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A Hypothetical Model for the Design and Development of a Science and Technology Park in the Developing Countries

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Abstract

This study develops an appropriate model for Science and Technology Park (STP) with a view to helping policy makers and STP managers implement and manage STP. The authors reorganize and prioritize the Cabral-Dahab Science Park Management Paradigm. The study identifies three critical groups of actors: determinants, reactors and executors and four sub-models were developed from the trajectories of the groups of actors: SmA, SmB, SmC and SmD. The authors place more emphasis on the "determinants" as the most important actors in the establishment and management of STP. A critical evaluation of the models reveals that the last sub-model was found to be the most appropriate for most of the developing countries. The paper concludes that determinants and policy makers should see STPs as a long term investment.

KEYWORDS: science and technology park, model, developing countries, Cabral-Dahab Paradigm

Introduction

The urge to develop science and technology capabilities is one of the reasons why most economies in transitions try to establish Science and Technology Park (STP). The establishment of institutions to support high technology firms and other instruments of technology diffusion are imperative to national and regional development.

These countries also realize that growth and achievement in innovation targets requires an appropriate level of science and technology infrastructures in the country (Al-Sultan, 1998). These infrastructures should have the capacity to increase value to knowledge base, create employments, encourage re-industrialization or urban renewal, promote commercialization of emerging technologies, stimulate commercial and industrial innovation, promote the use of locally produced goods and services and entrepreneurial ventures, provide high return on investment in knowledge creation and promote national/regional economic development(OECD, 1992). STP is one of these infrastructures. It constitutes part of economic development strategies. In fact, STP is an integral part of a successful National Innovation Systems (NIS) of many developed economies (Xue, 2006). STP can be described as a property-based economic strategy with basic focus on the transfer of technological know-how and industrialization. STPs usually have technological entrepreneurial biased tenants with infrastructures such as advice and service firms, financing institutions and government agencies.

Since the late 20th century, it is clearly understood that knowledge production is a major driver of sustainable growth and development, most nations have embarked on the creation of high-technology industries of various geographical scales (Goldstein and Luger, 1993). These are called by different names such as science cities when it occupies a particular region or city (e.g. Japan Technopolis) or innovation centres, technology incubators, research, science or technology parks when it occupies a smaller property (e.g. Silicon Valley and Route 128 in USA) (Bass, 1998). Nonetheless, there are three common characteristics of these schemes: they are property-based schemes, knowledge-based and technology-intensive firms and they assist in the growth of knowledge-based industries & technology transfers (Zhang, 2005).

The concept of external economies like knowledge spillover, strong labour market, backward and forward linkages within a local market are critical factors in explaining industrial concentrations in a particular geographical region (Marshal, 1920). This has been used to explain the factors responsible for the spread of high-technology firms in Technology Parks (TPs) such as the Silicon Valley, USA; Kyoto Research Park, Japan and the Cambridge Science Park, UK, among others. For instance, studies like Krugman, (1993) and Black and Henderson, (1999) have used the idea of Marshal to analyze the reasons why firms agglomerate. Marshallian externalities to the concentration of high-technology firms might has justified many tertiary institutions, research institutes and policy institutions to promote technology parks.

Several scholars have studied the history and development of science parks (e.g. Haxton, 1998; Zhang, 2005), the concept (e.g. Dahab and Cabral 1993; Al-Sultan, 1998), important factors for its establishment (e.g. Cabral and Dahab, 1998 and Zhang, 2004), role of science park members of staff and intellectual capital optimization (e.g. Gibb, 2007) and its role between industrial R & D and high-tech development (e.g. Stuart, 2000). Furthermore, countries and regions have adapted this technological policy instrument to their economies so as to promote sustained growth. One of the most common of these models is that of the Cabral-Dahab Science Park Management Paradigm (Cabral and Dahab, 1998) which has been validated in both developing and developed countries. As a matter of fact, it has been validated for Science Parks in Europe, the Americas, Arab Countries, Asia and Australia. The refined ten-point management paradigm (Cabral, 2004) is stated below.

It states that a successful science park must

1. Have access to qualified research and development personnel in the areas of knowledge in which the park has its identity.
2. Be able to a market its high valued products and services.
3. Have the capability to provide marketing expertise and managerial skills to firms, particularly SMEs, lacking such a resource.
4. Be inserted in a society that allows for the protection of products or process secrets, via patents, security or any other means.
5. Be able to select or reject which firms enter the park. The firm's business plan is expected to be coherent with the science park identity.
6. Have a clear identity, quite often expressed symbolically, as the park's name choice, its logo or the management discourse.
7. Have a management with established or recognised expertise in financial matters, and which has presented long term economic development plans.
8. Have the backing of powerful, dynamic and stable economic actors, such as a funding agency, political institution or local university.
9. Include in its management an active person of vision, with power of decision and with high and visible profile, who is perceived by relevant actors in society as embodying the

interface between academia and industry, long-term plans and good management – Mr./Ms. Science Park.

10. Include a prominent percentage of consultancy firms, as well as technical service firms, including laboratories and quality control firms.

However, it has been noted that developing countries should be wary of such adaptations in order to sustain growth and development of STP. Al-Sultan (1998) explained some of the reasons for this. Three of the key reasons are lack of support to the general educational system, brain drain, and difficulties at the civil society level. The latter is very important because innovators will focus on other money making activities instead of development of products and processes. It is within this context that this paper intends to develop a more appropriate model that could be used by developing countries in establishing a viable STP which could become an important pillar within their various NIS. This paper will also attempt to prioritize the ten-point Cabral-Dahab Science Park Management Paradigm with a view to modifying and refining the concept. This hypothetical model intends to sit on the strong framework of Cabral Dahab Pradigm which was empirically developed after observations of the IDEON science park in Lund, Sweden, and the BIORIO science park in Rio de Janeiro, Brazil.

Hypothetical Models of Science and Technology Parks

This paper conceptualises STP as a deliberate scheme to develop and accommodate high-technology cluster of firms/companies which engage in commercialization of high-technology products/services. The idea is to evolve a general hypothetical model for the design and development of an idealized STP with a focus on developing countries. These models span the critical four-phase developmental process of STPs: start-up, growth, maturity and diversification (Kirks and Catts, 2004). These models are informed from the fact that there has been a paradigm shift in the design and establishment of STPs. The onus of designing and establishing a STP now rests on collaboration/partnerships among academic institutions/research institutes, national government, non-governmental organizations, international organizations as well as the private sector organizations.

The paper proposes that for a successful design and implementation of a STP, three critical groups of actors would have to be taken into consideration. These actors in consecutive order are; determinants (those who are at the level of decisive policy direction), reactors (those who are with the responsibility of preparing, building, expanding and managing the park) and executors (those who are saddled with the management and commercialization of the products and services). This model is centered on these actors. The human capitals at the level of “decisive policy direction” are termed determinants. Four trajectories are possible depending on who is at the level of “decisive policy direction” which could be government, academic/research institutes, organized private sector, non-governmental organization/international organizations and local communities. Those who are involved in the location, preparation and management of the STP are called reactors, and the actors are mainly the human capital and the tenants. The executors are basically those who manage the output of the STP which could be the commercialization of high-technology goods and services, technology transfer, knowledge spillover, spin offs, innovations. This category of actor are supposed to profitably managed the park and create

wealth for both the immediate local community and ultimately for the national economy in the global market. The model recognizes the determinants as the most important factor to successful implementation of STPs. This is because they determine the focus of the STP (for instance, whether it should adopt a single technology/business or a multi-sector approach), the reactors and executors.

There is a general model which encompasses the framework of other sub-models (see figure 1). The general model created four scenarios under each of the determinants depending on the trajectories of the determinants. These scenarios are termed Sub-models (Sms). That is, SmA (Government trajectory), SmB (Academic/research institutes trajectory), SmC (Organized private sector trajectory) and SmD (the three-determinant trajectory).

In an attempt to prioritize the ten-point Cabral-Dahab Science Park Management Paradigm, the following reorganization of the management paradigm was suggested in line with the three crucial groups of actors in the models. These points are listed in order of importance together with the actors (in brackets) who will organize and execute each of the operations at each stage of the development.

A Science/Technology Park should

1. Include in its management an active person of vision (a group of people), with power of decision and with high and visible profile, who is (are) perceived by relevant actors in society as embodying the interface between academia and industry, long-term plans and good management – Mr./Ms. Science Park (Determinants).
2. Have a clear identity, quite often expressed symbolically, as the park's name choice, its logo or the management discourse (Determinants).
3. Have the backing of powerful, dynamic and stable economic actors, such as a funding agency, political institution or local university (Determinants).
4. Be inserted in a society that allows for the protection of products or process secrets, via patents, security or any other means (Determinants).
5. Have access to qualified research and development personnel in the areas of knowledge in which the park has its identity (Reactors).
6. Be able to select or reject which firms enter the park. The firm's business plan is expected to be coherent with the science park identity (Reactors).
7. Have a management with established or recognised expertise in financial matters, and which has presented long term economic development plans (Reactors).
8. Have the capability to provide marketing expertise and managerial skills to firms, particularly SMEs, lacking such a resource (Reactors).
9. Be able to a market its high valued products and services (Executors).
10. Include a prominent percentage of consultancy firms, as well as technical service firms, including laboratories and quality control firms (Executors).

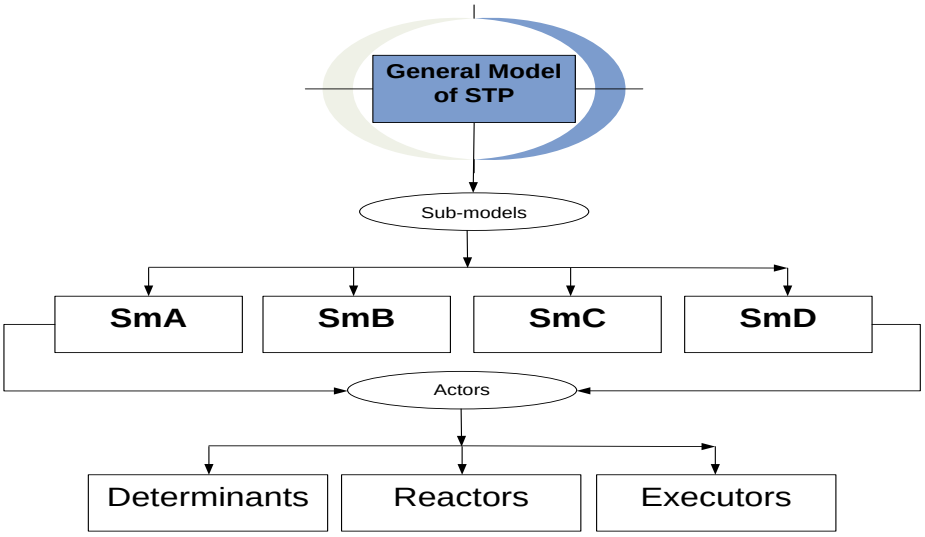

Figure 1: General Framework for the establishment of Science, Technology Parks

SmA: The Government trajectory

The national government can play an important role in the development of the economy. It can strengthen competition, facilitate networking and co-operation, strengthen links between science and industry, increase returns to investment in R&D and protect of intellectual property. For instance, the enactment of the Bayh-Dole Act of 1980 by the United States of America had a tremendous impact on the rate of technology transfer in the country (OECD, 2000). These roles have a direct bearing on the establishment of STP. Governments with a stronghold in the above activities are more likely to promote viable STP. For instance, USA, Britain and Japan have a return to investment in R&D and are also known to have a successful STP. In this countries, research has been identified as a significant component in knowledge generation and advancement. Research is also important for the improvement of labor skills and expertise. Therefore, research facilitates and accelerates economic development. It is assumed that in most cases research improves living conditions in the society (Bako, 2005). This goes along in our understanding for the reasons why China announced the increase in the annual funding of research and development. China also plan to build 30 new STPs by the year 2010 (Chong, 2006). Moreover, the creation of world-class research centres plays an important role in the formation of research networks and clusters and creation of STPs. This is evidenced in places such as BioRio in Brazil, Sillicon Valley in USA and Laval Science Park in Canada.

However, most of the governments' researches in the developing countries are usually directed towards public goals, such as education, improvement in social amenities, health care service delivery, energy and. Nonetheless, government policy will still have to balance provision of funds for basic research and implementation of specific projects. More often than not, they tend to provide more funds for the implementation of social infrastructures than basic research. For

instance, Nigeria's government only spent 1.3% of its budget on research in her federal universities (Harnett, 2000).

A scenario whereby government is at the level of decisive policy direction or determinant is shown in figure 2 below. In this scenario, government's roles will follow the prioritized ten-point management paradigm. In addition to this, it takes the initiative to establish the STP, provide the fund and hire the STP management. It also decides whether the STP should adopt a single technology/business or a multi-sector approach in implementing its objectives. This is done with a view to increasing competitiveness, promoting innovations, commercializing cutting edge technologies, creating spinoffs which should ultimately lead to employment generation and wealth creation for the citizenry. However, government establishments in the developing countries are not seen as a business ventures. In other words, they are not meant to be run as a profit-oriented organization but as service-providing institutions and this usually lead to its eventual death. STPs are capital intensive and property-based institutions that should be run as a business organization. However, this sub-model has been operated successfully in the developed countries across the world where there are well established level of infrastructures. This kind of model is also common in China where establishment of STPs is intrinsically linked to industrial development and Science and Technologies policies (OECD, 1997).

Another problem with the workability of this scenario in the developing countries is that of instability of civil society. Most of the government policies in the developing countries have been truncated in one way or other as a result of unstable political environment. STPs, as other long term investments, need a stable political environment to thrive in. It is known that most STPs do not have any positive significant impact until about 15-20 years (Kirks and Catts, 2004) after establishment.

Furthermore, experiences have shown that most governments' enterprises in the developing countries do have a very low probability of success. For example, in Nigeria, government enterprises such as former National Electric Power Authority, Nigerian Telecommunications Ltd (NITEL), Nigeria Airways, probably failed because government lacks the adequate capacity and commitment to maintain such infrastructures or as a result of wrong policies as it is the case in Tanzania (Van Engelen et al., 2001). According to Portelli (2006) the removal of government intervention in the productive economy might be responsible for the slight growth in some developing countries in East Africa. If these issues in developing countries are not addressed, it is not likely that STP which has government as its main determinant will succeed in most developing countries.

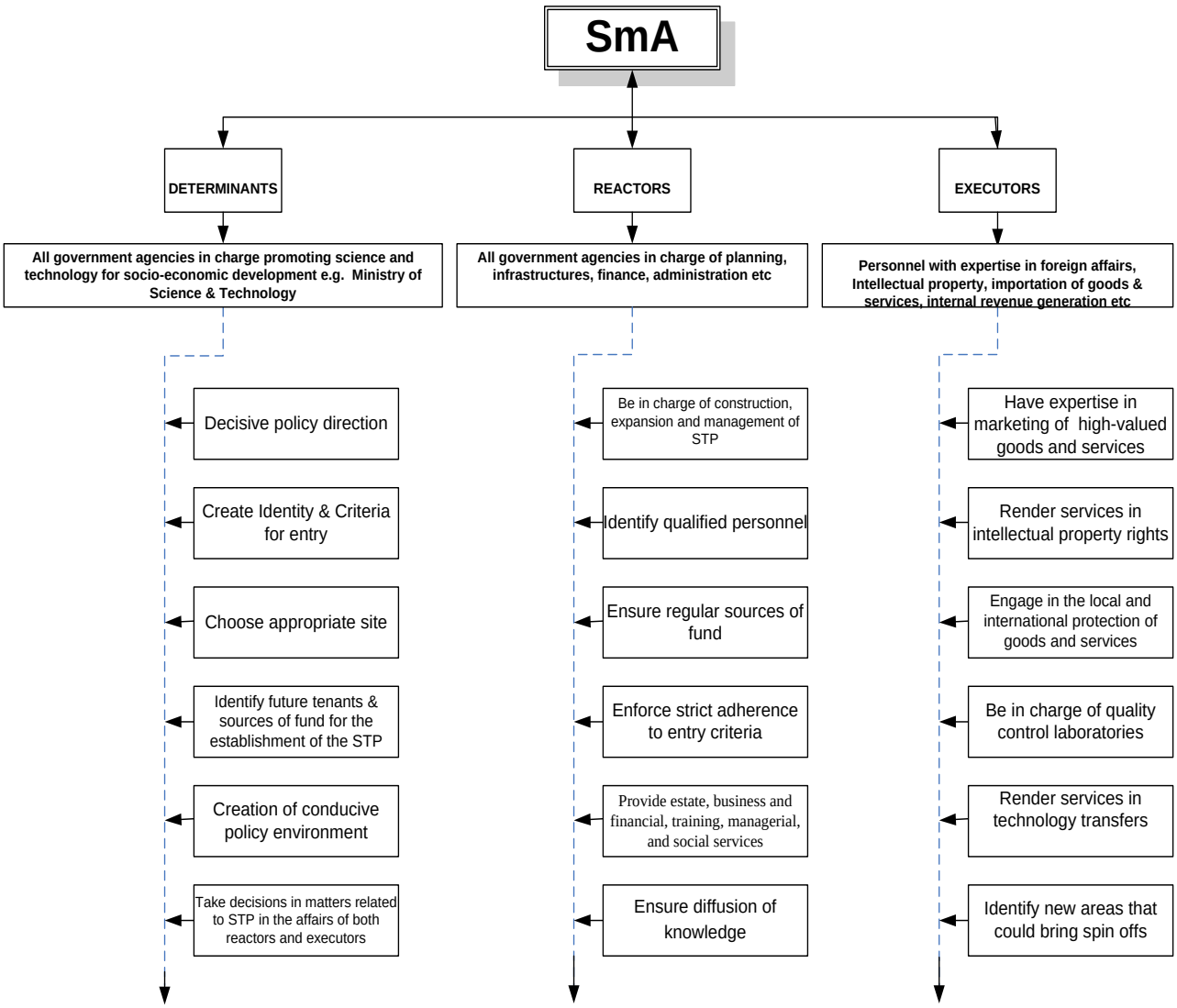

Figure 2: SmA: The Government trajectory

SmB: Academic/research institutes trajectory

It is becoming increasingly common for communities in which there are research centres or universities to develop a research/science park to leverage academic and laboratory resources to realize economic development. This sub-model discusses the trajectory of developing STP to leverage the assets of the academic/research institutes. This is based on the fact that major research centers can be key drivers of technology-based economic development. This is not an uncommon phenomenon in the developed countries. The "determinants" at the level of decisive policy direction are the universities or research institutes with inventions or new/emerging technologies which are ripe for commercialization. In addition to their roles in the prioritized management paradigm, they also take responsibility in appointing/employing the actors in the "reactors". The output usually involves inventions, entrepreneurships, employments, promotion

of industrial R&D and developing high-tech industries (Xue, 1997), wealth creation in and around their environments (see Figure 3). Those who have the tendency of establishing such capital intensive park with a view to running it as a profit making infrastructures have been categorized as "universities of innovation' while those whose primary function is to carry out research and training are called 'universities of reflection' (Cowan, et. al. 2008). These categories of STPs are usually called Research Parks (RP). It is therefore important to define what a research park is in order to better appreciate what its objectives, functions are within the economy.

The Association of University Related Research Parks (AURRP, 1997) has defined research park or science park as a property-based venture that has:
(1) existing or prospective land and buildings intended primarily for private and public research and development facilities, high-technology and science-based companies, and support services;
(2) a contractual and/or formal ownership or operational relationship with one or more universities or other institutions of higher education, and science research;
(3) a role in promoting research and development by the university in partnership with industry, assisting in the growth of new ventures, and promoting economic development; and
(4) a role in aiding the transfer of technology and business skills between the university and industry tenants.
From the above definition, the third and the fourth roles differentiate research parks from other types of STPs.

There are quite number of successful RPs in the developed countries. Some of the most popular ones are Stanford Industrial Park, in the Silicon Valley of northern California, Research Triangle Park, Waltham Industrial Centre, and Boston's Route 128 (Miller and Cote, 1987). We assumed that most universities and research institutes will be willing to attract companies that wish to leverage the expertise and resources of the laboratory/researchers in order to gain access to highly specialized, and often unique, facilities and equipment. A good example of research parks that developed by or located close to research institutes are Sandia Science and Technology Park, the National Aeronautics and Space Administration (NASA) Research Park at Ames and East Tennessee Technology Park at Oak Ridge National Laboratory.

Looking at the success stories of these RPs, many developing countries have started or starting to employ the same concepts without looking critically at the appropriateness of such models within the contexts of their own economic development. This is because some of these developing countries believe that the development of a RP is an important medium for moving economies forward in the advent of global market place (Malecki, 1991). Another assumption of most developing countries is that most of the shelves of researchers in most of their universities/research institutes have inventions and technologies that could be commercialized The lack of resources in developing countries also forces university personnel to carry out external work and consultancies, thus doing a "forced" technology transfer. However, the fact remains that employing this model of establishing STP hook, line and sinker may not be the best of options for the developing countries for so many reasons.

Most of the researches in the developing countries are not demand driven (Igwe, 1990, Bako, 2005) and majority of them usually end up in journals for the purpose of career advancement (Musa, 1988, Oyewale et al. 2007). Majority of the developing countries have a very low rate of return on investment on higher education and researches. For instance, between 1960 and 1980 the return on investment on higher education and researches range between 46% and 15% in most

of the sub-Saharan countries with Nigeria having the highest rate and Somalia recording the lowest rate (Hincliffe, 1987). Another problem is that of inadequate fund for the universities and research institutes to conduct researches (Donwa, 2006). It was noted that most of the investments in R&D in many countries could be as high as 6 to 10% of the GDP while that of Nigeria is less than 1% (Donwa, 2006). Some of other problems which are peculiar to most of the developing countries are lack of research skills in the modern methods, constraint of equipment for carrying out state-of-the-art researches, difficulty in accessing research funds, diminishing scope of mentoring junior researchers by seasoned and senior researchers due to brain drain (Okebukola, 2002). In addition to these difficulties, Hales and Kivleniece (2003) suggested that an existence of a university (or research institute) is not a pre-condition for the establishment of STP. A critical analysis of these problems suggests that an attempt for these developing countries to adopt this model to establish STP without addressing the basic difficulties could be a futile effort and a waste of resources.

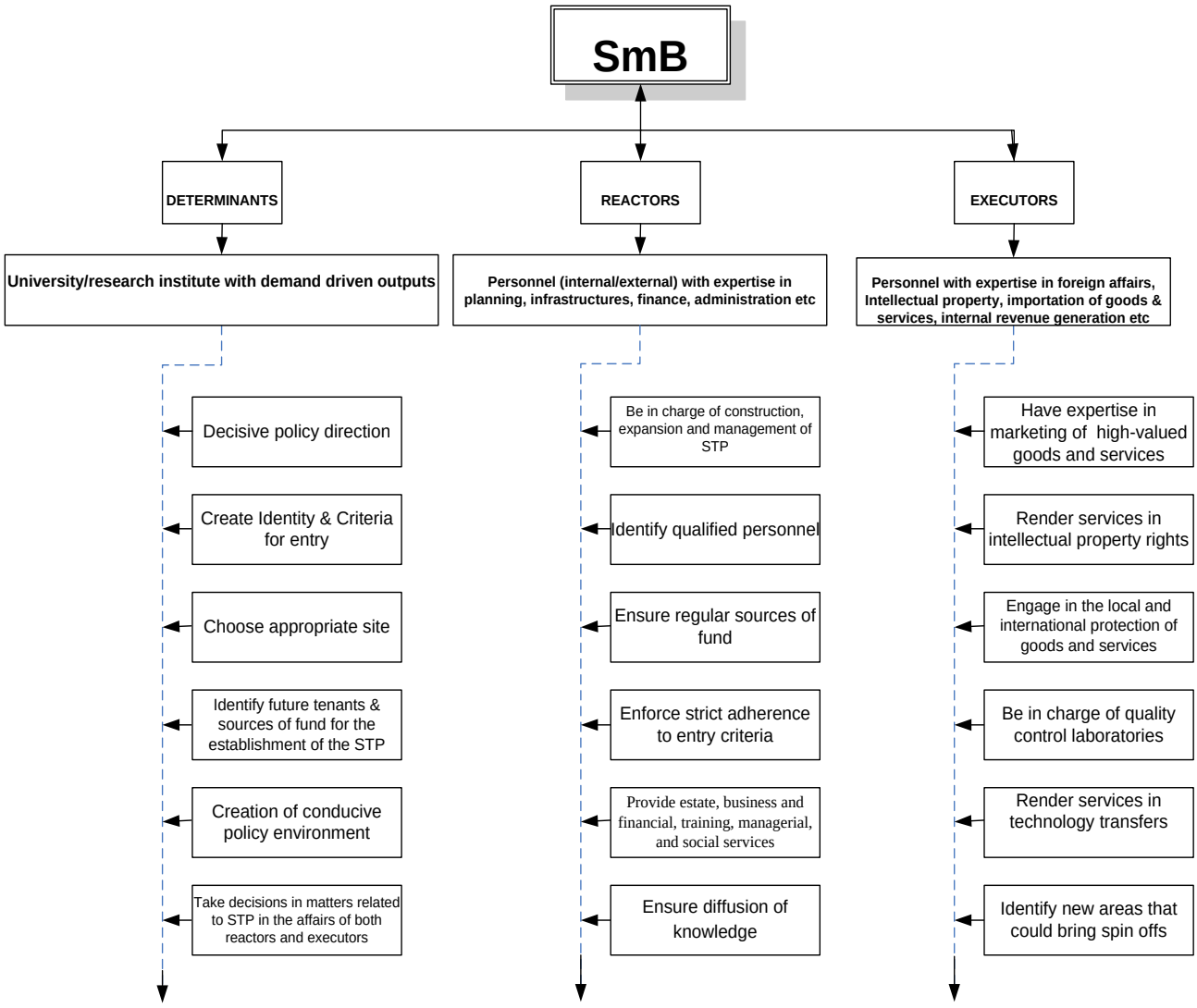

Figure 3: SmB: Academic/research institutes trajectory

SmC: Organized private sector trajectory

This model considers "determinants" to be the organized private sector. This model is probably the least common form of STP organization in the developing countries. This model also incorporates a university or other research organization either by affiliation or actual ownership, but the operational control lies with a commercial developer. One of the main roles of the park is that it could act as an interface to bring the researchers and industry to work for mutual benefits and for benefit of the society at large. It could also provide training and consultancy services to the various government, public and private sectors. A good example of a successful STP under the management of a property development company is that of Brisbane Technology Park in Australia. Although it was established in 1986 by the Queensland Government's Department of State Development, it was actually given to Graystone Group as the original development manager of the park. In order to achieve the objective for which the TP was set up, the Department of State Development of Australia contracted Zernike Australia Pty to provide specialized management services to resident companies and attract more companies that will embrace the objectives of the Park (Kirks and Catts, 2004). Zernike Australia engages in activities such as provision of experts in technology innovation and commercialisation, facility management, seed capital and technology park management (Kirks and Catts, 2004). This park demonstrates how private developers are given the role of a determinant in the management of the park. While this might have worked in some developed countries, the peculiar situations in the developing countries would almost make it impossible to work.

The problem with this type of model in the developing countries is that most of the indigenous private developers do not have the competence to manage this type of property-based venture. Moreover, foreign investors who could have shown interest in managing the park see this as a very "risky business" to dabble into. Another problem of this model with the developing countries is that there is the tendency for the developers to loose focus on the main objective of the park and focus more on the quantity rather than the quality of park (Kirks and Catts, 2004). Other problems which could make this model unviable for the developing countries include, unstable political systems, inadequate legal and regulatory framework, lack of coherent public private partnership strategy and processes and contractual and payment risks. This problem will ultimately lead to ineffective management of the park with grave consequence on its survival.

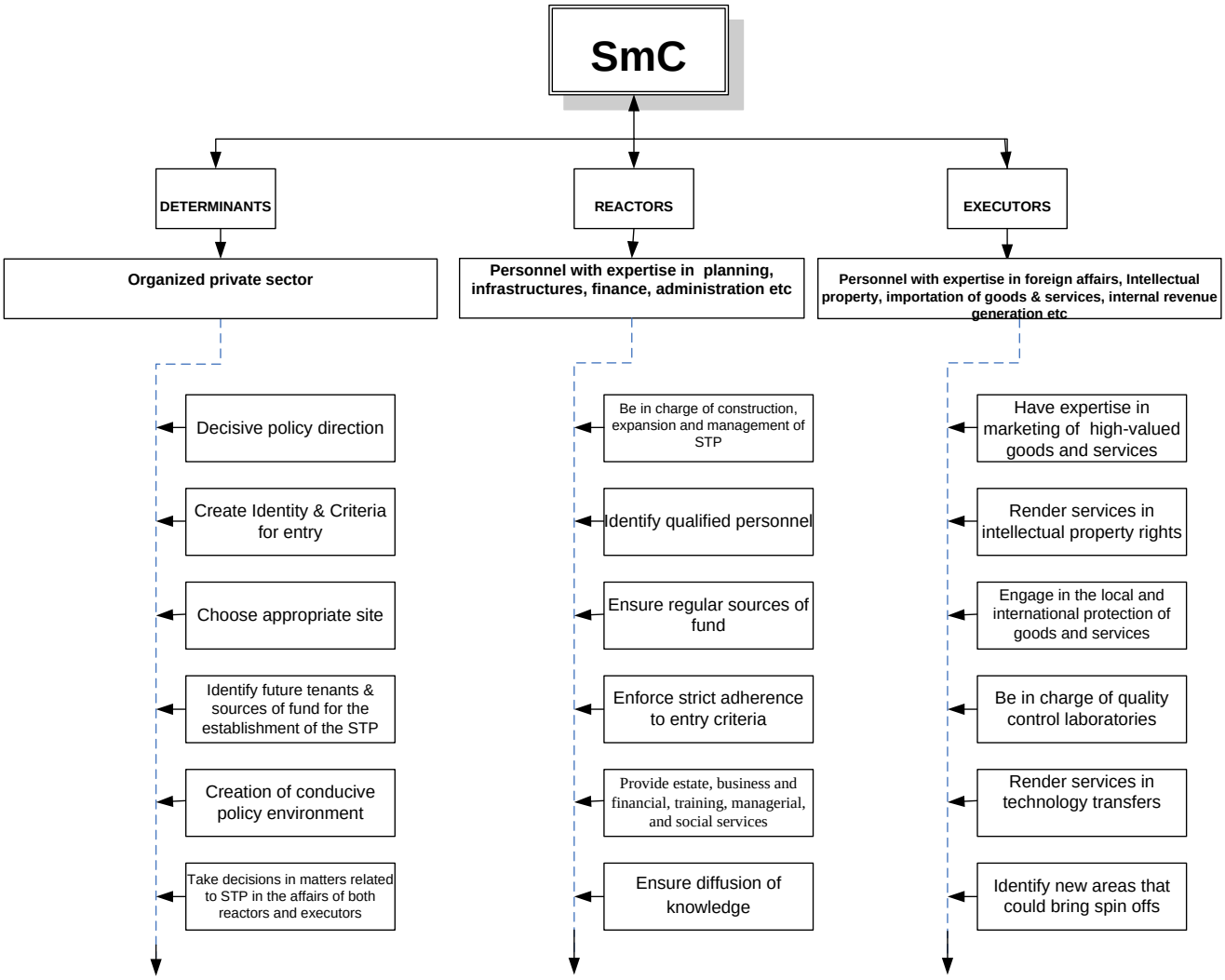

Figure 4: SmC: Organized private sector trajectory

SmD: The three-determinant trajectory

This model explores the possibility of the three stakeholder coming together to establish a sustainable STP. The word “three” in this model does not mean just the government, universities and the organized private sector but the collaboration which could be inform of partnership between some of or all the stakeholders. The model proposed in this paper could be said to have taken its root from the "triple helix" model (Henry Etzkowitz, 2002). However, the model transcends the "triple helix" model which has the triadic relationships among the institutional spheres (i.e. university-industry-government).

The stakeholders in the proposed model include the national/state/local governments, research institutes, universities, private developers, financial institutions, international organizations, non-governmental organizations, private investors etc. The rationale for this model is coming from the fact that establishment of STP has a high probability of success when these stakeholders pull their resources together for the establishment of STP. For instance, the universities/research

institutes will bring in their expertise in the area of research, training and consultancy; the government will provide the fund and infrastructures while the organized private sectors, international organization and non-governmental organizations will provide the fund, consultancy and some specialized services. This model is perhaps the most common among the three other models in the developed countries.

This model puts all or combination of some of these actors at the level of "determinants" where they are responsible for taking decisions on various aspects of the STP. These decisions range from establishing the park, having a mission and vision statements, designing organizational structure, creating criteria for entering the park, appointing the managing directors and other key "reactors". In this type of model, the academics/research institutes usually provide human capacity and research outputs, the financial institutions and the international organization provides the much needed fund, private developers gives their support on how well to build, manage and maintain the park. The governments at various levels provide the infrastructure and other public goods and services for the smooth running of the park. The output of the park will depend on the policy decisive direction that the "determinants" have chosen with the ultimate goal of economic development and wealth creation.

One of the successful examples of this model is that of the Delaware Technology Park. This park is a partnership among the state of Delaware, the University of Delaware and the private sector. The main goal of the park is to attract established industries and provide an incubation and acceleration for start-ups in high-technology fields, specifically those in biotechnology, information technology and advanced materials. It also provides networking access to services and resources to the clients. Another good example is that of the the Wrocław Technology Park which has the State Treasury, the City of Wrocław, the Wrocław University of Technology, the University of Wrocław, the Agricultural University of Wrocław, the Foundation for the Development of the Wrocław University of Technology, the Lower Silesian Chamber of Commerce, Dolmel Investment Association, and Bank Zachodni SA as its stakeholders. Other successful STPs like Sillicon valley, Route 128 have collaboration with other stakeholders.

This type of model will be most appropriate for the developing countries. This is because all the stakeholders all have a role to play starting from the inception, completion, smooth running of the programme, marketing of the output and expansion and management of the park. Participation of each of these stakeholders would have taken care of most of the challenges identified to be peculiar with developing countries that hinder successful development of STP.

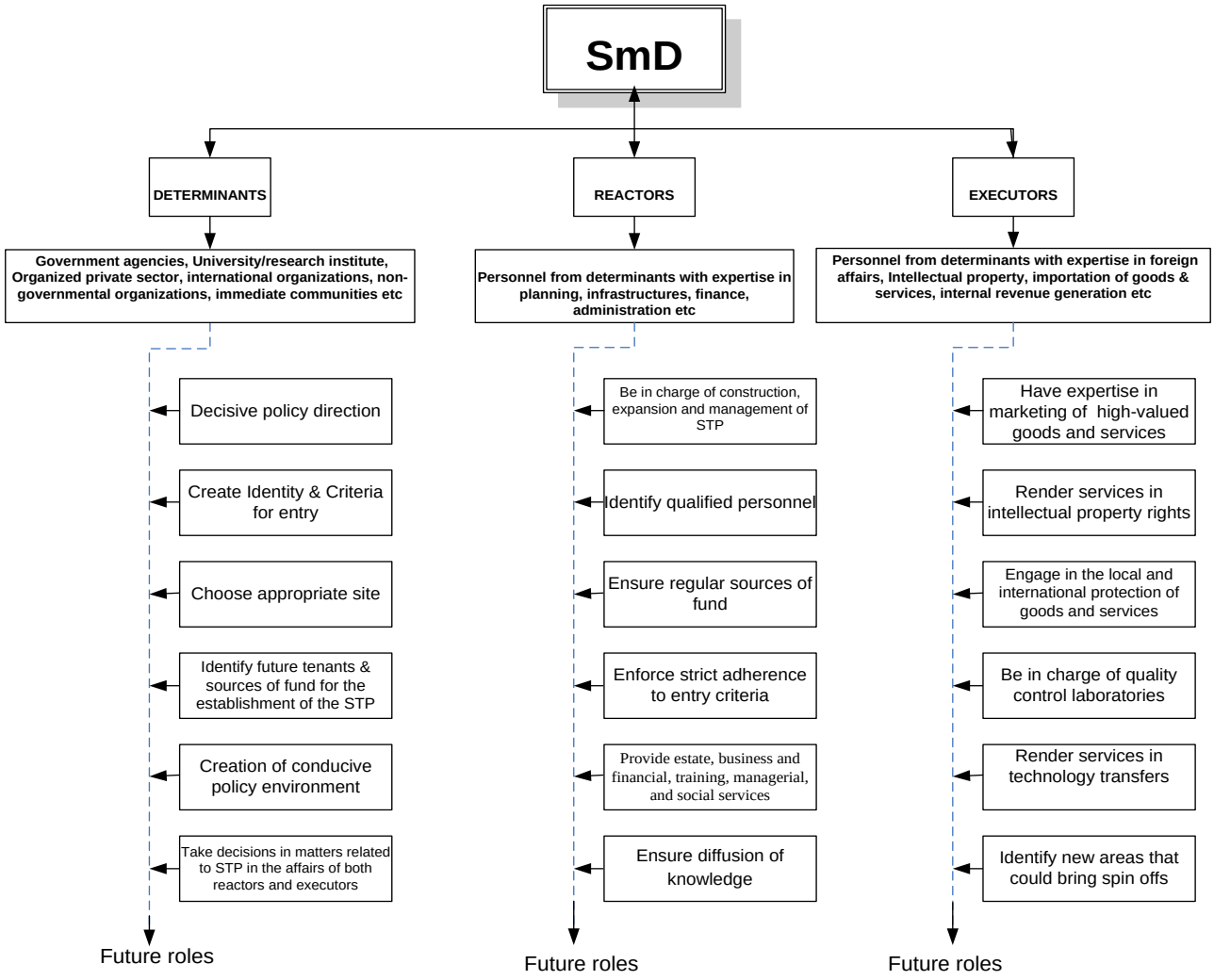

Figure 5: SmD: The three-determinant trajectory

Conclusion

Critical evaluation of the sub-modes shows that SmA would have been a good alternative for developing countries where most of them still depend on government for provision of basic amenities but this might not be a viable option because of the bad history of government enterprises. The appraisal of SmB revealed that although this model has been a success in the developed countries, this would not necessarily be the case in developing countries where the required infrastructural network is largely absent. Besides, most of the R&Ds in the developing countries are not demand-driven (Bako, 2005). The investigation of the trajectory of the organized private sector (SmC) established that due to the high cost of production of goods and services (Gerald, 2002) and instability of civil society in most developing countries, designing and developing STP is not attractive to the organized private sector.

The SmD, puts up a scenario whereby all the determinants at the level of decisive policy direction are in themselves major stakeholders in the design and development of STP. Within the SmD, the university/research institute provide majority of the human capital, the government provides the basic amenities, infrastructure and conducive policy environment while the organized private sector brings in its expertise and financial muscles. The SmD trajectory is therefore proposed as the best for developing countries. We recommend that:

1. STP determinants and policy makers in the developing countries must see STP as a long term investment which requires a proper design.
2. The developing countries must recognize the importance of the determinants, reactors and executors where determinants are the most important for effective STP management for a significant impact on their economies.
3. Economies in transition must see STP as having a distinctive organizational structure as a result of its myriad of collaborations and partnerships.
4. Policy makers in the developing countries must make sure that the establishment of STP is demand driven

In view of these, STP impacts in the developing countries therefore, will depend significantly on factors like ownership structure, conducive policy environment, adequate provision of hard and soft infrastructures and competent human capital.

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