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Science, Technology and Innovation in Caribbean Countries: Performance Indicators of a Generic Model

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Science, technology and innovation (STI) have been recognised as distinctive inputs to the creation of a nation's wealth through the stimulation of new ideas, processes and products. This paper discusses the relevance of STI to a nation's economic growth. Available country statistics acquired from different sources are analysed and a set of STI indicators (such as Business Competitiveness Index, Growth Competitiveness Index, Innovation Sub-index, and Information, Communication and Technology Sub-index) are identified. A generic model of STI development comprising primary innovation, learning and strategic loops is described. A model assessing the status of a nation's STI development is used with explanation with reference to The Republic of Trinidad and Tobago. There has been an increasing need to attain a balanced STI capability that forges competitiveness and future growth across different industry sectors. The country's experience provides some references for Caribbean countries to plan and develop STI initiatives for achieving sustainable development.

Keywords: Performance indicators, STI Development, Caribbean.

1. Introduction

According to the Organisation for Economic Cooperation and Development (OECD) [1], science, technology and innovation (STI) are the drivers of long-term economic growth and contribute to improved productivity and the real income of a nation. STI offers a range of options to various branches of the economy and forms the core of an emerging techno-economic paradigm [2,3]. The achievements have brought long-lasting benefits to many countries which compete in the global arena. For instance, the advance in information technology allows a new technological system in which far-reaching changes in the trajectories of electronics, computer and telecommunication technologies may be achieved [1,4]. Technological development affects economic growth of countries [14]. The prevailing business environment and a set of complex factors affect a nation's ability to adapt new technologies and become innovative. The technology index is comprised of innovation sub-index and ICT (information, communication and technology) sub-index [5,6]; both are important indicators to explain the link of innovation elements to economic growth. Besides technology, public institutions and the macroeconomic environment are another two influential variables driving economic growth [7,8]. Countries can be classified into two board categories; namely core innovators and non-core innovators. Core innovators usually refer to those advanced countries, whereas developing countries are

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mostly non-core innovators who rely heavily on technology transfer rather than innovation. Accumulation of technological capabilities is the basis for competition and economic growth. In developing countries, investing in STI is often given low priority when compared with other pressing social needs of societies, and knowledge of the underlying learning process is far from satisfaction. **Scherer** [8] argues that three common barriers would adversely affect efforts by non-core innovators to attain technological growth. Firstly, the lack of an appropriate legal and institutional framework is always the most important barrier. Secondly, many entrepreneurs are reluctant to venture into any developmental opportunities associated with modem technology. Lastly, limited funds, both public and private, are geared towards research and development (R&D) activities in these countries because of their low real per capita incomes.

The STI challenge stresses firstly the translation of knowledge, skills and experience into specific local needs, and secondly, an appropriate institutional framework and support from both the public and private sectors [9,10]. This rests significantly on investments in education, research, infrastructure and physical and human capitals [11,12]. This paper discusses the indicators used to determine the STI capabilities, and introduces a generic model of STI development for nations in the Caribbean region. A model assessing the status of a nation's STI development is used and explained with reference to The Republic of Trinidad and Tobago. The country's experience provides some references that may help Caribbean countries to plan their STI initiatives and build competence towards their nation-wide developmental goals.

2. Profiles of Caribbean Economies

The Caribbean region has 28 member countries, including English-speaking nations (such as Antigua and Barbuda, Barbados, Guyana, Grenada, Jamaica, St. Lucia, St. Kitts and Nevis, St. Vincent and The Grenadines, The Dominican Republic and Trinidad and Tobago, etc.) and non-English-speaking nations (such as French Guiana, Guadeloupe, Martinque and Montserrat, etc). Like many other developing nations, Caribbean countries would strive for new energy sources, efficient methods of food production, better quality products, improved human health, and better options for institutional changes and environmentally-benign technologies [13,14]. Some of them have undergone profound economic transformation over the years, from essentially agricultural economies towards predominantly service-oriented nations. Tourism and offshore banking have taken over as the principal economic activities in the region, particularly in the smaller countries (e.g., Antigua and Barbuda, Barbados, St. Kitts and Nevis). The larger countries (e.g., Jamaica and Trinidad and Tobago) have somewhat more diversified economies and have developed some manufacturing- and energy-related industries [15].

Among the selected economies in the region as shown in **Table 1**, the growth in Trinidad and Tobago's economy in terms of real gross domestic products (GDP) was 2.7% in 2002 compared with 3.3% in 2001. This was due to the contraction in the traded and non-traded sectors. Inflation was relatively low reflecting the low oil prices that prevailed over the period. Jamaica's economic growth was at 1.1% in 2002 with a further forecast of moderate growth. This growth was however restrained by the declines in the tourism, agricultural and mining sectors. In Antigua and Barbuda, contraction in real growth in

TABLE 1: *Percentage Real Growth in GDP of Selected Caribbean Countries, 2000 - 2002*

	% Real GDP		
Country	2000	2001	2002
Antigua & Barbuda	5.0	3.6	N/A
Barbados	2.5	2.5	0.5
Dominican Republic	1.6	0.7	-4.6
Grenada	7.5	6.4	N/A
Guyana	3.0	2.5	N/A
Jamaica	-0.4	-0.1	1.1
St. Kitts and Nevis	3.7	7.5	1.8
Saint Lucia	3.0	2.0	N/A
St. Vincent & The Grenadines	4.2	2.1	-0.2
Trinidad & Tobago	6.1	3.3	2.7

Sources: Abstracted from [16,17]

GDP was recorded from 5.0% in 2000 to 3.6% in 2001. Other countries (including Barbados, St. Kitts and Nevis, St. Vincent and The Grenadines, etc.) were suffering a contraction of their economic performance in 2002 compared with that in 2001. While considering the recorded GDP, inflation rate and current account balance among the selected Caribbean countries in 2002 (**Table 2**), Trinidad and Tobago has, however, a positive current account balance of 0.7%. Its GDP growth (i.e., 2.7%) was lower than that of the Dominican Republic (4.5%) and Grenada (3.0%) and its inflation rate (3.9%) was lower than that of Jamaica (6.0%) and the Dominican Republic (5.2%), respectively [16, 17].

TABLE 2: *Economic Performance in Selected Caribbean Countries, 2002*

Country	GDP %	Inflation Rate %	Current Account Balance %
Barbados	-1.0	2.6	-5.2
Dominican Republic	4.5	5.2	-3.0
Grenada	3.0	1.8	-12.6
Jamaica	2.0	6.0	-4.8
Trinidad & Tobago	2.7	3.9	0.7

Sources: Abstracted from [16,17]

3. Measuring Competitiveness and Economic Growth

The Business Competitiveness Index (BCI) and the Growth Competitiveness Index (GCI) were first introduced in The Global Competitiveness Report 2000 and 2001–2002, respectively. The two indices combine available hard data and data from the Executive Opinion Survey (Survey) conducted annually by the World Economic Forum [5,6]. The Survey would be carried out in collaboration with Partner Institutes of the Forum's Global Competitiveness Programme. These indices are used to evaluate the economic competitiveness of a large sample of countries [6]. The BCI measures the current levels of prosperity with respect to institutions, market structures and economic policies. It assesses current productive potentials and reflects the effectiveness of a nation's resources utilisation. On the other hand, the GCI measures the capacity of a nation's economy in achieving sustained economic growth over the medium term, while controlling the current level of development. A nation's GCI ranking is determined by several factors including:

1) Research and development (R&D);

2) Collaboration between businesses and the universities;

3) The level of tertiary education; and

4) An innovative business and academic community [6,12].

3.1 The GCI Rankings

In the 2003 Survey, the number of countries surveyed increased significantly from 80 to 102 (as compared to the Survey in 2002). The countries added are mainly from the developing world, especially Africa [6]. For facilitating the comparison, 20 countries were selected comprising countries from advanced nations (e.g., Finland, France, Japan, Sweden, Switzerland, the USA, and the UK, etc.) and representatives from developing countries including those in the Caribbean region (e.g., Argent ina, Brazil, Chile, the Dominican Republic, Jamaica, Trinidad and Tobago, and Venezuela, etc). The GCI rankings of the selected countries are shown in **Table 3**. Finland emerged as the leader, followed by the USA, Sweden, Taiwan and Switzerland. Japan's ranking increased considerably from 16th in 2002 to 11th in 2003 [5,6]. Other economies with an improvement in their GCI ranking included France and Mexico. Many countries slipped considerably in 2003. For example, Argentina recorded the most dramatic decline from 64th in 2002 to 78th (and 68th among the 2002 countries) in 2003, and Brazil from 45th to 54th (52nd in 2002), Italy from 33rd to 41st (39th in 2002), Sri Lanka from 59th to 68th (64th in 2002) and the UK from 11th to 15th. Many of these countries suffered financial crises and large falls in output. Trinidad and Tobago was one of the leading countries in the Caribbean region. Despite the fact that its status dropped from 42nd in 2002 to 49th place (i.e., 47th among 2002 countries) in 2003, it outperformed other Caribbean countries like the Dominican Republic at

TABLE 3: *Rankings of GCI and Associated Components of Selected Countries, 2002–2003*

	GCI Ranking		Technology Index (Rank)		Public Institutions Index (Rank)		Macroeconomic Environment Index (Rank)	
Country	2003[1]	2002[2]	2003	2002	2003	2002	2003	2002
Argentina	78 (68)	64	45	44	88	66	93	65
Brazil	54 (52)	45	35	35	53	45	75	67
Chile	28 (26)	24	31	33	19	19	35	13
Dominican Republic*	62 (58)	56	52	48	64	60	69	41
Finland	1 (1)	1	2	3	2	1	2	14
France	26 (24)	28	28	28	23	29	20	28
Greece	35 (33)	31	30	30	42	44	33	47
India	56 (53)	54	64	57	55	59	52	18
Italy	41 (39)	33	44	39	46	37	28	27
Jamaica*	67 (63)	57	53	46	70	51	86	74
Japan	11 (11)	16	5	5	30	25	24	29
Mexico	47 (45)	53	43	47	50	58	54	21
Sri Lanka	68 (64)	59	72	67	72	42	65	80
Sweden	3 (3)	3	4	4	7	15	8	34
Switzerland	7(7)	5	7	6	8	8	6	5
Taiwan	5 (5)	6	3	2	21	27	18	6
Trinidad & Tobago*	49 (47)	42	47	42	56	43	47	25
United Kingdom	15 (15)	11	16	15	12	6	12	16
United States	2 (2)	2	1	1	17	16	14	2
Venezuela*	82 (69)	68	58	53	89	73	94	72

* Caribbean countries.
[1] Among 2003 countries (Figures in brackets are among 2002 countries)
[2] Revised 2002 Rank
Sources: Abstracted from World Economic Forum [5,6]

62nd, Jamaica at 67th and Venezuela at 82nd places, respectively in 2003 [5,6].

On examining the technology index components, the USA was ranked first in the innovation sub-index, while occupying the 4th position on the ICT sub-index in 2002 (**Table 4**). The country has a more favourable macroeconomic environment compared with the other countries. Finland ranked 3rd both in the innovation sub-index and the information and technology sub-index. However, in terms of its macroeconomic index, it fell to 14th. Countries like Taiwan, Japan and Switzerland have very high rankings in the technology index, demonstrating technology as the key driver in economic growth and development. Trinidad and Tobago was relatively strong with 12th place in its technology transfer index compared with other developing countries [5]. This shows its emerging status as a non-core innovator with technology investment occurring in the oil and gas sectors and in some areas of manufacturing.

TABLE 4: *Rankings of Technology Index Components of Selected Countries 2002*

Country	Innovation Sub-index Rank	ICT Sub-index Rank	Technology Transfer Sub-index Rank
Argentina	30	47	20
Brazil	53	41	3
Chile	37	33	24
Dominican Republic*	46	55	14
Finland	3	3	-
France	18	25	-
Greece	27	31	31
India	62	69	2
Italy	25	27	-
Jamaica*	69	48	19
Japan	5	17	-
Mexico	56	46	27
New Zealand	19	21	-
Sri Lanka	74	70	33
Sweden	4	1	-
Switzerland	7	9	-
Taiwan	2	10	-
Trinidad & Tobago*	67	43	12
UK	14	13	-
USA	1	4	-
Venezuela*	47	51	37

* Caribbean countries
Sources: Abstracted from World Economic Forum [5]

3.2 The BCI Rankings

As shown in **Table 5**, Finland rose to the leading position over the USA in 2003. Sweden achieved good progress from 6th to 3rd rank, France from 15th to 10th, and New Zealand from 22nd to 18th. These achievements were attributed to the improvements in venture capital availability, intellectual property rights protection, the effectiveness in antitrust policy and buyer-sophistication. On the other hand, the UK (6th) and Switzerland (7th) were two advanced economies that have slipped in their rankings in 2003. Some developing countries (e.g., Jamaica (56th) and Mexico (48th)) have shown an improvement in their BCI rankings. However, Trinidad and Tobago has dropped its BCI ranking from 44th in 2002 to 53rd in 2003. The competitiveness of many developing countries (e.g., Argentina (69th), Sri Lanka (57th), and Venezuela (85th), etc.) was comparatively weak as indicated in their respective lower BCI ranking [5,6]. Evidence shows that many advanced countries (e.g., Finland, Sweden, the USA, and the UK) had typically started their industrialisation in some technologically, undemanding

TABLE 5: *Rankings of BCI and Associated Indexes of Selected Countries 1999-2003*

Country	BCI Rankings					Company Operations and Strategy Index (Rank)					Quality of the National Business Environment Indez (Rank)				
	1999	2000	2001	2002	2003	1999	2000	2001	2002	2003	1999	2000	2001	2002	2003
Argentina	40	45	54	65	69	39	45	53	57	63	40	44	53	68	73
Brazil	35	31	30	33	34	32	29	29	28	30	37	32	32	36	39
Chile	24	26	29	31	32	26	27	30	35	34	24	24	30	31	30
Dominican Republic*	-	-	60	61	61	-	-	59	50	57	-	-	61	53	63
Finland	2	1	1	2	1	7	3	2	4	4	2	1	1	2	1
France	9	15	13	15	10	6	9	10	10	9	11	15	13	21	14
Greece	36	33	46	43	39	45	32	51	47	39	34	33	43	41	40
India	42	37	36	37	37	48	40	43	40	40	43	37	34	37	36
Italy	25	24	23	24	24	15	17	13	18	24	27	26	24	24	23
Jamaica*	-	-	39	59	56	-	-	31	60	56	-	-	44	59	56
Japan	14	14	10	11	13	4	4	8	7	6	19	19	16	17	20
Mexico	34	42	52	55	48	30	42	46	45	37	35	43	52	60	51
New Zealand	16	19	20	22	18	16	22	19	25	23	14	17	20	20	13
Sri Lanka	-	-	58	47	57	-	-	58	52	52	-	-	56	43	59
Sweden	4	7	6	6	3	3	6	6	6	3	7	11	6	8	5
Switzerland	5	5	5	5	7	2	5	5	5	5	9	10	5	6	8
Taiwan	19	21	21	16	16	17	18	20	16	16	22	21	21	13	16
Trinidad & Tobago*	-	-	31	44	53	-	-	27	44	54	-	-	38	44	53
UK	10	8	7	3	6	13	11	7	3	8	8	9	8	3	6
USA	1	2	2	1	2	1	2	1	1	2	1	2	2	1	2
Venezuela*	51	54	67	72	85	53	49	67	73	74	51	55	66	72	87

* Caribbean countries

Sources: Abstracted from World Economic Forum [5, 6]

sectors and after accumulating and mastering a wide range of capabilities, they moved to the more demanding sectors such as telecommunication, biotechnology and hitech products [10]. The governments in these countries facilitated their nations to achieve the economies of scale and maintain diversity in their R&D activities. Moreover, many innovators in these countries reaped the benefits of the inflow of new technology and some concentrated on their targeted range of technological innovation such as the mobile communication industry in Sweden and Finland. Furthermore, the imitation processes taking place in developing countries would be mediated by the ways in which technology was being transferred from advanced nations [10]. Developing countries are usually weaker in sustaining business and entrepreneurial environments [8]. For instance, most R&D funding in advanced countries would come from the private sectors rather than relying on public sources. On the contrary, R&D expenditures in developing countries meager as they may be, and in many instances, rely predominantly on the government's and public sources.

4. Performance Indicators of STI

STI is a key driver of long-term economic growth and the determinant of productivity and competitiveness leading to an increase in real income [1,18]. The GCI, BCI, innovation and ICT sub-indices are regarded as STI performance indicators that help nations to understand their scientific and technological development and integrate variables with other measures of economic and social development [5,19]. These indicators serve as STI determinants and benchmarks for attaining the performance goals of a nation. They fulfill several functions below [12]:

1) Signalling or monitoring – i.e., to provide insight and draw attention to developments and trends in the STI system and the environment.

2) Accountability, evaluation and allocation – i.e., to set and justify STI budgets, and provide insight into the performance of the system against the goals established by policymakers and planners.

3) Legitimisation – i.e., to provide support for existing STI policies; and

4) Awareness – i.e., to provide information to set aside prejudices and incorrect perceptions of the STI system.

Many indicators are used to show the changes in the STI system and the impact on the economy and the society [20]. **Archibugi** [21] argues that the production and use of knowledge is at the core of value-added activities of firms' and nations' strategies for growth. The higher the level of R&D, the more advanced will be the level of economic development of the country. The data obtained or derived from these indicators is important for countries to formulate STI policies for meeting a nation's developmental needs [12,22]. In the Caribbean context, these indicators should address:

1) Public and private sector expenditure in R&D;

2) The establishment of new products, processes and patents arising from R&D;

3) The technological balance of payments as an indicator of international technology transfer;

4) Surveys on innovation and production technologies and university/ govemment/private sector partnerships;

5) Trading of high-tech products as measures of their current and future economic importance to a nation;

6) Human resource development in support of innovation and entrepreneurship;

7) The diffusion of information and communication technologies;

8) Publications emanating from a country's STI infrastructure;

9) Professionals engaged in STI activities; and

10) The priority areas for STI interventions to lead a nation's development thrust in the Caribbean region.

5. STI Development: A Generic Model

The development of STI is a process of interaction rather than based primarily on formal knowledge generated by R&D activities [23]. The process is concerned with the emergence, diffusion and combination of knowledge elements and also the translation of these into new products and production processes. The translation by no means follows a linear path, but is in fact characterised by complicated feedback mechanisms and interactive relations among science, technology, learning, production, institutions, organisations, policy and demand [11,24]. This involves technical and social components and interactions between various stakeholders (e.g., users, firms, research institutions and governments) and their environment. STI exists at various levels and is not confined within a country's border [10,12].

A nation's STI endeavour lies in its level of competence and capacity. The success of STI initiatives rests on the capability of the specialists and the degree to which their activities are coordinated, integrated and focused [25]. In order to help track the development of STI in developing countries with particular reference to the Caribbean region, a generic process model was proposed. The model adopts the principles of national innovation systems as suggested by OECD [11] and stresses the importance of interaction and interdependence as advocated by **Edquist** [9]. A diagrammatic representation for the model is given in **Figure 1**, comprising of three ascending loops of STI development. These are the primary innovation loop, the learning loop and the strategic loop with respect to various levels of STI capabilities in a nation [12,26].

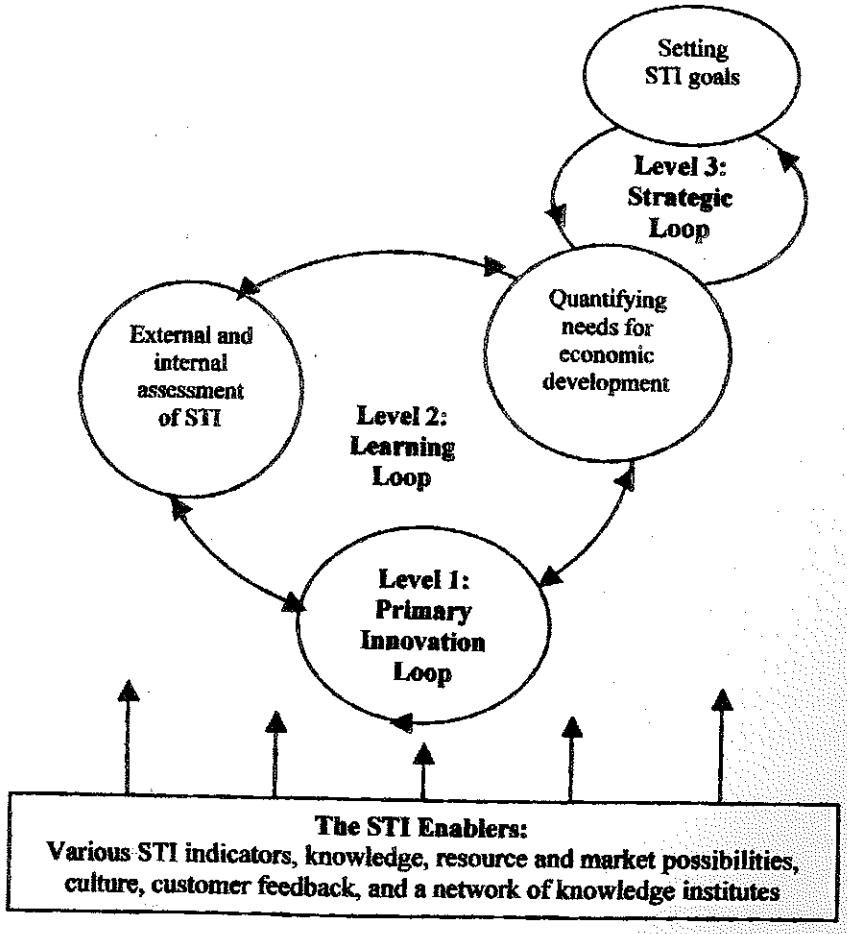

FIGURE 1: *A Generic Process Model of STI Development*

The model advocates that a static nation seldom innovates, although it may have a stable market position under existing conditions. The primary innovation loop starts at a basic level (i.e., Level 1) where a nation has the capability to manage a continuous STI process in a stable competitive and technological environment. The STI cycle would typically go through concept generation, product and process design and service development. The model also provides user-friendly, customer services through networks or software development skills. The learning loop in Level 2 stresses:

1) Building an effective governance structure with external and internal assessment of STI capabilities;

2) Safeguarding primary innovation; and

3) Quantifying the need for economic development in a nation. This aims to build the nation's strengths to adapt to changing environment. Lastly, a self-generating nation could set clear STI goals and policies and quantify the need for economic development using the strategic loop in Level 3. The nation could manage core STI capabilities and position itself on different markets and/or create new ones [6].

The model requires both inputs and outputs associated with the loops of STI activities. This spans from early-stage knowledge production, through basic, applied and development research to technology transfer, and finally, to the application and commercialisation of innovations. Several enablers facilitate the STI process and provide assistance for nations to move from one level to another. These include a set of STI indicators (e.g., GCI, BCI, innovation and ICT sub-indices), knowledge, resource and market possibilities, culture, and customer feedback, as well as a network of knowledge institutes. The network is concerned with the intensity of interaction among firms, public and private research organisations, the government and other public institutions. This approach could be made adaptable in developing countries aiming to acquire STI capabilities with respect to their developmental goals.

5. The Trinidad and Tobago's Experience

Trinidad and Tobago is situated in the Caribbean Sea between 10°–11.5°N latitude and 60°–62°W longitude. The country is classified as a small island in developing state with a relatively significant industrial sector, based principally on the petroleum, petrochemical industries and gas-based industries. The establishment of the Imperial College of Tropical Agriculture (ICTA) in 1923 marked the beginning of an organised system for science and research in the country. In 1960, ICTA became the nucleus of the Trinidad Campus, called the University of London College of the West Indies (and later became The University of the West Indies). The Faculty of Engineering was established in 1961. In 1962, the country gained its independence as The Republic of Trinidad and Tobago. In 1968, the National Scientific Advisory Council (NSAC) was established with the responsibilities of surveying the scientific and industrial resources of the nation and determining its scientific and technical needs. In 1976, the National Council for Technology in Development (NCTD) was established to replace the NSAC [27,28].

Since the 1970s, the country has been facing increased unemployment and high levels of imports of consumer goods. This resulted in the Government intensifying its efforts to diversify the growth of manufacturing sectors. The Government has sought to:

1) Develop the national infrastructure of science and technology;

2) Enunciate explicit policies; and

3) Deploy national resources in a coordinated framework with respect to the nation's developmental goals [13,28]. The post-independent governments have supported STI via institution building, human resource development and major recurrent funding. Trinidad and Tobago has established its R&D infrastructure like The University of the West Indies,

the Caribbean Industrial Research Centre, the Caribbean Agricultural Research Development Institute, and various government ministry efforts. However, little progress has been made to understand how public expenditure contributes to or has contributed to socio-economic process and developmental changes in a coherent way [13,28].

In 1995 and 2000, a Green Paper and a National Policy document on STI were published in Trinidad and Tobago, respectively [29,30]. STI was regarded as one of important contributors to national development of the country. Several areas were identified as the country's cluster industry strengths. These included:

1) Food-processing, agriculture, forestry and agro-industry;

2) Petroleum, natural gas, asphalt and energy;

3) Manufacturing;

4) Tourism and culture;

5) Biotechnology, pharmaceuticals, medical and dental supplies;

6) Information technology and telecommunications; and

7) Materials and construction.

Trinidad and Tobago ranked 49th in the GCI ranking and 53rd in the BCI ranking, respectively in 2003 (**Tables 4** and **5**). Sustaining its competitiveness rests significantly upon the ability to apply new knowledge and technology in products and production processes. Both local companies and multi-national corporations in the country must be supportive of indigenous scientific and technological innovation. The primary innovation loop, as advocated in the STI development model (**Figure 1**), needs to be facilitated and strengthened. The accessibility to the production and services activities would enhance the learning process. A skilled and educated manpower base would also attribute to achieving the developmental goals of the nation.

Trinidad and Tobago has been constrained by funds for both pure and applied research. The Government has realised the need to put more resources into developing STI and projected its budget for the fiscal years 2003–2005 to ensure that the economy continues to be managed for dynamic growth [17]. The real GDP growth rate is strong over the period with an expected growth rate of 6% by the end of the year 2005. Evidence shows that the main drivers of such growth are the investment and exports in the energy sector, and in turn, the national priorities on STI spending still remains in this sector. In recognition of the needs for sustainable development, the country should initiate a balanced STI development across different sectors and industries. Until recently, the government has stressed the redevelopment of the agricultural and manufacturing sectors that would contribute to food security, employment generation and diversification of the economy [31,32].

The inputs from the Government, knowledge institutes and the private sectors are crucial in facilitating Trinidad and Tobago moving from the primary innovation via learning towards strategic loops in the STI process. At present, the Government should take the leadership and commit inputs to the national innovation network. This entails the Ministry of Agriculture and also other ministries such as the Ministry of Education, the Ministry of the Environment and the Ministry of Works and Transport. Presently, the university sector is in collaboration with other agencies, such as the National Institute of Higher Education of Research, Science and Technology (NIHERST), Caribbean Industrial Research Institute (CARIRI) and others to form a knowledge circuit to the contribution to innovation and knowledge generation in agribusiness and agriculture. This cooperation between the institutions should extend to commercial R&D organisations, Trinidad and Tobago Bureau of Standards (TTBS) and the Environmental Management Authority (EMA).

For the immediate future, Trinidad and Tobago is expected to remain in its imitator role as many other developing countries. The country would mediate its learning loop in various ways depending on the extent of innovative competition and the existing conditions

such as licensing agreements, joint ventures, etc. Moreover, ensuring adequate inputs to the STI system entails improving the quality of education in general and increasing the opportunities for re-training in science and technology for the current workforce. Appropriate resources and incentives should be provided to secure a sufficient supply of technically-trained professionals from institutions of higher education. **Table 6** shows the number of graduates from the Faculty of Engineering at UWI since its inception in 1961. There is an urgent need for the Government and the University to re-examine the role of the engineering programmes and curriculum design so as to attract caliber students and produce graduates for different engineering disciplines to drive the development of STI [33].

In response to the nation's vision to obtain the "developed country status" by 2020 [34], the Government should define clear STI goals and policies and develop an effective governance structure with external and internal assessment of STI capabilities. The Government should also address the transferral of the economic model to technology, regarding the cost for establishment of new products vis-a-vis the economic capacity of practical innovation. In order to develop towards a self-generating nation (i.e., the strategic loop of the STI process), it is necessary for the country to:

1) Develop an intelligence for innovation activities in various industry sectors and benchmark the status and achievements of the activities with other countries;

2) Create an incentive regime conducive to innovation and encourage collaboration among the industries, the government and knowledge institutions;

3) Focus on the diffusion, assimilation, acquisition and adaptation of technologies for the development of new products, processes and services;

4) Develop human capital, manufacturing efficiency, product quality and national infrastructure; and

5) Support and encourage industry sectors to develop, innovate and apply new technologies that help practitioners to assure competitiveness and quality [12].

6. Conclusion

Patterns of international competitiveness are continuously changing. Caribbean countries must be aware of new opportunities if their standards of living are to be improved and sustained. They need to build STI capabilities to propel growth and competitiveness and to determine the priorities with respect to overall developmental objectives. This paper identifies several STI indicators on determining the competitiveness and economic development of a nation. The generic model described advocates three loops of STI development encompassing primary innovation, learning and strategic loops. It provides a feasible framework for the Government, policy-makers and planners of a nation to:

1) Assess the current status of STI development;

2) Plan strategically to drive the STI process;

3) Instill technology transfer and sharing of successful use of STI in industry; and

4) Enhance STI capabilities moving from being a static nation towards a learning and self-generating nation.

It is anticipated that a nation's productivity gain would be achieved by promoting effective links among stakeholders and beneficiaries. The Trinidad and Tobago's experience provides some references for Caribbean countries to plan and develop STI initiatives for achieving sustainable development. The adoption of the STI development model along with the identification of performance indicators would form a base for building up a nation's system of STI. Further research is needed to investigate the relative importance among various performance indicators of STI and assess the applicability of the model in the Caribbean context. Comparative evaluations and case studies are also suggested to examine the STI processes and determinants across various industry sectors.

TABLE 6: *Graduates by Territory from UWI's Faculty of Engineering, 1964 – 2003*

	Department									
	Agricultural	Chemical	Civil & Environmental	Electrical & Computer	Industrial	Mechanical & Manufacturing	Mechanical with Biosystems	Petroleum	Surveying & Land	Total
Anguilla	-	-	2	1	-	-	-	-	-	3
Anigua	3	2	15	15	-	2	-	-	-	37
Bahamas	-	1	4	4	-	4	-	-	-	14
Barbados	4	35	96	83	11	48	-	1	15	293
Belize	1	3	16	13	2	6	-	-	-	41
British Virgin Islands	-	-	1	-	-	-	-	-	-	1
Cayman Islands	-	-	2	-	-	-	-	-	-	2
Dominica	4	2	20	4	2	2	-	-	1	35
Grenada	1	4	15	17	2	9	-	-	-	48
Guyana	2	18	27	11	2	26	-	-	-	86
Jamaica	25	242	398	404	83	361	1	1	7	1,522
Monsterrat	-	-	5	4	1	1	-	-	3	14
St. Kitts & Nevis	2	1	7	4	3	2	-	-	1	20
Saint Lucia	3	3	31	13	2	5	-	-	2	59
St. Vincent	1	-	18	11	3	8	1	-	1	43
Trinidad & Tobago	33	465	470	867	205	849	5	46	174	3,144
Other	-	5	3	7	2	2	-	-	-	19
TOTAL	**79**	**781**	**1,130**	**1,458**	**318**	**1,325**	**7**	**48**	**205**	**5,351**

Source: Abstracted from [33, p.73]

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