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Department of Engineering

POLICY LINKS

Implementation Strategy for Centres of Excellence in Trinidad and Tobago

SUMMARY REPORT

A PRODUCT OF THE TECHNICAL COOPERATION AGREEMENT "STRATEGIC ROADMAP FOR PRODUCTIVE DEVELOPMENT POLICY IN TRINIDAD AND TOBAGO"

OCTOBER 2018

A report prepared by Policy Links (IfM ECS) for the Government of the Republic of Trinidad and Tobago (GORTT), on behalf of the Inter-American Development Bank (IDB)

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Authors

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The work presented in this report would not have been possible without the generous participation of more than seventy-five local stakeholders from industry, academia and government, not all of whom can be named here, who provided valuable time and insights.

Finally, this project was possible thanks to the financial contribution from the Inter-American Development Bank (IDB).

Cambridge, UK | October 2018

FOREWORD

Economic diversification away from hydrocarbons has long been the subject of thorough debate in Trinidad and Tobago (TT) and, while approaches and policies to pursue such goals have varied in the past, there is broad consensus on the need for more coordinated efforts to unlock Trinidad and Tobago's potential in non-hydrocarbon industries.

In this regard, the Government of the Republic of Trinidad and Tobago (GORTT) has recognised the need to strengthen its national innovation system as a way to foster economic competitiveness beyond its hydrocarbon sector and promote innovation-led economic growth. In particular, there is interest in understanding and exploring the role that Centres of Excellence (CoE) could play to foster innovation and support industrial competitiveness in the context of an integral economic diversification strategy for TT.

In 2015 the Inter-American Development Bank (IDB) was asked by the Government of the Republic of Trinidad and Tobago (GORTT) to support an investment programme aimed at enhancing the competitiveness of non-hydrocarbon sectors through investments in innovation. Specific objectives included: (i) to achieve a higher level of investments in innovation in a number of both established and emerging firms; (ii) to steer research and development outputs towards a better alignment with Trinidad and Tobago's developmental goals; (iii) to achieve better coordination among private, public and academic elements of the innovation system; and (iv) to achieve public sector capacities to carry out innovation policy at a level consistent with the development challenges faced by Trinidad and Tobago.

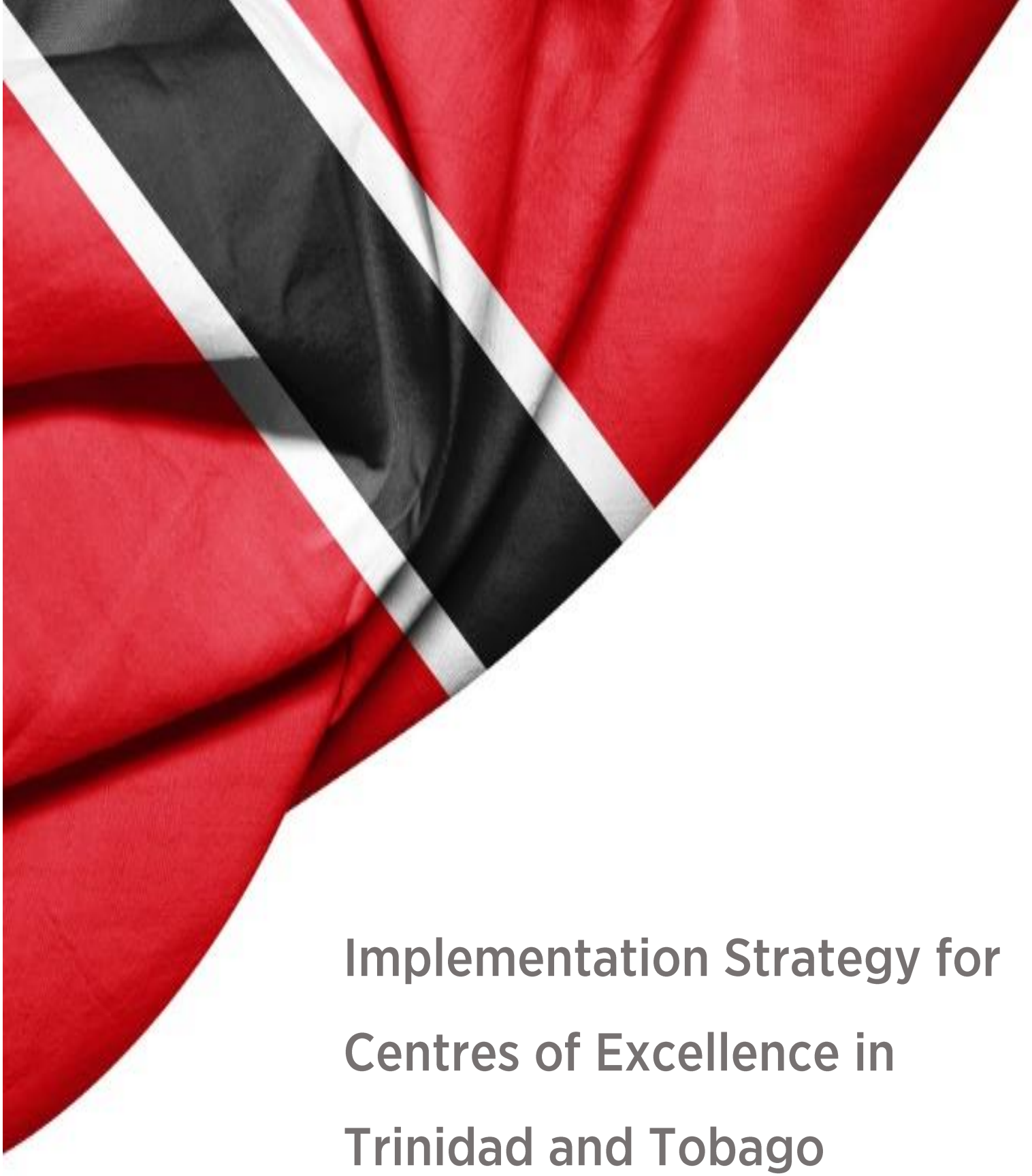
The 2017 "Consultancy on Technological Foresight", performed by IfM ECS under IDB's Technical Cooperation Agreement "Strategic Roadmap for Productive Development Policy in Trinidad and Tobago", produced initial specifications for five Centres of Excellence focused in key economic specialisation areas beyond the hydrocarbon sector. These included:

i. Indigenous high-value agricultural-based products;
ii. ICT products and services;
iii. Aviation services;
iv. Maritime services;
v. Energy engineering services.

Using tried and tested methodologies, this report has captured the views of a broad cross-section of industrialists, academics and institutions to refine and validate the initial specifications created for each CoE and suggest practical implementation steps that could be followed to move each Centre from concept to reality.

Although the information provided in this document represents a baseline to support the work of future Centre Managers and implementation teams, it is recognised that final customisation of these specifications is expected to be completed by the Executive Managers and Board of Directors assigned to these Centres, once appointed. In spite of this, the specifications and implementation roadmaps for Centres of Excellence contained in this report represent a tangible policy mechanism to pursue TT's diversification goals and unlock its considerable and much-needed innovation potential.

CONTENTS



Implementation Strategy for Centres of Excellence in Trinidad and Tobago

1 OVERVIEW

The need for economic diversification away from the oil and gas sector has been the subject of much debate in Trinidad and Tobago (TT) for decades. While important efforts have been made in the past, there is broad consensus on the need for more coordinated efforts to unlock Trinidad and Tobago's potential in non-hydrocarbon industries.

Against this backdrop, the Government of the Republic of Trinidad and Tobago (GoRTT) has identified the potential of Centres of Excellence (CoE) to drive a step-change in the competitiveness and innovation performance of selected non-hydrocarbon activities in the country.

This study, prepared by Policy Links and funded by the Inter-American Development Bank, has captured relevant insights to inform the design and implementation of new national Centres of Excellence in five key economic areas:[1]

vi. Indigenous high-value agricultural-based products;
vii. ICT products and services;
viii. Aviation services;
ix. Maritime services;
x. Energy engineering services.

A wide consultation with industry, academia and government stakeholders, as well as a thorough literature review and the study of international experience, have helped outline core specifications for these Centres and next steps for implementation, as demonstrated in the rest of this report.

It is expected that final customisation of these specifications will be completed by the Executive Managers assigned to the Centres, once designated. However, the information provided here represents a baseline to support the work of future Centre Managers, as well as a clear blueprint to move from planning to action.

Report structure

The rest of this report is divided into ten chapters: Chapter 2 presents an introduction to the project approach, while the third and fourth chapters discuss the national innovation context of Trinidad and Tobago and the basic concepts and definitions around Centres of Excellence, respectively. Chapters 5 to 9 introduce the Centres' specifications and design features. These include the sectoral innovation contexts of the five economic areas under study, core CoE mission, innovation services, areas of specialisation and other operational considerations. The report finalises by introducing a suggested governance framework for the Centres in Chapter 10 and by discussing next steps for implementation in the final chapter.

Examples from relevant international Centres of Excellence focusing on similar areas to those proposed in this study for TT are introduced in boxes across this report, in the hope that these can provide illustrative insights and lessons about relevant international practices.

[1] These five economic areas were selected through a participatory process with local stakeholders during a previous project titled *"Consultancy of Technological Foresight"*, performed by Policy Links in Trinidad and Tobago in 2017 under IDB's Technical Cooperation Agreement *"Strategic Roadmap for Productive Development Policy in Trinidad and Tobago"*.

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PROJECT APPROACH

The study was conducted between March and August 2018, involving a combination of desk-based research tasks and two fieldwork visits to the city of Port of Spain. A range of evidence sources were employed for the completion of this report (Figure 1).

Sources of evidence included the analysis of 15 comparator Centres of Excellence around the world working in areas related to those planned for TT (Appendix A), to obtain insights and lessons that could inform the design of Centres in TT. In particular, the review attempted to capture key information about international Centres, such as mission, areas of specialisation, innovation services, facilities, operational approaches, funding models, governance frameworks and key performance indicators. Lessons acquired from this review have been taken into consideration during the definition of the Centre specifications presented in this report.

Another source of evidence involved the review of existing policy literature and economic data regarding the innovation and economic context of TT, in order to present the reader with the necessary background information regarding the innovation needs and challenges faced by the national innovation system in TT and the distinct types of firm in the country.

A distinctive feature of the project approach has been the efforts made to capture the knowledge of local stakeholders in a systematic way. To this end, the project drew heavily upon a wide consultation with industry, academia and government communities. This involved the distribution of an innovation survey to more than fifteen local companies and the organisation of five industry roundtables and a policy workshop in Port of Spain, with the participation of more than sixty experts from industry, government and academia.

In addition, a roadmapping workshop was organised to design an implementation plan for a Centre of Excellence in ICT Products and Services. The purpose of this workshop was to demonstrate the potential of the roadmapping methodology for the design of practical and actionable implementation plans, with the aim of allowing members of the Ministry of Planning and Development to replicate this process for other Centres of Excellence in the future.

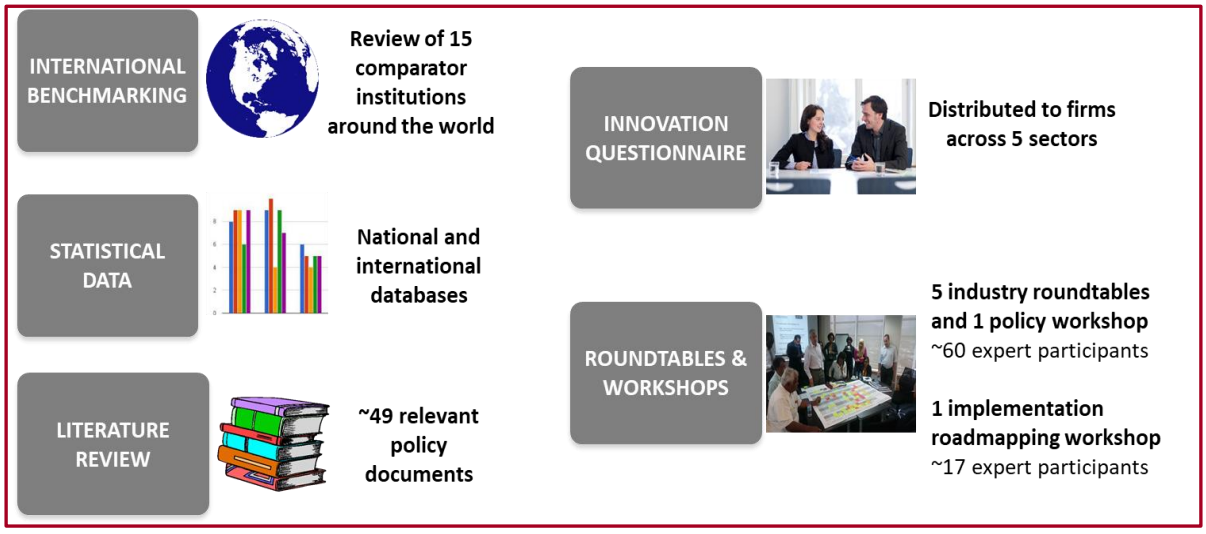

Figure 1: Sources of evidence

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THE INNOVATION IMPERATIVE IN TT

Analyses of TT's national innovation system by Policy Links (2017)[2] and Guinet (2014)[3] highlight that, although the country has comparable institutions for knowledge generation, diffusion and absorption to those of other high-income countries, a series of structural barriers constrain innovation and R&D in non-hydrocarbon sectors of the economy.

These include a highly fragmented governance structure in which no single institution performs a strategic planning function across the innovation system, low public and private investment in innovation compared to OECD levels (particularly in the business sector), limited linkages between industry and academia, and a relatively low innovation readiness of firms.

In terms of TT's structural under-investment in R&D and innovation, the country underperforms not only in comparison to OECD countries but also when compared to the Latin American average[4] (Table 1).

Table 1: R&D intensity in Trinidad and Tobago[5]

GERD as a percentage of GDP (%)		
	2010	**2014**
T&T	0.05	0.09
LatAm & Caribbean	0.66	0.71
OECD	2.28	2.36

The reasons behind such low R&D intensity can be associated with an economic structure oriented towards natural-resources-based sectors, historically relatively high levels of investments in low-tech sectors and operational inefficiencies at industry level.[6]

In addition, Figure 2 highlights the negligible contribution of the business sector to R&D expenditure in TT, in contrast with the 69% of R&D expenditure provided by the private business sector in OECD countries.

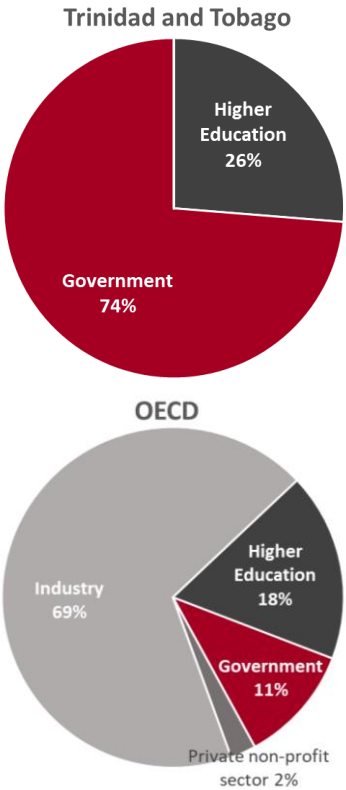


Figure 2: Gross domestic expenditure on R&D (2014 data)[7]

By linking public and private innovation efforts, Centres of Excellence represent a flexible mechanism to address some of these key structural barriers and promote investment in innovation, as discussed in the following section.

[2] Policy Links (2017). "Consultancy on Technological Foresight – Summary Report", University of Cambridge.
[3] Guinet (2014). Assessment of the National Innovation Ecosystem of Trinidad and Tobago, IDB.
[4] Navarro et al. (2014). The new imperative of innovation: policy perspectives for Latin America and the Caribbean, IDB.
[5] UNESCO (2018). UIS.Stat database; OECD (2016). "Key Figures", in Main Science and Technology Indicators.
[6] Navarro et al. (2014).
[7] UNESCO (2018).

4

DESIGNING CENTRES OF EXCELLENCE: BASIC CONCEPTS AND THEORY

What are Centres of Excellence?

Simply put, Centres of Excellence are organisations linking public and private innovation efforts. They can help de-risk innovation projects by acting as a bridge between businesses and the research and academic communities and enabling projects that no single actor would be able to perform by itself. They can also contribute beyond R&D in areas including: skills development; access to facilities and expert advice; provision of test beds for the development of new production processes and products; stakeholder engagement and network formation; and FDI attraction. As such, they represent a flexible tool to promote innovation and industrial competitiveness.

Why is public support for Centres of Excellence justified?

There is a role for government to address a number of coordination failures (the inability of firms to carry out joint investment without external coordination), information failures (a lack of information about the potential benefits of technology), and network failures (including technological lock-in and path dependency) that prevent companies from investing in knowledge and innovation. Investment in CoE can generate returns to society through spill-over effects such as the transfer of capabilities to local firms. This, in turn, could result in the improved performance of such firms, becoming more competitive, employing more people, paying more taxes and increasing national well-being.

Whom do the Centres of Excellence serve?

Centres of Excellence are expected to address the needs of firms operating in Trinidad and Tobago. As such, it is critical to recognise that different types of firm will have different types of need and challenge. While some companies might be able to engage in research activities, many others still have weak internal capabilities and require more basic technical services. Notably, small and medium-sized enterprises (SMEs) might require more basic capability-building services such as technical advice and training in the use of new technologies. Unlike universities, Centres of Excellence might need to focus initially on more basic technology services for local firms rather than attempting to emphasise research and development. When research is conducted by Centres of Excellence, this might need to be applied research (at high technology readiness levels (TRLs)) to facilitate exploitation by industry.

How do Centres of Excellence drive change?

In broad terms, the functions of Centres of Excellence fall under three categories:

- **Knowledge generator and importer** – development of knowledge resources (including technologies, tools and techniques) either through own research and development or through acquisition of foreign know-how.
- **Knowledge mediator and diffuser** – bridge building between universities and industry, diffusing relevant market and technological know-how among the industrial community and coordinating efforts between related firms.
- **Knowledge supplier and absorption facilitator** – offer of customised and timely services in a consultancy-like manner, including expert advice, technical training and new product development support.

Specifications for Centres of Excellence in Trinidad and Tobago

The following sections (5–9) highlight the suggested design specifications for five Centres of Excellence in Trinidad and Tobago:

5) Indigenous High-value Agricultural-based Products
6) ICT Products and Services
7) Aviation Services
8) Maritime Services
9) Energy Engineering Services

5

ICT PRODUCTS AND SERVICES: CENTRE SPECIFICATION

Where are we? Sectoral context and innovation challenges

Where do we want to go? Centre's mission and development vision

How can we get there? Centre's activities, outputs, outcomes and KPIs

Other operational considerations: funding strategy and resourcing

5.1 Where are we?
Sectoral context and innovation challenges

Sectoral landscape

In 2015 the ICT sector accounted for 3.4% of TT's GDP, up from 3% in 2006.[8] Ranked 67th (out of 139 countries) in the World Economic Forum Networked Readiness Index, which measures how well an economy is using ICT to boost competitiveness and well-being,[9] TT lags behind in the productive and innovative use of ICT when compared to advanced countries. A recent study by NIHERST[10] shows that some ICT sub-sectors are already relatively developed in TT, including software and Web development. The existence of a critical mass of companies in these sub-sectors makes the ICT sector a good candidate to drive the diversification path of the wider economy.[11]

In this regard, potential areas of opportunity[12] have been suggested, including business process outsourcing, cyber security and ICT regional headquartering. TT has also been identified as a competitive location in Latin America for the establishment of data centres and for potentially becoming a regional hub for software design and the provision of professional ICT services to international firms.[13]

Innovation challenges

An analysis of innovation challenges faced by firms at distinct innovation levels (Figure 3) shows that, although some differences exist, distinct types of firm tend to share a number of innovation barriers. Overall, firms at all innovation levels report difficulties acquiring staff with the right skills. There is an overall perception that the high-level scientific knowledge required to engage in key emerging ICT knowledge areas such as artificial intelligence or machine learning does not exist in TT's innovation ecosystem. This is partly attributed to the low level of funding available to support research in this technology area and the migration of skilled professionals away from TT, as reported by workshop participants.

Other challenges for companies willing to grow in this sector include low access to venture capital, the absence of economic incentives to innovate and the lower credibility and reputation that small local firms have in comparison to larger and more established international brands.

Table 2: TT's ICT sector SWOT analysis

Strengths	Weaknesses
• Government policies strengthening infrastructure and fostering technology use and ICT adoption. • Presence of a critical mass of software and Web development companies. • Global Services Internationalisation Hub. • Proximity to the Latin American and Caribbean markets.	• Low ICT skills among citizens and businesses. • Absence of a comprehensive legislative framework to govern electronic payments and data security. • Low degree of IT solution adoption in the business sector. • Low availability of personnel with adequate skills.
Opportunities	**Threats**
• Driver of diversification. • ICT-business process outsourcing (e.g. financial sector). • Development of data centres (i.e. data storage, co-location, cloud and enterprise data centre services).	• "Digital divide" between sectors with high ICT adoption (e.g. financial) and other sectors. • SMEs and some large companies still lag behind in IT adoption.

[8] Fastforward II (2017). Trinidad and Tobago's Draft National ICT Plan 2017 – 2021.

[9] WEF (2016). The Global Information Technology Report 2016, World Economic Forum.

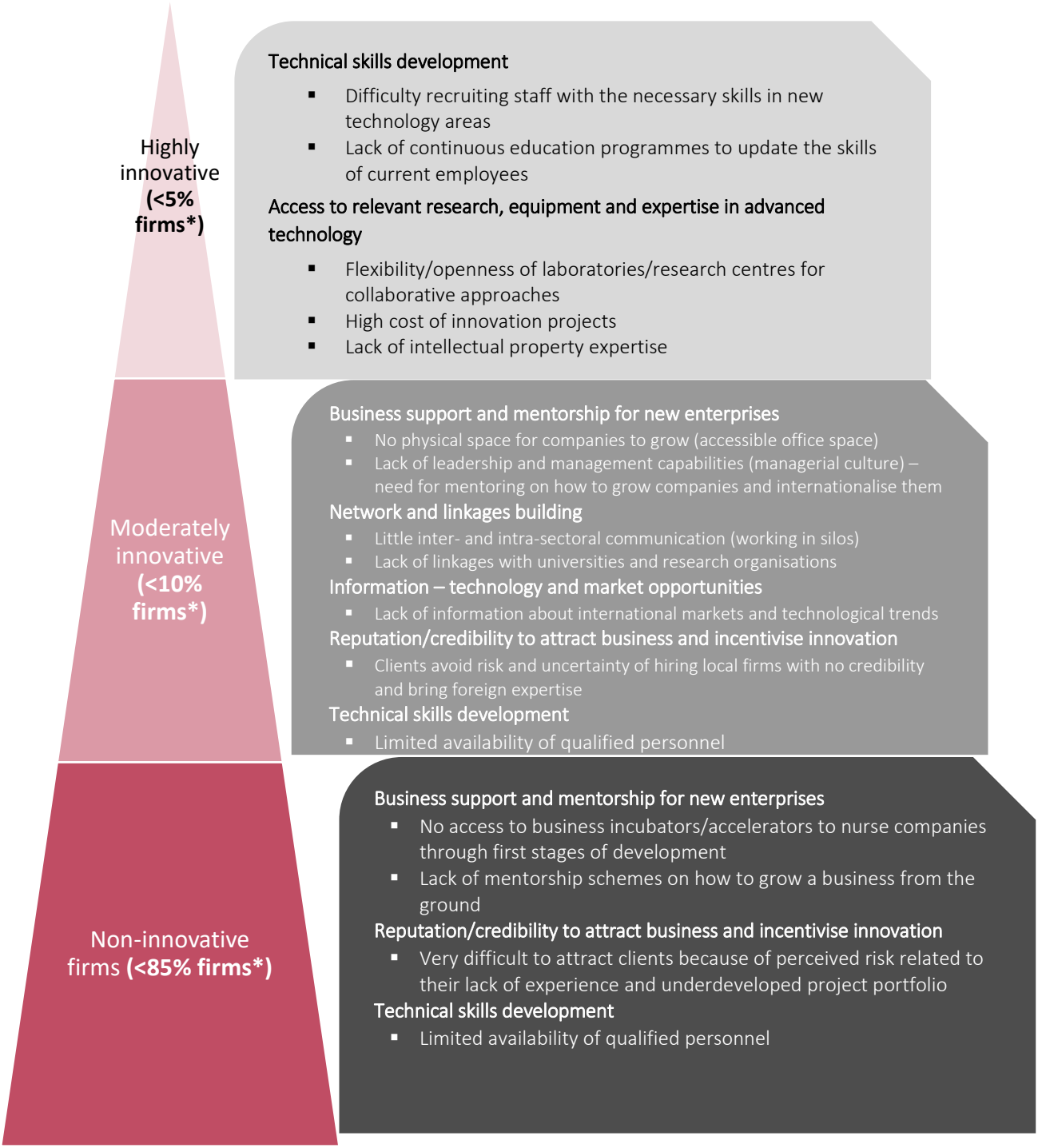
[10] NIHERST (2016). Sectoral Innovation Mapping (SIM) of the Software and Web Development industry in TT.

[11] THOLONS (2012). Trinidad and Tobago: Exploring Opportunities in the Global IT Service Market.

[12] US International Trade Administration (2017). Trinidad and Tobago country commercial guide.

[13] Existing initiatives such as the Global Services Internationalisation (GSI) Hub target these opportunities.

FIGURE 3: KEY INNOVATION NEEDS/CHALLENGES (ICT SECTOR)



*As reported by workshop participants.

Definitions:

- Highly innovative: Actively engaged in innovation and R&D / Has in-house R&D and/or innovation capabilities (e.g. skilled personnel and/or equipment) / Purchases R&D and innovation services from external organisations.
- Moderately innovative: Motivated to engage in innovation but lacking resources / Might have incipient in-house R&D and innovation capabilities / Might engage in minor R&D and/or innovation projects with external organisations.
- Non-innovative: Lacking resources to engage in innovation / No in-house R&D and/or innovation capabilities / No external R&D and/or innovation projects.

5.2 Where do we want to go?
Centre's mission and development vision

ICT technologies are seen by the stakeholders who were consulted as both enablers of productivity in strategic sectors for economic diversification and a sector in their own right. As such, it is believed that TT has the potential to develop both a product-based ICT industry for the global market and a service-based ICT industry that could first address the ICT needs of key domestic industries and later move to international markets.

Consequently, this report suggests that the core mission of a Centre of Excellence working in this area should first be the strengthening of TT's ICT sector firms. This should be done by providing support in key innovation areas, including services to de-risk innovation efforts in local firms, and providing other innovation and business assistance to create a more enabling environment for growth. From the evidence shown in Figure 3, it is suggested that a new Centre of Excellence in ICT Products and Services should target the innovation barriers that are most relevant for moderately innovative and non-innovative firms in TT, as these represent the bulk of firms in the sector and have the fewest resources to pursue innovation themselves.

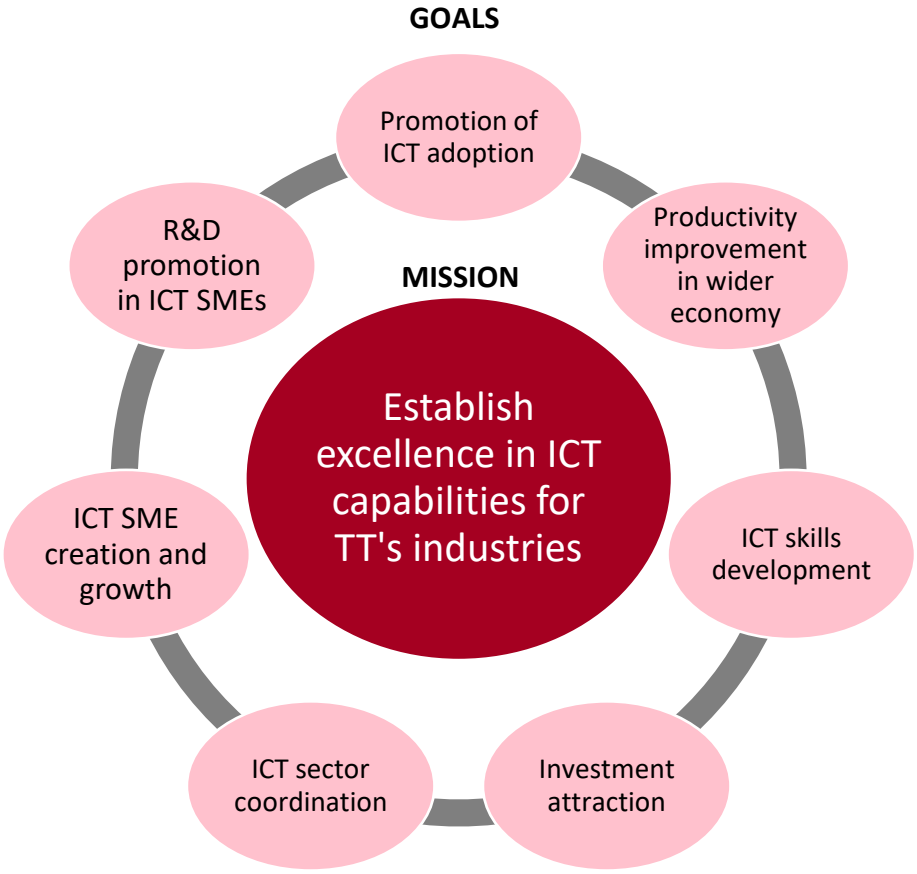
Once this primary mission is fulfilled, the Centre could then focus on other important goals, such as promoting ICT adoption in the wider economy to stimulate overall productivity growth. To do this, it is envisaged that the Centre should first develop technical capabilities related to the ICT firms it intends to serve in the short term as part of its primary mission.

This signifies acquiring capabilities related to the development of bespoke business and other specialised software solutions, focusing on quick-win technologies that could then serve as a basis for building technical competencies in more sophisticated and/or complex technologies through time.

In addition to technical competencies, the Centre is expected to fulfil innovation functions beyond R&D promotion, and it is therefore expected to develop non-technical capabilities related to network and institution building for knowledge diffusion (e.g. knowledge around technical standards, certifications and regulations, the ability to promote industrial dialogue and network building, capabilities for performing technology and market foresight analyses). Furthermore, the Centre is also expected to carry out a capability development function, including skills development in both business and technical areas and business mentorship and incubation, among others.

Figure 4 summarises the core mission, goals and development vision for the Centre of Excellence in ICT Products and Services.

FIGURE 4: COE IN ICT PRODUCTS AND SERVICES – MISSION AND DEVELOPMENT VISION



CENTRE DEVELOPMENT VISION

	Short term	Medium term	Long term
CoE Narrative	• Strengthen TT's ICT sector by supporting non-innovative and moderately innovative firms	• Develop services for government and other key sectors (e.g. Financial, Energy, Agri-tech, Food, Aviation, Maritime)	• Services for international market
Specialisation Areas	• Bespoke business and other specialised software solutions • ICT for key diversification sectors	• Data science / analysis • Financial Tech • Energy-based digital services • Animation / visualisation tools	• Cyber security / PEN testing • Artificial intelligence
Competencies	• Network / cluster building competencies • Information analysis and provision (technology and market foresight) • Training and mentorship (business and technical)	• Basic R&D and knowledge import competencies • Reputation / credibility certifications • Business incubation support	• Advanced R&D and knowledge generation competencies • International networking capabilities

5.3 How can we get there?
Services, outputs, outcomes and KPIs

As discussed earlier, a Centre of Excellence in ICT Products and Services is expected to address the innovation needs of firms operating in this sector, recognising that different types of firm have different types of innovation needs and challenges, as summarised in Figure 3. Based on this evidence, and informed by the international case studies analysed in this project (Appendix A), this section suggests a range of innovation services that could be offered by this Centre to help companies across all innovation levels to engage in research and innovation activities (Figure 5).

Although it is recognised that a certain level of service differentiation is required for distinct types of company, the aim is that all services offered by this Centre could be available for all types of company, if required. For example, while business operations' mentorship and advice could be more relevant for small start-ups, this service could also be available for larger firms with a higher level of sophistication, if required.

A logic model (Figure 6) has been designed to outline how inputs and activities from this Centre are linked to its stated mission and goals (impacts). Although these relationships are not linear, by presenting the relationships between the inputs and activities of the Centre (i.e. services), outputs (such as newly designed and/or improved ICT products and services) and outcomes (such as the adoption of innovative ICT technologies by firms), the logic model guides the design of monitoring and evaluation activities (i.e. key performance indicators, "KPIs").

Measuring the impact of new Centres of Excellence is an essential step to understanding how these Centres perform and how successful they are in achieving their stated missions and goals. Vigorous impact measurement can enable Centres of Excellence to guide their strategic direction and operations to understand how they can address innovation challenges in specific areas and drive economic growth in TT. In this regard, a set of key performance indicators is suggested in this section to evaluate not only the operation of a Centre of Excellence in ICT Products and Services but also its potential impact (Figure 7).

Successful performance evaluation of this Centre needs to be complemented with consistently defined and collected data across all of its activities, to enable evaluators to implement the proposed KPIs.

Box 1: The Fraunhofer Institute for Software and Systems Engineering (ISST) – Germany

The ISST is an institution of the Fraunhofer-Gesellschaft network. The ISST was founded in 1992 in Dortmund, Germany, with the aim of promoting applied research. The Institute's efforts focus on digitisation in logistics, digitisation in health care and digitisation in service industries.

- Services

The ISST provides a wide range of services, including: development, prototyping and pilot testing of IT solutions; standardisation, modelling and software development; and quality assurance and implementation of technologies, among many others.

- Example key performance indicators (2016)
  - Within contract research, industry projects accounted for 50% of the total number of projects.
  - More than three invention disclosures per working day.
  - More than two patent applications every working day.

Sources: Fraunhofer-Gesellschaft (2017). *Annual Report 2016. Embracing digitalization;* Fraunhofer-Gesellschaft (2018). *Patents/Licenses.*

FIGURE 5: COE IN ICT PRODUCTS AND SERVICES – SUGGESTED SERVICES

INNOVATION FUNCTIONS	Innovation needs	SERVICES (Type of firms indicative only. Services could be available to all firm types if needed)		
		Highly innovative firms	Moderately innovative firms	Non-innovative firms
Knowledge Supplier and Absorption Facilitator	TECHNICAL SKILLS DEVELOPMENT BUSINESS SUPPORT AND MENTORSHIP FOR SMEs REPUTATION / CREDIBILITY TO ATTRACT CLIENTS AND INCENTIVISE INNOVATION	**COMPETENCE DEVELOPMENT** • Skills development programmes in technical and business areas • Domestic and international apprenticeships, internships and fellowships	**COMPETENCE DEVELOPMENT** • Training and certification scheme in technology applications to foster credibility of local firms **CONSULTANCY/INDUSTRY SUPPORT** • Advisory and mentorship services (technical and business advice, including export, management, marketing, operations and managerial assistance) • Advice on how to meet international standards for ICT firms	**COMPETENCE DEVELOPMENT** • Training and certification scheme in technology applications to foster credibility of local firms **CONSULTANCY/INDUSTRY SUPPORT** • Advisory and mentorship services (technical and business advice, including export, management, marketing, operations and managerial assistance) • Business pitch training • Incubation services • Advice for non-ICT firms on how to integrate and implement new ICT technologies and identify their economic benefits
Knowledge Mediator and Diffuser	NETWORK AND LINKAGES BUILDING INFORMATION – TECHNOLOGY, STANDARDS AND MARKET OPPORTUNITIES	**CONNECTING BUSINESSES** • Formation of clusters to foster inter- and intra-sectoral cooperation (all types of firms) • Connecting firms with academics and enabling collaborations (provide hub for SMEs and collaborators to develop ideas) • Database of diaspora experts	**THOUGHT LEADERSHIP** • Domestic and international conferences and seminars • Create and manage case study database • Information on technology and market trends and opportunities • Advice for policy, regulation and academic curricula	**THOUGHT LEADERSHIP** • Self-assessments for companies to know how innovative they are • Information on technical standards, certifications and regulations • Information on sources of funding (domestic and international)
Knowledge Generator and Importer	ACCESS RESEARCH EQUIPMENT, EXPERTISE AND ADVICE	**ACCELERATING INNOVATION** • Links with international R&D labs • Advice on intellectual property rights (IPR)	**COLLABORATIVE R&D** • Access to specialised R&D expertise across CoE technology areas • Contract R&D projects to formulate and test application concepts	**COLLABORATIVE R&D** • Product design and development support (from proof-of-concept and prototype development to system demonstration in real-world environment and technology qualification and certification)

FIGURE 6: COE IN ICT PRODUCTS AND SERVICES – SUGGESTED LOGIC MODEL

INPUTS	ACTIVITIES	OUTPUTS	OUTCOMES	IMPACTS
FACILITIES, FINANCE AND EXPERTISE	**Knowledge Supplier and Absorption Facilitator** **COMPETENCE DEVELOPMENT** • Skills development in technical and business areas • Domestic and international apprenticeships, internships and fellowships • Training and certification scheme in technology applications to foster credibility of local firms **CONSULTANCY/INDUSTRY SUPPORT** • Advisory and mentorship services (technical and business advice, including export, management, marketing, operations and managerial assistance) • Advice on how to meet international standards for ICT firms • Business pitch training • Incubation services • Advice for non-ICT firms on how to integrate and implement new ICT technologies and identify their economic benefits	• New businesses created • Business cases made • Staff engaged in training / competence development • Qualifications / Skills enhancement • Employment • Technology adoption • Business credibility and competitiveness	• Sector-wide upskilled workforce • Greater understanding of the opportunities associated to ICT tech adoption • Firms adopt innovative technology • Business performance improvement • Confidence in local ICT firms increases (reduced risk) • Consumer interest in SME products and services grow • Business innovation capacity and capability increases • Resilience of the sector	•Promotion of ICT adoption •SME creation and growth •ICT skills development over wider economy •Productivity improvement in wider economy •ICT sector convening and coordination •R&D promotion in SMEs •Investment attraction
	Knowledge Mediator and Diffuser **CONNECTING BUSINESSES** • Formation of clusters to foster inter- and intra-sectoral cooperation (all types of firms) • Connecting firms with academics and enabling collaborations (provide hub for SMEs and collaborators to develop ideas) • Database of diaspora experts **THOUGHT LEADERSHIP** • Domestic and international conferences and seminars • Create and manage case study database • Information on technology and market trends and opportunities • Advice for policy, regulation and academic curricula • Self-assessments for companies to know how innovative they are • Information on technical standards, certifications and regulations • Information on sources of funding (domestic and international)	• New relationships • Connections made • Thought leadership publications that highlight technologies of the future • Interactions with organisations and agencies developing industry regulations and standards • Workshops, seminars and conferences • Collaborative agreements and secondments • Brochures, visuals, profile pieces, media and case studies • Self-assessment tool • Social media presence • Dissemination of research results / expertise / knowledge	• Industry and academia share ideas, build relationships, and develop expertise • New business partnerships established • Awareness of technological change in the sector develops • Decision-makers in the sector are better informed and policy making is improved • Businesses accessing new markets, customers and funding • Increased adoption of models and standards by firms sector • ICT CoE develops an international reputation and is seen as a focal stakeholder in the sector	
	Knowledge Generator and Importer **ACCELERATING INNOVATION** • Links with international R&D labs • Advice on intellectual property rights (IPR) **COLLABORATIVE R&D** • Access to specialised R&D expertise across CoE technology areas • Contract R&D projects to formulate and test application concepts • Product design and development support (from proof-of-concept and prototype development to system demonstration in real-world environment and technology qualification and certification)	• New and / or improved products, services and business models developed • Successful delivery of collaborative R&D projects • Publications • Intellectual property (e.g. patents, licences, expertise, standards, etc.) • Commercial revenue • Academic research agenda focused on industry needs	• Developers produce and test new ideas • Innovative new products and services come to market • Foreign firms invest and conduct R&D in TT • IP licences and patents issued • Reduced development barriers between R&D and business scale solutions • Improved commercialisation of ideas	

FIGURE 7: COE IN ICT PRODUCTS AND SERVICES – SUGGESTED KEY PERFORMANCE INDICATORS

		KEY PERFORMANCE INDICATORS (KPIs) AND THEIR START PERIOD		
ACTIVITIES	**TYPE OF INDICATOR**	**SHORT TERM**	**MEDIUM TERM**	**LONG TERM**
COMPETENCE DEVELOPMENT CONSULTANCY/ INDUSTRY SUPPORT	**DEVELOPMENT OF AN ADVANCED ICT SECTOR AND WORKFORCE**	• Number of students involved in Centre projects, internships, apprenticeships • Number of workers completing a Centre-led certification, apprenticeship or training	• Number of teachers or trainers participating in Centre-led training • Number of incubated companies • Number of ICT and non-ICT firms engaged in advisory and mentorship services	• Number of local firms certified under new CoE certification schemes • Number of expert consultants participating in Centre-led advisory and mentorship services
THOUGHT LEADERSHIP CONNECTING BUSINESSES	**IMPACT ON ICT'S INNOVATION ECOSYSTEM**	• Number and diversity of stakeholders engaged and connected (industry, academia, government) • Number of SMEs engaged and connected	• Number of dissemination publications produced • Number of workshops, seminars and conferences organised	• Case studies of successful linkages and network building examples, including communities of practice
ACCELERATING INNOVATION COLLABORATIVE R&D	**TECHNOLOGY ADVANCEMENT**	• Number of expert contributors / researchers participating in Centre-led R&D services	• Number and value of R&D projects	• Percentage of key project objectives met • Number and value of IP products produced and licenced
IMPACT AND INDUSTRY VALUE		• Success stories and case studies • Total number of ICT client companies engaged (by innovation level)	• Level and quality of co-investment by private sector • Total number of ICT client companies retained (returning business) • Total number of non-ICT client companies engaged (by innovation level)	• Number of jobs created and retained • Number of Centre R&D projects reaching commercial production • Number of spin-off companies created • Number of companies moving from non-innovative to moderately innovative and highly innovative

5.4 Other operational considerations: Funding, resourcing and implementation planning

The successful implementation and operation of Centres of Excellence require careful consideration and definition of fundamental operational aspects such as a Centre's funding and resourcing strategies, in addition to clear plans for the establishment, consolidation and growth of these Centres in the short, medium and long terms.

Funding strategy

As suggested by Hauser (2010),[14] both the level and type of funding vary significantly between distinct types of Centres of Excellence. However, the sources of funding can be broadly categorised as:

- **Core funding from national and regional government:** not always linked to specific activities or outcomes. A performance management framework is often in place for this investment.
- **Research grants and contracts from public bodies:** in most instances these are won on a competitive basis.
- **Research contracts from the private sector and revenue from services:** usually competitively tendered.
- **Additional income sources:** member fees, fee-for-service activities, intellectual property royalties, endowments, etc.

Based on a review of international practices, evaluation of the current ICT sector context in TT and consultation with local stakeholders, this study suggests a funding portfolio that includes strong core funding from the government during its first year (80%), reduced to 60% in years 2–3, 45% by the fourth year and 10% by year 7. It is envisaged that this would allow the Centre to establish its core competencies and develop a viable portfolio of services, which could gradually provide a stable revenue stream to substitute core government funding by year 7, as shown in Figure 8.

Resourcing and implementation planning

An "implementation roadmap template" was designed by IfM ECS (Figure 9) to identify the key actions required for the structured establishment of the CoE in ICT Products and Services in TT, including resourcing targets, in addition to other operational matters related to the creation, consolidation and growth of the Centre. This template was used during two roadmap workshops held in Port of Spain on 10–11 July 2018, attended by 23 local stakeholders from industry, academia and government, with the aim of developing a clear, consensus-based view of the implementation process and related funding and resourcing strategies.

The roadmap considers key implementation actions across a seven-year period for:

- Government approval and announcement;
- Strategy and business planning;
- Governance and management structure set-up;
- Personnel, operations and organisational structure set-up;
- Infrastructure, equipment and location planning;
- Innovation services delivery;
- Networking/alliances/sector integration and communication.

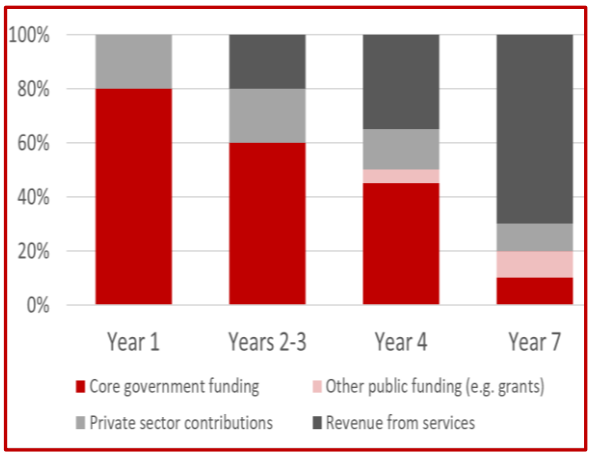


Figure 8: CoE in ICT Products and Services – funding sources

[14] Hauser (2010).

Box 2: Funding portfolios – international examples

Examples of funding portfolios from three distinct international organisations are given below. Different approaches are visible from this data, highlighting the need for every Centre of Excellence to adapt its funding portfolio configuration to its particular national/local context, missions and objectives.

▪ The Fraunhofer Institute for Software and Systems Engineering (ISST) – Germany

The Fraunhofer-Gesellschaft receives funding both from the public sector **(approximately 30%)** and through contract research earnings **(roughly 70%)**.

The *funds from the public sector* come from the German Federal Ministry of Education and Research (BMBF) and the state governments in a ratio of 90:10.

The *contract research segment* comprises three complementary areas of work: research conducted under contract to customers in industry and the service sector, publicly funded research projects, and pre-competitive research financed by means of the organisation's base funding.

- **Research budget:** EUR 2.3 billion (USD 2.8 billion), 87% generated through contract research.
- **Revenue:** ISST had a revenue of EUR 3.6 million (USD 4.4 million).

▪ RISE ICT – Sweden

RISE ICT is a division of RISE, a network of research and technology organisations owned by the Swedish government. RISE ICT is formed by four research centres with different areas of expertise within the field of information and communication technologies: RISE Acreo (ICT Hardware, Sensors and Actuators); RISE Interactive (Interaction Design and Visualisation); RISE SICS (Software Development and Computer Science); and RISE Viktoria (Sustainable Mobility).

Through these research centres, RISE ICT provides a wide range of services, from customised research and prototyping, to standardisation, collaboration platforms and customised training.

RISE ICT had a turnover of SEK 509 million (USD 60.2 million) in 2016, from five main sources:

- **National project funding (competitive grants):** 41%
- **National industry (e.g. contract research and other services):** 25%
- **Swedish government (core funding):** 17%
- **European Union (EU) funded projects (competitive grants):** 13%
- **International industry (e.g. contract research and other services):** 4%

▪ Eurecat Technology Centre – Spain

Eurecat works as a bridge institution between knowledge generation and industrial needs. The technological solutions provided by the Centre cover a variety of sectors: aerospace; automotive; construction; creative and cultural industries; energy; finance; food; information and communication technologies (ICT); and railway; among others.

Within the ICT sector, Eurecat's offerings range from product developing and prototyping, competitive intelligence, and network events, to certifications and training.

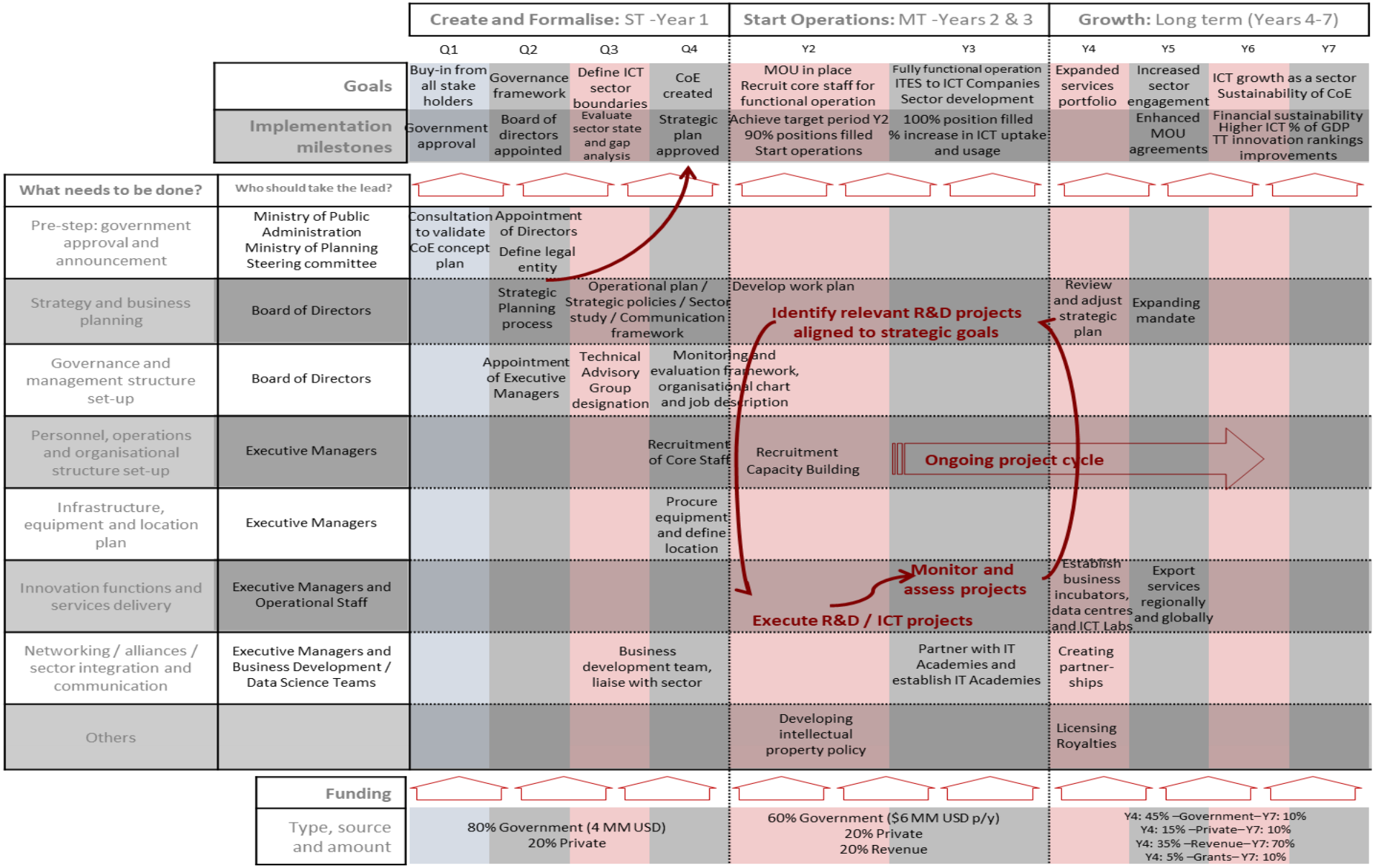
With regards to funding, Eurecat reported a revenue of EUR 30.7 million (USD 37.7 million) in 2016, from four main sources:

- **Spanish government (core funding):** 71.2%
- **National industry (e.g. contract research and other services):** 27.1%
- **Sales and other sources:** 1.7%

Sources:

- Fraunhofer-Gesellschaft (2018). *Finances;* RISE ICT (2016). *The result of RISE ICT;* Eurecat (2017). *Audited Financial Statements.*

FIGURE 9: COE IN ICT PRODUCTS AND SERVICES – FUNDING STRATEGY AND RESOURCING ROADMAP



6

HIGH-VALUE AGRICULTURAL-BASED PRODUCTS: CENTRE SPECIFICATION

Where are we? Sectoral context and innovation challenges

Where do we want to go? Centre's mission and development vision

How can we get there? Centre's activities, outputs, outcomes and KPIs

Other operational considerations: funding strategy and resourcing

6.1 Where are we?
Sectoral context and innovation challenges

Sectoral landscape

In 2016 the agricultural sector represented 0.4% of Trinidad and Tobago's total GDP, also accounting for 16.7% of land area. The arable land is estimated at 75,000 hectares, plus an additional 47,000 hectares under permanent crops. TT's main agricultural crops include cocoa, rice, citrus, coffee, vegetables and poultry; while citrus fruits, tomatoes, cocoa, sugar, coffee and cut flowers are among the main export products. TT's major agriculture export partners are countries such as the United States, Chile, Argentina, Spain, as well as countries in the Caribbean.

The economy of Trinidad and Tobago is characterised by being highly dependent on food imports from abroad. Development of the agricultural sector would have a double effect: reducing the country's food dependency from abroad by better supplying the domestic market with local production, and increasing the exports of the finest TT products, thus improving the balance of payment. The country already presents an institutional framework that could support development of the sector, with the presence of leading universities and research centres, particularly for cocoa research, which could work as a valuable lesson to develop high-value products from other indigenous species.

Innovation challenges

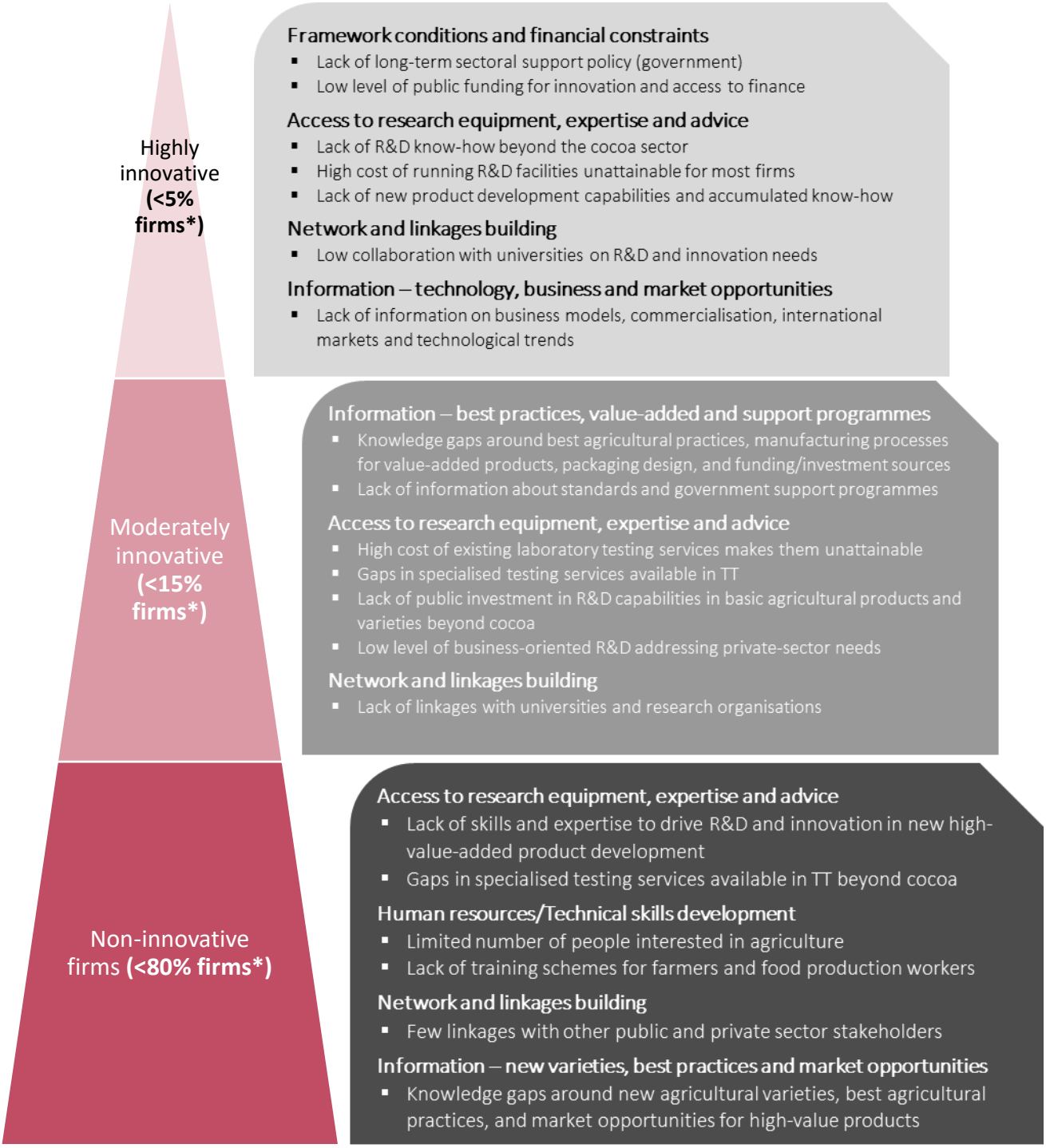
Figure 10 highlights a number of opportunity areas that could be addressed by a CoE supporting firms in the agricultural and food-production value chains. In particular, local stakeholders believe that few basic science R&D capabilities and little accumulated know-how exist in TT for indigenous species beyond cocoa (e.g. pepper, coconut, cassava). Furthermore, knowledge gaps around new agricultural varieties, best agricultural practices (demonstration), high-value product design, manufacturing processes for value-added products, packaging design, market opportunities and technological trends for high-value products were identified as key gaps that could benefit from information and expertise provision by a new CoE.

Additional challenges related to affordable access to quality testing laboratories for high-value products were mentioned. This could enable firms to gain easier access to international markets by meeting the required standards and certifications. Skills and training programmes on best agricultural practices (demonstration farms), the use of new varieties, and vocational skills related to food and other high-value product manufacturing have also been mentioned as key barriers to innovation for firms.

Table 3: TT's agriculture/food sector SWOT analysis

Strengths	Weaknesses
• Availability of physical resources to boost the sector (i.e. arable land, water, mineral resources, etc.). • Presence of key knowledge resources (including UWI, UTT, CARIRI, CARDI). • Low business cost. • Skilled workforce in certain sub-sectors.	• Need to increase local food production at competitive prices. • Low basic and applied research activity in products other than cocoa. • Low application of research to agricultural development.
Opportunities	**Threats**
• Award-winning fine flavour cocoa – industry experience could be replicated. • Opportunity to increase food security. • Domestic, regional and international demand for TT indigenous products (potential market development). • Existing manufacturing and logistics industries could facilitate the development and export of local products.	• Low entrepreneurship. • Need for effective flood mitigation system. • Need for a comprehensive water resources management plan.

Figure 10: KEY INNOVATION NEEDS/CHALLENGES (AGRIPRODUCTS)



*As reported by workshop participants.

Definitions:

- Highly innovative: Actively engaged in innovation and R&D / Has in-house R&D and/or innovation capabilities (e.g. skilled personnel and/or equipment) / Purchases R&D and innovation services from external organisations.
- Moderately innovative: Motivated to engage in innovation but lacking resources / Might have incipient in-house R&D and innovation capabilities / Might engage in minor R&D and/or innovation projects with external organisations.
- Non-innovative: Lacking resources to engage in innovation / No in-house R&D and/or innovation capabilities / No external R&D and/or innovation projects.

6.2 Where do we want to go?
Centre's mission and development vision

The stakeholders who were consulted see opportunities for supporting the development of high-value products with export potential around niche indigenous species in TT, building on the experience of the local cocoa industry. It is believed that the existing cocoa industry (in particular, the Cocoa Research Centre and other innovation initiatives in this sector) could be used as a pilot model to develop other high-value-added products based on honey, coconuts and peppers, as well as more sophisticated products such as nutraceuticals.

Based on previous work and consultations undertaken during this project, this report suggests that the focus of a Centre of Excellence working in this area could first be to strengthen the production of indigenous crops (e.g. honey, pepper, coconut and cassava) through the provision of information, demonstration and advice on best agricultural practices, new varieties and market opportunities for high-value products, in addition to specialised testing services for quality and certifications.

Once these activities are matured, the Centre could then focus on supporting the development of value-added semi-processed and processed products from niche indigenous crops. This could be facilitated by providing information and expert advice on product design, food-production processes and manufacturing, certifications and international market access, and general commercialisation expertise and guidance.

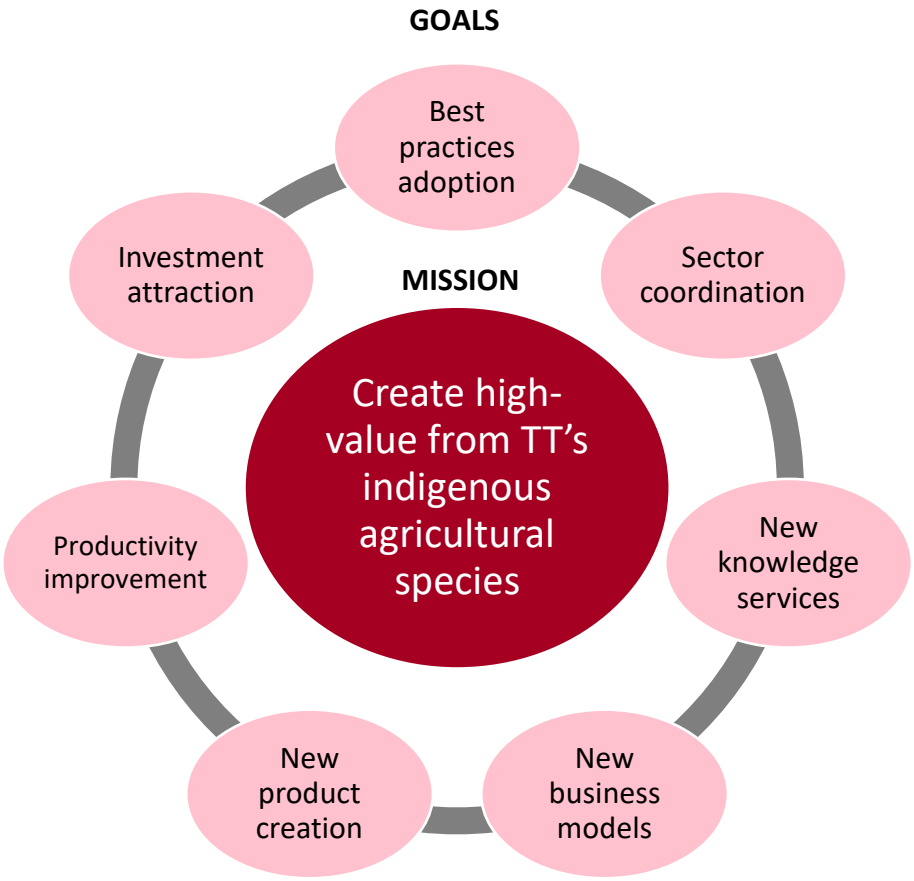
Beyond the provision of expert advice and mentorship, the Centre is expected to develop R&D capabilities in the medium and long terms in areas such as value-added product design, manufacturing, packaging design and new plant varieties. An area in which the Centre is expected to build significant capabilities is the provision of skills-development programmes in technical (e.g. agricultural practices, food production) and business areas (e.g. management support). In particular, training businesses through demonstration by facilitating access to pilot farms and production lines is seen as a core function for the Centre in the medium term.

The Centre is also expected to play an important role in the development of network linkages and industrial dialogue between firms in the sector, academics and relevant government counterparts. In general, the Centre is expected to represent a hub in which local stakeholders can co-develop ideas and enable collaborations, as well as representing an information hub that can be approached by local stakeholders willing to innovate and grow.

Once the Centre becomes well established in TT, it is envisaged that the aim will be to provide services in the regional/international markets, to increase its revenue streams and achieve its financial targets and goals.

Figure 11 summarises the core mission, goals and development vision for the Centre of Excellence in high-value agricultural products.

FIGURE 11: COE IN HIGH-VALUE AGRICULTURAL PRODUCTS – MISSION AND DEVELOPMENT VISION



CENTRE DEVELOPMENT VISION

	Short term	Medium term	Long term
CoE Narrative	• Build on the experience of TT's cocoa industry to strengthen production of other indigenous crops (i.e. pepper, coconut and cassava)	• Support development of value-added semi-processed and processed products of new crops	• Support diversification into international high-value added markets (e.g. nutraceuticals, cosmetics, etc.)
Specialisation Areas	• Best agricultural practices • New varieties • Commercialisation of small-scale production • Certifications and traceability	• Value-added product design • Food production systems • Packaging	• New plant varieties development • ICT as an enabler
Competencies	• Information and advice provision – best agricultural practices, new varieties, manufacturing processes, market opportunities for high-value products, certifications, market access and commercialisation • Networking / cluster-building activities	• Basic R&D for value-added product design, manufacturing and packaging • Specialised testing services for certification and traceability • Competence development (training)	• Advanced R&D for product design, manufacturing and plant varieties • IP management • Certification standards for local producers

6.3 How can we get there?
Services, outputs, outcomes and KPIs

A Centre of Excellence in High-Value Agricultural Based Products is expected to address the innovation needs of firms operating in this sector, recognising that different types of firm have different types of innovation needs and challenges, as summarised in Figure 10. Based on this evidence, and informed by the international case studies analysed in this project (Appendix A), this section suggests a range of innovation services that could be offered by this Centre to help companies across all innovation levels to engage in research and innovation (Figure 12). Although it is recognised that a certain level of service differentiation is required for distinct types of company, the aim is that all services offered by this Centre could be available for all types of company, if required. For example, while the demonstration of best agricultural practices through pilot farms could be more relevant for non-innovative and moderately innovative firms, this service could also be available for more sophisticated highly innovative firms if required.

A logic model (Figure 13) has been designed to outline how inputs and activities from this Centre are linked to its stated mission and goals (impacts). Although these relationships are not linear, by presenting relationships between the inputs and activities of the Centre (i.e. services), outputs (such as new high-value agricultural products developed and produced) and outcomes (such as increased global consumer interest in TT high-value agricultural products), the logic model guides the design of monitoring and evaluation activities and key performance indicators.

Measuring the impact of new Centres of Excellence is an essential step to understanding how these Centres perform and how successful they are in achieving their stated missions and goals. Vigorous impact measurement can enable Centres of Excellence to guide their strategic direction and operations to understand how they can address innovation challenges in specific areas and drive economic growth in TT. In this regard, a set of key performance indicators is suggested in this section to evaluate not only the operation of a Centre of Excellence in High-Value Agricultural Products but also its potential impact (Figure 14).

Successful performance evaluation of this Centre needs to be complemented by consistently defined and collected data across all of its activities, to enable evaluators to implement the proposed KPIs.

Box 3: Luxembourg Institute of Science and Technology (LIST) – Luxembourg

Established in 1987, the Luxembourg Institute of Science and Technology (LIST) is a public research centre with extensive international collaboration. Agritech services cover a broad range of innovation functions, from new agriculture technologies development, and climate change impact studies, to different types of chemical analyses and advice for compliance with regulations.

- Services

LIST's services cover a wide range of activities, including, for example: biocontrol pest management; the development of novel protocols for species monitoring; food safety and quality analyses; water quality analyses; and the characterisation of proteins, allergens and food contaminants.

- Example key performance indicators (2016)
  - LIST has published 207 scientific articles in international journals and conference proceedings.
  - Together with the University of Luxembourg, LIST has supervised 72 PhD students.
  - "Agroptimise" spin-off, in the field of precision agriculture.

Sources: LIST (2017). Annual Report 2016.

FIGURE 12: COE IN HIGH-VALUE AGRICULTURAL PRODUCTS – SUGGESTED SERVICES

INNOVATION FUNCTIONS	Innovation needs	SERVICES (Type of firms indicative only. Services could be available to all firm types if needed)		
		Highly innovative firms	Moderately innovative firms	Non-innovative firms
Knowledge Supplier and Absorption Facilitator	HUMAN RESOURCES / TECHNICAL SKILLS DEVELOPMENT BUSINESS SUPPORT AND MENTORSHIP – BEST PRACTICES, NEW VARITIES, TECHNOLOGY, BUSINESS AND MARKET OPPORTUNITIES	**COMPETENCE DEVELOPMENT** • Domestic and international apprenticeships, internships and fellowships **ACCELERATING INNOVATIVON** • Access to equipment and laboratory rental for analysis, testing and calibration services • Extension of available technology to businesses lacking technical capabilities • Adapt existing technologies to business needs	**COMPETENCE DEVELOPMENT** • Skills development programs in technical (e.g. agricultural practices, food production) and business areas • Train businesses through demonstration, participation and extension (pilot farms and production lines) **CONSULTANCY/INDUSTRY SUPPORT** • Advisory and mentorship services (technical and business advice, including product design, manufacturing, packaging design, export, marketing and operations) • Advice on how to meet international standards and certifications for high-value products	**COMPETENCE DEVELOPMENT** • Skills development programs in technical (e.g. agricultural practices, food production) and business areas • Train businesses through demonstration, participation and extension (pilot farms and production lines) **CONSULTANCY/INDUSTRY SUPPORT** • Advisory and mentorship services (technical and business advice, including product design, manufacturing, packaging design, export, marketing and operations) • Advice on how to meet international standards and certifications for high-value products
Knowledge Mediator and Diffuser	NETWORK AND LINKAGES BUILDING INFORMATION – BEST PRACTICES, NEW VARIETIES, TECHNOLOGY, BUSINESS AND MARKET OPPORTUNITIES FRAMEWORK CONDITIONS	**CONNECTING BUSINESSES** • Formation of clusters to foster inter- and intra-sectoral cooperation (all types of firms) • Connecting firms with academics and enabling collaborations (provide hub for local stakeholders to co-develop ideas) • Advice for sectoral innovation policy (including funding and other support programmes), regulation and certifications	**THOUGHT LEADERSHIP** • Domestic and international conferences and seminars • Provide information on sources of funding (domestic and international) • Supply information on technical standards, certifications and regulations • Publication of information packages on best practices, new varieties, tech, business and market trends and opportunities	**THOUGHT LEADERSHIP** • Domestic and international conferences and seminars • Provide information on sources of funding (domestic and international) • Supply information on technical standards, certifications and regulations • Publication of information packages on best practices, new varieties, tech, business and market trends and opportunities
Knowledge Generator and Importer	ACCESS TO RESEARCH EQUIPMENT, EXPERTISE AND ADVICE	**ACCELERATING INNOVATION** • Advice on intellectual property rights (IPR) **COLLABORATIVE R&D** • Contract R&D for new high-value-added product design • Contract R&D for new food production processes • Innovative packaging R&D	**COLLABORATIVE R&D** • Contract R&D projects related to new varieties for products beyond cocoa (i.e. pepper, coconut & cassava) and high-value-added product design • Contract R&D for new food production processes • Innovative packaging R&D	**COLLABORATIVE R&D** • Access to specialised R&D expertise and equipment across CoE technology areas • Contract R&D projects to formulate and test application concepts

FIGURE 13: COE IN HIGH-VALUE AGRICULTURAL PRODUCTS – SUGGESTED LOGIC MODEL

INPUTS	ACTIVITIES	OUTPUTS	OUTCOMES	IMPACTS
FACILITIES, FINANCE AND EXPERTISE	**Knowledge Supplier and Absorption Facilitator** **COMPETENCE DEVELOPMENT** • Skills development programs in technical (e.g. agricultural practices, food production) and business areas • Domestic and international apprenticeships, internships and fellowships • Train businesses through demonstration, participation and extension (pilot farms and production lines) **ACCELERATING INNOVATIVON** • Access to equipment and laboratory rental for analysis, testing and calibration services • Extension of available technology to businesses lacking technical capabilities • Adapt existing technologies to business needs **CONSULTANCY/INDUSTRY SUPPORT** • Advisory and mentorship services (technical and business advice, including product design, manufacturing, packaging design, export, marketing and operations) • Advice on how to meet international standards and certifications for high-value products	• Staff engaged in training / competence development • Qualifications / Skills enhancement • Technology and practices adoption • New high-value products developed and produced • Business credibility and competitiveness • Employment	• Sector-wide upskilled workforce • Business performance improvement • Business innovation capacity and capability increases • New markets accessed • Increased global consumer interest in TT high-value agricultural products • Resilience of the sector	Technology and best practices adoption Productivity improvement New business models
	Knowledge Mediator and Diffuser **CONNECTING BUSINESSES** • Formation of clusters to foster inter- and intra-sectoral cooperation (all types of firms) • Connecting firms with academics and enabling collaborations (provide hub for local stakeholders to co-develop ideas) • Advice for sectoral innovation policy (including funding and other support programmes), regulation and certifications **THOUGHT LEADERSHIP** • Domestic and international conferences and seminars • Provide information on sources of funding (domestic and international) • Supply information on technical standards, certifications and regulations • Publication of information packages on best practices, new varieties, tech, business and market trends and opportunities	• New relations and connections and collaborative agreements and secondments • Publications that highlight best practices and technologies: brochures, visuals, profile pieces, media and case studies • Workshops, seminars and conferences • Social media presence • Dissemination of research results / expertise / knowledge • Dissemination of other stakeholders and services available in the local value chain – visibility of suppliers	• Industry and academia share ideas, build relationships, and develop expertise • New business partnerships established • Awareness of technological change in the sector • Decision-makers in the sector are better informed: policy making and framework conditions improved • Businesses accessing new markets, customers and funding • Increased adoption of standards and certifications	Sector coordination New knowledge services
	Knowledge Generator and Importer **ACCELERATING INNOVATION** • Advice on intellectual property rights (IPR) **COLLABORATIVE R&D** • Contract R&D for new high-value-added product design • Contract R&D for new food production processes • Innovative packaging R&D • Contract R&D projects related to new varieties for products beyond cocoa (i.e. pepper, coconut and cassava) and high-value added product design • Access to specialised R&D expertise and equipment across CoE technology areas • Contract R&D projects to formulate/test application concepts	• New and / or improved high-value products and business models developed • Successful delivery of collaborative R&D projects • Publications • Intellectual property (e.g. patents, licences, expertise, standards, etc.) • Commercial revenue • Academic research agenda focused on industry needs	• Local firms produce and test new product concepts and ideas • Innovative new high-value products come to market • Foreign firms invest and conduct R&D in TT • IP licences and patents issued • Improved commercialisation of ideas	New product creation Investment attraction

FIGURE 14: COE IN HIGH-VALUE AGRICULTURAL PRODUCTS – SUGGESTED KEY PERFORMANCE INDICATORS

		KEY PERFORMANCE INDICATORS (KPIs) AND THEIR START PERIOD		
ACTIVITIES	**TYPE OF INDICATOR**	**SHORT TERM**	**MEDIUM TERM**	**LONG TERM**
COMPETENCE DEVELOPMENT ACCELERATING INNOVATION CONSULTANCY/ INDUSTRY SUPPORT	SECTOR MODERNISATION AND UPSKILLING	• Number of functional pilot farms / food production lines (demonstrators) and clients engaged • Number of farmers / workers completing technical and business skills development programmes, internships and apprenticeships	• New technologies and practices implemented (case studies, surveys, interviews) • Utilisation of testing facilities / equipment • Number of teachers or trainers participating in Centre-led training • Number of consultancy/advisory services provided	• Number of expert advisors / consultants participating in Centre-led advisory and mentorship services • Number of clients that successfully certified or adopted international standards to access foreign markets • Case studies of successful high-value products developed
CONNECTING BUSINESSES THOUGHT LEADERSHIP	DEVELOPMENT OF A LINKED AND INTERCONNECTED SECTOR	• Number and diversity of stakeholders engaged (industry, academia, government) • Number of SMEs and small producers engaged • Number of workshops, seminars and conferences organised	• Case studies of successful linkages and network building examples • Number of dissemination publications produced • Usage or access data about CoE dissemination materials	• Number of policy briefs and other evidence inputs produced for government stakeholders and adoption case studies
ACCELERATING INNOVATION COLLABORATIVE R&D	TECHNOLOGY ADVANCEMENT AND DEVELOPMENT OF R&D CAPABILITIES BEYOND COCOA	• Number of expert contributors / researchers participating in Centre-led R&D services	• Number and value of R&D projects (i.e. new high-value products, new or improved food production processes, new varieties)	• Number of new high-value agricultural products developed • Number and value of IP products produced and licenced • Measurable R&D capabilities and know-how developed in indigenous crops other than cocoa (i.e. pepper, coconut and cassava)
IMPACT AND INDUSTRY VALUE		• Total number and diversity of client companies engaged (by innovation level)	• Level and quality of co-investment by private sector • Evidence of new markets accessed by client companies • Total number of client companies retained by innovation level (returning business) • Perception of CoE usefulness by local stakeholders (surveys, interviews)	• Number of jobs created and retained • Number of Centre R&D projects reaching commercial production • Number of companies moving from non-innovative to moderately innovative and highly-innovative • Success stories and case studies

6.4 Other operational considerations: Funding, resourcing and implementation planning

The successful implementation and operation of Centres of Excellence require careful consideration and definition of fundamental operational aspects such as a Centre's funding and resourcing strategies, in addition to clear plans for the establishment, consolidation and growth of these Centres in the short, medium and long terms.

Funding strategy

As suggested by Hauser (2010),[15] both the level and type of funding vary significantly between distinct types of Centres of Excellence. However, the sources of funding can be broadly categorised as:

- **Core funding from national and regional government:** not always linked to specific activities or outcomes. A performance management framework is often in place for this investment.
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- **Research contracts from the private sector and revenue from services:** usually competitively tendered.
- **Additional income sources:** member fees, fee-for-service activities, intellectual property royalties, endowments, etc.

Based on a review of international practices, evaluation of the sector context and consultation with local stakeholders, this study suggests a funding portfolio that includes strong core funding from the government during its first year (90%), reduced to 70% in years 2–3, 65% by the fourth year and 50% by year 7 (Figure 15). As a result of the current state of development of firms in this sector, sustained public funding is considered critical to allow the Centre to establish its core competencies and guarantee its long-term operation. This is necessary to ensure that services are offered at an accessible price that would allow firms to transition from non-innovative to moderately or highly innovative in a challenging economic context.

Resourcing and implementation planning

An "implementation roadmap template" was designed by the consulting team (Figure 16) to identify the key actions required for the structured implementation of this CoE, including funding and resourcing targets, as well as other operational matters related to the creation, consolidation and growth of the Centre. The roadmap shown in Figure 16 has been completed by the consulting team and it is recommended that it should be validated by local stakeholders prior to execution (a task that is outside the scope of this project).

The roadmap considers key implementation actions across a seven-year period for:

- Government approval and announcement;
- Strategy and business planning;
- Governance and management set-up;
- Personnel, operations and organisational structure set-up;
- Infrastructure, equipment and location;
- Innovation services delivery;
- Networking/alliances/sector integration and communication.

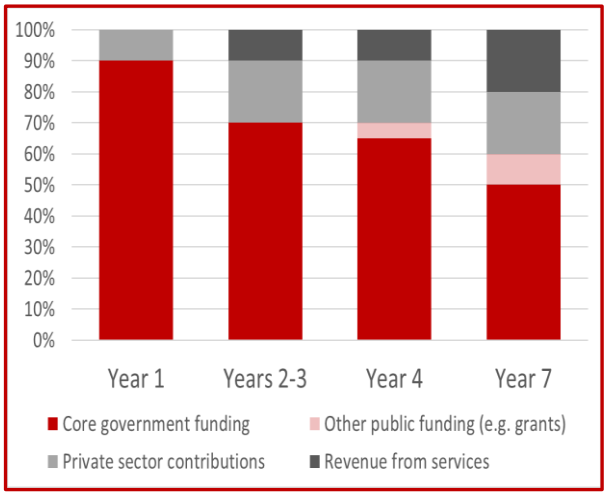


Figure 15: CoE in High-Value Agricultural Products and Services – funding sources

[15] Hauser (2010).

Box 4: Funding portfolios – international examples

Examples of funding portfolios from three distinct international organisations are given below. Different approaches are visible from this data, highlighting the need for every Centre of Excellence to adapt its funding portfolio configuration to its particular national/local context, missions and objectives.

▪ Danish Technological Institute – Denmark

The Danish Technological Institute (DTI) has a long history of collaborating with a broad range of industries in order to translate developments in research and technology into new or improved products. DTI's agro-tech services include field trials; tests of new products and technologies; software development; implementation of new technologies; biorefinery; quality control; and pathological analyses, among others.

The Institute is an independent, not-for-profit organisation. DTI's revenue comes from:

- **Commercial activities:** 60.5%
- **R&D activities:** 26.2%
- **Performance contract activities:** 13.3% (performance contract funds come from the Danish Ministry of Higher Education and Science)

▪ Luxembourg Institute of Science and Technology (LIST) – Luxembourg

LIST is a public research centre with extensive international collaboration. Agro-tech services are provided through the Environmental Research and Technology Platform. These services cover a broad range of innovation functions, from new agriculture technologies development and climate change impact studies, to different types of chemical analyses and advice for compliance with regulations. LIST's main clients are agri-food industries, pharmaceutical companies, biotech companies, water agencies, municipalities, universities and other research centres.

In terms of funding, the following revenue streams were reported for the year 2016:

- **Approximate total budget:** EUR 64 million (USD 78.6 million)
- **Contract research:** EUR 10.5 million (USD 12.9 million)
- **Competitive research:** EUR 14.5 million (USD 17.8 million)

▪ International Centre for Tropical Agriculture (CIAT) – Colombia

CIAT is an independent, non-profit research organisation with headquarters based in Cali, Colombia. It was founded in 1967, with the aim of addressing poverty and hunger in tropical contexts, through increasing agriculture productivity. The Centre's expertise is in agriculture. Its research is divided into three main areas: agrobiodiversity; decision and policy analysis; and soils and landscapes for sustainability.

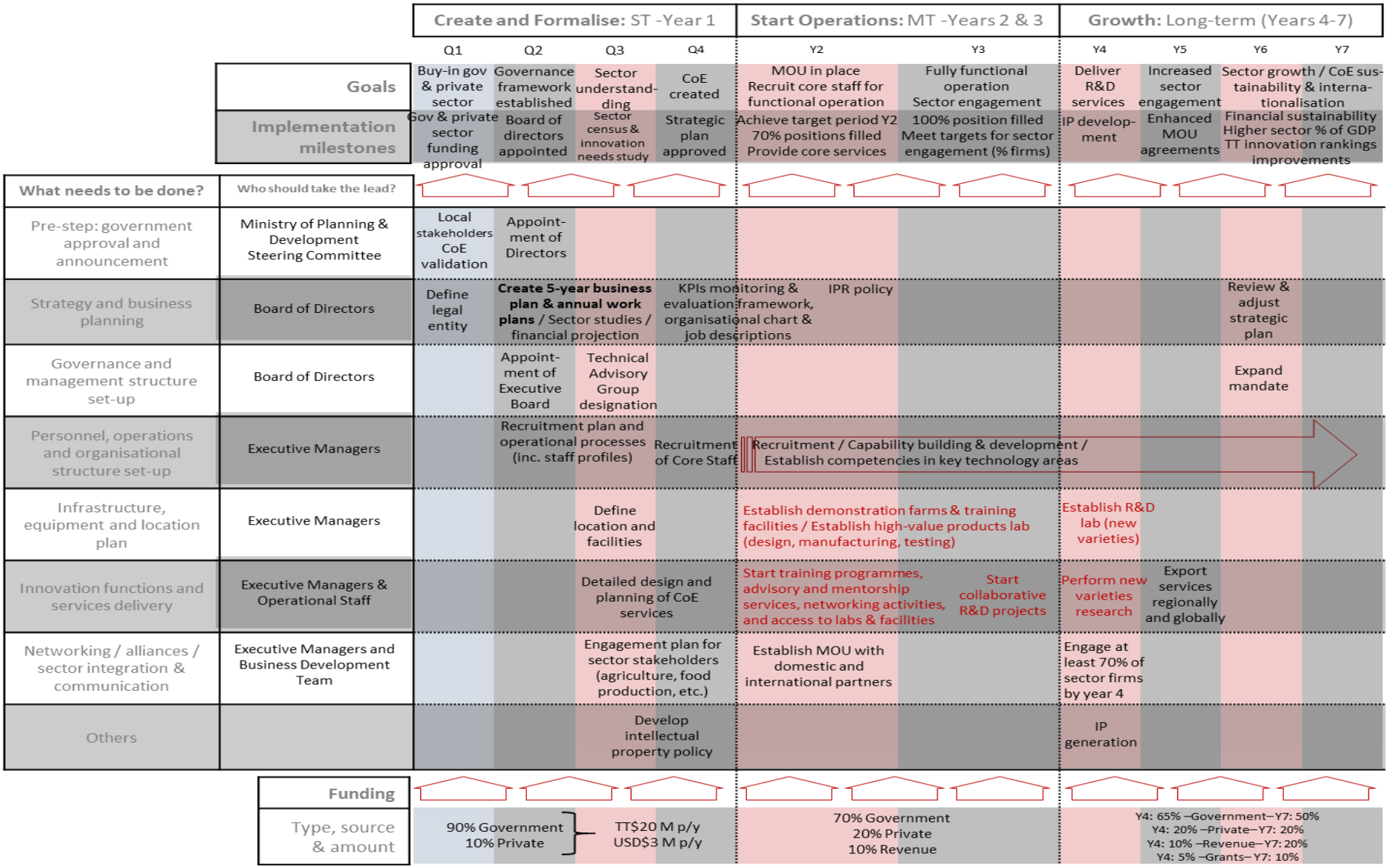
CIAT holds a gene bank of the world's largest collections of beans, cassava and tropical forages.

In terms of funding, in **2017 CIAT's revenue** summed **USD 84.5 million**, mainly from CGIAR's **multi-donors funds and bilateral agreements**. Some of CIAT's donors include: the Colombian government, the European Commission, Bill and Melinda Gates and IFAD.

Sources:

- DTI (2018). *Who We Are*; LIST (2017). Annual Report 2016; CIAT (2018). CIAT in review 2017-2018. Building a Sustainable Food Future.

FIGURE 16: COE IN HIGH-VALUE AGRICULTURAL PRODUCTS – FUNDING STRATEGY AND RESOURCING ROADMAP



7

ENERGY ENGINEERING SERVICES: CENTRE SPECIFICATION

Where are we? Sectoral context and innovation challenges

Where do we want to go? Centre's mission and development vision

How can we get there? Centre's activities, outputs, outcomes and KPIs

Other operational considerations: funding strategy and resourcing

7.1 Where are we?
Sectoral context and innovation challenges

Sectoral landscape

The energy sector is the main contributor to Trinidad and Tobago's economy, accounting for 35% of GDP in 2016. Although dominated by oil and gas, with most of the resources directed to exploration, production and refining activities, the exploitation of oil and gas reserves has also allowed for the development of downstream industries, as well as manufacturing activities. The energy sector value chain is today composed of the following main sub-sectors: downstream petrochemicals (e.g. methanol, ammonia, urea); energy services (e.g. ocean towing, heavy lift barge transportation, logistics, engineering services); manufacturing (e.g. moulding compounds, laminates, adhesives, plasticisers); and renewable energy (e.g. solar, wind).

Given the maturity of the energy sector in the country and its economic importance, accumulated expertise in energy engineering services could be exploited to develop a sustainable industry operating in the global marketplace, generating sustainable jobs and foreign exchange for Trinidad and Tobago.

Innovation challenges

Although the Energy Engineering Services sector is one of the most sophisticated sectors in TT, discussions with local stakeholders indicate that only around 25% of firms can be considered moderately innovative (Figure 17), while roughly 70% of firms could be considered non-innovative, and less than 5% can be considered innovative firms.

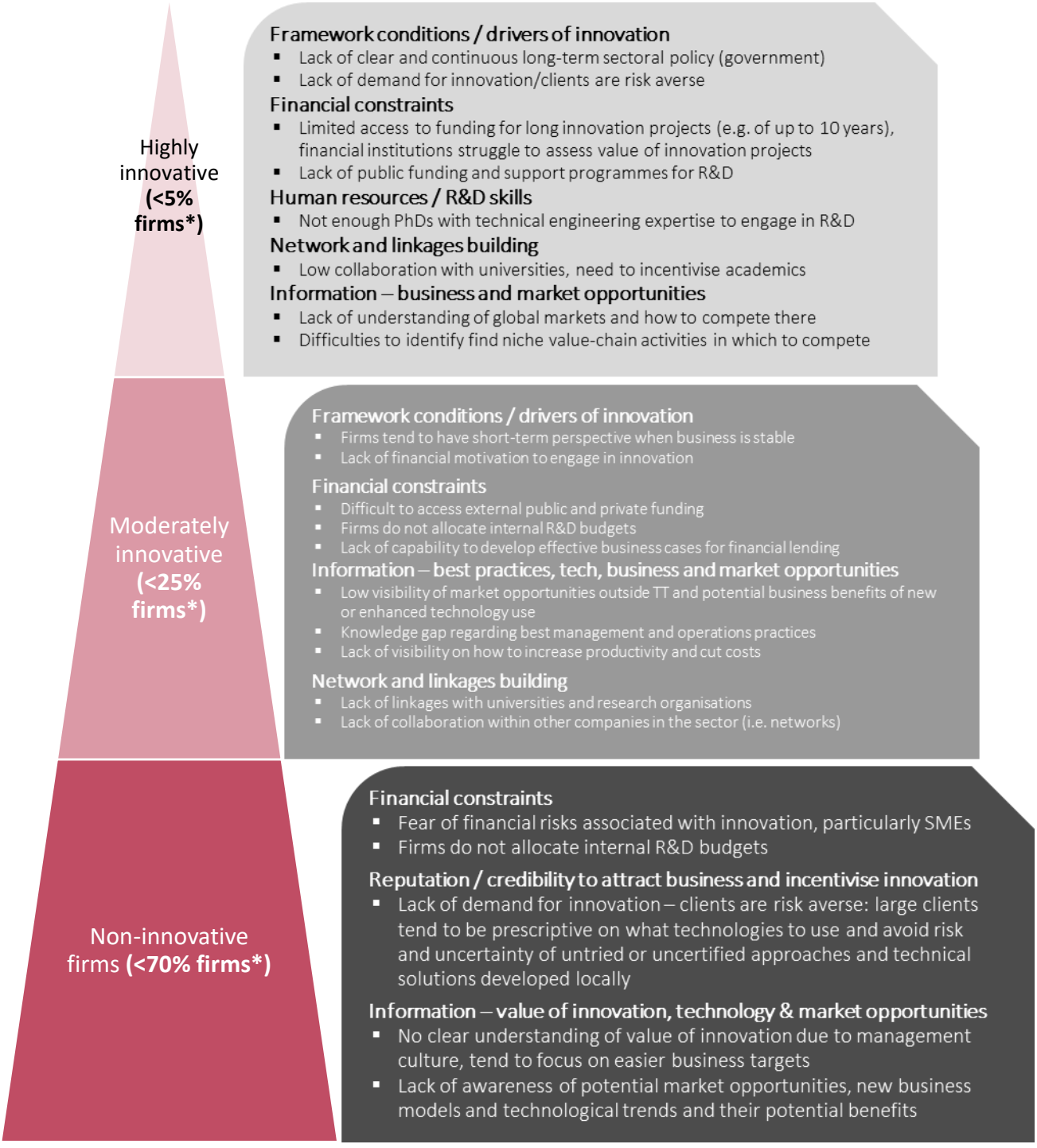
Overall, firms at all innovation levels report financial constraints as an important barrier to becoming more innovative. In particular, limited access to public and private funding to support innovation projects, as well as a chronic lack of internal R&D budgets and fear of the financial risks associated with innovation, are common financial constraints, especially for SMEs. Furthermore, firms struggle to understand the value of innovation because of existing management culture and inertia, which means they tend to focus on easier business targets. A lack of awareness of potential market opportunities, new business models and technological trends and their potential benefits was mentioned as a considerable barrier to innovation.

Other reported barriers include the low number of PhD graduates that exist in TT, which limits firms' potential to carry out high-level innovation projects, together with weak linkages with universities and research organisations. In addition, there is a perception that local firms have a lower innovation credibility and reputation, which results in clients avoiding the risk and uncertainty of new or untried and technical solutions developed locally.

Table 4: TT's Energy Engineering Services SWOT analysis

Strengths	Weaknesses
• Geographical proximity to key markets in North, Central and South America, including shared time zone. • Mature and well-established energy industry, including some innovative firms. • Workforce with technical and/or vocational skills. • Existing linkages with universities for training, including internship/trainee programmes for university students.	• Access to finance and venture capital to foster innovation is an enduring problem in the sector, especially for SMEs. • Linkages within and across energy sector value chain(s) not fully developed. • Low level of investment in R&D.
Opportunities	**Threats**
• Emerging opportunities in oil and gas (e.g. Guyana, Surinam, Colombia, Venezuela, Ghana). • Strengthening linkages with other economic sectors. • Potential for regional hub.	• Increasing global competition. • Changing global market and oil prices. • Advent of renewable energy and alternative fuels.

FIGURE 17: KEY INNOVATION NEEDS/CHALLENGES (ENERGY SERVICES)



*As reported by workshop participants.

Definitions:

- Highly innovative: Actively engaged in innovation and R&D / Has in-house R&D and/or innovation capabilities (e.g. skilled personnel and/or equipment) / Purchases R&D and innovation services from external organisations.
- Moderately innovative: Motivated to engage in innovation but lacking resources / Might have incipient in-house R&D and innovation capabilities / Might engage in minor R&D and/or innovation projects with external organisations.
- Non-innovative: Lacking resources to engage in innovation / No in-house R&D and/or innovation capabilities / No external R&D and/or innovation projects.

7.2 Where do we want to go?
Centre's mission and development vision

The stakeholders who were consulted agreed on the existence of key accumulated expertise in the Energy Engineering Services sector that could be exploited to develop a sustainable industry operating in the global marketplace, generating sustainable jobs and foreign exchange.

A vision for the development of this sector would first involve the generation of awareness on the value of innovation through intelligence/information provision and expert consultancy advice. This would focus on risk analysis and mitigation expertise, as well as reserve/resource analysis. The Centre is also expected to play a key role in the development of network linkages and industrial dialogue in the short term.

Moving forwards, the Centre is expected to support the financial and technical de-risking of innovation by providing access to expertise, facilities, training and basic R&D projects for local firms. The aim of medium-term goals is to expand the Centre's specialisation areas into data science (e.g. for processes, seismic subsurface and analysis technology), completion technology and asset restoration, and fabrication technology related to rig engineering and analysis, design and specialised welding.

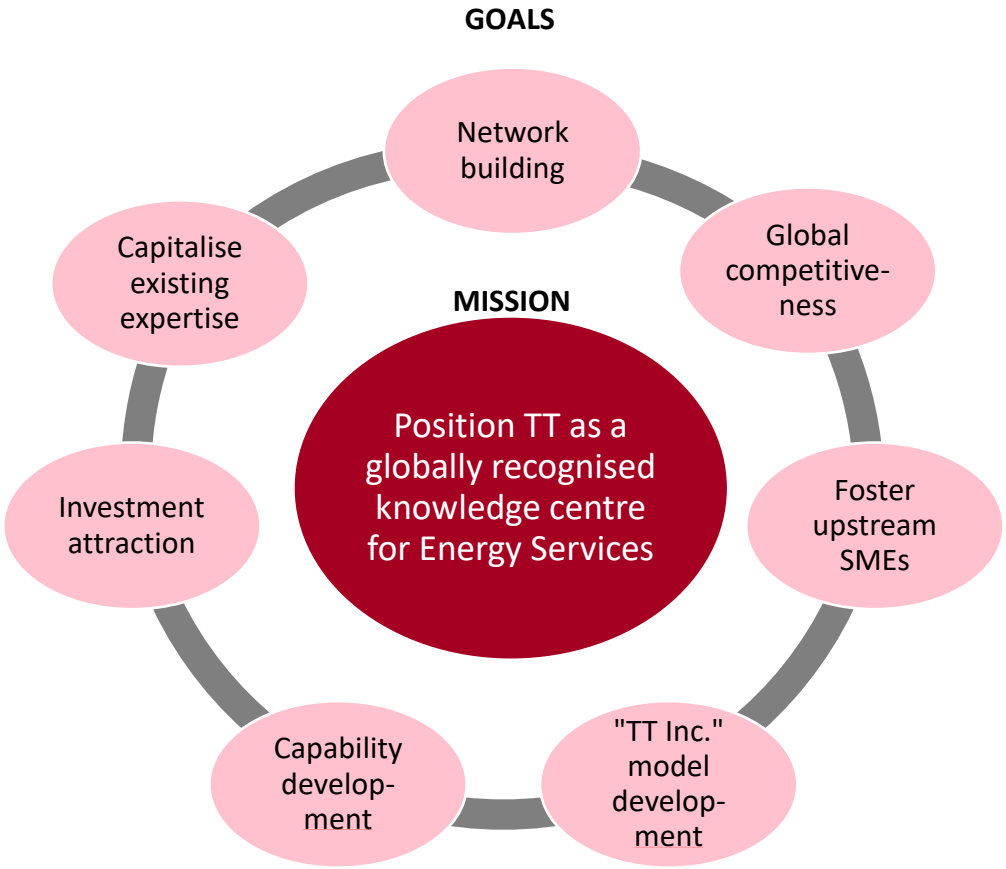
The aim of long-term goals is to establish T&T as a respected global brand for Energy Engineering Services, offering services for the international market and seeing the Centre's specialisation areas expanding into virtual plant operations and optimisation technologies, as well as sub-sea and deep-water supply-chain opportunities.

A key goal for this Centre would be not only to convene existing national expertise in Energy Services to support the development of a sustainable and international industry, but also to help de-risk innovation and build R&D capabilities within the private sector. In this regard, the Centre is expected to carry out applied R&D projects in the medium and long terms, bringing together existing expertise in the country and carrying out a financial de-risking function by providing access to specialised research facilities, equipment and testing services.

In addition to technical competencies, the Centre is expected to fulfil innovation functions beyond R&D promotion, and therefore it is expected to develop non-technical capabilities related to network and institution building for knowledge diffusion (e.g. knowledge around technical standards, certifications and regulations, ability to promote industrial dialogue and network building, capabilities for performing technology and market foresight analyses).

Furthermore, the Centre is also expected to carry out a competence development function, including vocational (technical) and PhD programmes, in collaboration with other local institutions. These programmes would be based around the specialisation areas of the Centre, as shown in Figure 18, which summarises the core mission, goals and development vision for the Centre of Excellence in Energy Engineering Services.

FIGURE 18: COE IN ENERGY ENGINEERING SERVICES – MISSION AND DEVELOPMENT VISION



CENTRE DEVELOPMENT VISION

	Short term	Medium term	Long term
CoE Narrative	• Convene existing national expertise in Energy Services to support the development of a sustainable industry operating in the global marketplace by supporting inter- and intra-sectoral network linkages development • Generate awareness of the value of innovation through intelligence provision and consultancy advice	• Support financial and technical de-risking of innovation by providing access to expertise, facilities, training and basic R&D projects for local firms	• Support the establishment of TT as a respected global brand for Energy Services and the internationalisation of local firms • Develop CoE services for the international market
Specialisation Areas	• Future skills needs • Risk taking (analysis / mitigation) • Reserve and resources analysis (need for depleting / end of life fields: balance supply and demand)	• Data science (Processes, seismic, subsurface, analysis technology) • Completion technology and asset restoration • Fabrication excellence (Manufacturing methods, Rig engineering and analysis, Design, Specialised welding)	• Sub-sea, deep water, supply chain opportunities • Virtual plant operation / optimisation technologies
Competencies	• Sector intelligence gathering, benchmarking of best practices, technology foresight • Information and advice provision regarding technological possibilities, their economic value and market opportunities • Networking / cluster building activities	• Basic R&D projects • Provision of technical expertise and advice in specialisation areas • Access to specialised research facilities, equipment and testing services • Competence development (training)	• Advanced R&D projects • IP management and technology commercialisation advice • Certification standards for credibility and market access • Inputs for sectoral policy design

7.3 How can we get there?
Services, outputs, outcomes and KPIs

A Centre of Excellence in Energy Engineering Services is expected to address the innovation needs of firms operating in this sector, recognising that different types of firm have different types of innovation needs and challenges, as summarised in Figure 17. Based on this evidence, and informed by the international case studies analysed in this project (Appendix A), this section suggests a range of innovation services that could be offered by this Centre to help companies across all innovation levels to engage in research and innovation (Figure 19).

Although it is recognised that a certain level of service differentiation is required for distinct types of company, the aim is that all services offered by this Centre could be available for all types of company, if required. For example, while collaborative PhD programmes could be more relevant for highly innovative firms, these programmes could also be available for less sophisticated firms if required.

A logic model (Figure 20) has been designed to outline how inputs and activities from this Centre are linked to its stated mission and goals (impacts). Although these relationships are not linear, by presenting relationships between the inputs and activities of the Centre (i.e. services), outputs (such as technology adoption by firms) and outcomes (such as business performance improvement), the logic model guides the design of monitoring and evaluation activities and key performance indicators.

Measuring the impact of new Centres of Excellence is an essential step to understanding how these Centres perform and how successful they are in achieving their stated missions and goals. Vigorous impact measurement can enable Centres of Excellence to guide their strategic direction and operations to understand how they can address innovation challenges in specific areas and drive economic growth in TT. In this regard, a set of key performance indicators is suggested in this section to evaluate not only the operation of a Centre of Excellence in Energy Engineering Services but also its potential impact (Figure 21).

Successful performance evaluation of this Centre needs to be complemented with consistently defined and collected data across all of its activities, to enable evaluators to implement the proposed KPIs.

Box 5: FORCE Technology – Denmark

FORCE Technology is a Danish, non-profit research organisation. It is part of the GTS Advanced Technology Group, a network of seven research and technology organisations. In the field of oil and gas, FORCE Technology **specialises in areas such as d**rilling and workover, fixed platforms, floating platforms, infrastructure and pipelines, onshore facilities and support vessels.

- Services

FORCE Technology's services cover a wide range of activities, including, for example: concept studies in structural design and engineering; corrosion modelling; hazard engineering assessment; weld technical consultancy; gas explosion assessment; equipment condition assessment; and advanced subsea inspection.

- Example key performance indicators (2016)
  - More than 9,700 customers.
  - More than 5,000 course participants.
  - More than 35 new R&D projects.
  - More than 100 business projects.

Sources: FORCE Technology (2017). Annual Report 2016.

FIGURE 19: COE IN ENERGY ENGINEERING SERVICES – SUGGESTED SERVICES

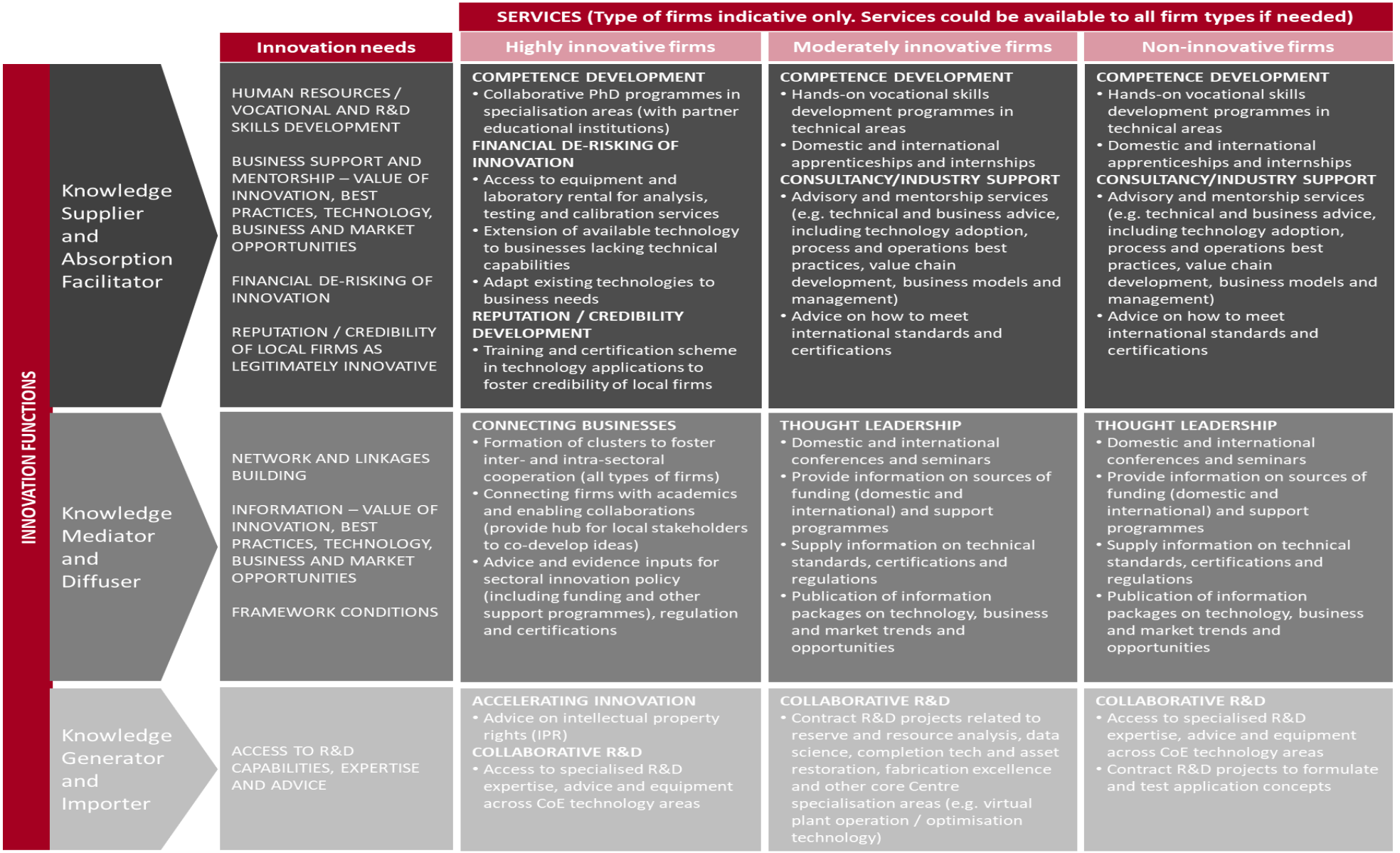


FIGURE 20: COE IN ENERGY ENGINEERING SERVICES – SUGGESTED LOGIC MODEL

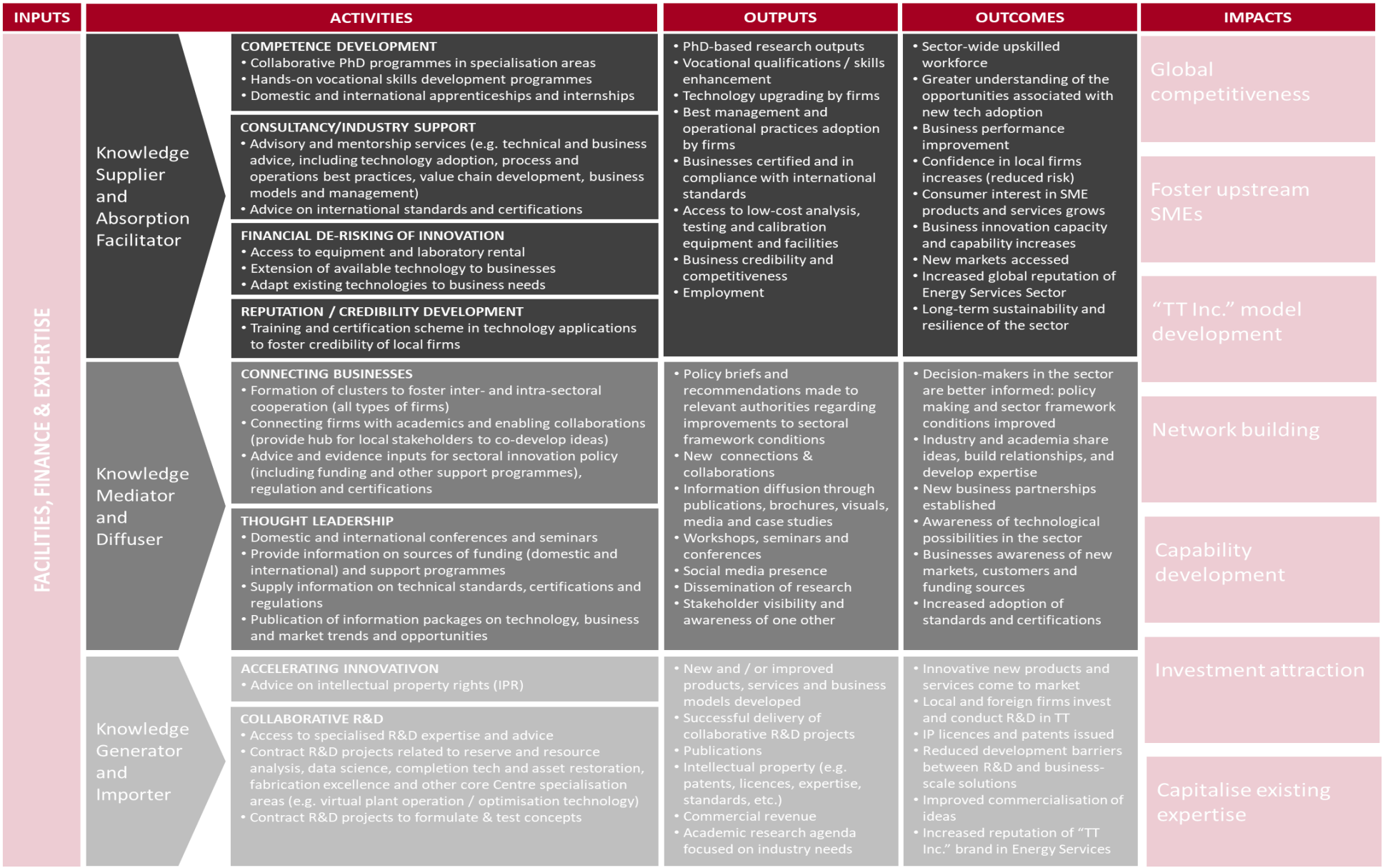


FIGURE 21: COE IN ENERGY ENGINEERING SERVICES – SUGGESTED KEY PERFORMANCE INDICATORS

		KEY PERFORMANCE INDICATORS (KPIs) AND THEIR START PERIOD		
ACTIVITIES	**TYPE OF INDICATOR**	**SHORT TERM**	**MEDIUM TERM**	**LONG TERM**
COMPETENCE DEVELOPMENT FINANCIAL DE-RISKING OF INNOVATION CONSULTANCY/ INDUSTRY SUPPORT REPUTATION / CREDIBILITY DEVELOPMENT	**DEVELOPMENT OF AN ADVANCED WORKFORCE AND INTERNATIONAL SECTOR BRAND**	• Number of staff completing vocational and business skills development programmes, internships and apprenticeships • Number of PhDs produced • Utilisation of testing facilities / equipment • New technologies and practices implemented (case studies)	• New technologies and practices implemented (case studies) • Utilisation of testing facilities / equipment • Number of teachers or trainers participating in Centre-led training • Number of consultancy/advisory services provided • Number of workers completing a Centre-led technology certification	• Number of expert advisors / consultants participating in Centre-led advisory and mentorship services • Number of local firms certified under new CoE technology certification schemes
CONNECTING BUSINESSES THOUGHT LEADERSHIP	**IMPACT ON ENERGY SERVICES SECTOR COHESION AND ABILITY TO CONVENE EXISTING EXPERTISE**	• Number and diversity of stakeholders engaged and connected (industry, academia, government) • Number of SMEs engaged and connected • Number of workshops, seminars and conferences organised	• Number of policy briefs and other evidence inputs produced for government stakeholders • Number of dissemination publications produced • Usage or access data to open publications	• Case studies of policy recommendations enacted by government • Case studies of successful linkages and network building examples, including communities of practice
ACCELERATING INNOVATION COLLABORATIVE R&D	**TECHNOLOGY ADVANCEMENT**	• Number of expert contributors / researchers participating in Centre-led R&D services	• Number and value of R&D and demonstration projects	• Percentage of projects meeting key technical objectives • Number and value of IP products produced and licenced
IMPACT AND INDUSTRY VALUE		• Success stories and case studies • Total number and diversity of client companies engaged (by innovation level)	• Level and quality of co-investment by private sector • Total number of client companies retained by innovation-level (returning business) • Number of jobs created and retained	• Number of Centre R&D projects reaching commercial production • Number of spin-off companies created • Number of companies moving from non-innovative to moderately innovative and highly innovative • Reputation of "TT Inc." brand (surveys)

7.4 Other operational considerations: Funding, resourcing and implementation planning

The successful implementation and operation of Centres of Excellence require careful consideration and definition of fundamental operational aspects such as a Centre's funding and resourcing strategies, in addition to clear plans for the establishment, consolidation and growth of these Centres in the short, medium and long terms.

Funding strategy

As suggested by Hauser (2010),[16] both the level and type of funding vary significantly between distinct types of Centres of Excellence. However, the sources of funding can be broadly categorised as:

- **Core funding from national and regional government:** not always linked to specific activities or outcomes. A performance management framework is often in place for this investment.
- **Research grants and contracts from public bodies:** in most instances these are won on a competitive basis.
- **Research contracts from the private sector and revenue from services:** usually competitively tendered.
- **Additional income sources:** member fees, fee-for-service activities, intellectual property royalties, endowments, etc.

Based on a review of international practices, evaluation of the current Energy Services Sector context in TT, and consultation with local stakeholders, this study suggests a funding portfolio that includes strong core funding from the government during its first year (80%), reduced to 60% in years 2–3, 45% by the fourth year and 10% by year 7. It is envisaged that this would allow the Centre to establish its core competencies and develop a viable portfolio of services, which could gradually provide a stable revenue stream to substitute core government funding by year 7, as shown in Figure 22.

Resourcing and implementation planning

An "implementation roadmap template" was designed by the consulting team (Figure 23) to identify the key actions required for the structured implementation of this CoE, including funding and resourcing targets, as well as other operational matters related to the creation, consolidation and growth of the Centre. The roadmap shown in Figure 23 was completed by the consulting team and it is recommended that it should be validated by local stakeholders prior to execution (a task that is outside the scope of this project).

The roadmap considers key implementation actions across a seven-year period for:

- Government approval and announcement;
- Strategy and business planning;
- Governance and management structure set-up;
- Personnel, operations and organisational structure set-up;
- Infrastructure, equipment and location planning;
- Innovation services delivery;
- Networking/alliances/sector integration and communication.

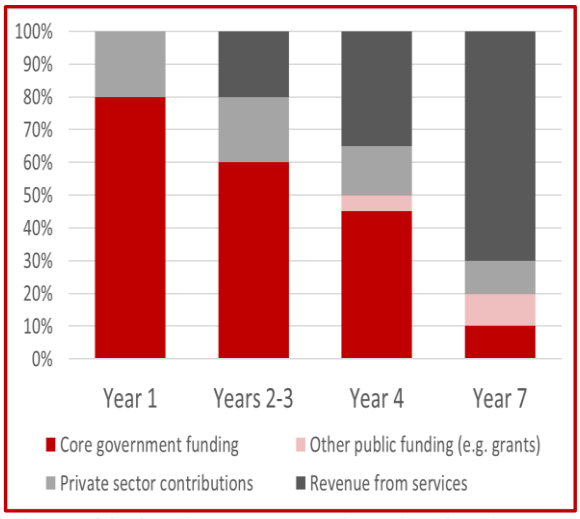


Figure 22: CoE in Energy Engineering Services – funding sources

[16] Hauser (2010).

Box 6: Funding portfolios – international examples

Examples of funding portfolios from three distinct international organisations are given below. Different approaches are visible from this data, highlighting the need for every Centre of Excellence to adapt its funding portfolio configuration to its particular national/local context, missions and objectives.

▪ Commonwealth Scientific and Industrial Research Organisation (CSIRO) – Australia

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is a public research institute with the mission to conduct research and translate new knowledge and technologies into business competiveness and social welfare. In the field of oil and gas, CSIRO conducts research and development and provides diffusion and deployment of knowledge services, such as software and systems design; strategy and foresight analyses; analyses of fluid inclusions; fire testing services; and calibration and certification services; among many others.

The annual revenue of CSIRO in 2016–17 amounted to AUD 1,271.3 million (USD 975 million). The sources of this revenue were:

- **Government:** 78%
- **Australian private sector:** 7.1%
- **Overseas entities and international:** 6.6%
- **Intellectual property (royalty and licence revenues):** 4.2%
- **Rural industry R&D corporations:** 3.2%
- **Cooperative research centres:** 1%

▪ FORCE Technology – Denmark

FORCE Technology is a Danish, non-profit research organisation. It is part of the GTS Advanced Technology Group, a network of seven research and technology organisations. In the field of oil and gas, Force Technology provides a wide range of services: concept development; verification of compliance with standards; and a variety of tests, analyses and monitoring services, among several others.

In 2016 FORCE Technology reported a DKK 1,376,493 million (USD 227,109 million) turnover, from the following sources:

- **Danish commercial turnover:** 40.1%
- **Foreign commercial turnover:** 52.2%
- **Technology transfers with the Ministry of Higher Education and Science:** 5.9%
- **Other research and development turnover:** 1.6%

▪ IFP Energies Nouvelles (IFPEN) – France

IFP Energies nouvelles (IFPEN) is a public research centre established in France in 1944. IFPEN works alongside major industrial players in the field of oil and gas, such as CGG, Petrobras and Repsol. Oil and gas R&D focus on geosciences simulation, oil recovery, water cycle management, petrochemical intermediates and natural gas conversion. IFPEN's subsidiaries provide knowledge deployment services, such as exploration and field studies. An integral part of IFPEN is its graduate engineering school, the IFP School, which offers training and postgraduate programmes.

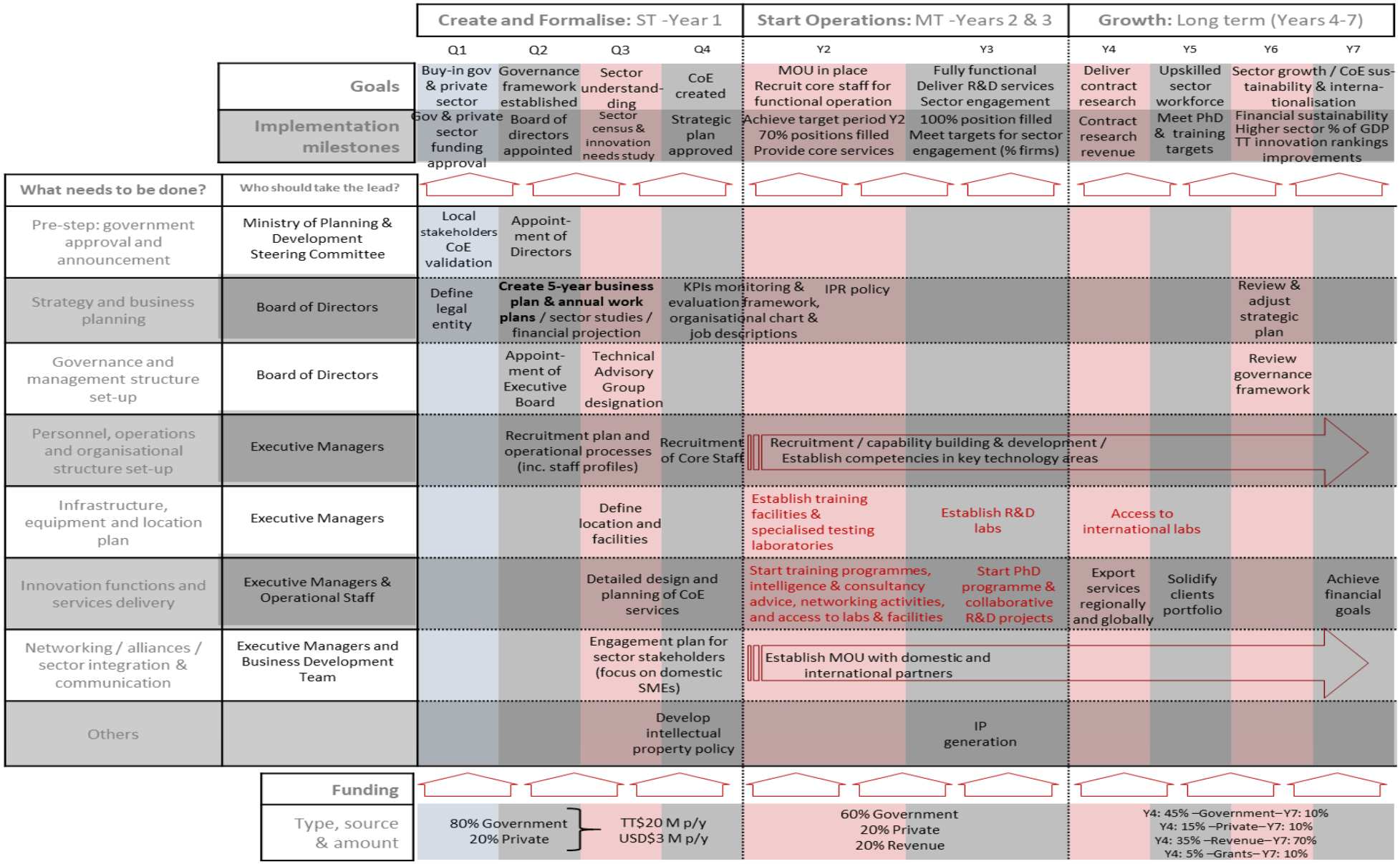
IFPEN is funded both by a state budget and through its own resources, provided by industrial partners. In terms of funding, IFPEN reported the following figures for 2016:

- **2016 budget:** EUR 280.8 million (USD 345 million)
- **Industrial partners (e.g. contract research and other services):** 50% of IFPEN's total budget in 2016

Sources:

- CSIRO (2017). Annual report 2016-2017; FORCE Technology (2017). Annual Report 2016; IFPEN (2018), In brief.

FIGURE 23: COE IN ENERGY ENGINEERING SERVICES – FUNDING STRATEGY AND RESOURCING ROADMAP



8

MARITIME SERVICES: CENTRE SPECIFICATION

Where are we? Sectoral context and innovation challenges

Where do we want to go? Centre's mission and development vision

How can we get there? Centre's activities, outputs, outcomes and KPIs

Other operational considerations: funding strategy and resourcing

8.1 Where are we?
Sectoral context and innovation challenges

Sectoral landscape

The commercial maritime sector of Trinidad and Tobago has been developed partly as an ancillary activity of the oil sector, given the need for exploration activities to have an efficient maritime presence. The sector has also benefited from a growing cargo and transhipment trade, as long as TT has become a major sub-hub for trade among smaller Caribbean islands. Today, the maritime industry of Trinidad and Tobago is composed of more than 350 companies mainly involved in the following sub-sectors: port operations; ship repair and dry docking; and marine services (i.e. off-shore bulk transhipment, bunkering and cold stacking).

In terms of infrastructure, the country is home to two international container ports, one LNG terminal, one bauxite transhipment facility, one petrochemicals loading port, and one petroleum terminal. Given its strategic geographical location, located below the hurricane belt in the Caribbean Sea, today over 63 shipping lines utilise ports in Trinidad and Tobago. The country also presents a well-developed yachting industry, with approximately 180 companies offering service repairs, maintenance, storage and ancillary services to transient yachts.

Innovation challenges

When asked about the most common barriers to innovation they face in their daily operations, local firms strongly emphasised issues related to framework conditions that constrain the efficient operation of the sector as a whole. In particular, issues around legislation, norms and regulation were mentioned as not providing enabling conditions for the sector as a whole, together with a lack of long-term policy continuity, a fragmented sectoral governance and a low level of public funding and incentives available to support innovation.

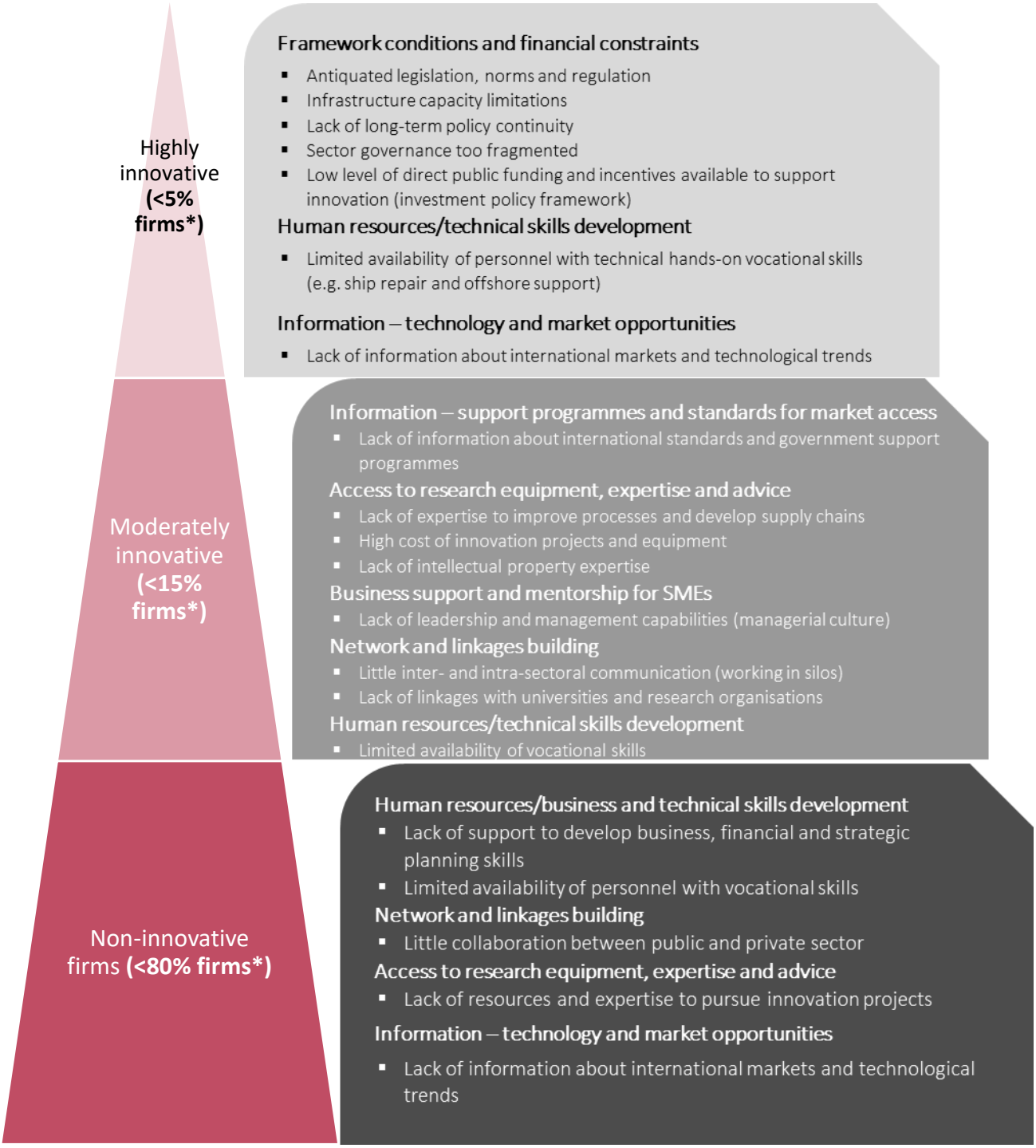
Beyond framework conditions, a common challenge faced by firms of distinct innovation levels is the availability of skilled workers, in terms of both technical and vocational skills, and business, financial and strategic planning competencies. A lack of awareness about technology and market trends relevant to the sector, as well as existing support programmes for firms in the sector, were also mentioned by distinct types of firm, particularly in relation to business support and mentorship for SMEs.

In terms of more sophisticated research activities, an overall lack of expertise on process improvement, supply chain development and intellectual property development, in addition to the high cost of innovation projects, were mentioned as important barriers. Other challenges include the limited collaboration that exists between public and private sector institutions, including a lack of linkages with universities and research organisations, and linkages with other sectors that might possess relevant expertise such as manufacturing.

Table 5: TT's Maritime sector SWOT analysis

Strengths	Weaknesses
• Strategic location (below the hurricane belt). • Manufacturing sector supporting the maritime sector. • Presence of two major ports. • Well-developed yachting industry.	• Maritime/logistic infrastructure. • High level of bureaucracy in the management of the sector. • Fragmented sector governance.
Opportunities	**Threats**
• Ship repair and dry docking facility. • Yachting industry. • Offshore bulk trans-shipment. • Marinas and ship storage facilities. • Port operations.	• New generation unwilling to enter into a career in the sector. • Inadequate/old infrastructure. • Both ports are constrained by their location (i.e. difficulties for further expansion).

FIGURE 24: KEY INNOVATION NEEDS/CHALLENGES (MARITIME SERVICES)



*As reported by workshop participants.

Definitions:

- Highly innovative: Actively engaged in innovation and R&D / Has in-house R&D and/or innovation capabilities (e.g. skilled personnel and/or equipment) / Purchases R&D and innovation services from external organisations.
- Moderately innovative: Motivated to engage in innovation but lacking resources / Might have incipient in-house R&D and innovation capabilities / Might engage in minor R&D and/or innovation projects with external organisations.
- Non-innovative: Lacking resources to engage in innovation / No in-house R&D and/or innovation capabilities / No external R&D and/or innovation projects.

8.2 Where do we want to go?
Centre's mission and development vision

The stakeholders who were consulted perceive that the development of the maritime sector could lead to the generation of good-quality jobs and foreign exchange, building on the natural competitive advantage of T&T's geographical location and the growing fleet of vessels that will need these types of service and technology in the Caribbean region.

From the evidence provided in Figure 24, there is agreement among consulted stakeholders that a Centre in this area could play a key role in helping to generate an enabling environment for firms in the sector by providing policy advice based on CoE specialisation areas and performing a sector coordination and networking function. In addition, a perceived sector priority in the short term would be for the Centre to help develop a skilled workforce by building vocational competencies around its basic specialisation areas, namely ship repair and maintenance, maritime technologies (e.g. shipping operations, shipbuilding and logistics) and port automation, among others.

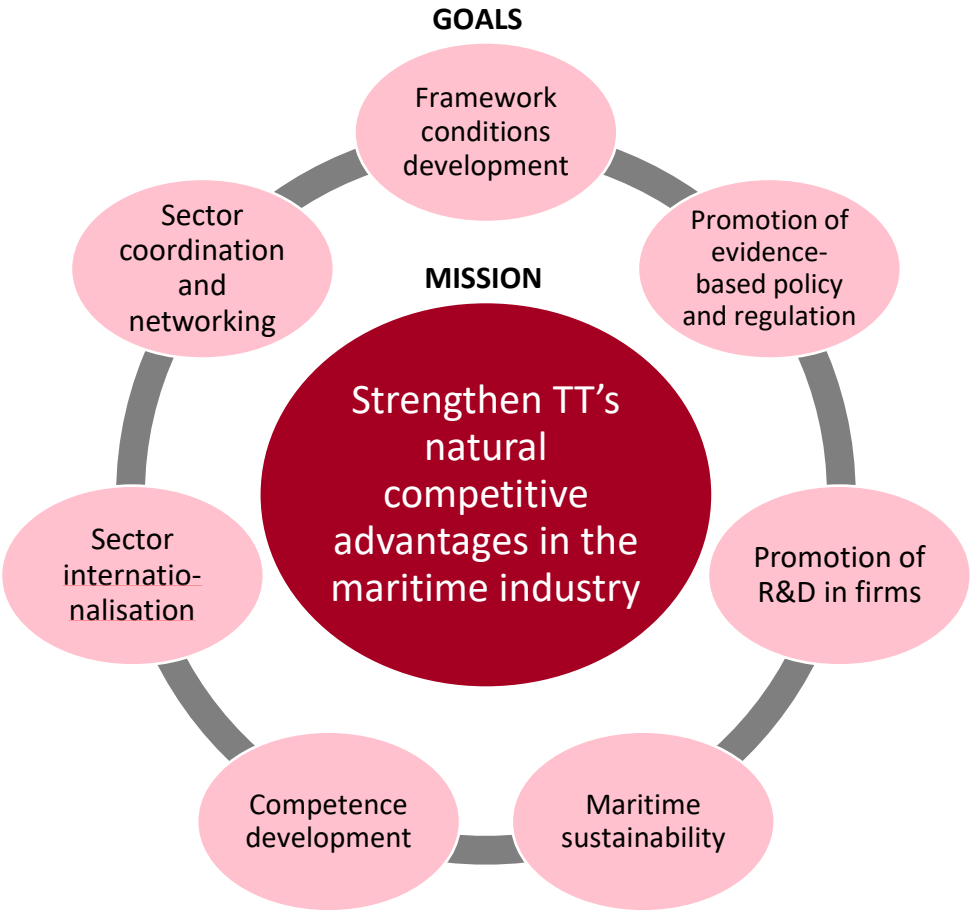
The Centre is also expected to quickly establish competencies to carry out benchmarking and foresight studies on technology and market trends, in order to provide informed advice and mentorship to firms in these areas.

The vision for this Centre would later see it expanding its range of services to address other innovation needs of key local sector stakeholders (e.g. shipping liners supply companies, freight, fuel, ICT, financial services, port infrastructure authorities, customs, logistics/warehousing, shipping and yachting associations), including basic R&D and training in logistics (e.g. ICT enabled tools), maritime environment and traffic analysis (cruise vs tourism). Further mentorship and advice provision on business incubation would help to nurture a new generation of technology-based firms in the sector.

In the long term, the Centre's vision involved the development of services for the international market, promoting linkages with the local and international energy and energy logistics sectors. It is also expected that advanced applied R&D capabilities in new technologies such as alternative fuels and autonomous ships will be developed to foster the knowledge-generation diffusion and deployment of advanced maritime technologies in TT.

Figure 25 summarises the core mission, goals and development vision for the Centre of Excellence in Maritime Services.

FIGURE 25: COE IN MARITIME SERVICES – MISSION AND DEVELOPMENT VISION



CENTRE DEVELOPMENT VISION

	Short term	Medium term	Long term
CoE Narrative	• Help to generate an enabling environment for firms in the sector by providing policy advice based on CoE specialisation areas and performing a sector coordination and networking function • Develop capabilities required to provide technical / innovation services in basic specialisation areas	• Expand range of services to address the needs of key local sector stakeholders (e.g. shipping liners supply companies, freight, fuel, ICT, financial services, port infrastructure authorities, customs, logistics /warehousing, shipping and yachting associations, etc.)	• Develop services for international market • Promote linkages with local and international energy sector and energy logistics
Specialisation Areas	• Ship repair and maintenance • Maritime technologies (e.g. shipping operations, shipbuilding and logistics) • Port automation • Port economics and efficiency	• Logistics (e.g. ICT enabled tools) • Maritime environment • Traffic analysis (cruise vs tourism)	• Autonomous ships • Alternative fuels and associated technology
Competencies	• Inputs for sectoral policy / legislation / regulatory framework improvement • Networking / cluster building activities • Benchmarking and information provision (best international practices, technology and market foresight)	• Basic R&D projects and access to equipment and facilities • Competence development in technical and business areas • Business incubation/mentorship	• Advanced R&D projects and knowledge generation • International networking capabilities

8.3 How can we get there?
Services, outputs, outcomes and KPIs

A Centre of Excellence in Maritime Services is expected to address the innovation needs of firms operating in this sector, recognising that different types of firm have different types of innovation needs and challenges, as summarised in Figure 24. Based on this evidence, and informed by the international case studies analysed in this project (Appendix A), this section suggests a range of innovation services that could be offered by this Centre to help companies across all innovation levels to engage in research and innovation (Figure 26). Although it is recognised that a certain level of service differentiation is required for distinct types of company, the aim is that all services offered by this Centre could be available for all types of company, if required. For example, while advice on technology, business and market trends and opportunities could be more relevant for non-innovative firms, this service could also be available for more sophisticated firms if requested.

A logic model (Figure 27) has been designed to outline how inputs and activities from this Centre are linked to its stated mission and goals (impacts). Although these relationships are not linear, by presenting relationships between the inputs and activities of the Centre (i.e. services), outputs (such as workers engaged in vocational skills programmes) and outcomes (such as increased global reputation of TT's maritime sector), the logic model guides the design of monitoring and evaluation activities and key performance indicators.

Measuring the impact of new Centres of Excellence is an essential step to understanding how these Centres perform and how successful they are in achieving their stated missions and goals. Vigorous impact measurement can enable Centres of Excellence to guide their strategic direction and operations to understand how they can address innovation challenges in specific areas and drive economic growth in TT. In this regard, a set of key performance indicators is suggested in this section to evaluate not only the operation of a Centre of Excellence in Maritime Services but also its potential impact (Figure 28).

Successful performance evaluation of this Centre needs to be complemented with consistently defined and collected data across all of its activities, to enable evaluators to implement the proposed KPIs.

Box 7: Centre for Mechanical, Naval and Electrical Technology – Brazil

The Centre for Mechanical, Naval and Electrical Technology (CTMNE) is one of the 12 research centres that operate under the structure of the Instituto de Pesquisas Tecnológicas (IPT). In particular, the CTMNE provides services related to maritime technologies, from research and development, prototyping, to testing, calibration services and training. CTMNE's activities focus on: naval engineering; oceanic engineering; thermal engineering; field trials; waterways and ports; and oil equipment.

- Services

CTMNE's services cover a wide range of activities, including, for example: R&D in fuels and biofuels, reduction of emissions, energy efficiency and oceanic and naval engineering; tests for compliance with standards; failure analysis in metallic equipment and components; oceanic engineering (offshore platforms, anchorage systems, wind tunnel testing); and design of waterways, vessels and terminals.

- Example key performance indicators (2016)
  - Services provided to 3,100 companies.
  - 24 articles published in partnership with companies.
  - BRL 96.6 million (USD 28.3 million) of revenue.

Source: IPT (2017). Relatorio Annual 2016.

FIGURE 26: COE IN MARITIME SERVICES – SUGGESTED SERVICES

INNOVATION FUNCTIONS	Innovation needs	SERVICES (Type of firms indicative only. Services could be available to all firm types if needed)		
		Highly innovative firms	Moderately innovative firms	Non-innovative firms
Knowledge Supplier and Absorption Facilitator	HUMAN RESOURCES / BUSINESS AND TECHNICAL SKILLS DEVELOPMENT BUSINESS SUPPORT AND MENTORSHIP – STANDARDS, TECHNOLOGY ADOPTION, BEST PRACTICES, BUSINESS STRATEGY, MANAGEMENT AND OPERATIONS	**COMPETENCE DEVELOPMENT** • Hands-on vocational skills development programs in technical areas (e.g. ship repair and offshore support) • Domestic and international apprenticeships and internships **ACCELERATING INNOVATIVON** • Access to equipment and laboratory rental for analysis, testing and calibration services • Extension of available technology to businesses lacking technical capabilities • Adapt existing technologies to business needs	**COMPETENCE DEVELOPMENT** • Hands-on vocational skills development programmes in technical areas (e.g. ship repair and offshore support) • Domestic and international apprenticeships and internships • Skills development programmes in business, financial and strategic planning areas **CONSULTANCY/INDUSTRY SUPPORT** • Advisory and mentorship services (e.g. technical and business advice, including process improvement, value chain development, leadership, management, financial and strategic planning) • Advice on how to meet international standards and certifications	**COMPETENCE DEVELOPMENT** • Hands-on vocational skills development programmes in technical areas (e.g. ship repair and offshore support) • Skills development programmes in business, financial and strategic planning areas **CONSULTANCY/INDUSTRY SUPPORT** • Advisory and mentorship services (e.g. technical and business advice, including process improvement, value chain development, leadership, management, financial and strategic planning) • Advice on how to meet international standards and certifications
Knowledge Mediator and Diffuser	NETWORK AND LINKAGES BUILDING INFORMATION – SUPPORT PROGRAMMES, STANDARDS, TECHNOLOGY, OPERATIONS, STRATEGY, BUSINESS AND MARKET OPPORTUNITIES FRAMEWORK CONDITIONS	**ENABLING ECOSYSTEM (GOV)** • Advice for sectoral innovation policy (including funding and other support programmes), regulation, certifications and international benchmarking of best practices **CONNECTING BUSINESSES** • Formation of clusters to foster inter- and intra-sectoral cooperation (all types of firms) • Connecting firms with academics and enabling collaborations (provide hub for local stakeholders to co-develop ideas)	**THOUGHT LEADERSHIP** • Domestic and international conferences and seminars • Provide information on sources of funding (domestic and international) and support programmes • Supply information on technical standards, certifications and regulations • Publication of information packages on technology, business and market trends and opportunities	**THOUGHT LEADERSHIP** • Domestic and international conferences and seminars • Provide information on sources of funding (domestic and international) and support programmes • Supply information on technical standards, certifications and regulations • Publication of information packages on technology, business and market trends and opportunities
Knowledge Generator and Importer	ACCESS TO RESEARCH EQUIPMENT, EXPERTISE AND ADVICE	**ACCELERATING INNOVATION** • Advice on intellectual property rights (IPR) **COLLABORATIVE R&D** • Access to specialised R&D expertise, advice and equipment across CoE technology areas	**COLLABORATIVE R&D** • Contract R&D projects related to process improvement, new maritime technologies and other core Centre specialisation areas (e.g. ship repair techniques, port automation, logistics, traffic analysis, autonomous ships, alternative fuels)	**COLLABORATIVE R&D** • Access to specialised R&D expertise, advice and equipment across CoE technology areas • Contract R&D projects to formulate and test application concepts

FIGURE 27: COE IN MARITIME SERVICES – SUGGESTED LOGIC MODEL

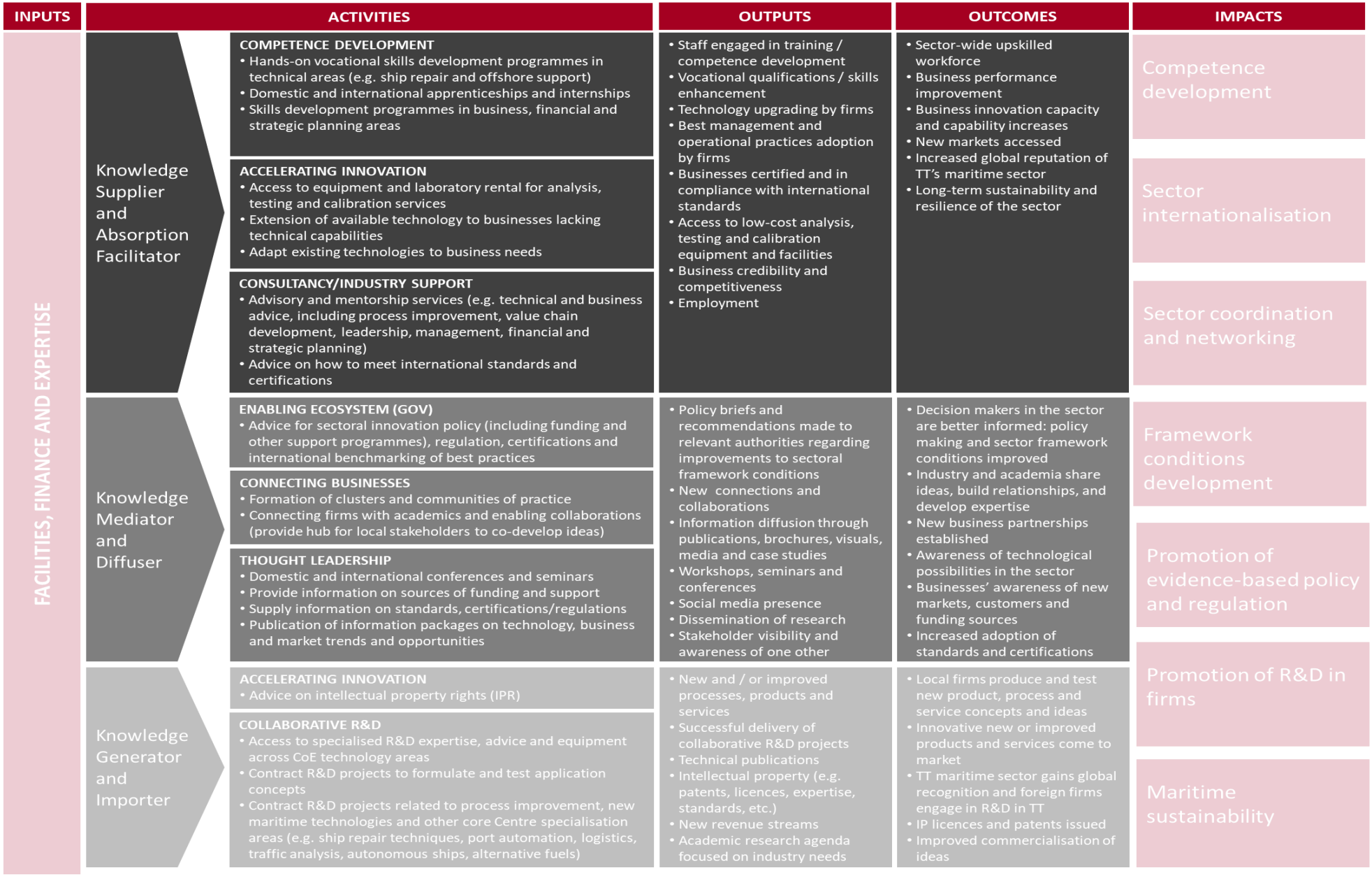


FIGURE 28: COE IN MARITIME SERVICES – SUGGESTED KEY PERFORMANCE INDICATORS

ACTIVITIES	TYPE OF INDICATOR	KEY PERFORMANCE INDICATORS (KPIs) AND THEIR START PERIOD		
		SHORT TERM	MEDIUM TERM	LONG TERM
COMPETENCE DEVELOPMENT ACCELERATING INNOVATION CONSULTANCY/ INDUSTRY SUPPORT	TT'S MARITIME SECTOR MODERNISATION AND UPSKILLING	• Number of staff completing vocational and business skills development programmes, internships and apprenticeships	• New technologies and practices implemented (case studies) • Utilisation of testing facilities / equipment • Number of teachers or trainers participating in Centre-led training • Number of consultancy/advisory services provided	• Number of expert advisors / consultants participating in Centre-led advisory and mentorship services
ENABLING ECOSYSTEM (GOV) CONNECTING BUSINESSES THOUGHT LEADERSHIP	MARITIME SECTOR FRAMEWORK CONDITIONS IMPROVEMENT AND SECTOR COHESION	• Number and diversity of stakeholders engaged and connected (industry, academia, government) • Number of SMEs engaged and connected • Number of workshops, seminars and conferences organised	• Number of policy briefs and other evidence inputs produced for government stakeholders • Number of dissemination publications produced • Usage or access data to open publications	• Number of policy recommendations enacted by government • Case studies of successful linkages and network building examples, including communities of practice
ACCELERATING INNOVATION COLLABORATIVE R&D	TECHNOLOGY ADVANCEMENT	• Number of expert contributors / researchers participating in Centre-led R&D services	• Number and value of R&D and demonstration projects	• Percentage of projects meeting key technical objectives • Number and value of IP products produced and licenced
IMPACT AND INDUSTRY VALUE		• Success stories and case studies • Total number and diversity of client companies engaged (by innovation level)	• Level and quality of co-investment by private sector • Total number of client companies retained by innovation level (returning business)	• Number of jobs created and retained • Number of Centre R&D projects reaching commercial production • Number of spin-off companies created • Number of companies moving from non-innovative to moderately innovative and highly innovative

8.4 Other operational considerations: Funding, resourcing and implementation planning

The successful implementation and operation of Centres of Excellence require careful consideration and definition of fundamental operational aspects such as a Centre's funding and resourcing strategies, in addition to clear plans for the establishment, consolidation and growth of these Centres in the short, medium and long terms.

Funding strategy

As suggested by Hauser (2010),[17] both the level and type of funding vary significantly between distinct types of Centres of Excellence. However, the sources of funding can be broadly categorised as:

- **Core funding from national and regional government:** not always linked to specific activities or outcomes. A performance management framework is often in place for this investment.
- **Research grants and contracts from public bodies:** in most instances these are won on a competitive basis.
- **Research contracts from the private sector and revenue from services:** usually competitively tendered.
- **Additional income sources:** member fees, fee-for-service activities, intellectual property royalties, endowments, etc.

Based on a review of international practices, evaluation of the current Maritime Services sector context in TT, and consultation with local stakeholders, this study suggests a funding portfolio that includes strong core funding from the government during its first year (90%), reduced to 80% in years 2–3, 55% by the fourth year and 40% by year 7 (Figure 29). As a result of the current state of development of firms in this sector, sustained public funding is considered critical to allow the Centre to establish its core competencies and guarantee its long-term operation. This is necessary to ensure that services are offered at an accessible price that would allow firms to transition from non-innovative to moderately or highly innovative in a challenging economic context.

Resourcing and implementation planning

An "implementation roadmap template" was designed by the consulting team (Figure 30) to identify the key actions required for the structured implementation of this CoE, including funding and resourcing targets, as well as other operational matters related to the creation, consolidation and growth of the Centre. The roadmap shown in Figure 30 was completed by the consulting team and it is recommended that it should be validated by local stakeholders prior to execution (a task that is outside the scope of this project).

The roadmap considers key implementation actions across a seven-year period for:

- Government approval and announcement;
- Strategy and business planning;
- Governance and management structure;
- Personnel, operations and organisational structure set-up;
- Infrastructure, equipment and location;
- Innovation services delivery;
- Networking/alliances/sector integration and communication.

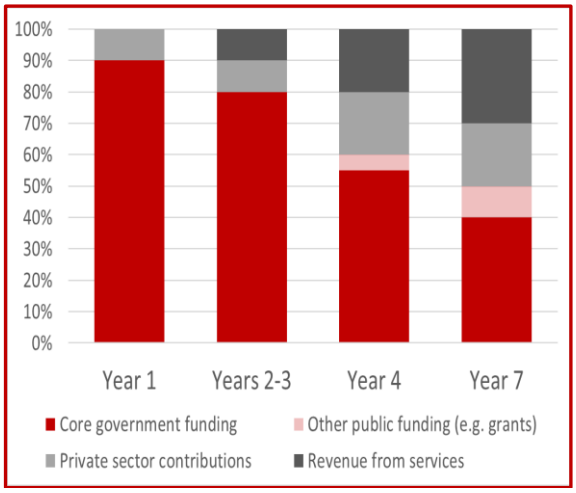


Figure 29: CoE in Maritime Services – funding sources

[17] Hauser (2010).

Box 8: Funding portfolios – international examples

Examples of funding portfolios from three distinct international organisations are given below. Different approaches are visible from this data, highlighting the need for every Centre of Excellence to adapt its funding portfolio configuration to its particular national/local context, missions and objectives.

▪ Fraunhofer Center for Maritime Logistics and Services – Germany

The Fraunhofer Center for Maritime Logistics and Services (CML) was established in 2010. It is part of the Fraunhofer Institute for Material Flow and Logistics (IML), one of the 69 Fraunhofer institutes. Within IML, CML provides innovation services in the areas of transport market assessment; sea traffic and nautical solutions; and ship and information management.

The Fraunhofer-Gesellschaft receives funding both from the **public sector (approximately 30%)** and through **contract research earnings (roughly 70%)**. The funds from the public sector come from the German Federal Ministry of Education and Research (BMBF) and the state governments **in a ratio of 90:10.**

In 2016 the Fraunhofer Institute for Material Flow and Logistics generated a revenue of EUR 20.5 million (USD 25.2 million).

▪ Centre for Mechanical, Naval and Electrical Technology (CTMNE) – Brazil

The Centre for Mechanical, Naval and Electrical Technology (CTMNE) is one of the 12 research centres that operate under the structure of the Instituto de Pesquisas Tecnológicas (IPT). In particular, the CTMNE provides services related to maritime technologies, from research and development, prototyping, to testing, calibration services and training. The CTMNE's activities focus on: naval engineering; oceanic engineering; thermal engineering; field trials; waterways and ports; and road and oil equipment.

In terms of funding, the following figures were reported for 2016:

- **56%** of the revenue was derived from the **provision of services.**
- **44%** of the resources came from the **Government of the State of São Paulo.**
- The revenue from the **provision of services** is divided as follows:
    - **32.9%** research and development
    - **27.6%** test and analyses
    - **26.8%** technical advice and studies
    - **5.7%** calibrations and inferences
    - **3.2%** reference material
    - **0.4%** educational activities

▪ Stiftelsen SINTEF – Norway

SINTEF is a non-profit, independent research organisation founded in Norway in 1950. It is one of the largest contract research institutions in Europe. In the field of "ocean space", SINTEF provides services in knowledge generation (engine, marine structures and fuel systems R&D); knowledge diffusion (software development); and knowledge deployment (analyses, tests, calibration and verification). The Institute is organised as an enterprise group consisting of seven research institutes. In addition, SINTEF Holding manages SINTEF's ownership in start-up companies and other enterprises.

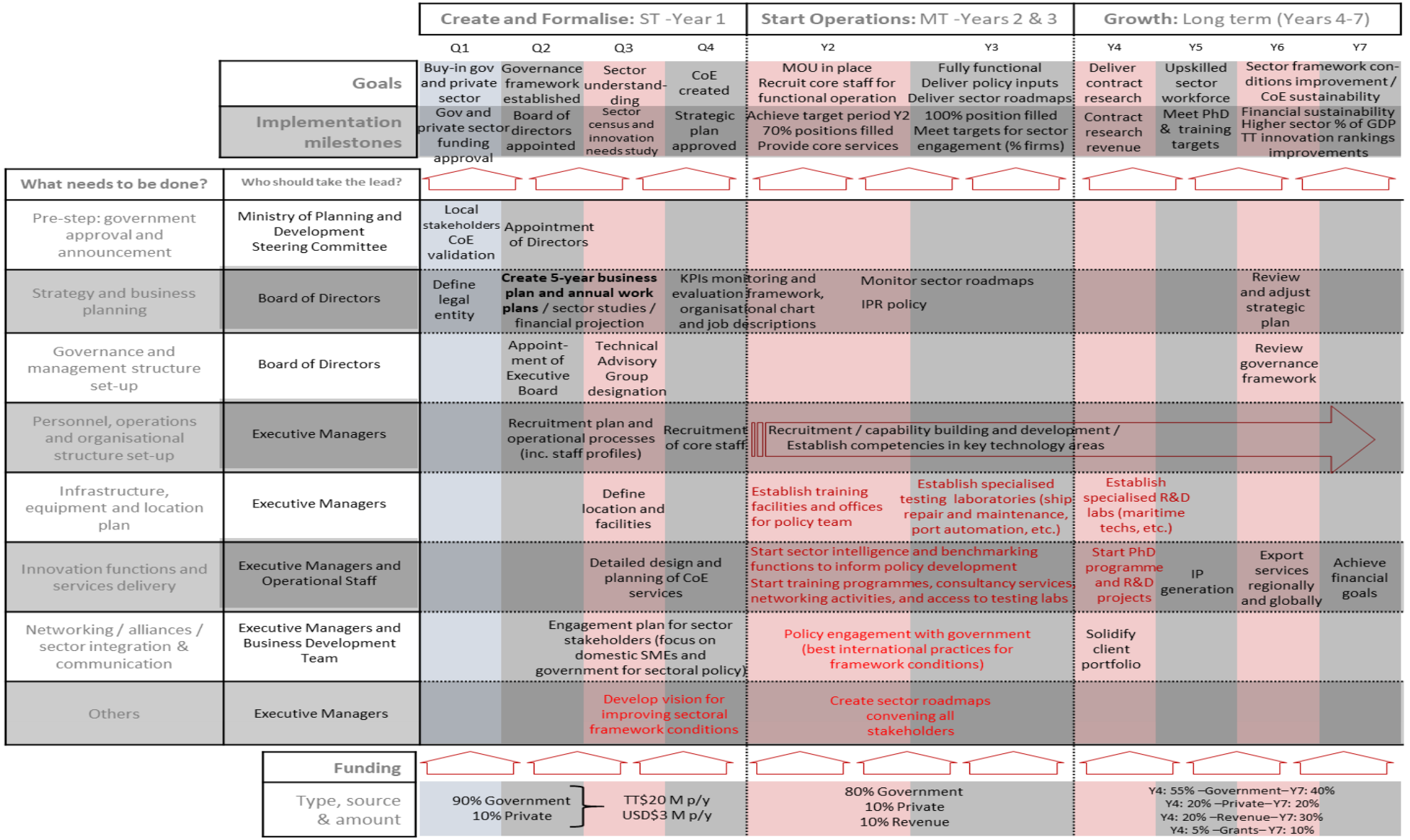
In 2016, the revenues summed NOK 3,147 million (USD 402 million). From these:

- **Project grants from the Research Council of Norway**: 23%
- **Basic grants from The Research Council of Norway:** 7%
- **Business and industry:** 41%
- **Public sector:** 10%
- **EU:** 7%
- **Other international contracts:** 7%
- **Other sources:** 5%

Sources:

- IPT (2018). Institucional; SINTEF (2017). Annual report 2016; Fraunhofer-Gesellschaft (2018). Finances; IML (2018). Research halls and laboratories.

FIGURE 30: COE IN MARITIME SERVICES – FUNDING STRATEGY AND RESOURCING ROADMAP



9

AVIATION SERVICES: CENTRE SPECIFICATION

Where are we? Sectoral context and innovation challenges

Where do we want to go? Centre's mission and development vision

How can we get there? Centre's activities, outputs, outcomes and KPIs

Other operational considerations: funding strategy and resourcing

9.1 Where are we?
Sectoral context and innovation challenges

Sectoral landscape

The history of Trinidad and Tobago's aviation sector dates back to 1939 with the British West Indian Airlines (BWIA). Today, the sector presents a specialisation in aircraft maintenance, given the presence of two national air operators, the Caribbean Airlines (CAL) and National Helicopter Services Ltd (NHSL). The sector also benefits from the presence of other private air operators and two airports. Training programmes are also being delivered by local institutions such as UTT (e.g. Caribbean Centre of Expertise in Aviation Safety – CCEAS), the Civil Aviation Authority (e.g. Civil Aviation Training Centre), and the Aviation Training Centre (ATCEN). Opportunities for further development of the sector exist in the maintenance repair and overhaul facility (MRO), which will require an effort to consolidate labour, education and public and private capital in that direction.[18]

Innovation challenges

The development of a successful Aviation Services sector in TT would require not only the promotion of new firms in aviation services but also the diversification of existing firms from other sectors (e.g. manufacturing) with capabilities that could be developed to serve the aviation industry.

The first challenges observed for the participation of firms in the aviation sector are related to the lack of information on how to develop capabilities for maintenance and repair operations (MRO) and aerospace manufacturing, as well as mentorship on how to achieve the necessary certifications and quality accreditations required for such a rigorous industry. Workforce development with skills in aerospace manufacturing technology and quality compliance represents an additional challenge.

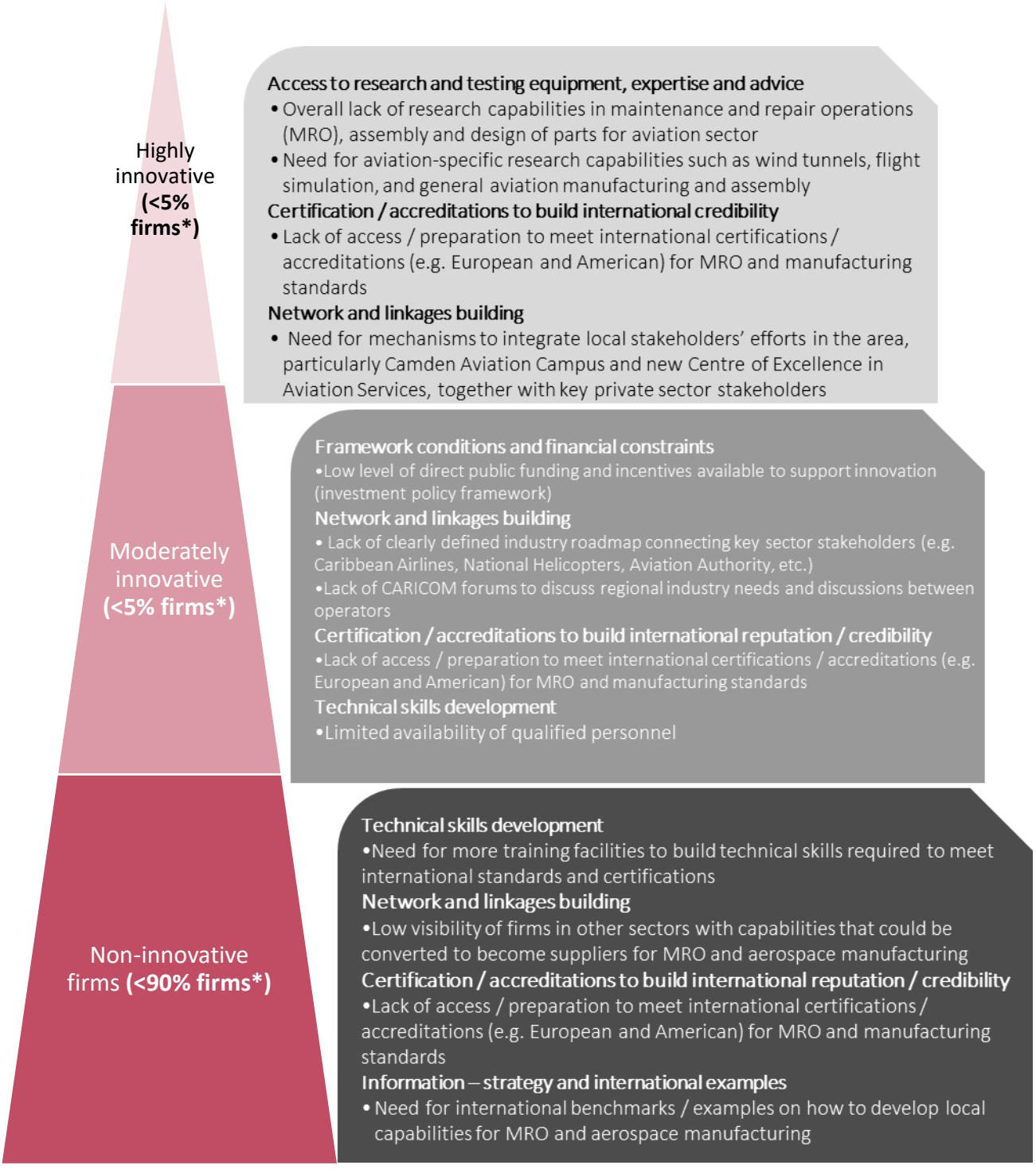
The need for mechanisms to integrate local stakeholders' efforts in the area, particularly the Camden Aviation Campus and a new Centre of Excellence in Aviation Services, together with key private sector stakeholders, is also seen as a priority challenge that could potentially be addressed by a new CoE in this area. Furthermore, more access to specialised research and testing equipment and expertise is required. In particular, the lack of existing research capabilities in maintenance and repair operations (MRO) and aerospace design and manufacturing represents a singular challenge for this potential industry. Specific aerospace research capabilities beyond MRO and manufacturing would also be required in areas such as wind tunnels, flight simulation and manuals development.

Table 6: TT's Aviation sector SWOT analysis

Strengths	Weaknesses
• Two national air operators and two publicly owned airports. • A number of private air operators. • Strategic geographical location. • Specialised training experience. • Low cost of labour.	• Lack of business activities involving foreign markets and operators. • Lack of private capitals willing to invest in the sector.
Opportunities	**Threats**
• Opportunities in the maintenance repair and overhaul facility (MRO). • Joint venture among regional stakeholders in the aircraft maintenance operations.	• Change in market structure and demand. • Lagging behind in terms of technology. • Regulation (in the aviation sector).

[18] Jaggernath P. (2018). Aviation: market overview; The Research & Development Department.
National Training Agency of Trinidad and Tobago (2011). Developing Human Capital in the Aviation Industry.

FIGURE 31: KEY INNOVATION NEEDS/CHALLENGES (AVIATION SERVICES)



*As reported by workshop participants.

Definitions:

- Highly innovative: Actively engaged in innovation and R&D / Has in-house R&D and/or innovation capabilities (e.g. skilled personnel and/or equipment) / Purchases R&D and innovation services from external organisations.
- Moderately innovative: Motivated to engage in innovation but lacking resources / Might have incipient in-house R&D and innovation capabilities / Might engage in minor R&D and/or innovation projects with external organisations.
- Non-innovative: Lacking resources to engage in innovation / No in-house R&D and/or innovation capabilities / No external R&D and/or innovation projects

9.2 Where do we want to go?
Centre's mission and development vision

The stakeholders who were consulted agree on the existence of key capabilities and regional competitive advantages that could be further exploited to create sustainable jobs in the aviation industry. In particular, interviewees agreed that existing efforts in the area such as the Camden Aircraft Engineering Training Campus by UTT could be leveraged to provide a solid foundation for sector expansion.

In this regard, a new Centre of Excellence in Aviation Services would be expected to complement the activities of the Camden Aircraft Engineering Training Campus, particularly in terms of developing local skills and capabilities for maintenance and repair operations (MRO) in the short term.

Additional early targets for this Centre could involve the development of aircraft simulation services, followed by the full establishment of the training and development services in aerospace manufacturing and assembly of light aircraft components in the medium term. This would include developing competencies in international standards, certifications and accreditations, and building a team of experts that could provide expert advice and mentorship to firms in the sector on these topics. This could set the foundation for long-term industry growth and expansion into general aviation manufacture and assembly.

Additional goals for the medium term would involve the development of basic R&D competencies in aerospace manufacturing and MRO, as well as technology and strategy roadmapping to develop the appropriate sectoral roadmaps. These roadmaps could help the Centre to fulfil a key sector coordination and networking function, developing linkages between firms and other stakeholders in government and academia. The Centre could provide a forum for innovation and communities of practice to develop around aviation services.

In the long run, the Centre would be expected to complement its sector coordination role by also mapping key local value-chain capabilities and interfaces, and to play an active role in helping firms from other sectors (e.g. manufacturing) to diversify into the aviation value chain of activities. Advanced research activities in aerospace manufacturing would also be expected to develop in the Centre once it builds its expertise and know-how from MRO activities into more sophisticated manufacturing activities.

Aviation-related activities beyond MRO and manufacturing are also expected to take place in this Centre in the long term, including the development of industry manuals and the continued provision of aircraft simulation services and skills development. Finally, the long-term vision for this Centre involves the development of services for the international market, promoting linkages with international aviation stakeholders, positioning TT in the global aviation sector map.

Figure 32 summarises the core mission, goals and development vision for the Centre of Excellence in Aviation Services.

FIGURE 32: COE IN AVIATION SERVICES – MISSION AND DEVELOPMENT VISION

CENTRE DEVELOPMENT VISION

	Short term	Medium term	Long term
CoE Narrative	• Complement activities of the Camden Aircraft Engineering Training Campus • Develop local skills and capabilities for maintenance and repair operations (MRO)	• Enable the development of local capabilities in aerospace manufacturing and assembly for light aircraft parts	• Help establish the foundations for design and manufacturing of general aerospace components in TT
Specialisation Areas	• Skills for maintenance and repair operations (MRO) • Aircraft simulation services and skills development	• Skills for manufacturing and assembly of light aircraft parts • International standards, certifications and accreditations	• Skills for research and design of general aerospace components • Industry manuals development
Competencies	• Technical MRO and manufacturing technology training competencies • Local and international network / cluster building competencies • Information analysis and provision (technology foresight, benchmarking)	• Basic R&D competencies • Knowledge of international standards and accreditations to provide international certifications • Technology and strategy roadmapping	• Advanced R&D and knowledge-generation competencies • Mapping of key local value chain capabilities and interfaces

9.3 How can we get there?
Services, outputs, outcomes and KPIs

A Centre of Excellence in Aviation Services is expected to address the innovation needs of firms operating in this sector, recognising that different types of firm have different types of innovation needs and challenges, as summarised in Figure 31. Based on this evidence, and informed by the international case studies analysed in this project (Appendix A), this section suggests a range of innovation services that could be offered by this Centre to help companies across all innovation levels to engage in research and innovation (Figure 33). Although it is recognised that a certain level of service differentiation is required for distinct types of company, the aim is that all services offered by this Centre could be available for all types of company, if required. For example, while advice on how firms can meet international certifications/accreditation could be more relevant for non-innovative and moderately innovative firms, this service could also be available for more sophisticated firms, if requested.

A logic model (Figure 34) has been designed to outline how inputs and activities from this Centre are linked to its stated mission and goals (impacts). Although these relationships are not linear, by presenting relationships between the inputs and activities of the Centre (i.e. services), outputs (such as workers technical publications and patents) and outcomes (such as commercialisation of ideas and technological solutions), the logic model guides the design of monitoring and evaluation activities and key performance indicators.

Measuring the impact of new Centres of Excellence is an essential step to understanding how these Centres perform and how successful they are in achieving their stated missions and goals. Vigorous impact measurement can enable Centres of Excellence to guide their strategic direction and operations to understand how they can address innovation challenges in specific areas and drive economic growth in TT. In this regard, a set of key performance indicators is suggested in this section to evaluate not only the operation of a Centre of Excellence in Aviation Services but also its potential impact (Figure 35).

Successful performance evaluation of this Centre needs to be complemented with consistently defined and collected data across all of its activities, to enable evaluators to implement the proposed KPIs.

Box 9: Aerospace Research Centre – Canada

The Aerospace Research Centre is part of the National Research Council Canada. The Aerospace Research Centre conducts research and technology development across the full spectrum of issues related to the design, manufacture, qualification, performance, use and maintenance of air and space vehicles.

- Services

The Aerospace Research Centre's services cover a wide range of activities, including, for example: alternative fuels and aerodynamics research; modelling and simulation; airframe structure certification; non-destructive evaluation; static, fatigue, durability and damage tolerance tests; composite structures development, manufacturing and performance; and mechanical components and tribology; among others.

- Example key performance indicators (2004–9 impact)
  - Economic: ability to retain aerospace manufacturing jobs; attraction of foreign firms.
  - Environmental: more fuel-efficient aircraft.
  - Social: improved pilot and aircraft safety through the development of evidence-based operating standards, product improvement and ongoing research.

Source: NRC (2018). Annual Report 2016-2017.

FIGURE 33: COE IN AVIATION SERVICES – SUGGESTED SERVICES

INNOVATION FUNCTIONS	Innovation needs	SERVICES (Type of firms indicative only. Services could be available to all firm types if needed)		
		Highly innovative firms	**Moderately innovative firms**	**Non-innovative firms**
Knowledge Supplier and Absorption Facilitator	TECHNICAL SKILLS DEVELOPMENT CERTIFICATIONS / ACCREDITAIONS TO BUILD INTERNATIONAL CREDIBILITY	**COMPETENCE DEVELOPMENT** • Skills development programmes in relevant technical areas (e.g. MRO, manufacturing tech) • Domestic and international apprenticeships, internships and fellowships **ACCELERATING INNOVATION** • Access to equipment and laboratory rental for analysis, testing and calibration services • Access to specialised equipment such as wind tunnels and flight simulators	**COMPETENCE DEVELOPMENT** • Training and certification scheme in technology applications to foster credibility of local firms **CONSULTANCY/INDUSTRY SUPPORT** • Advice on how firms can meet international certifications / accreditations (e.g. European and American) for both maintenance and repair operations (MRO) and manufacturing quality • CoE as accredited body to provide corresponding certifications in TT	**COMPETENCE DEVELOPMENT** • Training and certification scheme in technology applications to foster credibility of local firms **CONSULTANCY/INDUSTRY SUPPORT** • Advice on how firms can meet international certifications / accreditations (e.g. European and American) for both maintenance and repair operations (MRO) and manufacturing quality • CoE as accredited body to provide corresponding certifications in TT
Knowledge Mediator and Diffuser	NETWORK AND LINKAGES BUILDING INFORMATION – STRATEGY AND INTERNATIONAL EXAMPLES FRAMEWORK CONDITIONS AND FINANCIAL CONSTRAINTS	**CONNECTING BUSINESSES** • Formation of clusters to foster inter- and intra-sectoral cooperation (particularly with manufacturing firms that could diversify into MRO and aerospace manufacturing) • Connecting firms with academics and enabling collaborations **ENABLING ECOSYSTEM (GOV)** • Advice for sectoral innovation policy (including funding and other support programmes), regulation, certifications and international benchmarking of best practices	**THOUGHT LEADERSHIP** • Development of sectoral roadmaps to coordinate and integrate existing efforts in the area • Domestic and international conferences and seminars (CARICOM Forums) • Information on technical standards, certifications and regulations **CONNECTING BUSINESSES** • Develop international linkages • Pursue strategic collaboration with key stakeholders' efforts in the area (e.g. CAL, Camden Aircraft Engineering Training Campus)	**THOUGHT LEADERSHIP** • Information on technical standards, certifications and regulations • Information on technology trends and international examples of MRO / aerospace manufacturing sectors development **CONNECTING BUSINESSES** • Database of manufacturing firms that could become aerospace suppliers through appropriate certifications
Knowledge Generator and Importer	ACCESS RESEARCH EQUIPMENT, EXPERTISE AND ADVICE	**ACCELERATING INNOVATION** • Access to specialised R&D expertise in maintenance and repair operations (MRO), assembly and design of parts for aviation sector	**COLLABORATIVE R&D** • Contract R&D projects to formulate and test application concepts	**COLLABORATIVE R&D** • Contract R&D projects to formulate and test application concepts

FIGURE 34: COE IN AVIATION SERVICES – SUGGESTED LOGIC MODEL

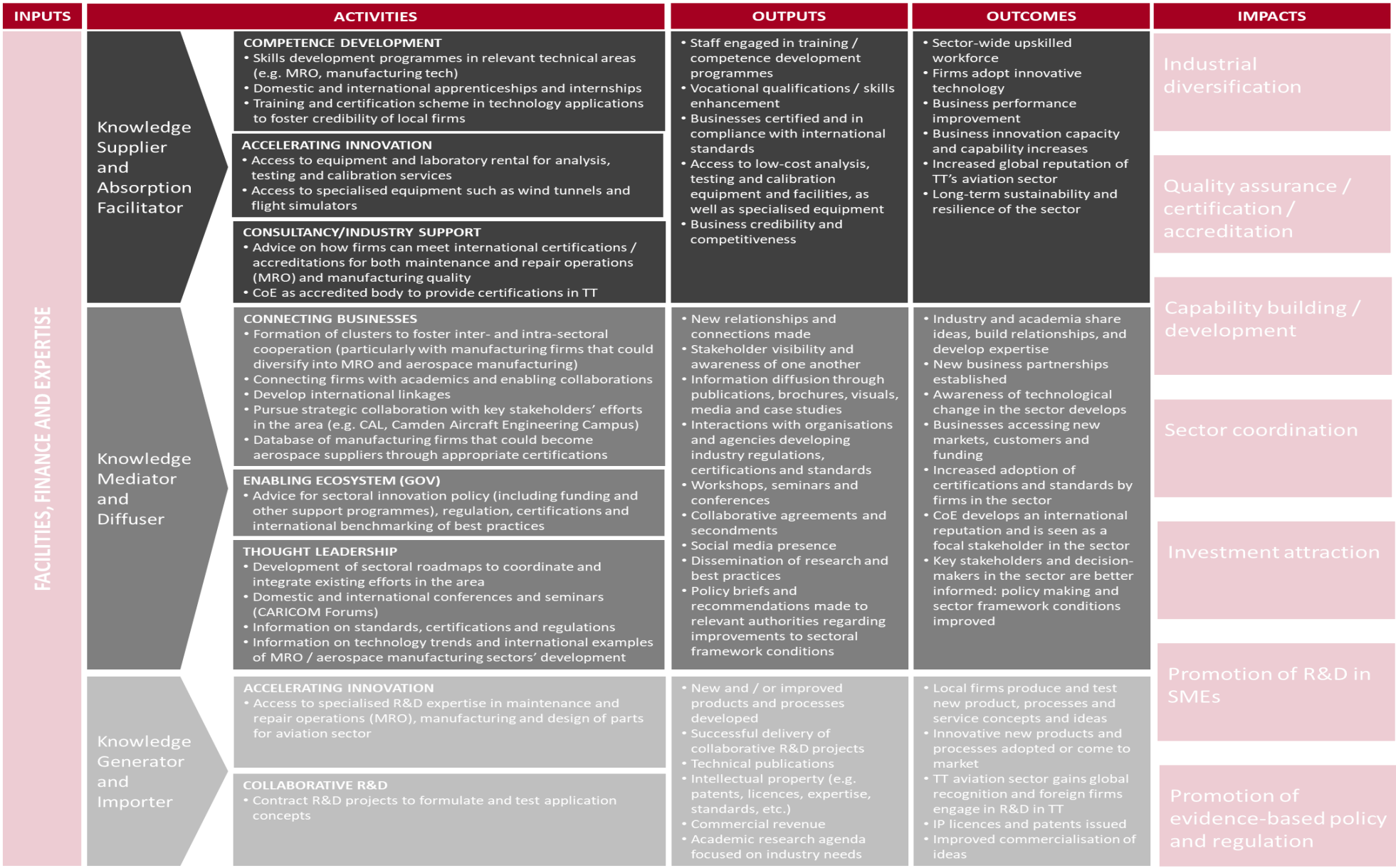


FIGURE 35: COE IN AVIATION SERVICES – SUGGESTED KEY PERFORMANCE INDICATORS

		KEY PERFORMANCE INDICATORS (KPIs) AND THEIR START PERIOD		
ACTIVITIES	**TYPE OF INDICATOR**	**SHORT TERM**	**MEDIUM TERM**	**LONG TERM**
COMPETENCE DEVELOPMENT ACCELERATING INNOVATION CONSULTANCY/ INDUSTRY SUPPORT	**CREATION OF AN AVIATION SERVICES SECTOR AND WORKFORCE**	• Number of workers completing a Centre-led certification, apprenticeship or training • Number of consultancy/advisory services provided	• Utilisation of testing facilities / equipment • Number of teachers or trainers participating in Centre-led training and certifications	• Number of firms that acquire international industry certifications
ENABLING ECOSYSTEM (GOV) CONNECTING BUSINESSES THOUGHT LEADERSHIP	**DEVELOPMENT OF A LINKED AND INTERCONNECTED AVIATION SECTOR**	• Number and diversity of stakeholders engaged and connected (industry, academia, government) • Number of SMEs engaged and connected • Number of workshops, seminars and conferences organised	• Number of policy briefs and other evidence inputs produced for government stakeholders • Number of dissemination publications produced • Usage or access data for open publications	• Case studies of successful linkages and network building examples, including communities of practice • International linkages developed • MOUs signed with local and international organisations • Sectoral roadmaps produced and coordinated
ACCELERATING INNOVATION COLLABORATIVE R&D	**TECHNOLOGY ADVANCEMENT AND CREATION OF R&D CAPABILITIES**	• Number of expert contributors / researchers participating in Centre-led R&D services	• Number and value of R&D and demonstration projects	• Percentage of projects meeting key technical objectives • Number and value of IP products produced and licenced
IMPACT AND INDUSTRY VALUE		• Success stories and case studies • Total number and diversity of client companies engaged (by innovation level) • Level and quality of co-investment by private sector	• Total number of client companies retained by innovation level (returning business) • Number of manufacturing firms that diversify into aviation sector • Number of firms that acquire international industry certifications • Volume of MRO and aviation manufacturing activities developed in TT	• Number of jobs created and retained (success in creating aviation services industry) • Number of Centre R&D projects reaching commercial production or adoption • Number of companies moving from non-innovative to moderately innovative and highly innovative • Industry value perception (surveys)

9.4 Other operational considerations: Funding, resourcing and implementation planning

The successful implementation and operation of Centres of Excellence require careful consideration and definition of fundamental operational aspects such as a Centre's funding and resourcing strategies, in addition to clear plans for the establishment, consolidation and growth of these Centres in the short, medium and long terms.

Funding strategy

As suggested by Hauser (2010),[19] both the level and type of funding vary significantly between distinct types of Centres of Excellence. However, the sources of funding can be broadly categorised as:

- **Core funding from national and regional government:** not always linked to specific activities or outcomes. A performance management framework is often in place for this investment.
- **Research grants and contracts from public bodies:** in most instances these are won on a competitive basis.
- **Research contracts from the private sector and revenue from services:** usually competitively tendered.
- **Additional income sources:** member fees, fee-for-service activities, intellectual property royalties, endowments, etc.

Based on a review of international practices, evaluation of the current Aviation Services sector context in TT and consultation with local stakeholders, this study suggests a funding portfolio that includes strong core funding from the government during its first year (90%), reduced to 80% in years 2–3, 55% by the fourth year and 40% by year 7 (Figure 36). As a result of the current state of development of firms in this sector, sustained public funding is considered critical to allow the Centre to establish its core competencies and guarantee its long-term operation. This is necessary to ensure that services are offered at an accessible price that would allow new and existing firms to transition from non-innovative to moderately or highly innovative in a challenging economic context.

Resourcing and implementation planning

An "implementation roadmap template" was designed by the consulting team (Figure 37) to identify the key actions required for the structured implementation of this CoE, including funding and resourcing targets and other operational matters related to the creation, consolidation and growth of the Centre. The roadmap shown in Figure 37 has been completed by the consulting team and it is recommended that it should be validated by local stakeholders prior to execution (a task that is outside the scope of this project).

The roadmap considers key implementation actions across a seven-year period for:

- Government approval and announcement;
- Strategy and business planning;
- Governance and management structure;
- Personnel, operations and organisational structure set-up;
- Infrastructure, equipment and location;
- Innovation services delivery;
- Networking/alliances/sector integration and communication.

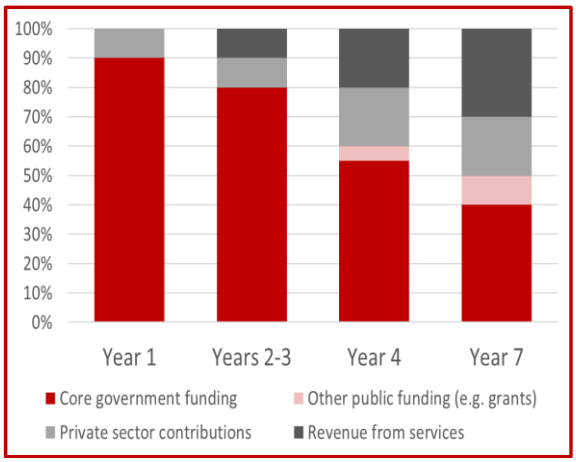


Figure 36: CoE in Aviation Services – funding sources

[19] Hauser (2010).

Box 10: Funding portfolios – international examples

Examples of funding portfolios from three distinct international organisations are given below. Different approaches are visible from this data, highlighting the need for every Centre of Excellence to adapt its funding portfolio configuration to its particular national/local context, missions and objectives.

▪ Centre Suisse d'Electronique et de Microtechnique (CSEM) – Switzerland

CSEM is a public–private partnership supported by the Swiss Confederation and several Cantons. A number of well-known Swiss companies have supported the CSEM and have become shareholders. Currently, three-quarters of the shares are held by leading actors from across Switzerland's industries and economy. Some examples of CSEM's services are: concept design, prototyping, coating services and small series production.

In terms of funding, CSIM reported the following figures for 2016:

- Total revenue of CHF 79 million (USD 81.1 million):
  - **32%** basic government funding
  - **29%** industrial funding
  - **13%** CTI (Swiss Confederation supported projects)
  - **12%** Cantons
  - **9%** EU projects
  - **5%** other public projects

▪ IK4-TEKNIKER – Spain

IK4-TEKNIKER is a research and technology organisation established in 1995. It is a non-profit organisation. The organisation's areas of expertise are: energy; health; transport and mobility; and advanced manufacturing. In the aerospace field, IK4-TEKNIKER offers services on manufacturing; predictive maintenance, coatings and new materials; systems and equipment; and inspection and measurement solutions. These services range from research and development to knowledge deployment.

IK4-TEKNIKER generated a revenue of EUR 24 million (USD 29.4 million) in 2016. Of these:

- **48.5%** from companies
- **25.2%** Government of the Basque Autonomous Community
- **24.1%** from the European Union (EU)
- **2.2%** from other sources

▪ Aerospace Research Centre – Canada

The Aerospace Research Centre is part of the National Research Council Canada. The NRC is an agency of the Government of Canada, reporting to Parliament through the Minister of Innovation, Science and Economic Development. The Aerospace Research Centre conducts research and technology development across the full spectrum of issues related to the design, manufacture, qualification, performance, use and maintenance of air and space vehicles. The services that the Research Centre provides range from proof of concept and prototyping to modelling, testing, certification and professional advice.

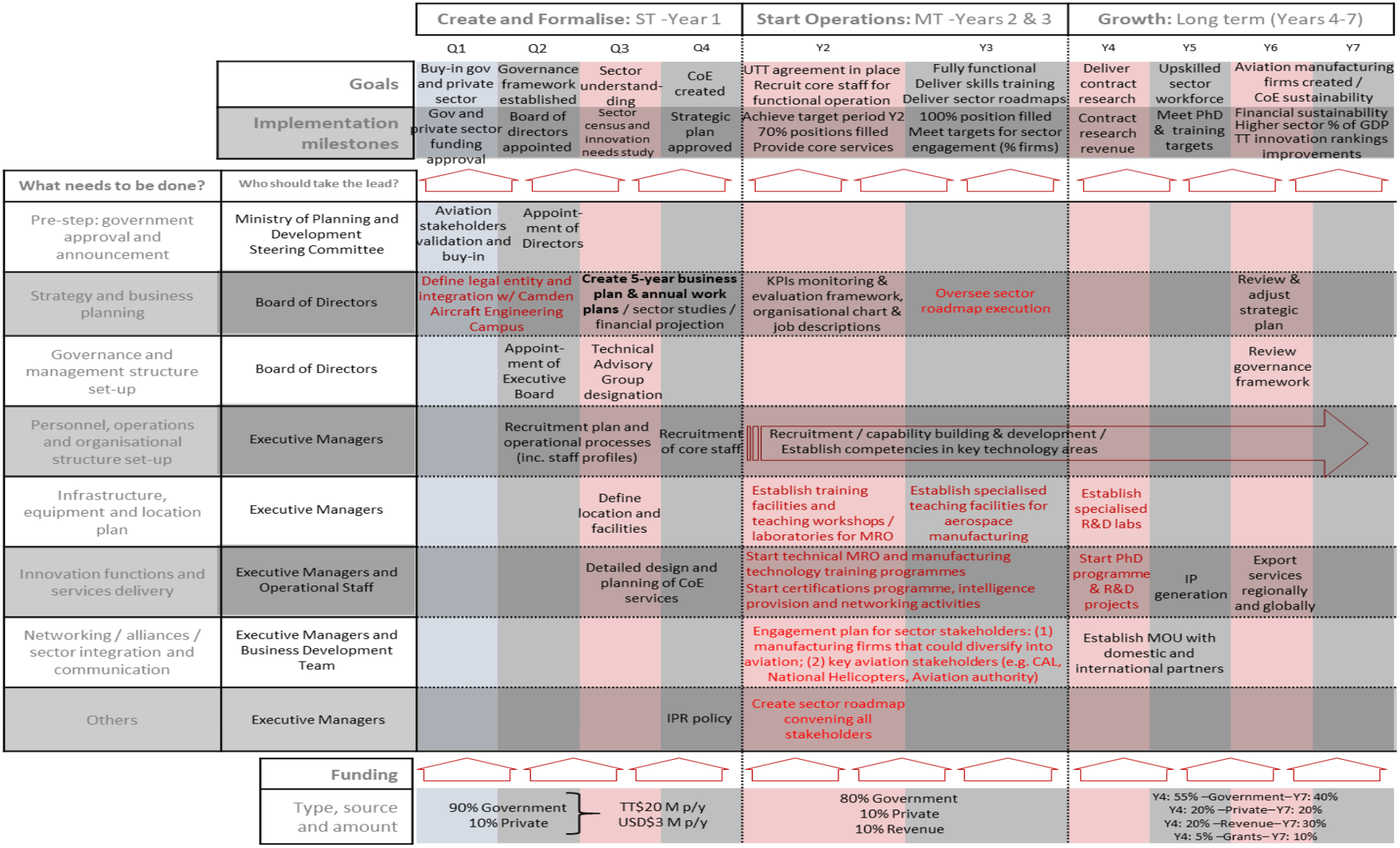
Based on data from 2016–17, the total revenue of the Aerospace Research Centre amounted to CAD 1,040 million (USD 814.6 million). From these:

- **80.5%** funding provided by the government
- **9.3%** technical services
- **5.4%** research services
- **1.7%** grants and contributions
- **0.8%** intellectual property, royalties and fees
- **0.74%** sales of goods and information products
- **1.5%** other sources

Sources:

- CSEM (2017). Annual report 2016; IK4-TEKNIKER (2017). Informe Anual 2016; NRC (2018). Consolidated financial statements.

FIGURE 37: COE IN AVIATION SERVICES – FUNDING STRATEGY AND RESOURCING ROADMAP



POLICY **LINKS**

Governance Framework and Next Steps

Sections 10–11 discuss the key features of the suggested governance framework for Centres of Excellence in TT, in addition to the practical next steps for their implementation based on the work presented in this report.

10

OVERSEEING CoE OPERATION: GOVERNANCE FRAMEWORK

Although different international models exist to govern both the internal management of a Centre of Excellence and its relationships with the outside world, namely with government and other actors in the innovation system, some general trends can be identified, as outlined below.

Centres of Excellence tend to be independent organisations

Centres of Excellence perform missions in the public interest, and are at least partially funded through public resources, which means they are responsible to government.[20] However, they require sufficient operational independence to guarantee their effective and efficient operation, the impartiality of their research and advice, and their ability to adapt quickly to changing conditions and opportunities in their research fields and operating environments.

Centres of Excellence usually have legal forms, which preclude the predominance of individual self-interested parties.[21] A minority of them are owned directly by government, while others have the government as the principal shareholder or stakeholder. Others are established as foundations or non-profit associations, with a large number of "associates" in order to avoid any single majority interest.[22]

Even when government is the owner or main shareholder, it is necessary for Centres of Excellence to maintain operational independence. In such cases, the government has the responsibility to ensure that a Centre's mission remains pertinent and that adequate resources are made available to it.[23] However, Centre management must be allowed operational independence in order to ensure the neutrality necessary for its public-service mission.

In any case, although government ownership is not necessary for a strong CoE, sustained government commitment is needed. This requires strong promotion of the role of a CoE in the innovation system, alongside universities and other research institutes.[24] As noted above, it is common for the government, or the organisation in charge of the CoE, to focus its activities on sectors or technologies that capitalise on local and national strengths, rather than having a wider spread of institutes in many technology or sectoral fields.

For example,[25] ITRI in Taiwan was set up to help build one specific industry, and TNO in the Netherlands devises its research programmes to support social themes developed in close cooperation with the government. By contrast, the Senate of the Fraunhofer-Gesellschaft in Germany is responsible for deciding the society's basic research policy and is made up of eminent figures from the world of science, business, industry and public life, as well as government.[26]

[20] EURAB (2005). Research and Technology Organisations (RTOs) and ERA, European Research Advisory Board.

[21] EARTO (2007). Research and Technology Organisations in the Evolving European Research Area – A Status Report with Policy Recommendations. European Association of Research and Technology Organisations.

[22] Ibid.

[23] Ibid.

[24] Hauser (2010). The Current and Future Role of Technology and Innovation Centres in the UK. A report by Dr Hermann Hauser for Lord Mandelson, Secretary of State, Department for Business Innovation & Skills, UK.

[25] Ibid.

[26] Hauser, 2010.

Centres of Excellence are mostly not-for-profit organisations

This is at least true for around 80% of EARTO members, where "not-for-profit" means that any surplus of income over expenditure is retained in the organisation and employed in accordance with the Centre's core mission. In other words, any surplus is not distributed to third-party owners, shareholders or other beneficiaries.[27]

Governance models need to be adapted to the local/national context

A study comparing governance models for Centres from five countries (Denmark, Germany, Sweden, Finland and the Netherlands) found that these varied from formally governed groups to ad hoc Centres of Excellence, with little or no networking between the individual Centres.[28]

Formal governance and grouping is common, for example, in Germany, Japan and South Korea.[29] The Fraunhofer Institutes in Germany have a complex structure, including Members, a General Assembly and a Senate. The benefit of these formal structures is that they are able to set strategic direction and research activities and carry out performance evaluation. However, within this federal structure, individual Fraunhofer Institutes have a high degree of autonomy to set their own research priorities, to pursue commercial opportunities and to compete with one another to win funding from business or the public sector.

The French Carnot system has a Members' Association, which acts in a similar way to a trade association, promoting the brand and providing some shared membership services, although there is no common governance structure.[30] However, these looser networks still have the benefit of shared experience, they can promote easier collaborations and they have the ability to ensure the quality of services provided.

A governance model for Trinidad and Tobago's Centres of Excellence

Based on the insights gathered from local stakeholders, the analysis of the local context, and international trends, a suggested governance model for TT's Centres of Excellence is an "arms-length" model[31] in which sustained long-term government commitment is provided (particularly in terms of partial funding), while maintaining sufficient distance to guarantee the autonomy and operational strategic independence of each Centre. A clear output from the stakeholder consultation is the recognition that a governance model for Centres in TT needs to combine clearly defined long-term missions, as suggested in this report, with medium-term (e.g. five to seven years) rolling programmes of work and budgets. The aim of this governance model would be to balance the public responsibility of a CoE and its managerial independence, while giving the relevant shareholders and stakeholders the responsibility of adjusting the Centre's mission when needed.[32]

Additional key features of the suggested governance model can be summarised as follows (Figure 38):

- Ownership and legal entity

Local stakeholders expressed the view that these Centres should enjoy long-term sustained support from government, as well as having strong involvement from the private sector and other relevant actors in TT's economy and innovation ecosystem. Although distinct schemes could be followed to achieve this, a public–private partnership[33]

[27] EARTO, 2007.

[28] Arnold, E., Clark, J., and Jávorka, Z. (2010). Impacts of European RTOs – A Study of Social and Economic Impacts of Research and Technology Organisations. A Report to EARTO.

[29] Hauser (2010).

[30] Ibid.

[31] EURAB, 2005.

[32] Ibid.

[33] See Box 11 – international examples, Switzerland.

in which shares are distributed between government and leading actors from across TT's industries and economy could provide the right balance to ensure that all distinct views and interests are represented, while ensuring that Centres' missions remain relevant for TT's key industries. Even if other legal arrangements are explored (fully public or fully private schemes), involvement from the private sector is considered essential to guide the strategic development of these Centres and ensure their relevance for TT's economy.

- Not-for-profit nature

Independently of the legal form acquired by these Centres, international experience suggests that their not-for-profit nature should be maintained in order to ensure they are considered a public good (i.e. any surplus of income over expenditure is reinvested in the organisation in support of their activities and not distributed to shareholders).

- Government support, private sector leadership and accountability

Based on conversations with local stakeholders, this study suggests that either the Ministry of Planning or Ministry of Trade and Industry could take the initial lead in setting up each Centre, following the specifications and basic roadmaps suggested in this report. Following the creation of each Centre, Government representatives are expected to take part in their governing bodies to maintain an appropriate link and accountability to government (proportional to the funding provided), while ensuring Centre independence and autonomy. However, it is expected that, once suitable governing bodies are appointed, Centres will become highly independent and autonomous, while being strategically driven by the missions agreed with the government during their creation. They would also become private-sector-led in the long term, with close linkages to industry. Sunset clauses might be included to ensure that the Centres' performance and national relevance are periodically reviewed against their stated missions.

- Governing bodies

Appointed by neutral actors and including safety mechanisms to preclude one group from gaining too much influence, the suggested governing bodies for these Centres would include (Figure 39):

- **Board of Directors,** formed by one chairman and six members (1–CEO; 3–private sector; 1–academia; 1–government).
- **A Technical Advisory Group (TAG),** formed by private sector, academic and government figures (ideally from key firms, industry associations, universities, innovation agencies and departments), would provide the Board of Directors with inputs for strategy, ensuring representation of a wide range of stakeholders relevant to TT's industries and innovation system.
- **Executive Board** integrated at a minimum level by a CEO and Directors for each key Centre functional area (e.g. Director of Engagement for "Thought Leadership" and "Connecting Businesses" functions; Director of Consultancy Services for "Competence Development Programmes" and "Consultancy/Industry Support" functions; Director of Research and Innovation for "Accelerating Innovation" and "Collaborative R&D" functions, etc.). Other administrative functions might also require Directors, as appropriate (e.g. human resources, finance).

- Interaction and collaboration with local and international researchers, universities, public and private sector stakeholders

The intention is for Centres of Excellence to become autonomous entities with sufficient freedom to devise their own engagement strategies with other stakeholders of the innovation system, based on their mission and strategic goals.

A mechanism followed by other similar institutions internationally, and in TT for establishing closer relations with a range of local and international stakeholders, is the Memorandum of Understanding (MOU). Furthermore, it is anticipated that TT's Centres of Excellence would seek membership in relevant international

associations such as the European Association of Research and Technology Organisations (EARTO), to develop closer links with international peers and leaders in their fields.

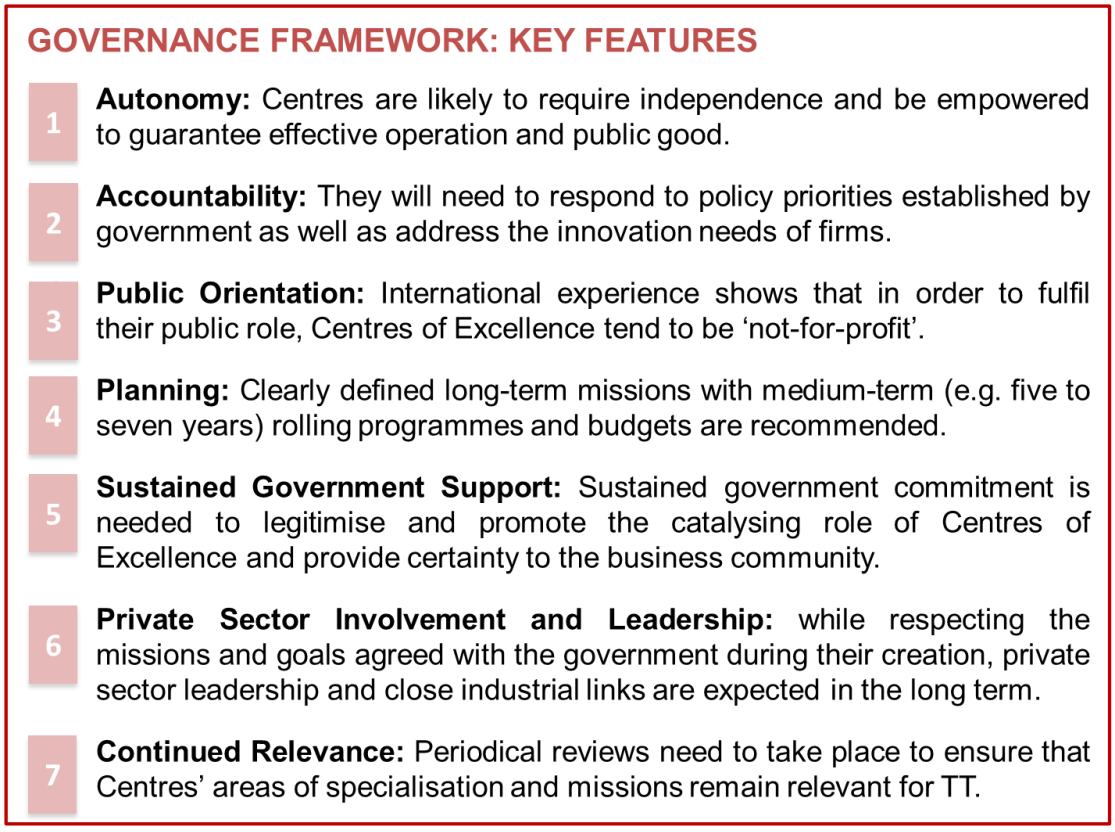


Figure 38: Governance framework – key features

Figure 39: Governance framework – governing bodies

Box 11: Ownership and Governing Bodies – international examples

Examples of funding portfolios from three distinct international organisations are given below. Different approaches are visible from this data, highlighting the need for every Centre of Excellence to adapt its funding portfolio configuration to its particular national/local context, missions and objectives.

▪ Danish Technological Institute (DTI) – Denmark

The Danish Technological Institute is a **self-owned (private)** and **not-for-profit** institution that develops, applies and disseminates research and technologically based knowledge for the Danish and international business sectors.

Main governing bodies include:

- **Executive Board:** consists of one President, eight Vice-presidents (one per division), one CFO and one Building Manager Lawyer.
- **Board of Representatives**: Consists of up to 33 Members appointed by the leading industrial and professional organisations in Denmark.
- **Board of Trustees:** Consists of nine Members, seven of which are selected by the Board of Representatives, while two Members are elected from among the Institute's employees.

▪ Centre Suisse d'Electronique et de Microtechnique – Switzerland

Not-for-profit research and technology organisation (RTO) and **public–private partnership**.

Around **one-quarter of the shares are publicly held**, either by the ETH domain (Swiss federal institutes of technology and related research bodies) or by the Canton or the town of Neuchâtel. The **remaining three-quarters** are held by **leading actors from across Switzerland's industries and economy.**

Main governing bodies include the Board of Directors, Executive Board, divisional and functional heads, and a Scientific Advisory Board:

- **Members of the Board of Directors** include representatives from the fields of watchmaking, medtech and energy.
- **The Executive Board** supports the CEO in the management of the company. An extended management board oversees the management of divisions and functions.
- **The Scientific Advisory Board** helps set general directions for applied research. The Board is made up of visionaries and experts from the worlds of industry and academia.

▪ Centre for Mechanical, Naval and Electrical Technology (CTMNE) – Brazil

The CTMNE is one of the 12 research centres that operate under the structure of the Instituto de Pesquisas Tecnológicas (IPT) in Brazil, **a public research institute** founded more than a hundred years ago. The IPT is an institute **under the Ministry of Economic Development, Science, Technology and Innovation of the State of São Paulo**. It provides technological solutions and services in the fields of energy, transportation, oil and gas, environment, construction, cities and health and safety.

It has four main governing bodies:

- **Management Board**
- **Advice Board**
- **Fiscal Council**
- **Executive Board**

Sources:

- IPT (2018). *About IPT*; DTI (2018). *Who We Are*; CSEM (2018). *Governance.*

11

NEXT STEPS

This report has presented detailed design specifications and implementation roadmaps for five new national Centres of Excellence in Trinidad and Tobago, based on consultations with industry, academia and government stakeholders, as well as on a thorough literature review and study of international experience for five areas:

i. Indigenous High-value Agricultural-based Products;
ii. ICT Products and Services;
iii. Aviation Services;
iv. Maritime Services;
v. Energy Engineering Services.

Although the information provided in this document represents a baseline to support the work of future Centre Managers and implementation teams, it is recognised that final customisation of these specifications is expected to be completed by the Executive Managers and Board of Directors assigned to these Centres, once appointed.

In this regard, a number of practical steps are required in order to move from planning to action, as outlined in the implementation roadmaps developed in this report. Overall, next steps for implementation could include the following key milestones:

- Obtain the necessary buy-in from government authorities and private sector stakeholders (consortium), including financial commitments to fund the new Centres of Excellence.
- Create a legal entity for each Centre.
- Create a governance structure for each Centre by appointing a Board of Directors, which would in turn appoint an Executive Board and Technical Advisory Group.
- Create interim delivery teams to assist the newly appointed Directors and Executive Managers with the creation and formalisation of each Centre. Delivery teams would be composed of government officials and/or private sector experts recruited for this purpose, with relevant knowledge of sectoral innovation needs. These teams would help to establish each Centre prior to them having an official physical space and/or employees. They will help draft five-year business plans and annual work plans for each Centre (strategic plans), in addition to carrying out detailed sector studies, stakeholder consultations, financial projections, recruitment plans, operational processes and other strategic activities related to the implementation of each Centre.
- Define the required infrastructure, facilities and location plan for each Centre.
- Create a detailed engagement plan for sector stakeholders.
- Validate and refine the service portfolio of each Centre according to strategic plans and priorities.
- Once the funding is in place, recruit core staff and initiate annual work plans.

Economic diversification away from hydrocarbons has long been the subject of thorough debate in Trinidad and Tobago. The specifications and implementation roadmaps for Centres of Excellence contained in this report represent a tangible policy mechanism to pursue such diversification goals and unlock Trinidad and Tobago's considerable and much-needed innovation potential.

APPENDIX A

See attached document “International benchmarking of Centres of Excellence”

APPENDIX B

Consulted stakeholders (sectoral roundtable discussions and policy workshop):

Name	Affiliation
Bede Rajahram	Trinidad and Tobago Apiculture Co-operation
Gabrielle Agostini	Coconut Growers Association
Marlon Knights	The University of Trinidad and Tobago (UTT)
Kieron Swift	Ministry of Planning and Development
Ruqayyah Thompson	Ministry of Planning and Development
Sharda Sardarsingh	Ministry of Planning and Development
Thackwray Driver	Energy Chamber
Douglas Boyce	Upstream Energy Projects
Philip Julien	Worley Parsons Trinidad Ltd.
Roger Bissessar	IChemE
Lisa Mohammed	TOSL Engineering Ltd
Parissram Jaggernauth	The University of Trinidad and Tobago (UTT)
Rooplal Dass	Briko Air Services
Hayden Newton	Airports Authority of Trinidad and Tobago
Marlon Indar Persad	The University of Trinidad and Tobago (UTT)
Trevor Benjamin	The University of Trinidad and Tobago (UTT)
Francis Regis	Trinidad and Tobago Civil Aviation Authority
Ernest Ashley Taylor	Point Lisas Industrial Port Development Corporation Ltd.
Shahnaz Isahak	National Training Agency
Abigail Edwards	Ministry of Trade and Industry
Phillip Miller	Eric Miller and Co. Ltd.
Colin Barcant	Independent
Hayden Charles	CARIRI
Robert Martinez	NIHERST
Ronald Hinds	Teleios
Deidre Lee Kin	Dingole Ecommerce Services
Selma Lee	IBM
Patrick Hosein	University of the West Indies (UWI)
Colin Gopaul	IEEE
Alphanso Williams	TTIFC
Tracy Hackshaw	Ministry of Planning and Development (Global Services Promotion Programme)
Abigail Bynoe	Ministry of Public Administration and Communications
Vidya Mohan	Ministry of Energy and Energy Industries
Robert Nunes	CARIRI
Norman Gibson	CARDI
Rianna Paul	T&T Chamber
Sarim Al-Zubaidy	The University of Trinidad and Tobago (UTT)
Karlene Francois	Ministry of Planning and Development
Lisa Henry-David	Ministry of Education
Carol Bickram	Ministry of Education
Pathmanathan Umaharan	UWI - Cocoa Research Centre
Kavita Maharaj	Inter-American Development Bank (IDB)

Consulted stakeholders (implementation roadmap workshop):

Name	Affiliation
Karlene Francois	Ministry of Planning and Development
Sara Mohammed	Ministry of Planning and Development
Sharda Sardarsingh	Ministry of Planning and Development
Carol Bickram	Ministry of Education
Lalloo Ramlal	Intellectual Property Office
Abigail Johnson	T&T Chamber
Eddy Devisse	T&T Chamber
Glynis Alexander-Tam	E-Business Roundtable - InfoLink Services Limited
Simon Aqui	E-Business Roundtable - IBM
Kevin Khelawan	Teleios
Robert Martinez	NIHERST
Kyle DeFreitas	University of the West Indies (UWI)
Naresh Seegobin	University of the West Indies (UWI)
Fasil Mudeen	University of the West Indies (UWI)
Desron Palmer	Ministry of Public Administration and Communications
Shanaz Mohammed	Ministry of Public Administration and Communications
Joy Francis	TTMA

Consulted stakeholders (strategy and synthesis workshop):

Name	Affiliation
Karlene Francois	Ministry of Planning and Development
Sharda Sardarsingh	Ministry of Planning and Development
Robert Martinez	NIHERST
Naresh Seegobin	University of the West Indies (UWI)
Desron Palmer	Ministry of Public Administration and Communications
Shanaz Mohammed	Ministry of Public Administration and Communications

Other consulted organisations

- Aerial World Services Ltd.
- DC Power Systems Ltd.
- Lennox Petroleum Services Ltd.
- Point Lisas Industrial Port Development Corporation Ltd. (PLIPDECO)
- Rig Bound Ltd.
- Ixanos Intelligent Software and Technology Systems
- Baker Hughes (Trinidad) Ltd.
- Cargo Consolidators Agency Ltd.
- Kenson Group of Companies
- Martulus-IQA Ltd.
- Namalco Construction Services Ltd.
- TOSL Engineering Ltd.

The consulting team thanks AMCHAMTT, TTCIC, the Energy Chamber of Trinidad and Tobago and the Couva Point Lisas Chamber of Commerce for assisting in the distribution of the innovation questionnaire among their members.

ABOUT POLICY LINKS

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