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The Influence of Causation and Effectuation Logics on Targeted Policies: The Cases of Singapore and Israel

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Abstract
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Keywords: Biotechnology; Causation and Effectuation; Innovation policies; Targeting.

Introduction

During the last two decades, many countries have started to devote a growing part of their innovation efforts to developing their biotechnology sectors (Cooke 2004). The decision to invest in biotechnology is commonly followed by well-defined national and regional policy programs and is commonly part of an overall innovation strategy for growth (Lord Sainsbury 1999; OECD 2001; Zhang et al. 2011). However, while billions of euros have been invested all around the world in promoting the emergence of biotechnology clusters, the number of recognized success stories is limited (Cooke 2007).

The economic (as well as technological) development path of the biotech sector, which is yet not defined, calls for a strategic innovation policy with a high level of system adaptation capabilities. The aim of this paper is to investigate two different policy approaches for the development of the biotech cluster. The first approach, used in Singapore, is based on top down, strategically planned vertical targeting. The second approach, used in Israel, is based on horizontal targeting where prioritization results from the on-going identification of specific market failures in sectors with high growth potential. We analyze which of the two approaches provides better support for the development of biotech clusters.

We will use Sarasvathy's (2001) concept of effectuation and causation for explaining entrepreneurs' behavior to analyze these two different approaches. According to Sarasvathy, entrepreneurs who follow causation logic tend to plan their desired objectives ("ends") while defining the necessary "means" that are required. On the other hand, effectuators tend to define (and re-define) their desired ends as they become more knowledgeable about what realistic ends can be achieved with their existing means. According to Sarasvathy, this logic has special value in cases in which the entrepreneurial activity takes place in fields that have no clear development path.

Although the process of policy design and implementation is much different from entrepreneurial activity, we maintain that the main elements of these two approaches may add important value to the discussion on strategic policy. In other words, the policy decision process can be paralleled to the behavior of the entrepreneur. Therefore, the two approaches represent not only practical entrepreneurial behavior, but also provide a prism through which strategies for dealing with situations that are characterized by high levels of uncertainty can be analyzed. More specifically, using this framework will improve our understanding of how the policy co-evolves with the implementation of the policy. It will also help us determine at what stage in the cluster's development this co-evolution is important. It is important to note that the concept of causation and effectuation is being used as an 'ideal' construct and by no mean represent prescriptive approaches or methodologies that are used or should be used by governments.

This comparison between Israel and Singapore is especially interesting because these two countries share some similar economic and historical characteristics. Both Singapore and Israel are relatively young countries (becoming independent in 1965 and 1948, respectively) and have succeeded in creating very high annual growth rates. By 2010, both countries had a GDP of about US $250 billion. In addition, both countries have created an impressive biotech industry, though with very different characteristics. Singapore focuses mainly on large multinational pharmaceutical manufacturers, while the majority of Israeli biotechnology firms are small (fewer than 20 employees) and is based on start-up companies. In fact, Singapore views the main drawback of its biotechnology policy as its difficulty in promoting local bio-entrepreneurship (Sandstrom 2009), while Israel views the fact that almost none of its nearly 1,000 start-ups have succeeded in growing substantially as a failure (Kaufmann and Levin 2002).

Effectuation vs. Causation

According to Sarasvathy (2008), the main differences between the logic of effectuation and the logic of causation relates to the way they perceived the future. In other words, the two approaches are rooted in the belief or lack of belief that current actions will necessarily lead to certain results. Whereas the causation logic assumes that the future is predictable and controllable, and as a result can be planned in detail, the logic of effectuation views the future as unpredictable and uncontrollable, so planning in detail is impossible. Given that causators assume that the future is predictable (Sarasvathy

2001), their planning can accurately depict the means and the actions that are needed in order to achieve their desired ends. Thus, policies using the causation logic will commonly try to clone the success of other countries. However, for effectuators, defining the means is regarded as an irrational activity, because the future is unpredictable (Brettel et al. 2012). Unlike causators who ask, ”What means are required for achieving specific ends,” effectuators ask, ”What effects can be achieved with a set of existing means.” Effectuators insist that exact copying is impossible and that the catching-up process should include modifications that take local considerations into account (Malerba and Nelson 2012). Thus, the differences between the two approaches result in two very different behaviors. Whereas those who subscribe to causation logic devote their efforts to selecting the most appropriate means for achieving their desired ends, those who subscribe to effectuation logic concentrate on choosing among the possible ends that can be achieved using their existing means. Given that causators follow a detailed plan, their learning activities tend to take the form of continuous evaluations that try to measure how well the plan is being implemented and what should be corrected or added in order to best achieve the pre-set goals. A substantial deviation from the original planning may cause them to terminate their entrepreneurial activity. Effectuators, on the other hand, focus their learning activities on more general market and sector studies, trying to identify what can best be achieved with their existing means. Changes in the means or in the way they perceive the market may lead to an adjustment of their desired ends. Effectuators, unlike causators, treat the policy implementation as a process of trial and error. By learning about the market as they go along, they evaluate the ability of a given policy to achieve its goals. Armed with that knowledge, they then adjust either the policy or the desired ends. Thus, effectuation allows the co-evolution of the policy and its objectives. Policy adaptability of the two approaches may also be expressed differently. For causators it may be expressed in adjusting the 'means' while for effectuators it may be expressed in changing desired 'ends'.

Sarasvathy argues that successful entrepreneurs are more likely to follow the effectuation approach. Such entrepreneurs co-evolve with the markets they are acting in, improving their understanding of the market as their business develops. They implement learning processes that enable them to continuously adjust their goals while taking into consideration their available resources. Sarasvathy's findings challenge the common perception that requires entrepreneurs to invest efforts in preparing a detailed business plan prior to the establishment of their venture. Alternatively, her study points out the need to dedicate efforts to establishing learning mechanisms that can follow and direct their venture after it has been established.

Applying this framework to the approaches used in Singapore and Israel, we may ask whether policies should be extracted from well defined strategic plans (as in the case of Singapore) or should they be continuously adapted to changes in the market (as in the Israeli case). In countries where the policy design process is based on the logic of causation, knowledge about the nature of the prioritized sector and its development path is treated as static. Therefore, the accumulation of knowledge during the implementation period of the policies will not influence the pre-defined ends. In other words, in such countries knowledge is treated separately from the means. However, in countries that base their policy process on effectuation logic, the knowledge that is accumulated is treated as part of the overall means. Thus, new knowledge is translated into new means, which in turn lead to a re-definition of the desired ends. While for causators policies are aimed at creating new means that are needed to achieve the desired ends, for effectuators policies are aimed at optimizing the functionality of the existing means. In addition, in both approaches the accumulation of knowledge is assumed to be a by-product of the experience that is gained during the policy implementation period. However, for causators, this knowledge has no impact on the desired ends. However, for effectuators, this accumulated knowledge may influence the desired ends. As a result, we expect differences to appear between the two types of policy processes in relation to the objectives of the learning process. Whereas causators will focus their learning on assessing the success of their existing policies in creating the desired means, effectuators will devote their learning process to improving their understanding of the nature of the sector and the market in order to re-define the desired goals.

Although one might think that these two approaches are mutually exclusive, we argue that they can both be implemented in sequence or in parallel. Duncan (1976) suggested the term "ambidexterity" to describe the need for adaptive approaches that could be added to planned causation ones, while Brettel et al. (2012) broadened this concept to include the logic of effectuation. It is possible that in the pre-emergence phase of cluster development (Avnimelech and Teubal 2008), where no causal link between means and ends can be forged, the effectuation logic may have a better chance of achieving the country's vision, because the very conditions that are used to calculate the optimal outcomes may change during the implementation period[1]. However, when moving to the cluster's emergent phase (ibid), the causal links between means and ends

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[1] The paper by Phil Cooke on this issue describes how the discovery of system biology changed the investment patterns in biotechnology and, in fact, discouraged many investors from investing in start-up companies.

become clearer. At this stage, it becomes possible to define competitive goals, best practice R&D, and process and product standards in the context of the local circumstances. In addition, opportunities emerge by adjusting the catching-up process to the development trajectory of leading countries. Finally, direct exposure to the experience and development of industries in frontier countries through brain gains, technological intelligence, and access to components that are still missing in the domestic sectoral innovation system also offer significant benefits.[2] At this stage, adopting the causation logic may be a better strategy for realizing the country's vision. This view accords with Brettel et al.'s (2012) findings. They pointed out that effectuation is positively related to success in highly innovative ventures, while causation is more efficient for less innovative undertakings.

Methodology

The paper is based on an in depth study of the Singapore biomedical initiative and the Israeli policy endeavors to become a global leader in this field. The study of Singapore included site visits and meetings with key representatives of key policy agencies as well as with other stakeholders in the Singaporean bio-innovation program. Meetings were held with managers at The Agency for Science, Technology and Research (A*Star), the main public agency for nurturing public sector research and development in the biomedical sciences, physical sciences and engineering; The Ministry of Finance; The Economic Development Board (EDB) – Biomedical Sciences Division; The School of Biological Science; The National Research Foundation (NRF); The Ministry of Trade

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[2] Based on insights from one of the paper's referees.

and Industry; NUS Enterprise, the technology transfer arm of the National University of Singapore; Temasek Holdong, an Asian investment house; The National Medical Research Council; two multinational drug companies operating in Singapore and two private SMEs. The visit took place in the fall of 2009 and was organized through the Israeli embassy in Singapore. We formulated specific questions for each interview. The interviewees' answers were summarized during the course of the interview, and the main themes were later identified. This self-reporting method may be biased by the subjective impressions of the interviewers. In order to cope with this problem, we cross analyzed the answers of different interviewees and compared them to those described in other studies.

The Israeli case was based on an on-going study of Israel's innovation program over the last two decades with a special emphasis on Israel's biotech policy. The study included interviews with most of key figures in the Israeli biotech sector such as the chief scientist at the Ministry for Labor, Trade and Industry who is responsible for the design and implementation of Israel's innovation policy; The Ministry of Science; managers of private venture capital companies; managers of technological incubators; several TTOs of leading hospitals and universities; and face-to-face interviews with leaders of more than 50 companies. This long-term evaluation led to a number of reports and academic papers (Kaufmann and Levin 2002; Kaufmann et al. 2003; Kaufmann and Schwartz 2008). Our study of the Israeli case included a thorough examination of various reports on the bio-sector that were submitted to the Israeli government, including those of the Katzir Committee (Katzir 1988), the Israel National Committee for Biotechnology (Katzir and Herzberg 1992), Haim Aviv (1997, 2007), Monitor (2001), the Ministry of Science (Meser-Yaron, 2001), and Glenrock (2007).

These two countries represent two extremes of biotechnology policies. Singapore with its very detailed, centralized, strategic planning can be associated with the logic of causation. Israel, which represents a neutral policy with little tendency to prioritization, can be associated with the logic of effectuation.[3]

Biotechnology Policy in Singapore

The Biomedical Initiative

By the end of the 1990's, Singapore decided to develop a biotechnology cluster as one of four economic growth engines. The decision to target biotechnology was followed by a precise work plan with a defined budget, timeframes and success indicators (Wong 2006) aimed at "redefining the national institutional context in light of developments in biotechnology" (Chaturvedi 2005, p. 106). This initiative included establishing special funds, building a bio-park (Bio-Polis), attracting multinational drug companies, investing in research facilities and advanced teaching, and investing in local bio-entrepreneurship. According to one of the managers of Bio*One, a public venture capital fund oriented toward investing in biotech firms globally: "The decision to invest in bio was taken to better understand the world biotech markets in order to enable us better support our future start-ups. Our success is measured not only in simple return on investment measures but also on its relevancy to our economy" (Interviewee 4). The decision to prioritize biotechnology was a part of an overall governmental strategy of turning Singapore into one of the leading Asian (as well as the world's) biotechnology

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[3] Recently, the National Economic Council has decided on prioritizing several areas, but these do not include biotechnology.

clusters (Finegold et al. 2004). This decision also was in line with Singapore's vision of turning Singapore into a knowledge based economy by advancing three other clusters in the fields of electronics, chemicals, and engineering (Ministry of Trade and Industry Singapore 2003). This systemic approach taken by the Singaporean government has made the country a prime example of the causation approach.

From the very beginning, it was clear to the government that the development of the biotech cluster, unlike the other three sectors, should relate to a broad spectrum of Singapore's innovation program. The rationale was that Singapore lacked neither a well-established science base nor an industrial base in this field (Shahid and Nabeshima 2006). Therefore, policies that related to the entire value chain, from basic research to product development and full-scale manufacturing, were articulated under the Biomedical Initiative (BMI). The meta-frame of the BMI may best be described as a portfolio of policies, institutions and support schemes all aimed at creating a biomedical cluster in Singapore (Finegold et al. 2004; Shahid and Nabeshima 2006).

Figure 1 portrays the elements of Singapore's R&D system that take part in the BMI[4]. The country's policy structure can be divided into three sections: (A) the **Doing Level** – where the formation and implementation of support schemes takes place; (B) the **Policy Level –** where policy is formulated and (C) the **Strategic Level** – where specific entities that are in a position to monitor the entire system set general directions and close gaps when necessary.

[FIGURE 1 APPROXIMATELY HERE]

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[4] Figure 1 displays the structure of Singapore's R&D policy system. This structure applies not only to the BMI, but also to the country's entire R&D policy system.

The entire structure works under 5-year work plans called phases. The first phase's (2000-2005) objective was to build capabilities in the field of biotechnology. Singapore had virtually no capabilities in biomedicine at the beginning of the decade, so the country invested massive resources to build them. More specifically, during 2000-2005, a new world-class bio-industrial park consisting of offices and scientific facilities was established (the Biopolis), national research institutes for biomedicine were opened, Singapore's universities received large funds to establish programs in the field, star scientists from abroad were targeted and approached, and multinational corporations received large subsidies to open R&D centers in the city-state. The next phase (2006-2010) addressed translational science and developing clinical research capabilities. The third and current phase (2011-2015) is trying to deal with the emergence of a local industry by promoting mission-oriented programs and fostering entrepreneurship. The total investment in each phase was $US 4-5 billion.

The Strategic Level

National Research Foundation and its Decision Councils

Singapore's R&D strategy is set by the National Research Foundation (NRF) within the Prime Minister's Office. The synchronization of policies happens at this level. The NRF reports directly to the Research, Innovation and Enterprise Council (RIEC), an advisory forum that consists of all ministers dealing with issues related to biotechnology and is headed by the Prime Minister.[5] The ministries at the Policy Level are strongly influenced by the direction set at the Strategic Level and act accordingly. The fact that all ministries are represented at the REIC is designed to insure that the level of coherence between the players remains high. In other words, they try to assure that all

[5] The REIC also includes world experts in different fields from the private sector.

agents involved in the process conceptualize the objectives of the prioritization process in a coherent way. Although the ministries work under a 5-year timeframe, the RIEC meets once a year to evaluate current progress and tweak the direction of the country's R&D system in light of unfolding events.

The NRF serves as the secretariat for the RIEC and ensures that its decisions are translated into actions. Accordingly, the NRF identified several strategic research programs for Singapore's R&D needed to support Singapore’s vision while taking into consideration geo-strategic perspectives. The NRF identified areas of weakness such as the water supply (Singapore has a problem with supplies of clean water) and the treatment of specific Asian diseases. Selecting rather specific fields to be promoted makes it easier to follow the overall progress in terms of success. The fact that fields are chosen for their geo-strategic importance and not for their expected market value alone compensates for the risk of choosing fields that may be prove to be unprofitable. Uncompetitive results that nonetheless answer the country's challenges will not be considered a complete failure.

The Doing Level

In Singapore, various ministries are responsible for monitoring the policy objectives, but not for the formulation and implementation of the support schemes that will be used to achieve these policy goals. The formulation of support schemes is handled by government agencies that work under the ministries and report back to them. Each agency is responsible for specific goals and has to create its own working plan. The ministries themselves are not concerned with implementation and devote their time and effort to dealing with macro level issues and with the formulation of the policy objectives for the next 5-year timeframe.

In such a system, all programs designed to achieve policy goals are enacted by different people than those who formulate the goals themselves. In practice, the ministries are involved in the approval of each agency's 5-year work plan, but the responsibility to realize these goals rests with the agencies. This separation allows each segment of the policy structure to be evaluated according to different indicators. While the ministries are assessed for their ability to achieve broad strategic goals such as employment and growth, the agencies are measured by concrete numerical goals such as the number of newly established firms. The more specific the responsibility of the operating body, the more specific the indicators on which its performance is measured.

Coordinating the various players is a fundamental prerequisite for successful targeting. Singapore's system allows for cross-level coordination. Setting different responsibilities for the Policy Level and the Doing Level, and evaluating their performance according to success indicators make it easier to follow progress on multiple fronts. It also allows the Strategic Level entities to monitor the entire system and determine when progress has been insufficient. All of the interviewees constantly mentioned the success indicators, or KPIs (Key Performance Indicators), which play a central role in policy formulation in the country. As one of the interviewees described: “The concept of the KPIs is part of our organizational DNA. We know that we will be measured according to them and we are all oriented to achieve them” (Interviewee 10). Each policy goal set at the Policy Level is translated into specific KPIs at the Doing Level. The success of the various support schemes is then measured according to their achievements. For example, NUS Enterprise, the technology transfer office of the National University of Singapore, is measured by the number of start-ups it succeeded in fostering, the number of students involved in entrepreneurial studies, the number of entrepreneurial awards, etc. In Exploit Technologies, a technology transfer arm of A*Star, success in measured by the net profits, the number of patents as well as by counting the number of researchers who are moving from research labs to industry.

The KPI system is a verification of the causation approach of the Singaporean policy system. It is based on the assumption that certain means can promote certain achievements and that these are linear and measurable. Setting the KPIs is a process that involves both the ministries that are responsible for setting policy and the agencies that are involved in policy implementation, so they include some of the knowledge that has been gained previously. In fact, the KPIs are the result of a continuous dialog between the Strategy Level that provides the needs and the Doing Level that tries to rationalize what can be achieved with the given means. Indeed, one of the interviewees stated that: "Discussing the KPIs may yield further investments or even open new units or in some other cases change the KPIs to more realistic ones" (Interviewee 9).

The KPIs force both the ministries and the agencies to conduct frequent evaluations of progress. Given that the KPIs are known to all, it is easy to measure progress. Public officials at the Doing Level are aware of the KPIs and treat them as their personal targets. Even though the system operates under a 5-year timeframe, progress towards the KPIs is evaluated every 2.5 years by the ministries and continuously by the agencies. The KPIs also make it easier to analyze the overall impact of policy and determine the means that are needed to fill identified gaps. Figure 2 shows some of the KPIs that were defined for the Economic Development Board (EDB) and the Agency for Science, Technology and Research (A*STAR) as they appear on Singapore's Ministry of Trade and Industry's Science and Technology 2010 Plan from February 2006.

[FIGURE 2 APPROXIMATELY HERE]

Selecting biotechnology as a field to be prioritized was not means driven but rather was a reaction to what was seen as a market opportunity that accorded with the strategic decision to transform Singapore into knowledge based industry (Chturvedi 2005; Wong et al. 2005). Once this field was selected, a meta plan was formulated that included identification of the means needed to achieve this goal. Moreover, specific budgets were allocated in order to allow future investments once the need for them was identified during the implementation process. The system as a whole was structured to supply all the means necessary to achieve the desired ends. Since the inception of the BMI 12 years ago, the original objectives of the program have remained the same.

Twelve years after its creation, the BMI has succeeded in attracting most of the large pharmaceutical companies such as Merck, GlaxoSmithKline, Abbot, AstraZeneca, Pfizer and Novartis to Singapore (Okamoto 2009). However, Singapore still lacks major entrepreneurial activity that contributes to the development of young biotech firms (Fingold et al. 2004; Wong 2006). Indeed, the share of Singapore in PCT life-science patent applications is yet very low, accounting for only 0.6% of the total number of applications in the field (OECD 2009 data)[6]. According to the A*Star[7] 2009 survey, the biomedical sector was responsible for only 5% of the total patents applied for by the private sector in Singapore. Moreover, according to the Singapore Association of Pharmaceutical Industry[8] (2012), out of 25 pharmaceutical companies that are active in Singapore, only three were formed in Singapore. In total, only six biomedical companies (including medical devices) have been established by local entrepreneurs[5].

[6] OECD Biotechnology Statistics 2009

[7] Agency for Science, Technology and Research

[8] http://www.sapi.org.sg/

On a macro level, the BMI has contributed to a manufacturing output of US $25 billion in 2009, up by more than three times from US $8 billion in 2000. The share of biotechnology in Singapore's total manufacturing output increased from 4% in 2000 to 10% in 2009. The annual growth of the sector from 2000 to 2009 was 14% and represents the success of Singapore in building capabilities in the field. In 2009, biotechnology accounted for 21% of the total manufacturing value-added in Singapore (US $12 billion), a significant increase from 2000 (US $5 billion). In 2009, the sector employed some 13,000 workers, more than twice the number in 2000 (A*Star press release, October 2010).

Biotechnology Policy in Israel

Israel's innovation policy is horizontal and characterized by a high level of neutrality. It is based mainly on the market failure approach (Teubal 1997; Bizan 2003, Breznitz 2007). Innovation policies are derived from concrete failures that are identified either at the sector level or are general to the economy (R&D support, technology transfer, promotion of pre-competitive research, etc.). Innovation policies are rarely derived from any strategic objectives set by the government. With the exception of a very few cases, the innovation policies are oriented toward solving market failures that are associated mainly with R&D activities (Trajtenberg 2002). Prioritization occurs when specific market failures of sectors with high growth potential are being recognized (commonly with the intervention of different stakeholders). As such, the Israeli case provides an interesting example of policy processes that follow the effectuation approach. A common remark of many interviewees in key positions either at the Ministry of Industry, Trade and Labor (MOITAL) or the treasury is that the market forces "know better" where to lead the market, so the government should not intervene in directing it. With a few exceptions (e.g., alternatives fuel for transportation) most cases of prioritization (e.g. biotechnology, nanotechnology or promoting R&D in traditional industries) are aimed at solving a sector's specific failures and are not part of an overall strategy. Changes in the allocation of budgets (among and not only within ministries) or the introduction of new institutes, regulations or legislation as a result of strategic policies targeting specific sectors are rare. Prioritization, where it exists, is relatively limited in scope and usually has no detailed budget or timeframe. Policies aimed at prioritizing the biotech sector have seldom set any performance or success indicators. Moreover, the term "biotechnology" has never been defined. Therefore, prioritization, in cases where it exists, is very broad and relates to various sub-sectors such as cosmetics, agro-bio, informatics as well as pharmaceuticals and bio-services.

Despite several studies over the last 20 years that have been conducted to evaluate Israel's potential in biotechnology (see Avnimelech on this issue) and recommend specific policy actions, the Israeli government has steadfastly maintained its view that market forces alone should determine the technological directions of the future (Trajtenberg 2002).

The key player in the Israeli policy efforts to support and promote R&D and innovation is the Office of the Chief Scientist (OCS) at the MOITAL. Biotech companies can benefit from all of the horizontal support measures provided by the OCS. However, two measures do provide some extra support to biotechnology. First, R&D projects of biotech firms are granted 50% of their project costs (whereas projects in other fields are granted 40%-50%). Second, the NOFAR scheme was established with the aim of supporting academic partnerships with industry (a similar scheme exists for other sectors as well). The OCS policy is characterized by a horizontal, bottom-up approach in which excellence in R&D and the ability of the firm to implement its proposed projects serve as the main selection criteria (Kaufmann et al. 2003).

The support provided by the OCS takes the form of conditional grants and risk sharing. If a project fails to become commercialized, the provided support is treated as a grant. If the project succeeds, it is treated as a loan, and the company has to repay the money it received. The OCS works at different levels of R&D (applicative, pre-competitive and technology transfer) and manages several programs that promote innovation as described below:

[FIGURE 3 APPROXIMATELY HERE]

(1) **The Regular R&D Program**: At the heart of the Israeli R&D support schemes is the OCS's regular program with an overall budget of US $350 million. This program supports R&D activities at a rate of 40%-50%. This program has no specific priorities and selects projects according to their merit. Thirty percent of the regular program fund is allocated to life science projects.

(2) **MAGNET**: The Magnet program is aimed at supporting pre-competitive R&D activities conducted by a consortium that consists of a number of companies together with academic institutes. It provides projects with 60% of the allowable costs for a period of up to five years. The Magnet operates a few other sub-programs aimed mainly at technology transfer. Examples of such programs include Magneton, NOFAR for projects in the field of life science and Katamon for projects in the field of water technologies.

(3) **Technological Incubators Program ("Hamamot")**: Over the last two decades, incubators have been a major tool in the Israeli policy for supporting R&D in SMEs. The program supplies entrepreneurs with physical premises, financial resources,

professional guidance and administrative assistance. Since its inception, 1,452 companies have "graduated" from the incubators. Approximately 60% of the projects within the incubators are in life sciences, of which 65% are developing medical devices and 35% are dedicated to pure biotechnology (Kaufmann and Gore 2009).

(4) **International Support Schemes**: Israel has been an associate state of the European framework programs since 1994 and is a member of the EUREKS program. In addition, Israel has signed bi-lateral agreements for the support of collaborative R&D projects with various countries including Singapore, Korea, China, India, Spain, France, Germany and many others.

The strong entrepreneurial spirit of Israel together with the high level of academic research in the life sciences, and the limited capacity of the universities to host all of the research activity has prompted the explosion of start-up companies (Kaufmann and Schwartz 2008). This extensive business activity has led the government to implement various schemes that are aimed at assisting the growth of the sector. Such a response contrasts with Singapore where promoting biotechnology is a result of a strategic government decision to target the sector. According to the Israeli Life Science Association (ILSI), a total of 702 life science companies are currently active, of which 57% are developing medical devices (400 firms), 18% biotechnology products (126 firms) and 11% (76 firms) are categorized as pharmaceutical companies. Most of the companies are small with 57% employing 1-10 employees and 71% employing 1-20 employees. Only 16% of the companies employ more than 50 employees. In total, the industry employs approximately 21,000 employees with 7,000 of them employed by the pharmaceutical giant Teva. The presence of large multinational pharmaceutical companies is limited to local logistics centers with no manufacturing or substantial R&D centers. Fifty-two companies are conducting clinical trials with eight molecules being tested in phase 3. Thirty-eight companies are public with market capitalizations of US $2 billion (excluding Teva). The share of Israel in PCT patent applications in biotechnology was 1.5% in 2009. According to the ILSI survey, the biotech sector was responsible for 18% of the total number of patents granted to Israeli firms in 2009. Nevertheless, over the last 30 years, and with the exception of Teva’s Copaxon for multiple sclerosis, no Israeli company has succeeded in introducing blockbuster drugs to the market.

Elements of Targeting and their Implementation in Israel and Singapore

Targeted policies are aimed at promoting specific sectors or technologies (Avnimelech and Teubal 2008). Weiss (2011) has argued that developing new sectors is vital for maintaining continuous economic growth. However, the failures that are associated with the creation of new sectors such as knowledge spillovers, entrepreneurial activity and sub-optimal investments together with the coordination of new multi-agent structures has led many countries to develop policies that better suit these market failures. The targeting approach also requires countries to develop new knowledge based policy processes and sometimes new governance structures in order to support the targeting approach (Hausmann et al. 2008).

Although one can identify targeting with the logic of causation (i.e. defining the specific needs that are required to achieve a specific end), the fact that most common targeting activities refer to sectors with no clear or yet unknown development paths make it difficult to link the means and the ends in a linear manner. In such cases, the means and ends might co-evolve and even switched when a means (e.g. developing a dedicated service sector for the bio-cluster) becomes an end, as was the case of North Carolina

(See Avnimelech on this issue). Countries that use an effectuation approach may be better positioned to manage such dynamics.

The Target Project, financed by the European FP6, tried to empirically analyze what policy elements are responsible for the successful targeting of biotechnology clusters. The project compared six different clusters from Europe, Israel and the U.S. The Target Report[9] (2011) identified five elements necessary for successful targeting with a specific focus on biotechnology. As we will demonstrate below, these five elements are present in or absent from the approaches of causation and effectuation.

(1) **A strategic decision to target:** The Target Project reveals that a successful targeting policy requires a clear policy at the macro-level to target a sector. Commonly, the decision will be part of an overall strategy aimed at achieving some general strategic goals. The strategic decision to target, and more importantly the strategic process that yields such a decision, is important in order to create a broad consensus among all stakeholders about the need to target. Causators and effectuators differ in their approach to targeting. For causators, the decision to target is a direct result of their strategic plans, because they assume linearity between the targeted objective and the desired ends. For effectuators, the decision to target may be a reaction to market forces and thus lack the strategic process. Singapore and Israel provide good examples of such dynamics. At the visionary level, Singapore decided to transform itself into a knowledge-based economy. This vision was translated into a meta-strategy that included a detailed description of four technological sectors that should be targeted, and a precise and comprehensive plan on how to foster each one of them. This detailed planning included investment in various elements of the innovation system, the articulation of specific pieces of

[9] Targeted R&D Policy report. Available on demand from: Dan@jiis.org.il

legislation and regulations, and the creation of new government institutes. Moreover, the decision to target was followed by the creation of new governmental bodies (such as the NRF and the biomedical initiative) that were aimed at supporting the targeting process itself. Thus, we can see a clear process of identifying the means that are needed in order to achieve the desired ends. In Israel, the decision to promote innovation in general was a derivative of a similar general vision. However, the decision to target biotechnology was a response to a bottom-up process led by several stakeholders (Monitor Report, 2001), not the result of any strategic decision to target a specific sector. Alternatively, it was a local decision that was taken by the OCS as part of its overall strategy that was set at the end of the 1970s to promote industrial R&D. Once the OCS recognized the potential of the biotechnology sector, it began formulating policies for maximizing the benefits for the Israeli economy. These policies, unlike the case of Singapore, have remained general and did not specify any sub-sectors. Moreover, they related only to R&D activities, ignoring other elements of innovation that are the responsibility of other units or ministries. For example, no policies regarding academic research in the field of biotechnology were designed, nor were there any discussions about what biotechnology is. It is important to note, however, that this policy dynamic does not contradict the need of targeting approaches to be part of a strategic decision to target. The Israeli case reflects one of the main hazards of "pure" effectuation based policies, namely, a targeting process that is not part of a strategic process and thus is not backed by the entire innovation policy system.

(2) **The objective of targeting is a strategic objective**: In order to obtain the commitment of the entire policy system to foster the sectors that are to be targeted, it is crucial that all of the stakeholders consider these sectors to be strategic. Under the logic of causation, which is by definition planned, it is most likely that the strategic level of the

targeted objective will be the reason for its selection. Effectuators, on the other hand, react to market opportunities that can be achieved by using their existing means, while paying less attention to the strategic level of the targeted objectives. From the outset, Singapore's targeting of biotechnology was strategic (Okamoto 2009). Moreover, the government further defined the sector by identifying five specific fields as strategic. The selection of these fields was based on their potential contribution to social, political and economic objectives. In contrast, biotechnology in Israel, though prioritized, was never defined as a strategic objective. In fact, biotechnology was chosen as a sector to target based on perceptions about Israel's potential in the field, not as a strategic goal in and of itself.[10] Indeed, the prioritization of the field remained very general with a loose definition of the sector's borders ranging from pharmaceuticals to agro-bio, medical devices, diagnostics and health IT.

(3) **The existence of a dedicated entity for coordination**: Given that the targeting of multi-agent sectors requires a high level of coordination among the stakeholders involved, successful targeting requires a dedicated entity that will be responsible for coordinating the design and implementation of the processes. For effectuators, such a coordinating body is crucial, because for them targeting is not planned in detail as it is among causators. Indeed, when we compare Singapore and Israel, we can see that the two have adopted very different paths with regard to coordination. As a result of complex planning, Singapore established the NRF in 2006 as a permanent body in charge of strategic policy planning and coordination. In contrast, Israel has no coordination body for the implementation of the biotech policy. Targeting

[10] Unlike, for example, Israel's decision to target the development of fuel substitutes for transportation (Government Resolution 2790, January 30, 2011).

biotechnology was not treated as a task that should involve several agents of the innovation system, but rather was a local initiative of the OCS.

(4) **Dedicated budgeting:** For causators, budgeting in an essential part of the planning process and is necessary for assessing the effectiveness of their targeting efforts. Given that they assume the future is predictable, investing in means is considered positive as long as such investment is seen as profitable. For effectuators, budgeting is difficult, because they assume a high level of uncertainty. Indeed, in Singapore, budgeting encompasses a wide variety of elements within the biomedical innovation system, including higher education, infrastructure, human resources, foreign investment, industrial R&D and manufacturing. In Israel, targeting biotechnology was an ad-hoc decision and as such was limited to a narrow set of actions that were basically an extension of existing policy measures (e.g. 50% instead of 40% public support for R&D activities). No additional budgets were allocated to the targeting activity either within the OCS or nationally. Such an approach underscores the hazards for effectuators. Despite the fact that the means shape the prioritization process, the targeting efforts still need to be planned, comprehensive and funded.

(5) **On-going learning process:** System transformation requires real-time evaluation of the effects of policy implementation (Nill and Kemp, 2009). For both causators and effectuators, on-going learning is crucial for success. For causators, such a unit is required in order to control and evaluate the implementation process, while for effectuators, such an ability to learn as they go along is fundamental in order to assess market opportunities. The KPI regime in Singapore forced the Singaporean system to conduct real-time evaluations as a routine. In Israel, the decision to target biotechnology was based on in-depth studies (see Avnimelech on this issue) of the field. However, no additional evaluations or in-depth studies of the sector have been conducted since the

inception of the targeted policy six years ago. Moreover, Israel lacks any institution similar to the Singaporean NRF, which is devoted to learning about the market. Therefore, the ability of policymakers to catalyze the socialization of knowledge about the sector and create feedback mechanisms involving the various stakeholders and the different phases of the policy process is limited. This lacuna has led to questions about Israel's ability to cope successfully with the rapid changes in the field, and more importantly, with changes in what are perceived as opportunities.

Limits of the two logics

Countries implementing the effectuation logic commonly direct their policies to solving market failures. Prioritization occurs when a sector's specific failures are identified. By solving these failures, effectuators expect to ride the waves towards the desired, though uncharacterized, ends. However, the case of Israel demonstrates that although the decision to target biotechnology was taken by the government its ability to activate and synchronize the different policy agents in a way that will support the emergence of missing parts of the sector's eco-system appear to be absence. The rooted neoclassical policy approach seems to rule-out the formal decision to target the sector. It reveals that prioritization, which is the outcome of identifying a specific sector's market failure, is not a substitute for targeting, which relates to the transformation of the eco-system to support process of cluster creation.

Causators, on the other hand, have specific, desired ends. They identify the missing elements in the innovation system and try to create them. The case of Singapore demonstrates that detailed planning followed by a generous allocation of resources can lead to the creation of advanced infrastructures and can help create an attractive business environment. However, it may fail to change the "softer" parts of the innovation system such as the entrepreneurial culture or the culture of academic excellence. It is difficult to estimate how long it takes to create such elements.

Targeting requires policy makers to adopt a systemic approach that encompasses several dimensions of the system such as basic research, infrastructure, legislation, regulations, business networks, cultural and socio-political elements and financing. The question is one of system transformation (targeting), as opposed to a simple problem of market failures (prioritization). In sectors with an unknown development path that are characterized by frequent technological changes, the ability to assume linearity and use causation logic is limited (Brettel et al. 2012). Such an approach can lead to either a lock-in effect in which companies seek to develop means that are aimed at meeting markets that no longer exist or to ends that cannot be supported by the existing means. However, as we can learn from the case of Israel, implementing a targeted policy that is based purely on the effectuation logic may also be limited. Targeting a specific sector may require the taking of actions that are beyond simple reactions to identified market failures. Instead, these actions should contain elements that direct the development of the market by creating new market entities aimed at assisting the sector in moving from one phase of emergence to the next.

The two case studies reveal that both the causation and effectuation approaches, when being used alone, may be insufficient for dealing with the complexities associated with targeting new and dynamic sectors. The former will find it very difficult not only to predict the future development of the sector (and what objectives can be perceived as realistic), but also to understand what vectors are influencing its dynamics. The latter may fail to identify and create specific capabilities and institutions that do not fall under the clear definition of market failures. The case of Singapore provides an example of pure causation. The targeting of the biotechnology sector was planned into detail while assuming linearity between interventions and results. However, though the Singaporean BMI succeeded in turning Singapore into an Asian leader in the manufacture of life-science products, it failed to create a vibrant biotech industry with high levels of entrepreneurship or translational research.

Similarly, the Israeli pure effectuation approach failed to turn its biotechnology sector into a real growth engine. Whereas the focus of the Israeli policy on relatively generic means directed towards general market failures such as supporting industrial R&D activities, fostering technology transfer or promoting entrepreneurship have succeeded in creating several hundred dedicated biotechnology firms, the lack of more specific policies aimed at closing the gaps with leading countries such as attracting large pharmaceuticals or establishing dedicated venture capital funds, hampered the ability of these dedicated biotechnology firms to grow and contribute substantially to the economy (Katsnelson 2005). Although the Israeli policy approach has contributed a great deal to the country's international competitive advantage in R&D capabilities, including in biotech, it has left Israel at the same starting point of having considerable, though unrealized, potential in the biotechnology sector. It is worth emphasizing that many consider the Israeli case a failure because the contribution of the sector to the country's overall growth and employment has been disappointing. In sectors with an unknown development path, policies can be targeted only if narrow objectives are set that have specific timeframes. It appears that neither Israel nor Singapore considered the time that is needed in order to build a full-fledged bio-cluster.

Avnimelech and Teubal (2008) have discussed the term "evolutionary targeting" as a strategic effort to "re-enforcing and sustaining market-led evolutionary processes of emergence of multi-agent structures” (p.153). While analyzing the development of the Israeli VC industry, Avnimelech and Teubal (2010) elaborated on the extended industry life-cycle perspective and identified four stages of the cluster development process: 1) the existence of background conditions; 2) the pre-emergence phase in which variation (and selection), capabilities and supportive institutions emerge; 3) the emergence phase in which full-fledged clusters can be observed characterized by the development of a supportive eco-system that includes collective learning, exploiting economies of scale, reputation and networking; and 4) the maturity phase in which the cluster starts to lose its competitive advantage.

From the above analysis of the two countries, it is clear that Israel and Singapore are not at the same phase of cluster development. Whereas Singapore’s efforts are focused on entering the pre-emergence phase, Israel is struggling to move from the pre-emergent phase to the creation of a full-fledged cluster. The failure of the two countries to reach their desired goals may indicate that the use of the logics of causation and effectuation may be varied across the different phases of cluster development. Whereas policies aimed at nurturing the early stages of cluster development (i.e. moving from the background to the pre-emergence phase) may be enhanced by the causation approach, policies aimed at promoting the innovation system in its move towards the later phases of cluster development (i.e. from pre-emergence to emergence) may benefit from the effectuation approach. Ironically, the two countries adopted the wrong approach for their stage of development.

Conclusions

The lessons learnt from our two case studies revealed that both causation logic (Singapore) and effectuation logic (Israel) are limited in their ability to build a full-fledged biotech cluster. The Singapore policy that resulted from a strategic planning process and was followed by massive investments in the creation of a new bio-innovation system has yielded a strong bio-manufacturing infrastructure that is based mainly on multinational companies. Currently, despite the massive investments in basic science in the field, local entrepreneurship is quite limited. In contrast, the Israeli policy that is based on strengthening local capabilities with the goal of transforming the biotech sector into a main engine of growth, has led to the establishment of a large number of relatively small firms. The contribution of the sector to economic growth or to employment is still quite limited.

These two case studies underscore the point that for the targeting process to succeed, a combination of causation and effectuation approaches should be used. In sectors that are constantly changing, the ability to assume linearity is limited. In such sectors, both the means and the ends can be defined only as experience is gained, as knowledge about the sector's development path is accumulated and as the capabilities of both firms and government become clearer (Lall and Teubal 1998). While it seems that policies adopting the effectuation logic can better support sectors that are characterized by high levels of change and uncertainty, the case of Israel reveals that such a logic, when used exclusively, may lead to the ignoring of specific market needs that are beyond market failures, such as the need for a dedicated infrastructure or supportive institutions that are required for the creation of a well-functioning sector. Although the ability of policy makers to assume linearity in their intervention is limited, in some cases their attempts to avoid the risks of implementing an incorrect policy measure may be "risky" for a successful targeted policy.

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Figure 1. Singapore's Biomedical R&D Policy Structure

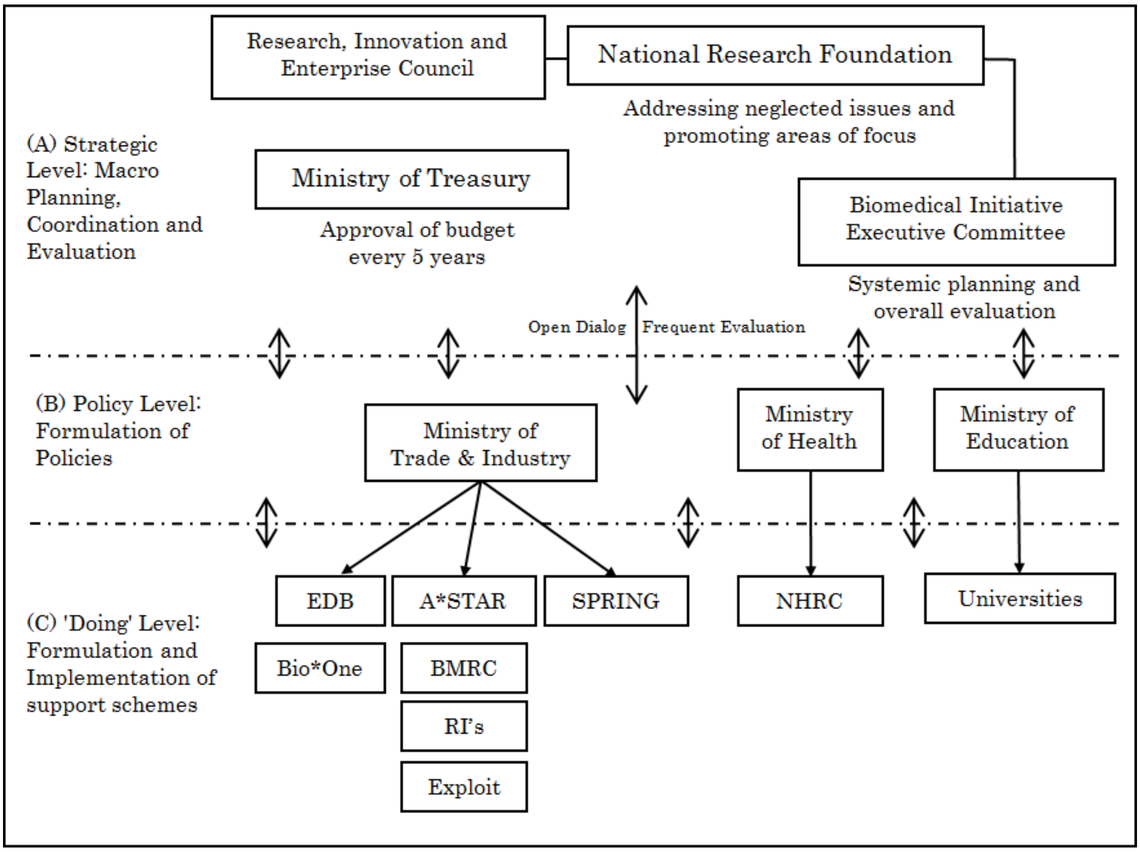

Figure 2. KPIs for A*STAR and EDB

Source: Science and Technology Plan 2010, Ministry of Trade and Industry Singapore 2006

Indicators for A*STAR	Projected (2001-05)	Target (2006-10)
Human Capital Development		
1. Number of PhD students trained and graduated	215	220
2. Number of RI staff spun out to locally-based industry as RSEs	706	835
Intellectual Capital Development		
3. Number of primary patent applications	850	1,100
4. Number of papers published (in science citation and engineering index journals)	5,727	7,940
Industrial Capital Development		
5. Number of projects with industry	952	1,120
6. Industry funding ($m)	143	197

Indicators for EDB	Actual (FY01-05)	Target (FY06-10)
1. Total Research Investment (TRI)	$8.5 bil ($1.7 bil p.a.)	$9-10 bil ($1.8-2 bil p.a.)
2. No. of large R&D projects (defined as projects >= $50 mil TRI)	40	45
3. No. of RSE positions created	6,449	7,500

Figure 3. Total R&D Budget for All Support Routes; Authorized Commitment (Million NIS).

Source: Summary of Activities in 2009 - Office of Chief Scientist, Ministry of Industry, Trade, and Labor