other political and economic actors.

While the Schumpeterian development agency at the periphery of the public sector was thus a seed bed for experimental policy-making, reform-oriented agents faced two problems.

¹While countries can also rely on the incremental upgrading of policies and industries to achieve economic growth, the development of new activities by entrepreneurial actors is more relevant for competition in RIB industries (Hall and Soskice 2001) It is also more relevant for developing countries to the extent that growth is based on the diversification rather than the deepening of comparative advantage (Rodrik 2007).

First, the same lack of resources that insulated Schumpeterian development agencies from political fights limited their capacity to scale projects, even in areas where scale-up was necessary to meaningfully affect sectoral or national outcomes. For example, the limited ability to offer material incentives made it more difficult to engage the private sector actors, whose participation was central to innovation and growth. The lack of finance also rendered reform-oriented policy-makers constantly vulnerable to the risk that other policy-makers might fail to support or actively undermine new initiatives.

Second, to the extent that the reform-oriented policy-maker could scale new initiatives, however, their success could impair their capacity to monitor, adapt and terminate established programs or introduce new ones. Successful projects generated powerful constituencies, who resist efforts to criticize, modify or eliminate policies. Meanwhile, the agency itself could become a target of political infighting as it increased in political salience and acquired more resources. Success, in other words, imposed cognitive constraints in identifying success and failure, as well as political obstacles in continuing to adopt experimental new policies. Policy-makers thus struggled with a continual process of institutional ‘dis-entrenchment,’ seeking to surmount special interests in their efforts to modify or terminate ineffective policies, which was in many ways inversely related to their success and centrality in the public sector. This paper explores how policy-makers in small states navigated these twin challenges, leveraging domestic networks and international openness to scale and monitor experimental STI policies.

2. Schumpeterian Development Agencies in Small States

In order to understand how Schumpeterian development agencies in smaller states successfully managed this dilemma, it is important to understand how small states differ from

their larger counterparts. First, small states are characterized by smaller and more cohesive inter-elite networks. Repeated interaction among elites is most visible in the so-called small, neo-corporatist economies of Western Europe that rely on formal, centralized bargaining among organized industry and labor associations or functionally equivalent units such as the banking bloc (Katzenstein 1984; Katzenstein 1985). This focus on formal institutions, however, obscures the extent to which elites in corporatist *and* non-corporatist countries can rely on informal institutions such as common educational background, military service, public service, corporate boards and private clubs to create a similar environment (Breznitz 2005a; Breznitz and Zehavi 2010; Moen and Lilja 2005; Ornston and Rehn 2006). In both cases, repeated interaction ensures that policy-makers, industry representatives and other key decision-makers are more likely to know and trust one another, enhancing communication among and between public and private sector actors.

These dense networks enabled SDAs to quickly scale a multitude of experimental innovation policies with a small amount of financing and little political clout. More specifically, reform-oriented agents were able to use networks not only to convince and coordinate activity with other policy-makers as well as private sector actors. More specifically, reform-oriented agents were better able to convince firms to share information, commit resources, and cooperate with public sector initiatives as well as with each other. In so doing, they were able to more effectively address shirking, cheating or other forms of non-compliance to construct broad projects that spanned the private and public sectors (Breznitz 2007b; Breznitz and Zehavi 2010).

At the same, cohesive, inter-elite networks created several problems. Consensual political and social systems have been difficult to penetrate, particularly for peripheral actors such as the SDAs mentioned above. To the extent that SDAs could do so, the same cohesive networks and

social capital that enabled them to scale projects prevent them from killing projects that proved to be inefficient. Consensus-building could blind policy-makers to the disadvantages associated with new programs, while program beneficiaries could rely on dense, inter-personal networks to block reform. Luckily, reform-oriented policy-makers could leverage a second characteristic of small states to monitor and adapt portfolios. More specifically, small states are more dependent on international markets than their larger counterparts (Campbell and Hall 2009; Katzenstein 1985; Kristensen and Levinsen 1983).

International openness facilitated monitoring in several ways. First, international openness enabled reform-oriented agents to more quickly identify and modify or terminate failing projects. For example, using leading international MNCs and financiers as partners and customers, mean that domestic projects are subject to external evaluation of the highest standards (Breznitz and Zehavi 2010). Second, policy-makers could more easily adapt and terminate programs, as policy-makers lacked the fiscal resources to support loss-making enterprises and industries within a small, open economy (Katzenstein 1985). Finally, international organizations such as the WTO and EU generated pressure to abandon infant industry programs as industries mature, even if the programs were not generating significant losses (Schrank and Kurtz 2005).

At the same time, international openness is not a panacea. While international openness facilitated rapid policy adaptation during economic crises, it did not facilitate monitoring when the economy was growing, particularly when new STI policies complied with WTO and EU regulations. As a result, SDAs that introduced experimental new STI policies during economic crises in the 1970s and 1980s struggled to adapt policies and introduce new ones during the 1990s and 2000s.

In the next two sections, we analyze the histories of two, very different, ideal-type examples of small states with transformative Schumpeterian development agencies – Finland and Israel – as a theoretical framework building and elaboration exercise. Our aim is to develop these theoretical insights in an attempt to come with specificities in terms of mechanisms and processes that we can then generalize into coherent policy implications as well as test in future studies using a larger, more varied, sample. The following two sections demonstrate that while Finland and Israel relied on different economic institutions and policy instruments to promote RIB competition, they relied on strikingly similar processes to scale and monitor those policies. More specifically, Schumpeterian development agencies at the periphery of the political system, leveraged inter-elite networks and international openness to scale and monitor new STI policies. At the same time, successful policy implementation and economic growth generated cognitive and political barriers to successful adjustment, hindering experimentation in recent decades.

3. Constructing a Portfolio of High-Technology Research Projects in Finland

This section explores how Finland transformed itself from one of the least research-intensive economies in the OECD, with low-technology, forest-based products accounting for over half of the country's exports, into a global leader in wireless communications and knowledge-intensive production more generally. As noted below, new innovation policies in turn played an important facilitating role in stimulating private sector research and industrial diversification. This section explains how these policies were introduced and implemented within the confines of a highly consensual, historically low-technology economy. It focuses on Sitra, an independent think tank and Schumpeterian public agency. Part one documents Sitra's

peripheral position in the Finnish political system and explains how this helped the agency to introduce experimental, new innovation policies. Part two describes how Sitra could compensate for limited hard resources by leveraging social networks, and how this enabled Sitra to scale new programs with remarkable speed. Part three describes how reform-oriented policy-makers relied on economic openness to monitor and adapt portfolios, adapting established policies and introducing new ones. Part four concludes by discussing recent developments and the limitations associated with Finnish adjustment.

Creating a Schumpeterian development agency during the 1970s

Historically, Finland possessed one of the most concentrated, lowest-technology and least research-intensive economies in the OECD. As recently as 1980, pulp, paper and related forest-based products exceeded half of the country's exports (Koski and Ylä-Anttila 2006) and research and development as a share of GDP stood at 1.16% (Eurostat 2010). Private sector institutions and public institutions reinforced Finnish reliance on established, resource-extractive, low-technology industries. For example, the four large banking groups that monopolized Finnish finance redistributed capital to established, pulp and paper firms (Rehn 1996). The Bank of Finland reinforced investment in capital-intensive, resource-extractive industries by relying on policies such as credit rationing (Rehn 1996) and periodic currency devaluations (Lilja and Tainio 1996). The latter restored competitiveness in forest and mining companies, but increased costs in import-sensitive industries such as electronics. While public agencies used industrial policies to promote diversification, they did so by establishing state-owned enterprises (Rehn 1996). These initiatives succeeded in mature, capital-intensive manufacturing industries such as

steel and chemicals, but faltered in new, high-technology industries during the 1970s (Rehn 1996; Sabel and Saxenian 2008).

Public support for industrial research, by contrast, remained limited until the 1970s. While policy-makers had subsidized research as early as the 1920s, funding was modest (Murto et al. 2006) and revolved mainly around academic institutions such as the Academy of Finland (Murto et al. 2006). Indeed, technology policy or industry-oriented support was not treated as an independent budgetary item until 1967 and received so little attention within the Ministry of Trade and Industry that policy-makers would propose stripping the ministry of its responsibilities in this space (Murto et al. 2006).

In fact, institutional innovation occurred not within the Ministry of Trade and Industry, but at the periphery of the Finnish public sector with the establishment of an independent think tank, Sitra. The Finnish National Fund for Research and Development was established in 1968 as a gift to celebrate the Finnish parliament's 50th anniversary.² Klaus Waris, the Bank of Finland Governor that lobbied for Sitra and served as its first president, envisioned that Sitra could use interest from its 145 million Euro endowment to increase productivity and accelerate industrial restructuring. Stated more plainly, Waris sought to promote entrepreneurship and private sector enterprise more generally as an alternative to increasing reliance on socialist or collective instruments such as bank-based finance, planning and bilateral trade with the Soviet Union (Murto et al. 2006). As the foundation's name suggests, Sitra promoted entrepreneurship by distributing grants and soft loans to co-finance risky long-term research by private corporations. Consistent with its mandate to promote productivity and restructuring more generally, the foundation also launched the first of many surveys to assess the international competitiveness of

²Like most other Finnish policies, this idea was imported from abroad. Sweden's central bank had established an identical fund to celebrate their parliament's 300th anniversary (Murto et al. 2006)

Finnish industry in 1969 (Murto et al. 2006) and administered courses on economic policy (initially to integrate Communist politicians and trade union representatives) during the 1980s (Rehn 1996).

Sitra's peripheral position in the Finnish political and economic system gave it more latitude in introducing new innovation policies. Like Nokia, Sitra entered research because 'big boys' such as the Ministry of Trade and Industry and the Bank of Finland had monopolized traditional instruments such as nationalization, investment grants and credit rationing. Meanwhile, Sitra's 18 million Euro research budget was small enough that new activities did not threaten political incumbents such as the Ministry of Trade and Industry or attract the attention of large, established forestry firms. In fact, pulp and paper companies were conspicuously underrepresented in the initial round of funding. Grants were distributed to electronics and engineering firms such as KONE, Vaisala, Airan and Perlos. During the first ten years, over a quarter of Sitra's funds were allocated to electronics, far out of proportion to the industry's significance in the Finnish economy (Murto et al. 2006). In fact, one of the earliest beneficiaries was Nokia which received one million Euro from Sitra's initial budget of 18.1 million Euro (Murto et al. 2006).

At the same time, Sitra's impact on the Finnish economy as a whole remained modest. While the new agency increased R&D support by 50% over previous levels (Murto et al. 2006), public investment in research played a limited role during the 1970s, outweighed by credit rationing, industrial subsidies, nationalization and other instruments. The following section seeks to explain how Sitra, and reform-oriented policy-makers more generally, used formal and informal social networks to scale these new innovation-based policies.

Using neo-corporatist and social networks to scale technology policies during the 1980s

As described below, institutional innovation in Finland was shaped by the country's reliance on foreign markets. More specifically, the OPEC-induced oil crises of the 1970s forced policy-makers and private sector actors to adapt industrial policy instruments. The crisis directly threatened energy-intensive, resource-based industries such as forestry. While Finland avoided the worst of the crisis, it did so by relying on bilateral trade with the Soviet Union. Bilateral trade, which approached a quarter of Finnish exports by the early 1980s (Honkapohja et al. 1999), was perceived as a geopolitical threat, sparking interest in diversification away from traditional, resource-extractive industries. At the same time, it was increasingly apparent that traditional industrial policies would not accomplish this. The high-profile failure of state-owned enterprises in telecommunications and televisions discredited nationalization, while a related corruption scandal placed even greater pressure on politicians to disassociate themselves from traditional policy instruments (Rehn 1996; Sabel and Saxenian 2008). In other words, international openness created an opportunity to expand hitherto peripheral technology policies.

The speed with which Finnish policy-makers did so was remarkable. Industrially-oriented technology policies had reached the parliamentary level by the late 1970s. By the early 1980s, politicians, consulting with peak-level industry associations, agreed to dramatically expand Sitra's research program by establishing a new agency, Tekes.³ 'The Finnish Funding Agency for Technology and Innovation' represented a significant commitment to commercial research. The agency's initial budget quadrupled Sitra's expenditure and rose sharply in subsequent years from 40 million Euro in 1984 to over 400 million by 2000 (Murto et al 96). By then, the public

³Significantly, policy-makers did *not* expand Sitra's resources in this domain. As described below, the apparent marginalization of Sitra encouraged the agency to experiment with new policy instruments during the 1980s

sector (government and university) research had climbed from 0.60% of GDP to 0.95% of GDP, the highest in the EU. The increase in public sector research expenditure is particularly impressive because it stimulated even greater effort by private sector enterprises. Total expenditure on R&D increased from 1.17% of GDP in 1980 to 3.35% of GDP by 2000, trailing only Sweden and Israel (Eurostat 2010). Finland, in other words, was unique in its capacity to rapidly and successfully scale new technology policies over the course of the 1980s. Increasing research in turn enabled firms, most notably Nokia, to enter expensive new, high-technology markets such as digital mobile communications.⁴

Finland was able to do so, because reform-oriented policy-makers could use non-market networks to diffuse new ideas about research and development. This was most explicit in the case of formal neo-corporatist institutions, which organized industry and labor into hierarchical peak-level associations. The peak-level, bipartite Science Policy Council (subsequently expanded into a tripartite Science and Technology Policy Council) emerged as an important instrument for prioritizing technology policy, linking ministers from the departments of education and industry to peak-level societal representatives and the prime minister. The Council prioritized investment in research and development (most notably during the recession of the early 1990s) and coordinated activities among different policy-makers (Murto et al. 2006).

While consensus-building was most visible within peak-level, neo-corporatist structures, informal institutions were just as important. For example, Sitra's courses on economic policy became an important instrument for educating policy-makers, corporate executives, trade union leaders and journalists about the importance of innovation and related inputs, such as research and development (Moen and Lilja 2005). Collectively, these measures forged a consensus on

⁴For example, new technology policies funded risky, long-term research in mobile communication technologies. Tekes co-financed the private-public cooperation that created the software protocol for the GSM (Groupe Special Mobile) digital mobile communications standard (Interview with former project director on 8 November 2005).

research and development that transcended traditional partisan divisions. One politician who presided over a significant increase in R&D expenditure surprisingly declined take credit for what other interviewees characterized as a ‘heroic’ decision noting, “all parties of the right, conservatives, liberals, the center party and at least social democrats, maybe even Communists of that time were able to support that policy orientation. There was even competition, who was most favorable political movement to support that” (Interview with former member of parliament, 10 October 2005).

The same formal and informal social networks that enabled reform-oriented policy-makers to persuade and coordinate activity among their peers also explains Finland’s unique capacity to engage private sector actors. Industry was well-represented within the Council and Tekes (Interview with former director general of Tekes, 1 November 2005). Industry representatives could in turn rely on dense organizational structures to diffuse ideas about the importance of research to their members. For example, Kari Kairamo, CEO of Nokia during the 1980s, in turn used his position as chairman of the Confederation of Finnish Industry to mobilize support for new technology policies (Moen and Lilja 2005). Membership in informal clubs was just as important, with Kairamo using a weekly roundtable to persuade not only like-minded industrialists as well as fellow elites within the rural Center Party (Interview with roundtable participant 20 October 2006).

As a result, corporate representatives suggest that the courses and peak-level dialogue on innovation policy more generally strengthened technology officers relative to top management.⁵ In the words of a research director at a foreign subsidiary that used funding at the height of the

⁵This point was made in interviews with the former research director of forestry firm (13 October 2005), the executive officer of an engineering firm (25 October 2005), the research director of a forestry firm (2 November 2005) the chief executive officer of software firm (3 November 2005), the research director of an engineering firm (4 November 2005) and the former chief executive officer of a forestry firm (31 October 2005).

dotcom downturn to support an ongoing project, “in all companies, these kinds of investments are so big and they are constantly monitored by management and can even be stopped, you can only afford them here and there ... I think [the credibility] was quite important” (Interview with electronics firm research director, 19 October 2005). It also pressured firms to actively participate in new technology programs, committing resources to avoid being ostracized within professional networks. In the words the research director above, “you know each other relatively well and it is such that people have to perform. Your peers are watching and your reputation is on the line” (Interview with electronics firm research director, 19 October 2005).

Adapting innovation policy portfolios during the 1990s

If social networks enabled Finnish elites to implement new research policies and, by extension, facilitate movement into risky and expensive new industries such as mobile communications, those same networks created political and cognitive barriers to effective monitoring. Economic openness proved critical in enabling reform-oriented policy-makers to adapt new innovation policies, more effectively identifying unprofitable projects and surmounting political resistance. Indeed, policy-makers consciously exploited Finland’s status as a small, open economy in designed research policies. Indeed, one of the decisions that illuminated the limitations of traditional industrial policy was the state’s decision to co-invest with a foreign multinational. Hitachi’s decision to divest its stake in the government-sponsored television enterprise highlighted the initiative’s weakness (Rehn 1996). During the 1980s, research grants focused on export-oriented manufacturing firms, whose performance on international markets was relatively easy to measure and provided a more accurate picture of their commercial potential (Interview with Tekes program director, 28 November 2006).

Vulnerability to external economic and political developments enhanced the efficacy of these design features. For example, the economic crisis of the early 1990s accelerated institutional innovation. The economic crisis hastened the demise of traditional industrial policies as it was not feasible to bail out uncompetitive enterprises within the confines of a small open economy.⁶ The near-collapse of the Finnish financial system also exposed weaknesses in Finland's industrial structure, most notably its reliance on large firms in both old (UPM-Kymmene) and new (Nokia) industries. The technology policies of the 1980s, which revolved around large, established firms did little to alleviate the lack of funding in this space. They also violated new EU restriction state aid. Consequently, Tekes was pressured to adapt established technology policies, reorienting funding away from large companies, and requiring these firms to collaborate with small and medium-sized enterprises (Interview with Tekes program director 27 November 2006).

In addition to adapting established policies to address funding deficits among small and medium-sized enterprises (see table 1), policy-makers adapted policies in other ways. As noted below, Finland was one of the first countries to adopt the concept of a 'national innovation system' in a 1990 Science and Technology Policy Council Report (STPC 1990), coordinating activity across multiple ministries and agencies. Policy-makers also introduced novel instruments more explicitly targeted at new, growth-oriented enterprises, dramatically expanding the supply of early stage risk capital (Luukkonen 2006). Like the technology policies described above, risk capital initiatives originated at the periphery of the Finnish political system. More specifically, the Finnish venture capital market can be traced to the establishment of Tekes and the subsequent marginalization of Sitra within the field of research financing. Having more than

⁶The European Union's requirement that states limit debt to 60% of GDP reinforced external, market pressures. With unemployment climbing to nearly 20%, Finland reached this ceiling in less than three years. Policy-makers cut virtually expenditure in virtually every domain except research and early stage risk capital.

quadrupled Sitra's budget (Murto et al. 2006), Tekes effectively forced Sitra out of research and development (Interview with former fund manager and Finnish Venture Capital Association president on 22 November 2006).⁷ Sitra's inability to protect its territory, however, encouraged it to assume a new and revolutionary role within the peripheral field of early stage risk capital.

Sitra's shift to early stage risk capital began as early as the 1970s as the Ministry of Trade and Industry increased research financing for large enterprises, focusing on even smaller firms, which the Ministry neglected (Murto et al. 2006). The creation of Tekes accelerated this shift. Inspired by a visit to the United States in the mid-1980s, Sitra managers converted soft loans and grants to equity states, and using the endowment's budget to invest in venture capital funds and directly in new, growth-oriented enterprises. Consistent with the design features mentioned above, Sitra also co-invested with foreign venture capital funds both within Finland and abroad to enhance its monitoring capacity (Interview with former fund manager and Finnish Venture Capital Association president on 22 November 2006).

When the financial crisis of the early 1990s exposed the limitations associated with traditional industrial policies, Sitra relied on similar social networks to rapidly scale investments in early stage risk capital markets. For example, Sitra established an industry association for the venture capital industry to more effectively lobby the Ministry of Trade and Industry (Interview with former fund manager and Finnish Venture Capital Association president on 22 November 2006). Partly as a result of such efforts, Kera, a regional development agency, launched the first dedicated public venture capital fund, Start Fund of Kera in 1991 and an even larger fund, Finnish Industry Investment (FII) in 1996. Meanwhile, the professional association that Sitra established worked with the Ministry of Trade and Industry and other stakeholders to lobby

⁷Sitra also stopped writing surveys on international competitiveness, 'outsourcing' the activity to the Research Institute on the Finnish Economy. Sitra, however, would continue to conduct research on productivity, innovation and restructuring.

private sector investments such as pension funds and insurance companies to increase their allocation to early stage risk capital markets (Interview with venture capital director on 20 November 2006), to the point where they represented over half of all funds raised within the industry (Luukkonen 2006).

Collectively, these developments increased investment in early stage risk capital markets from 19 million Euro in 1991 to 397 million Euro by 1999, third in the European Union when adjusted for gross domestic product (Eurostat 2010; Luukkonen 2006). Increasing funding for small, growth-oriented enterprises in turn facilitated industrial growth and diversification. For example, Nokia relied on Tekes-brokered networks to identify and engage suppliers, most notably within the field of software (Interview with Nokia executive, 24 November 2006). Suppliers like Elcoteq in turn used risk capital from Finnish Industry Investment and private sector investors to internationalize alongside Nokia (Ali-Yrkkö 2003). At the same time, not all new, growth-oriented enterprises were equally successful.

Flexible Adjustment Reconsidered: Contemporary Challenges

While Finland demonstrated formidable capacities to adapt established policy instruments and introduce new ones, Finnish innovation policies were an unqualified success. On the contrary, the dot com crash at the turn of the century exposed significant weaknesses. While its macroeconomic impact was limited, the economic downturn revealed that public and private sector investments were not particularly profitable. Fund-raising plummeted from 492 million euro in 2001 to 295 million euro by 2003 (Luukkonen 2006) and was slow to recover in subsequent years (Eurostat 2010). More importantly, the crash demonstrated that policy-makers had neglected soft skills such as management and marketing that were critical for

commercialization (Leiponen 2004; Luukkonen 2006; Maula and Murray 2003). The dot com crash thus precipitated another significant reorientation of Finnish innovation policy.

Like the initiatives in venture capital described above, diversification reflected Sitra's efforts to identify a new role within an increasingly crowded policy domain. As public actors such as FII and privately managed venture capital funds assumed a more prominent role in the Finnish venture capital market by the end of the 1990s, Sitra sold its own holdings to private investors and reduced its fund of fund activity. In their place, Sitra launched a range of initiatives that can be broadly understood as demand-side innovation policy, reorienting support from monetary inputs in research and risk capital toward the interaction between suppliers, producers and consumers. For example, the foundation launched a mentoring service to link new, growth-oriented enterprises to established firms (Luukkonen 2006), initiatives in health care and food processing to connect established firms with end users and internationally-oriented programs that linked Finnish firms to suppliers and consumers in foreign countries such as China and India (Interview with Sitra program director 27 November 2006).

These demand-side initiatives received peak-level attention in the wake of the dot com crash.⁸ As a result, the last decade has witnessed efforts to scale new, demand-side initiatives to. For example, Tekes has targeted 'demand side' innovation (Nikulainen and Tahvanainen 2008), the Confederation of Finnish Industry has launched a program to facilitate internationalization among small and medium-sized suppliers (Interview with executive director of Technology Industries of Finland association on 9 November 2006) and Finland has launched a peak-level "re-branding" committee (Rantanen and Raeste 2010). Finland's status as a small state has thus

⁸For example, the Science and Technology Policy Council and the Prime Minister's office both prioritized demand-side innovation in policy proposals in 2008.

contributed to its capacity to monitor, adapt and expand its portfolio of private-public projects to promote innovation.

At the time, the crisis illuminated more fundamental challenges. First, Sitra's increasing salience within the Finnish innovation system and public sector has made it more difficult to introduce experimental new policies. Partly as a result of the increasing coordination of the Finnish innovation system, above, Sitra's venture capital investments during the 1990s were closely linked to Tekes' technology policies. In fact, virtually every recipient of Sitra funding received a Tekes grant (Hyytinen and Väänänen 2003). As a result, it is not surprising that investments in early stage risk capital proved problematic, as coordination effectively reinforced dependence on established policies in the realm of research and development.

This increasing dependence on specific policy instruments extends to individual industries and firms as well, as the preceding analysis describes how Nokia used Tekes-brokered networks to identify (and some entrepreneurs suggest poach) promising individuals and ideas. One venture capitalist, commenting on his inability to retain talent noted, "Nokia has been a big tree in the electronic industry, [which] shadows and kills almost everything ... For example, we were investing in one [firm] and we had 17 people up in Northern Finland and one year. Nokia hired from that company seven people, more than one-third of the company. And think about a small start-up company!" (Interview with venture capital manager, 20 November 2005).

Finally, while policy-makers have introduced a new policies, initiatives remain modest in size and scope. Demand-side experiments are considerably smaller than the ambitious technology and venture capital initiatives of the 1980s and 1990s. Furthermore, Finland has devoted comparatively less attention to other policy domains such as continuing education or the aggressive recruitment of foreign direct investment that stimulated demand-side innovation in

other countries such as Denmark (Lundvall 2002) or Israel (Breznitz 2007b). While such initiatives remain possible, the preceding analysis suggests that significant restructuring will not occur until Finland experiences a more severe economic shock. The following section documents similar developments in Israel.

4. Israel

Today Israel is considered an ICT powerhouse with more companies listed on the NASDAQ, than any other country bar the USA. The Israeli ICT industry is based on an R&D-intensive novel product-based, export-oriented business model. Elscint, a medical imaging company, listed on the NASDAQ as early as 1972. This early move, three years after its founding and less than two years after it produced its first medical imaging device, symbolizes the very different development paths of the Israeli IT industry compared with other emerging countries.⁹ Looking at this impressive record raises a question: how did Israel, a country that as late as 1965 had one of the lowest industrial R&D expenditure as percentage of GDP in the world (standing at less than one percent), move to having such an R&D-intensive ICT industry, and became a global leader in R&D expenditure with four percent of GDP by the late 1990s surpassing even Finland (Katchalski 1968)?

The rest of the section follows the co-evolution of Israel's industrial science and technology policies and to show the critical role played by a Schumpeterian development agency – the Office of the Chief Scientists in the Ministry of Trade Industry and Employment (OCS) –

⁹ For more on the early electro-medical industry in Israel, see (Breznitz 2005b; Teubal et al. 1976; Teubal and Spiller 1977). For the semiconductor industry's history in Israel, see (Autler 2000). For a descriptive history of Israeli high-technology industry, see (Levav 1998). For two accounts which briefly discuss the software industry and the causes of its success, see (Ariav and Goodman 1994; de Fontenay and Carmel 2001). For a recent volume on the software industry in emerging economies, see (Arora and Gambardella 2005). For a comparative study of Israel with other successful former emerging economies, see (Breznitz 2007b).

trying to analyze how with very limited resources it managed to play such a critical role in industrial transformation, as well as its inability to produce much changes in the last decade.

The beginning of the Industry and the creation of Israel's S&T Schumpeterian development agency

Similarly to Finland, most financial institutions in Israel in the period starting in creation of the state until the mid-1990s were unwilling to sponsor new technology technology-based firms (NTBF). However, there was one critical exception, at the beginning of the 1960s, the Discount Bank investment group (now known as Discount Investment) was joined by Dan Tolkowsky, former commander of the Israeli Air Force. In 1961, he first met Uzia Galil, the founder of the Elron group, and throughout the 1960s and 1970s, the Elron group and Discount were the main source of high-technology companies in Israel. Elron, Elbit, and Elscient, which all went through an IPO on NASDAQ, were created through this partnership.

Tolkowsky was also crucial at another juncture for the Israeli IT industry. By the end of the 1960s, he realized the Israeli industry needed experienced VCs with larger funds than Discount could muster. In 1971, Tolkowsky decided to fly to the United States to persuade the young VC industry to invest in Israel. Tolkowsky met Fred Adler of New York, one of the prominent VCs at the time who was involved in applied materials and data systems. Adler visited Israel and became involved with Elscient. Realizing it was futile to raise VC financing in the United States, Adler decided to circumvent the whole process by bypassing the VC stage and raising money through an IPO. Adler assumed that after several IPOs had been successful the Israeli industry would look more inviting to American investors and the VC problem would be solved. Little did he know that he had established a process that would become the modus

operandi of Israeli IT industry until the late 1990s, since the VC problem would not be elevated until the OCS initiated policies to expand it in the mid-1990s.

Another critical point was reached in 1968. As in Finland, experimentation was precipitated by geopolitical vulnerability and dependence on foreign countries. In the Israeli case, a French military embargo led policy-makers to channel large investments and R&D power into military high-technology efforts. Similar changes followed in the civilian R&D industrial policy. The most important was the establishment of the Office of the Chief Scientist in the Ministry of Trade and Industry.

The OCS's first action was to define its objective as the maximization of industrial R&D by fixing market failures without targeting any specific sectors or technologies. This led the OCS to embark on a long series of Horizontal Technology Policies (HTP).¹⁰ The first program, which continues to this day under the name "the main R&D fund," provides conditionally repayable loans of 50% of the cost for any approved industrial R&D project originating from the private industry and aimed at developing a new exportable product. The loan is payable only if the R&D project ended with a profitable product.¹¹ Interestingly, the decision to opt for conditionally repayable loans given the export-oriented product development projects became useful in providing the OCS with external foreign-market validation of its screening criteria and an incentive to closely monitor the progress of the companies which it sponsored. Specifically since these royalties have become an increasing percentage of the OCS annual operating budget, reaching twenty percent during the 2000s.

¹⁰ We follow Teubal's definition of HTPs as: "a category of technological policies whose objective is to promote technological development per se, and associated R&D and search management and organizational routines, irrespective of industrial branch or technological area" (Teubal 1997).

¹¹ See the report of the Katchalski committee, (Katchalski 1968). For the OCS's earlier definition of its own role as fixing market failures in civilian R&D, see (OCS 1975), and (OCS 1977) For an analysis of the OCS systems in its early years, the logic behind it, and effects of its industrial sector "neutrality," see (Teubal 1983; Teubal 1997). For an argument that Israel should be seen as a case of R&D capability diffusion from the Academic sector to industry, and not R&D capabilities creation, see (Breznitz).

Many of the earlier employees of the OCS viewed its actions in terms of an R&D-based development ideology. Like Sitra, OCS hoped to infuse industrial transformation by educating and mobilizing social and collective action. This was achieved through intensive and repeated meeting with decision makers in private industry, educating them about the value of R&D and infusing them with enthusiasm toward technological innovation. One of the first employees of the OCS described the early years:

During the early period we tried to create a dynamic of R&D activities, we wanted the industry to routinely conduct R&D and to create a dynamic that will infuse the idea that R&D is something that should be done throughout the industry. To create a sort of paradigmatic change in the way businesses thought about what they are doing. Nobody in the industry even thought about R&D at the time, it seemed to them as a horrible risk, so Yaakov [the first chief scientist] just started going around the country trying to convince managers to conduct R&D. We did not really care who, what, why, when, we just wanted to create an R&D dynamic. (Interview with OCS employee, 2 May 2002)

The OCS was soon joined by another agency put under its jurisdiction, the United States-Israel Binational Industrial Research and Development Foundation (BIRD). BIRD was approved in 1975 and began fostering and financing cooperation between Israeli and US companies. It funded projects where the R&D was done in Israel and the marketing in the United States. BIRD became crucial not only in sponsoring and helping Israeli NTBFs, but also as an organization that ensured NTBFs a critical window into their main market, the United States. BIRD became vital in the latter part of this period and throughout the 1980s and 1990s, enticing American MNCs to open R&D subsidiaries in Israel.

In so doing, BIRD supplied the Israeli Schumpeterian development agencies with extremely high level foreign monitoring and validation services. The MNCs by screening and monitoring their investments acted as “external” high quality evaluators of projects. In addition, since the financial sector in Israel was unwilling to finance high-technology companies, it is crucial not to understate the influence that the specific structure of the OCS and BIRD programs on the organizational development of NTBFs in Israel. Throughout the 1970s and 1980s a

significant percentage of the financial and management resources available to entrepreneurs, could be accessed only if they followed a business model based on R&D-intensive product development and American-controlled distribution channels. Consequently, although the financial resources given to the OCS and BIRD were so small that the first Chief Scientist commented in an interview that:

“Haim Bar Lev was Minister of Industry and Commerce, and he asked me to be chief scientist after I retired as the head of R&D for the Military. It was very easy for me to get into this job since I already knew what existed in Israel, I have already sponsored every technology company in Israel during my role as the Military R&D chief and I can say there were not many of them. When I entered the office they told me the budget was unlimited, but I soon discovered that the scope of research and development was very limited. If in my military role I played with a budget of about 500 million dollar, in the industry it was less than ten million and the state treated it very cautiously. This had a few reasons, most importantly was that nearly everyone in the Ministry did not understand what it is that they were supposed to be doing. Most of the Ministry personal thought that industrial R&D is a waste of money. Money that can be used to buy meat in Argentina, it was, don't forget, the ministry of commerce and industry. (Interview with Itzhak Yaakov 9/12/2000).

Nonetheless, the same quote also attest to the tight long-term relationships with which Yaakov could mobilize resources to kick start what the OCS team viewed as a paradigmatic shift in industry. Not only Yaakov was for many years the head of the Military R&D apparatus, but his first Minister, Bar Lev, was a former IDF chief of staff, and Efraim Katchalski (Katzir), the head of the Katchalski committee that institutionalized the OCS, who was just elected to become the President, was a renowned scientist, one of the pioneers of the Israeli Defense Industry, and one of Yaakov closest mentors.

While the seeds of the Israeli ICT industry had been planted and some hardware companies had achieved worldwide success in the late 1960s and early 1970s, the software industry was practically non-existent. However, the rapid expansion of defense R&D, and the fast accumulation of ICT skills by both university graduates and graduates of the military technological units created local demand for ICT usage, the knowledge base to supply it, and a

positive attitude toward this nascent industry.¹² As venture capital for the industry was not available, the business model of many companies was either a joint venture with a more established company that acted as the financial backer and/or the main customer, or to find their first customer before the development phase. Some developed from an ICT consultancy business, but few of these successfully transformed to a product-based business model. In addition, these companies could not secure enough capital to open an American branch, so their first export market tended to be the European market.

Economic crisis and the rise to prominence of STI policy and the ICT industry

In the 1980s and continuing at a higher rate in the 1990s, another transformation became apparent: the high-technology industry grew while the traditional and mixed industries and agriculture lost ground. By 1988, 59% of Israel's industrial exports were high-technology products, and by 1998 this was over 71%. This transformation continued—as early as 2000, according to Israel's Central Bureau of Statistics, the IT industry accounted for over 70% of GDP growth (CBS 2001).

The economic crisis of the 1970s and the growing military alliance with the United States after the 1973 war meant the need and economic ability of Israel to develop full-scale weapons platforms diminished. Starting in the mid-1980s, major downsizing initiatives of the defense industry were implemented. For the private IT industry, these decisions proved to be a boon; a few thousand highly trained and experienced engineers were let go by the defense industries. Many received redundancy packages that enabled them to dedicate their time and money toward entrepreneurial activities.

¹² For more on the role of the military in the development of the software industry, see Breznitz 2005a.

But the most crucial decision of long-term consequences of these years was the enactment of the R&D law in 1984, which significantly strengthened the OCS. One of the main provisions of the new law indicated that the OCS would indeed have an unlimited annual budget for its main R&D fund, so all approved projects suggested by private industry to develop high-technology products would be supported. This was possible, since the overall demand for R&D funding in Israel was relatively small, and indeed as the industry grew and became successful a budgetary limit was reintroduced in the 1990s. However, by then the number of grants had grown exceptionally. Many of these projects proved to be successful in international markets, evidenced by the rising amount recouped by the OCS as payment for successful projects: from a mere eight million in 1988 to \$139 million in 1999. These payments were immediately injected into the industry, continuing this growth cycle until the mid-1990s. In addition, the influence of the extended activities of the OCS on industrial sector innovative outputs is well documented (Trajtenberg 2000; Trajtenberg 2001).

<<Table 4 OCS total grants/repayments 1988-1999 about here>>

Consequently, during the second half of the 1980s and the beginning of the 1990s, many Israeli ICT companies expanded their activities to penetrate foreign markets. Indeed by 1992 Israel had its first two pure software companies IPOs on NASDAQ, Magic, one of the first companies to offer a RAD tool for database application on the new PC platform, and New Dimension, which excelled in platform crossover data management.

During this period OCS grants proved to be critical in the decision of the founders of key companies to come back to Israel to establish their companies. Two prominent examples are Comverse and Mercury Interactive. Comverse began in 1982. Kobi Alexander, an Israeli native,

was working as an investment banker for Shearson Loeb Rhodes (now Salomon Smith Barney) in New York, when he met engineer Boaz Misholi, an Israeli native. Misholi had an idea for developing centralized voice and fax messaging hardware systems to enable big organizations and telecommunication service providers to offer voice and fax mail to their customers. The two returned to Israel, where they knew they could apply for OCS grants, and established Efrat Future Technology. In 1984, the founders returned to New York and established Comverse, which became the parent company of the Israeli Efrat. Like many Israeli companies, Comverse went public on NASDAQ in 1986 and used its IPO as a final VC round. While full details of the support Comverse has been granted through the various OCS and BIRD programs are not public, Comverse companies were awarded at least sixty-nine R&D grants for different projects through the main OCS program between 1990 and 2000.

Aryeh Finegold, an Israeli native who was the founder and manager of Daisy, a 1980s high-flying Silicon Valley firm, founded Mercury Interactive, with a group of former Daisy executives led by Amnon Landan. The group approached Finegold and managed to convince him to join them in establishing a new company whose main product would be a software-debugging tool. The group decided that, although well connected in Silicon Valley, they would establish Mercury with the help of OCS grants in Israel. Mercury went public in 1993, started to acquire other companies in 1995, and with the growing importance of the internet, changed its main product line from software debugging to testing and analyzing the performance of enterprise and web-based applications. By the time it was purchased by HP, Mercury was Israel's third-largest software company in terms of sales. While full reports are not public, Mercury was awarded at

least fourteen grants for different projects through OCS's main program between 1990 and 2000.¹³

In summary, the late 1980s and the first three years of the 1990s saw a surge both in the number of new ICT companies and the number of veteran companies that successfully started to sell their products worldwide. OCS's grants became more numerous and larger, and the Israeli ICT industry was producing companies that were on the technological cutting edge. Moreover, the early 1990s saw the first NASDAQ's IPOs by Israeli software, and not only hardware, firms. However, two important ingredients were still missing for the Israeli ICT industry to reach its full potential: (i) large-scale professional venture financing, especially at the seed and the early sales and distribution stages; and (ii) business and management knowledge and information. While the knowledge of how to do business, and especially how to interact with American financial markets, was accessible to some in the Israeli industry, it was limited to the few firms that had been successful, and there was no systematic sharing and dissemination of that knowledge.¹⁴

Rapid Growth – The maturation of the Israeli ICT industry and the adaptation of STI policy

The year 1989 marks the beginning of the rapid international growth period in the development of the Israeli ICT industry. The USSR started its democratization and break-up process, and Jews who had been previously unable to emigrate started the last large immigration

¹³ In another—this time negative—example of the intimate relationship of the Israeli software industry with the American financial markets, both Comverse and Mercury have been embroiled in options backdating SEC investigations. Mercury opted to merge with HP in November 2006 after Amnon Landan was fired as the CEO, and Kobi Alexander is currently seeking refuge from the SEC in Namibia, while Comverse remains independent.

¹⁴ For example, in 1987 a leading Israeli software company was in severe financial difficulties with a few million dollars in future orders but not enough working capital. At that time, the founders, all technologists without any business education, started to look around frantically for venture capital. Fortunately, a founder's wife worked for Comverse, and Kobi Alexander, Comverse's financial entrepreneur, agreed to meet with them. He was somewhat surprised to learn that they sought investment instead of using the simple financial tool of bridge loans.

wave into Israel. This wave was seen as bringing the best and the brightest technologically educated workforce from the USSR, and together with the thousands of engineers who were made redundant by the defense industry, the question of how to tap this body of knowledge topped the political agenda.¹⁵

While this convergence was a historical accident, by then the OCS's two decades of patiently developing and introducing policies using an HTP framework had established a paradigmatic influence on the shape of Israel's S&T policies (Dosi 1982). In an almost ideal example for S&T policies based on increasingly more sophisticated waves of HTPs, the OCS initiated and implemented three new programs aimed at a specific goal: the enhancement of the formation, survival, success rates, and R&D capabilities of firms. However, each of these programs was tailored to a different stage in the NTBF life cycle: formation, growth, and gaining long-term sustainable competitive advantage. Interestingly, while the last three programs, the Technological Incubators, Yozma, and Magnet, started operation between 1992 and 1995, they were planned and approved in 1991, the year seen as the high point of the political window of opportunity opened by the massive wave of immigration from the former USSR, which also mark the end of the period where S&T Industrial Innovation policies were seen as politically peripheral.

When the OCS initiated the Technological Incubators Program in 1991, the program was presented as a solution to two problems. First, there was the inexperience and inability of many technically oriented or scientific entrepreneurs to become successful commercial entrepreneurs

¹⁵ Interestingly enough, while the wave of immigration from the former USSR created the pretext with which the OCS was able to secure finance and political agreement to start these four programs, the Russian immigrants themselves have not, thus far, become successful technological entrepreneurs, and seem to play the important but more minor role of providing highly skilled labor. A preliminary analysis of an original dataset of the career paths of founders of Israeli NTBFs that went public on foreign exchanges has yet to find one new immigrant from the former USSR among the 151 founders on which comprehensive data was acquired. This finding is strengthened by an analysis done by researchers at the Central Bureau of Statistics on the distribution of new immigrants in the IT labor market (Avnimelech and Teubal 2002).

and find very early stage financing for their ideas. In short, the program aimed to solve the lack of management skills and resources problems that first-time technological entrepreneurs face. The second problem was assisting the technologically skilled Russian immigrants in finding jobs and integrating into a capitalist society. The idea was to open a network of technological incubators to help entrepreneurs in the very early stage of transforming an immature idea into a commercial reality, giving them space, financial support, and professional business and management help. Like other OCS programs, incubation proposals have to come from the market.¹⁶

Before 1990, ten Israeli firms listed NASDAQ. In 1991, three companies went through IPOs, and in 1992 there were another nine. Moreover, unlike the low valuation IPOs of the past, some of these IPOs resulted in a market capitalization large enough to allow a respectable exit for an American VC. Under these new conditions and having learned from the failure of an earlier attempt by the Ministry of Finance to start publically-traded on the Tel Aviv Stock Exchange Venture Capital companies called Inbal, in 1992 the OCS initiated another program inducing the creation of a vibrant VC industry in Israel—Yozma. The aim of this initiative was twofold: increasing the amount of venture capital available to Israeli firms, especially in their expansion phases, and injecting the Israeli high-technology industry with systematic knowledge of the American financial and products markets.

This time, the OCS decided the necessary skills and knowledge did not exist in Israel, and to succeed there, the VC industry needed strong networks with foreign financial markets rather than the Tel Aviv Stock exchange. As a result, Yozma was created as a government VC fund of \$100 million that had two functions. The first was to invest \$8 million in ten private

¹⁶ Interview with the director of the incubators program (8 February 2000), (Trajtenberg 2000), and the incubation program web site <http://www.incubators.org.il>. For two thorough reviews of the Israeli incubator program, see (Economics 2001; Shefer and Frenkel 2002).

limited partnership venture funds, which would be 40% or less of the total capital—the rest was provided by other private limited partners. To get this financing, the funds’ managers had to secure investment and partnership from at least one local and one established foreign financial institution.¹⁷

Yozma was highly successful and became a model for VC-aimed policy worldwide. The establishment of the 11 Yozma funds, the growing success of Israeli companies on NASDAQ, the many high-quality Israeli NTBFs looking for capital, and the rapid growth in the demand for IT and the related financial boom resulted in excellent returns for the Yozma funds and a rapid investment of capital into the Israeli VC industry. Today the Israeli VC industry consists of over 70 funds, with many top US and global funds starting operations in Israel and the Industry is considered the most advanced and sophisticated in the world of the US’ (Avnimelech and Teubal 2003a; Avnimelech and Teubal 2003b; Avnimelech and Teubal 2004; Ber 2002; Breznitz 2007b; Breznitz and Zehavi 2010; EI 2000; Giza 2000; IVA 1997-2006).

VC is only one way a state can induce the growth of IT industries. Moreover, VC policies are given more credit for the economic development influence than they actually have. However, in Israel, not only has Yozma been an unmitigated success in securing its own goals, but for better or worse, the subsequent growth of the VC industry completely transformed the Israeli software industry by ever more intimately connecting it, and its future, to the American financial markets. The success of Israeli companies in the United States in the 1990s, and the growth of the local American-funded VC industry, transformed the industry’s institutional environment.

The last initiative designed by the OCS in 1991 was MAGNET, which started operations in 1992. Unlike the other OCS programs, MAGNET, which stands for Generic Non-Competitive R&D, addresses two problems related to the later stages of the development and maintenance of

¹⁷ Interview with Yigal Erlich, Chief Scientists at the time of Yozma’s launching, 21 August 2000.

the long-term competitive advantage of Israeli NTBFs. The first problem is the large number of companies in Israel in the same technological space, all of them too small to compete on the basis of, or to advance, cutting edge infrastructural research activities that are crucial to sustaining competitive advantages against the bigger MNCs. The second problem is the underutilization of academic research done in Israel. Like the OCS programs, MAGNET grants aid to programs initiated by private industry. However, MAGNET aims to create a consortium to develop generic technologies. MAGNET consortiums are created for a period of up to three years, and all IP outputs are shared among the consortium members, who also agree to license this IP to local companies at a cost that does not reflect monopoly status. Over the years, many research consortia in highly heterogeneous technological fields have been formed. For an industry whose companies compete on the basis of their R&D capabilities, MAGNET proved important in enabling companies to develop R&D-related capabilities that they otherwise could not develop or even know about.

The Price of Success – Political Interference and Resources Stagnation in the 2000s

If the 1990s were the decade in which the OCS has received praise and elevated social stature for its important role in transforming the Israeli industry from one of the world's least R&D-intensive to one which almost completely relies on novel product R&D, the last decade has seen the OCS suffers the political consequences of this success. First and foremost, for the first time in its history the budget allocation of the OCS has been steadily declining throughout the decade.

<< Table XX OCS budget and allocations 2000-2010 >>

However, at least as importantly is the continuous erosion in the independence of the OCS, as well as the growing political interfering in its' decisions. Two examples, one that shows the impact of direct political interference and one that shows how other agencies, such as the Ministry of Finance, force decisions on the OCS are the short and rocky period of Carmel Vernia as the Chief Scientist, and the current turmoil caused by the decisions of the Ministry of Finance (MoF) to introduce legislation that would make it illegal for the OCS to support R&D project by companies with more than \$100 in annual revenues.

In May 2000, after a (first ever) public selection process led by committees headed by the then president of Ben-Gurion University, Carmel Vernia, the former COO of Comverse, was appointed as a Chief Scientist. The main reasons given for his selection were specifically his vast experience in running big organizations and the wish to both formalize the OCS activities and achieve the goal of building more large (in terms of global sales) companies in Israel. Nonetheless, very quickly Vernia discovered that one of the main promises he received when agreeing to take the job, and that is that the OCS would legally become an independent unit and released from the direct control of the Ministry of Trade and Industry, was vehemently opposed by the new Minister and her chosen Director General, who viewed control over what by then was already the most important sector of the economy as crucial to their political power. After less than two years, shortly after the Minister, Dalia Itzik decided to transfer fourteen million shekels out of the OCS to be used at her discretion to help “distressed” companies without even informing him, Vernia resigned (Editors 2000; Peretz 2002; Rolinik 2002)

In July 2010, the MoF, inserted a regulation that would have prevented the OCS from sponsoring any R&D activities conducted by ‘large companies’ defined in the proposed paragraph as these with more than \$100 million in annual sales (Grimeland and Coren 2010).

Whether that proposition would become a permanent law or not, is less worrisome from the point of view of the OCS' ability to act as a Schumpeterian development agency, as the fact that this is just another indication for the constant interference of other units not only in the OCS decisions, but also in the basic professional judgments the OCS is allowed to use in order to fulfill its mission statement.

However, even within these new limitations that OCS has been acting as a Schumpeterian S&T agency during the 2000s, specifically on three fronts. First, with the great success of the ICT sector and the concentration of private financing around it, the OCS, for the first time in its history moved away from strictly neutral HTPs, and initiated several sectoral focused policies in clean-tech, nanotech, and biotechnology. In so doing, the OCS continues to view its role as fixing market-failures and intervening where the risks are too high for private industry to bare by itself (OCS 2010).

A second initiative is to tackle the perceived as the over-focus of the Israel industry on ICT, with the very low spillovers and linkages between the ICT R&D-producing sector and the rest of the economy. A disconnect that has by now developed to a classic dual economy situation in Israel (Breznitz 2007a; Breznitz 2007b; OCS 2010; Trajtenberg 2001). In order to foster these linkages and maximize R&D across the business sector, starting in 2005 the OCS has allocated internal budget to a new program focusing on the traditional industry. The program tries to tackle these issues from both the demand-side (educating traditional industries firms how to conduct R&D), and the supply-side by offering incentives and grants for both graduate level research students and R&D engineers, to work and intern in, and do research about, traditional industries' SMEs with the hope that they will then bridge the two domains and come with new ideas and products specific to the traditional industry in which they are embedded. The program has grown

steadily in the last five years and brought a significant number of established companies to apply for OCS grants for the first time (OCS 2010). Last but not least, in the aftermath of the dot com and the financial crises, the OCS has institutionalized various programs focused on assisting first time technological entrepreneurs in the pre-seed and seed phases (OCS 2010). Nonetheless, with steadily declining budget and constant political interfering from both politicians and other bureaucratic agencies, the OCS has found it more difficult to scale-up its new initiatives. Indeed the complete budget for all R&D sponsoring projects approved by the OCS in 2010 is less than 50% of the OCS' 1999 budget.

5. Conclusion

In describing how Finland and Israel entered new, high-technology industries, this paper highlighted how reform-oriented policy-makers can play a transformative role in introducing experimental STI policies and facilitating RIB competition. At the same time, this paper challenges arguments that 'developmental' agencies occupy a commanding position within the public sector or social networks more generally (Amsden 1989; Ansell 2000; Chibber 2002; Evans 1995; Johnson 1982; O'Riain 2004; Wade 1990). On the contrary, this paper demonstrated that institutional innovation originated at the periphery of the public sector, in agencies that were not trapped by established routines or beholden to entrenched interests.

While analysis has focused on Finland and Israel, policy innovation is by no means limited to these two countries. We observe similar developments in Ireland, where the crisis-induced decision to split the Industrial Development Authority permitted the development of new industrial policies targeted at domestic software entrepreneurs (Breznitz 2007b; O'Riain 2004). In Denmark, steep cuts to the Ministry of Trade and Industry paradoxically created space

for a new generation of policy-makers to promote restructuring using sectoral dialogue and local inter-firm networks (Campbell and Pedersen 2007; Morris 2005). In this case, policies were imported from outside the government, from an independently organized roundtable linking politicians, policy-makers and industry leaders (Pedersen et al. 1992). Outside of Europe, ITRI introduced the innovation policies that transformed Taiwan into a leading semiconductor manufacturer.

In each case, reform-oriented policy-makers relied on similar instruments to scale and monitor new, STI policies. For example, SDAs used formal and informal inter-personal networks to rapidly transport experimental STI policies to the center of national discourse. For example, Irish policy-makers constructed industry organizations such as the Irish Software Association to raise awareness about new policies (O'Riain 2004), while Danish policy-makers leveraged local, inter-firm networks to implement new labor market initiatives (Morris 2005). At the same time, policy-makers in small, open-economies relied on international openness to challenge established industrial policies and monitor new ones. Indeed, innovative policies targeting early stage risk capital in Ireland and labor market activation in Denmark reflected responses to deep economic crises during the 1980s (Morris 2005; O'Riain 2004), which discredited traditional industrial policies and created space for innovative new actors at the periphery of the public sector.

This is not to suggest that peripheral public agencies will successfully scale and monitor new STI policies in all states. In identifying the specific mechanisms that permit scaling and monitoring, the paper explains why some states (including larger countries) may be less innovative than others. For example, states may lack effective coordinating and consensus-building institutions. They may be fragmented along ethnic, religious or ideological lines, or

power may be concentrated in ways that inhibit effective private-public and inter-sectoral dialogue. Alternatively, states may be less vulnerable to external pressure, either because of domestic policy choices that reduce international openness or their location in a region with less geopolitical competition (Doner et al. 2005; Herbst 2000). Some states may suffer doubly, from a fragmented society *and* limited international exposure, making it more difficult to scale and monitor new innovation policies. The preceding analysis suggests that policy-makers can mitigate these disadvantages, using formal and informal institutions to build inter-elite networks (for example, Sitra's courses) and more explicitly linking new STI policies to international economic competition (for example, Israel's Yozma program).

In identifying the specific mechanisms that facilitate scaling and monitoring, this paper also suggests how even successful countries run into trouble eventually. In successfully scaling new initiatives, Finnish and Israeli SDAs dramatically raised their profile within the public sector and the economy as a whole, increasing political interference and inhibiting policy experimentation. While policy-makers could rely on international competition and regulations to monitor and adapt new initiatives, this proved more difficult within the context of a successful, rapidly growing economy (particularly to the extent that new initiatives did not violate EU or WTO rules). This decreasing experimental capacity has heightened vulnerability to disruptive economic shocks, most notably in the case of Ireland, but even within otherwise successful, 'model' innovators such as Finland and Israel.

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