2016/17 KNOWLEDGE SHARING PROGRAM WITH Costa Rica

Center for International Development
Korea Development Institute

Long-term Employment Projections and Manpower Planning for Research Personnel in Science and Technology of Costa Rica

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February 22nd 2017

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Background and Objectives

- **Costa Rica is a country that has growing opportunities for FDI specifically in the areas of technology and ecotourism.**
  - **During the last several decades, U.S. technology, electronic, and medical service companies as well as other countries and industries have begun establishing operations in Costa Rica.**
  - **Several important multinational companies, including Hewlett Packard, IBM, Intel, Procter and Gamble and Western Union, decided to start operations in the country.**
  - **In addition, a growing number of local firms have been created in order to provide ICT products and services globally..**

Background and Objectives

- This has resulted in a shortage of Costa Rican workers with the necessary knowledge and skills to work in the technology industry (Mata, Matarrita, & Pinto, 2012).
- Several factors constrain the capacity of the country to keep up with the growing demand of qualified trained personnel.
  - the country´s small population, the reduced coverage of upper secondary and tertiary education
  - the limited capacity of the private universities to graduate computer professionals, and the weak technical and para-academic educational programs in the country

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Background and Objectives

- ▸ The level of R&D investment made in this country (approximately 0.57 percent of GDP in 2014) and the participation of the private sector is low.
  - The rate of return on R&D for Costa Rica is 34 percent, as compared to a 6 percent return on investment in physical capital (Lederman and Maloney, 2003)
  - Not all innovation needs to be based on formal expenditures on R&D. Importing capital equipment, licensing, worker training, recruitment of more skilled labor, management retooling and efforts to enter (or reposition in) production value chains, et cetera, can also help to promote innovation.
- ▸ However, Cohen & Levinthal (1990) found that the firm's absorptive capacity determines the extent to which this extramural knowledge is utilized, and this absorptive capacity itself depends on the firm's own R&D.

Background and Objectives

- Most technologically oriented countries have between three and five times more researchers, and researchers specifically dedicated to R&D activities, than Costa Rica (Monge-González, 2016).
  - The number of researchers dedicated to R&D activities per million people, Costa Rica occupies an intermediate position.
  - In terms of R&D expenditure relative to GDP, Costa Rica is similar to that of México, Chile, and Uruguay, but very low relative to most technologically oriented countries, which invest between three and eight times more in R&D than Costa Rica does.
- This lack of innovative culture largely explains the low number of researchers, in per capita terms, and helps to explain why R&D investment is too low in Costa Rica.

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Background and Objectives

- In order to support the country's competiveness in the global market, and to understand the human resource situation, a demand and supply study is to be conducted.
- The purpose of this study was to forecast supply and demand of research personnel in science and technology to make recommendations regarding HRD policies for Costa Rica. More specifically
  - Identify the issues and obstacles that hinders the development process
  - Identify a proper analytic and planning methods or techniques
  - Make recommendations on which methods or techniques should be developed further for Costa Rica

Main Contents ; Challenges

Insufficient research and planning capacity

- HRD forecasting requires skilled staff and an organizational base. It calls for a team approach. Researchers with many required areas of expertise are still in short supply.

Inappropriate methods and poor inter-institutional cooperation

- Even if the information generated is of great value to planning, training, and management, task and functional arrangements among related institutes have sometimes been considered too complex and costly to execute

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Main Contents ; Challenges

- **Lack of appropriate, ongoing processes for statistical survey and database building**
  - HRD forecasting has traditionally suffered from being concerned merely with surveying numbers of different kinds of workforce, while ignoring long-term process.
  - Appropriate forecasting requires a long-term perspective that includes survey and DB design, tentative model development, pilot studies, et cetera.
- **Lack of timely and accurate data**
  - It is difficult to get an exact picture of the structure and distribution of specific knowledge that a researcher or a technicians hold.

Main Contents ; Challenges

- **According to Oppenheimer (2014; 283)**
  - "… a climate that produces a collective enthusiasm for creativity, and glorifies productive innovators in the same way that the great artists or great sportsmen are glorified and that challenges people to take risks without fear being stigmatized by failure …"
- **According to Monge-Gonzales, Rivera, and Rosales (2010: 7)**
  - "… for the most part, government failures rather than market failures have been the main justification for PDP(productive development policies)s. Even in the presence of market failures, the instruments applied in the policy design are not necessarily the most efficient (according to economic theory), but rather the most politically feasible options (lower political cost) ..."

Main Contents ; Korean Experiences

Institution	Title	Forecast target	Forecast period	Year of publication
Institutions with specific responsibility for the workforce forecasting				
Science and Technology Policy Institute	Prospects for Long-term Demand for Science and Technology Personnel for the 21st century	Science and Technology Workforce	1988 - 2001	1990
Korea Science and Engineering Foundation	Long-term Forecasts on Demand and Supply of R&D Personnel: 2000-2010	Researcher	2000 – 2010	2000
Ministry of Science and Technology	Long-Term Forecast on Demand and Supply of the S&T Human Resources: 2001-2010	Science and Technology Workforce	2001 – 2010	2001
Korea Labor Institute	Mid/Long-term Forecast on Industrial Workforce: 2005-2020	Industrial human resources (All industries)	2005 – 2020	2005.11
Jeonbuk Research Institute	Industrial Workforce on Jeollabuk-do Demand and Supply Forecasts	Industrial human resources on Jeollabuk-do (All industries)	2005 - 2020	2006
Ministry of Education and Human Resources Development	A Study on Improvement of Mid/Long-term Manpower Demand and Supply Forecasts	Human resources by Academic level	2006 - 2016	2007.12
Ministry of Education and Science Technology	Mid/Long-term Science & Technology Manpower Demand and Supply Forecasts	Science and Technology Workforce	2008 - 2018	2008
Korea Creative Content Agency	A Demand/Supply Forecast on Human Resources and Advanced Case Study in Contents industry	Contents industry Workforce	2009 – 2018	2010.03

Main Contents ; Korean Experiences

Institution	Title	Forecast target	Forecast period	Year of publication
Institutions with specific responsibility for the workforce forecasting				
Ministry of Employment and Labor	Mid/Long-term Forecast on Industrial Workforce: 2011-2020	Industrial human resources	2011 - 2020	2012.06
Jeju National University Dept. of Tourism Institute of Management & Economics	A Study on Mid/Long-term Industrial Workforce on Jeju-do Demand and Supply Forecasts	Industrial human resources on Jeju (All industries)	2011 - 2020	2012
Korea Institute of Science & Technology Evaluation and Planning	A Study on the Demand and Supply Forecast of Nano-Technology(NT) Personnel	Nano-Technology(NT) Workforce	2012 – 2022	2013.02
Korea Employment Information Service	Forecasts on Demand of S&T Personnel	Science and Technology Workforce	2012 - 2017	2013.06
Ministry of Employment and Labor	Mid/Long-term Forecast on Industrial Workforce: 2013-2023	Industrial human resources	2013 - 2023	2014
Ministry of Agriculture, Food and Rural Affairs	A Forecast on Food Industry and Education Demand	Food industry Workforce	2013 – 2018	2014.03
Korea Internet & Security Agency	A Study on the Status and Demand/Supply Forecast of Information Security Personnel in 2014	Information security Workforce	2013 – 2017	2014.12
Korea Health Industry Development Institute	Mid/Long-term Forecasts on Health Industry Workforce Demand and Supply: 2013-2023	Health industry Workforce	2013 - 2023	2015.01
Korea Employment Information Service	A Revision Study on Mid/Long-term Forecast on Industrial Workforce: 2014-2024	Industrial human resources (All industries)	2014 - 2024	2015.12

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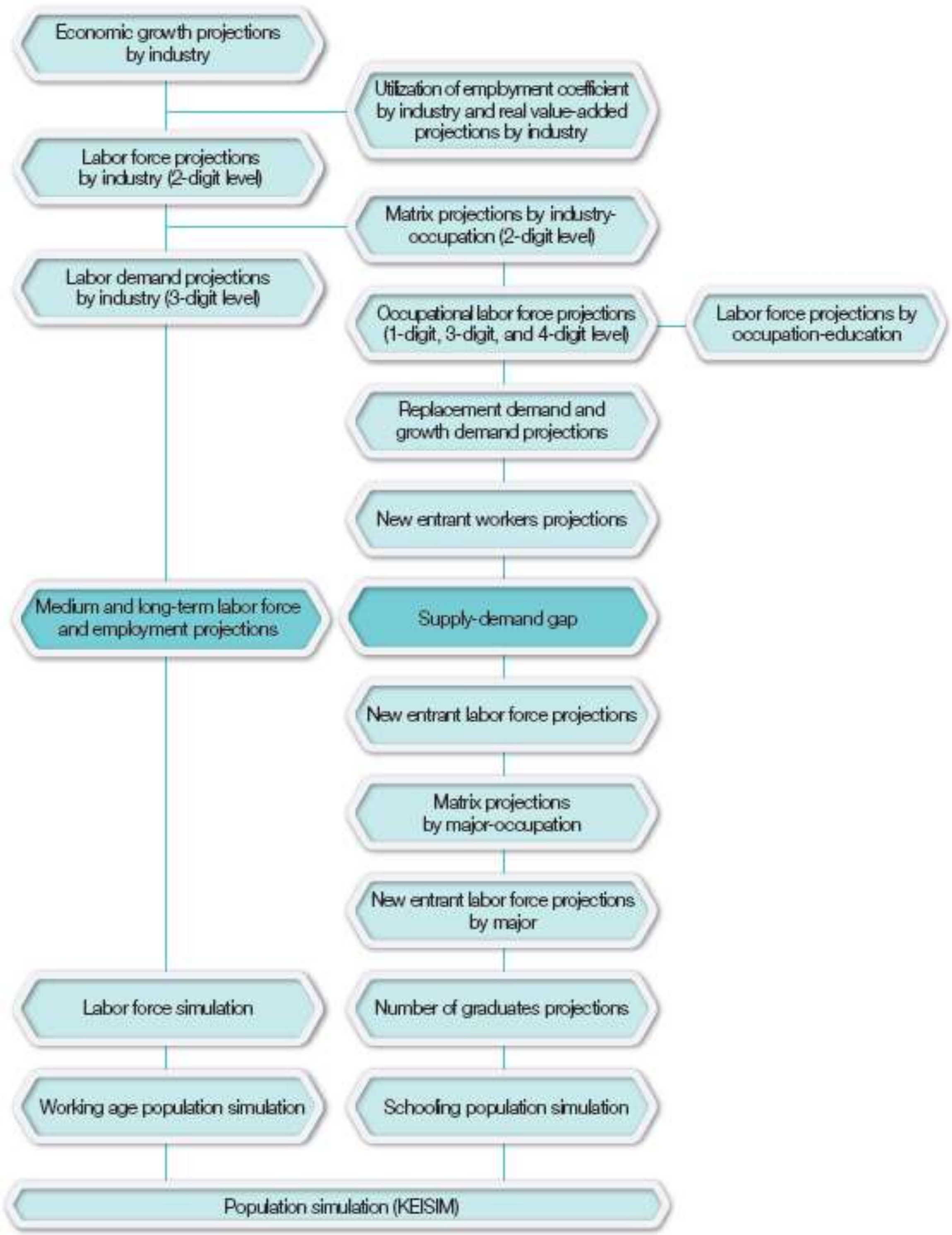
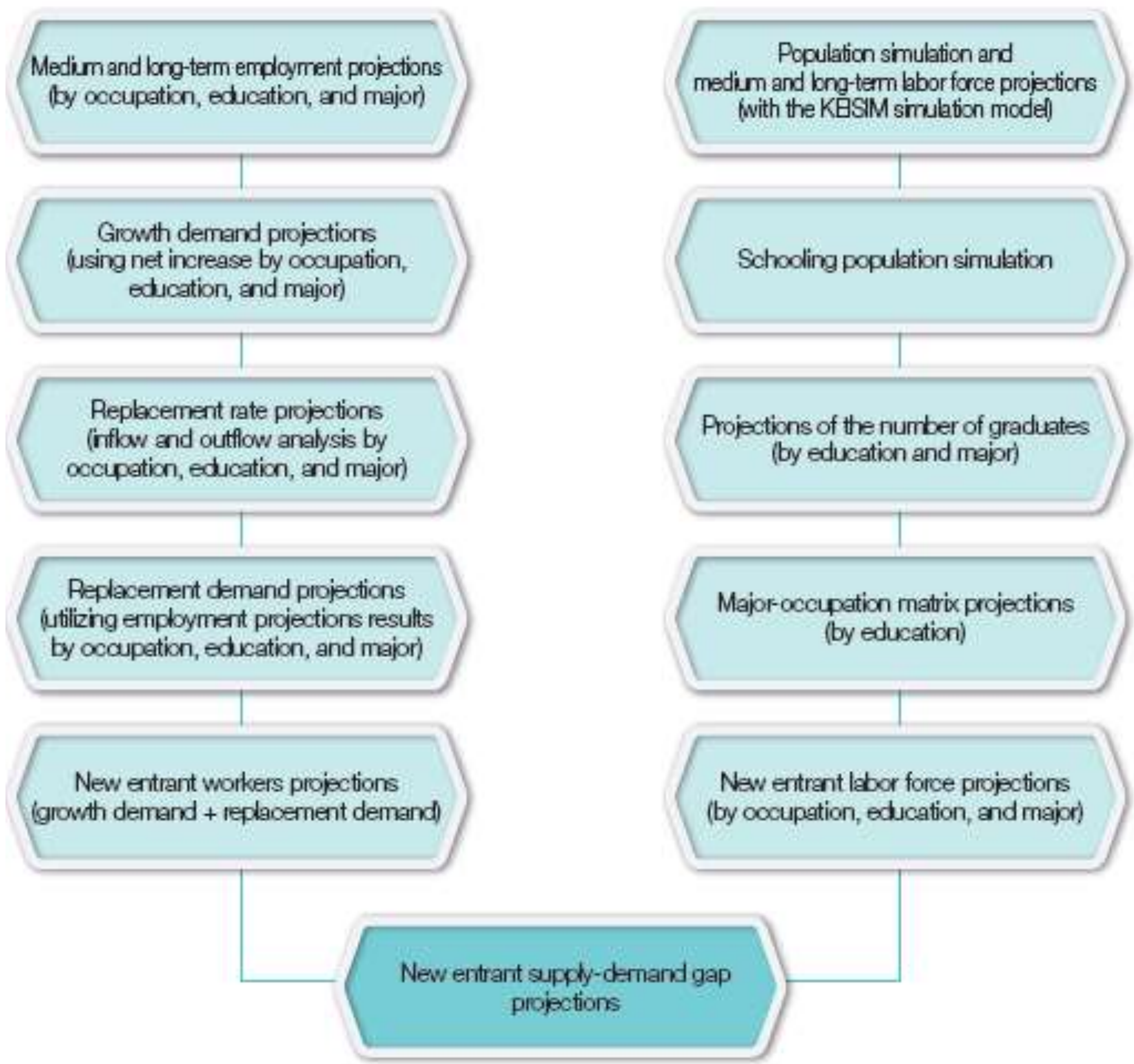
Main Contents ; Korean Experiences

Institution	Title	Forecast target	Forecast period	Year of publication
Institutions with specific responsibility for the workforce forecasting				
Science and Technology Policy Institute	Prospects and Responces of S&T Human Resources Demand and Supply in Restructuring Period	A Research on Governance of Human Resource Training		1999
Science and Technology Policy Institute	Realization of 21st Century S&T Human Resource Power: Key Challenges and Policies	A Research on Governance of Human Resource Training		2003
Science and Technology Policy Institute	A Study on Status and Improvement of Science & Technology Workforce	A Research on Methodology of the Workforce Forecasting		2004.07
Human Resources Development Service of Korea	A Study on the Improvement Model of Industrial Personnel Demand and Supply Forecast: Focusing on the model of German Industry	A Research on Methodology of the Workforce Forecasting		2014.12

Structure of the forecasting model ; employment projections



Structure of the forecasting model ; Projections of supply-demand gap



Structure of the forecasting model ; Definition of S&T Personnel

- **The term scientific and technical personnel is used in various ways depending on the purpose and type of research.**
- **There are three major international definitions related to scientific and technical personnel.**
  - **S&T Personnel at UNESCO – Classification by occupation**
  - **R&D Personnel in the OECD Frascati Manual - Classification by occupation**
  - **The OECD Canberra Manual on Science and Technology Human Resources (HRST) - Classification by occupation and qualification**

Structure of the forecasting model ; Definition of S&T Personnel

S&T Personnel by occupation (UNESCO)

- "… the total number of people participating directly in S&T activities in an institution or unit, and, as a rule paid for their services. This group should include scientists and engineers, technicians and auxiliary personnel…"
- The UNESCO definition is based on S&T activities, i.e. an S&T occupation irrespective of level of qualification.

R&D personnel and researchers (OECD Frascati Manual)

- Research and development (R&D) personnel consists of all individuals employed directly in the field of research and development (R&D), including persons providing direct services, such as managers, administrators, and clerical staff.
- A R&D researcher can be employed in the public or the private sector - including academia - to create new knowledge, products, processes and methods, as well as to manage the projects concerned.

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Structure of the forecasting model ; Definition of S&T Personnel

Human Resources in Science and Technology (OECD Canberra Manual)

(1) General definition

- **HRST refers to those persons who fulfill one or the other of the following conditions; (a) successfully completed education at the third level, (b) not formally qualified as above, but employed in a S&T occupation where the above qualifications are normally required.**

(2) Further specification

- **HRSTE: human resources in science and technology by level of education. Those people who have successfully completed a tertiary level education (until 2013, ISCED97 - levels 5A, 5B, 6; starting with 2014, ISCED2011 - levels 5 to 8);**
- **HRSTO: human resources in science and technology by occupation. Those people not formally qualified as above but employed in a S&T occupation where the above qualifications are normally required (ISCO-08 major groups 2 and 3);**
- **HRSTC(core) refers to those people who have successfully completed a tertiary level education AND are employed in a S&T occupation**
- **SE: scientists and engineers. Those people who work in ISCO-08 groups 21 Science and engineering professionals, 22 Health professionals, 25 Information and communications technology professionals;**

Structure of the forecasting model ; Definition of Competencies

International Standard Classification of Education 2011 (UNESCO)

The following ranges of duration of ISCED levels are used as criteria for classifying formal education programmes:

- ISCED 0: no duration criteria, however a programme should account for at least the equivalent of 2 hours per day and 100 days a year of educational activities in order to be included;
- ISCED 1: duration typically varies from 4 to 7 years. The most common duration is 6 years;
- ISCED 2: duration typically varies from 2 to 5 years. The most common duration is 3 years;
- ISCED 3: duration typically varies from 2 to 5 years. The most common duration is 3 years;
- ISCED 4: duration typically varies from 6 months to 2 or 3 years;
- ISCED 5: duration typically varies from 2 to 3 years; and
- ISCED 8: duration is a minimum of 3 years.

The typical duration of ISCED levels 6 and 7 is more easily described by reference to the durations of programmes at the respective levels as the duration of the ISCED level depends on the sequence of programmes offered at these levels in different countries.

- ISCED 6: the duration of Bachelor's or equivalent level programmes typically varies from 3 to 4 or more years when directly following ISCED level 3, or 1 to 2 years when following another ISCED level 6 programme;
- ISCED 7: the duration of Master's or equivalent level programmes typically varies from 1 to 4 years when following ISCED level 6, or from 5 to 7 years when directly following ISCED level 3.

Structure of the forecasting model ; Definition of Occupation

Human resources in science and technology-related occupations (KSCO)

1-digit level	2-digit level	3-digit level	Occupation title
1 Managers	13 Professional Service Management Occupations	131	Research, Education and Legal Related Managers
		135	Information and Communication Related Managers
		139	Other Professional Service Managers
2 Professionals and Related Workers	21 Science Professionals and Related Occupations	211	Biological and Natural Science Related Professionals
		212	Liberal Arts and Social Science Professionals
		213	Biological and Natural Science Related Technicians
	22 Information and Communication Professionals and Technical Occupations	221	Computer Hardware and Telecommunication
		222	Information System Development Professionals
		223	Information System Operators
		224	Telecommunication and Broadcast Transmission Equipment Technicians
	23 Engineering Professionals and Technical Occupations	231	Construction and Civil Engineering Engineers and Technicians
		232	Chemical Engineers and Technicians
		233	Metal and Material Engineers and Technicians
		234	Environment Engineers and Technicians
		235	Electrical, Electronic and Mechanical Engineers and Technicians
		236	Safety Managers and Inspectors
		237	Aircraft Pilots, Ship Engineers, Controllers
		239	Engineering Professionals and Related Office Workers
	24 Health, Social Welfare and Religion Related Occupations	241	Medical Diagnosis and Treatment Professionals
		242	Pharmacists and Oriental Pharmacists
		243	Nurses
		244	Dietitians
		245	Physical Therapists and Medical Technologists
		246	Health and Medical Related Workers
	25 Education Professionals and Related Occupations	251	College Professors and Instructors
		252	Teachers
		254	Liberal Arts and Sciences, Technical and Arts Instructors
	26 Legal and Administration Professional Occupations	261	Legal and Administration Professional Occupations
	27 Business and Finance Professionals and Related Occupations	274	Technical Sales Representatives and Brokerage Related Workers
3 Clerks	33 Legal and Inspection Occupations	330	Legal and Inspection Clerks

Employment projections ; human resources in science and technology

			Employment				Employment change (number)				Employment change (annual average rate)			
1-digit level	2-digit level	3-digit level	2008	2013	2018	2023	2008~2013	2013~2018	2018~2023	2013~2023	2008~2013	2013~2018	2018~2023	2013~2023
Professionals and Related Workers	Engineering Professionals and Technical Occupations	Construction and Civil Engineering Engineers and Technicians	270.5	227.6	238.0	244.2	-42.9	10.4	6.1	16.5	-3.4	0.9	0.5	0.7
		Chemical Engineers and Technicians	22.9	31.1	36.0	39.3	8.3	4.9	3.3	8.2	6.4	2.9	1.8	2.4
		Metal and Material Engineers and Technicians	8.7	12.1	14.2	15.5	3.4	2.1	1.3	3.4	6.9	3.3	1.8	2.5
		Environment Engineers and Technicians	16.1	27.2	33.5	37.7	11.1	6.4	4.1	10.5	11.0	4.3	2.4	3.3
		Electrical, Electronic and Mechanical Technicians	237.1	284.3	310.7	322.6	47.2	26.4	11.9	38.4	3.7	1.8	0.8	1.3
		Safety Managers and Inspectors	39.8	48.2	56.9	63.6	8.5	8.6	6.8	15.4	3.9	3.3	2.3	2.8
		Aircraft Pilots, Ship Engineers, Controllers	16.6	18.4	20.3	21.4	1.8	1.8	1.1	2.9	2.1	1.9	1.1	1.5
		Engineering Professionals and Related Office Workers	73.0	113.3	155.1	195.6	40.3	41.8	40.5	82.3	9.2	6.5	4.8	5.6
	Health, Social Welfare and Religion Related Occupations	Medical Diagnosis and Treatment Professionals	82.4	114.9	126.8	139.4	32.5	11.9	12.6	24.5	6.9	2.0	1.9	2.0
		Pharmacists and Oriental Pharmacists	34.3	36.6	37.8	39.6	2.3	1.2	1.8	3.0	1.3	0.7	0.9	0.8
		Nurses	170.2	209.0	227.1	245.9	38.8	18.1	18.8	36.9	4.2	1.7	1.6	1.6
		Dietitians	23.9	32.9	38.0	41.1	9.0	5.1	3.0	8.2	6.6	2.9	1.5	2.2
		Physical Therapists and Medical Technologists	101.0	144.9	171.7	193.7	43.8	26.8	21.9	48.8	7.5	3.5	2.4	2.9
		Health and Medical Related Workers	106.1	178.9	217.7	245.7	72.8	38.7	28.1	66.8	11.0	4.0	2.5	3.2

			Employment				Employment change (number)				Employment change (annual average rate)			
1-digit level	2-digit level	3-digit level	2008	2013	2018	2023	2008~2013	2013~2018	2018~2023	2013~2023	2008~2013	2013~2018	2018~2023	2013~2023
Managers	Professional Service Management Occupations	Research, Education and Legal Related Managers	41.8	35.8	34.9	36.3	-6.0	-1.0	1.4	0.4	-3.1	-0.5	0.8	0.1
		Information and Communication Related Managers	8.8	6.2	7.1	7.6	-2.6	0.9	0.5	1.4	-6.7	2.8	1.3	2.0
		Other Professional Service Managers	19.5	19.7	20.1	23.4	0.2	0.4	3.3	3.7	0.2	0.4	3.1	1.7
Professionals and Related Workers	Science Professionals and Related Occupations	Biological and Natural Science Related Professionals	25.7	46.5	64.0	70.2	20.8	17.5	6.2	23.7	12.6	6.6	1.9	4.2
		Liberal Arts and Social Science Professionals	6.0	14.0	20.7	23.9	8.0	6.7	3.2	9.9	18.4	8.2	2.9	5.5
		Biological and Natural Science Related Technicians	7.7	10.8	15.0	16.2	3.1	4.2	1.2	5.4	6.9	6.8	1.5	4.1
	Information and Communication Professionals and Technical Occupations	Computer Hardware and Telecommunication Engineering Professionals	45.6	49.2	54.8	58.0	3.6	5.6	3.2	8.8	1.5	2.2	1.1	1.7
		Information System Development Professionals	212.8	286.2	330.3	385.4	73.4	44.2	55.1	99.2	6.1	2.9	3.1	3.0
		Information System Operators	62.6	64.5	70.4	72.1	1.9	6.0	1.7	7.7	0.6	1.8	0.5	1.1
		Telecommunication and Broadcast Transmission Equipment Technicians	15.1	7.1	7.5	9.3	-8.1	0.5	1.7	2.2	-14.2	1.3	4.3	2.8

Overview of Costa Rica ; School enrollment, Tertiary

Country	2008	2009	2010	2011	2012
Costa Rica and Comparable Countires : School Enrollment, Tertiary					
Costa Rica	..	..	..	44.5	46.7
Korea, Rep.	101.8	101.6	101.0	100.8	98.4

Source: Author's calculations using data from World Bank, World Development Indicators.
Note: … = data not available. Gross enrollment ratio (GER) for tertiary (ISCED 5 and 6) is the total enrollment in tertiary education (ISCED 5 and 6), regardless of age, expressed as a percentage of the total population of the five-year age group following the completion of secondary education.

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Overview of Costa Rica ; Average Years of Formal Education

Country	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013
Costa Rica and Comparable Countries : Average Years of Formal Education										
Costa Rica	8.0	7.9	7.9	8.0	8.2	8.3	8.2	8.3	8.4	8.4
Korea, Rep.	10.6	11.4	11.4	11.5	11.6	11.7	11.8	11.8	11.8	11.8

Source: Author's Calculations using data from United Nations Devlopment Program (http://hdrstats.undp.org/en/indicators/103006.html)

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Overview of Costa Rica ; Percentage of Graduates from Tertiary Science Programs

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Costa Rica and Comparable Countries : Percentage of Graduates from Tertiary Science Programs, both Sexes											
Costa Rica	6.0	..	..	..	..	6.9	..	..	5.7	5.7	..
Korea, Rep.	10.1	10.6	10.2	7.4	7.3	7.4	7.6	7.5	..	7.3	7.1

Source: Authors calculations using data from UNESCO
Note: … = data not availble.

Overview of Costa Rica ; Percentage of Tertiary Graduates in Engineering, Manufacturing, and Construction

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Costa Rica and Comparable Countries : Percentage of Tertiary Graduates in Engineering, Manufacturing, and Costruction, both Sexes											
Costa Rica	6.0	..	..	..	..	6.2	..	..	5.7	6.2	..
Korea, Rep.	30.0	28.4	27.5	29.5	28.1	26.4	24.8	23.4	..	24.6	23.9

Source: Authors calculations using data from UNESCO
Note: … = data not availble.

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Overview of Costa Rica ; Researchers per Million Inhabitants

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Costa Rica and Comparable Countries : Researchers r Million Inhabitants											
Costa Rica	291.0	281.0	253.0	334.0	720.0	789.0	754.0	1,570.0	1,669.0	1,868.0	..
Korea, Rep.	4,093.0	4,253.0	4,487.0	4,990.0	5,426.0	6,077.0	6,268.0	6,710.0	7,139.0	7,699.0	..

Source: Authors calculations using data from UNESCO
Note: … = data not availble.

Overview of Costa Rica ; Researchers in R&D Activities per Million People

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Costa Rica and Comparable Countries : Researchers in R&D Activities per Million People											
Costa Rica	…	131.4	108.1	121.9	…	…	257.0	973.4	1,199.9	1,289.0	…
Korea, Rep.	3,059.0	3,246.4	3,337.9	3,823.1	4,228.9	4,665.0	4,933.1	5,067.5	5,450.9	5,928.3	..

Source: Authors calculations using data from UNESCO
Note: … = data not availble.

Overview of Costa Rica ; R&D Expenditure/GDP

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Costa Rica and Comparable Countries : R&D Expenditure / GDP											
Costa Rica	…	0.4	0.4	…	0.4	0.4	0.4	0.5	0.5	0.5	
Korea, Rep.	2.4	2.5	2.7	2.8	3.0	3.2	3.4	3.6	3.7	4.0	

Source: Authors calculations using data from the World Bank: data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS/countries
Note: … = data not available
Expenditures for R&D are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.

Overview of Costa Rica ; Patent Applications by Residents

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Costa Rica and Comparable Countries : Patent Applications by Residents*											
Costa Rica	..	..	..	..	..	..	..	..	8.0	14.0	10.0
Korea, Rep.	76,570	90,313.	105,250	122,188	125,476	128,701	127,114	127,316	131,805	138,034	148,136

Source: Author's calculations using data from World Bank, World Development Indicators
* Worldwide patent applications field through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights to an invention.

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Overview of Costa Rica ; R&D investment by sector (as percentage of GDP)

Sectors	2006	2007	2008	2009	2010	2011
Costa Rica : R&D investment by Sector *(as percentage of GDP)*						
All	0.43	0.36	0.40	0.54	0.50	0.45
Public sector	0.06	0.06	0.07	0.13	0.18	0.14
Academy	0.16	0.18	0.19	0.26	0.21	0.22
NGOs	0.02	0.02	0.02	0.01	0.01	0.01
Firms	0.19	0.11	0.12	0.14	0.09	0.09

Source: Innovation Surveys, Ministerio de Ciencia, Tecnologia y Telecomunicationes (MICITT).

Overview of Costa Rica ; R&D Firms involved in Innovation Activities by type of Innovation (as percentage of GDP)

Innovation Type	2006-2007	2008	2009	2010-2011
Firms Involved in Innovation Activities by type of Innovation (as percentage of total manufacturing firms)				
Any type of innovation	93.6	90.1	87.5	87.1
Product/service	75.6	69.5	65.5	68.0
Process	65.0	56.6	49.2	62.7
Organizational	46.7	36.0	31.4	41.5
Commercialization	55.4	45.7	39.8	43.7

Overview of Costa Rica ; Sociodemographic estimates

Indicator	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Sociodemographic estimates for Costa Rica											
Gross birth rate (per thousand)	15.3	15	14.8	14.5	14.2	13.9	13.7	13.4	13.1	12.9	12.7
Annual deaths rate (per thousand)	4.4	4.4	4.5	4.5	4.6	4.6	4.7	4.8	4.8	4.9	5
Growth rate (per hundred)	1.2	1.2	1.1	1.1	1	1	1	0.9	0.9	0.9	0.8

source: Roberto Cruz's elaboration with data from INEC, 2016

Overview of Costa Rica ; Participation & Employment

Figure	2010	2011	2012	2013	2014	2015	2016(II)
Total Net Participation (Rate) and Employment (Rate) in Costa Rica							
Total Net Participation	205,169	215,454	218,174	221,056	227,977	224,291	215,731
Employment	190,216	198,953	201,225	202,247	205,960	202,751	195,475
Total Net Participation Rate	59.1	60.7	60.1	59.8	62	60	57.2
Employment Rate	54.8	56	55.4	54.7	56.6	55.4	52.5

source: Roberto Cruz's elaboration with data from INEC, 2016

Overview of Costa Rica ; STEM fields graduates, by sub-field

Fields	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Gr (14-10)
STEM Fields graduates in Costa Rica by sub-fjeld																
Agricultural Science	299	287	276	251	236	314	345	281	316	372	408	383	532	510	461	3.4%
Natural & Exact Science	516	565	622	657	807	995	892	1,060	996	891	980	995	1,286	1,708	1,165	6.5%
Medical Science	1,324	1,285	1,215	1,445	1,393	1,642	1,527	1,760	1,843	2,019	2,342	2,975	3,507	4,020	5,084	10.9%
Technology & Engineering	1,229	1,318	1,438	1,623	1,894	2,235	1,937	2,439	2,665	2,901	3,488	3,769	3,945	4,268	5,086	11.5%
Total	3,368	3,455	3,551	3,976	4,330	5,186	4,701	5,540	5,820	6,183	7,218	8,122	9,270	10,506	11,796	10.1%

Source : Roberto Cruz's elaboration with data from State of the Science, Technology and Innovation, 2016.

Overview of Costa Rica ; R&D personnel in Costa Rica by occupation

R&D personnel	2010	2011	2012	2013	2014
R&D personnel in Costa Rica by occupation					
R+D Personnel	6,156	7,708	6,483	7,193	6,370
Researchers	3,384	3,970	3,414	3,884	3,776
Doctorate Candidates	185	417	216	407	296
R+D Technical Support Personnel	2,587	3,321	2,853	2,902	2,298

Source: MICITT, 2016, p.46

Overview of Costa Rica ; R&D Researcher by area of specialization

Area	2010	2011	2012	2013	2014
R&D Researchers in Costa Rica distribution by area of specialization					
Humanities	142	161	141	159	130
Unspecified	417	250	211	228	244
Agricultural Sciences	499	645	475	608	551
Medical Science	522	672	566	628	531
Engineering and Technology	539	74	497	570	678
Natural and Exact Sciences	589	714	680	711	682
Social Sciences	676	788	844	980	953

Source: MICITT, 2016, p.49

Overview of Costa Rica ; R&D expenditure in Costa Rica in proportion to the GDP

Proportion	2010	2011	2012	2013	2014
R&D expenditure in Costa Rica in proportion to the GDP					
Absolute ($ millions)	180.7	197.7	257.7	276.4	289.3
Relative (% of GDP)	0.5	0.48	0.57	0.56	0.58

Source : Roberto Cruz's elaboration with data from MICITT, 2016.

Overview of Costa Rica ; Distribution of degrees obtained by STEM

Degree	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Distribution of degrees obtained by STEM professionals in Costa Rica, all areas												
Doctorate	0.1%	0.5%	0.7%	0.4%	0.2%	0.8%	0.6%	0.4%	0.4%	1.4%	0.3%	0.5%
Masters	7.3%	9.4%	8.5%	8.4%	9.0%	10.0%	9.6%	11.2%	9.7%	9.3%	10.1%	7.4%
Professional specialization	5.8%	4.1%	5.0%	3.5%	3.2%	3.5%	3.0%	2.9%	2.8%	2.9%	2.4%	3.0%
Licenciate	50.3%	50.9%	48.1%	53.9%	50.2%	49.9%	50.9%	50.0%	53.4%	54.0%	55.4%	55.8%
Bachelors	36.5%	35.1%	37.7%	33.8%	37.5%	35.8%	35.9%	35.4%	33.7%	32.4%	31.8%	33.2%

Source : Roberto Cruz's elaboration with data from State of the Science, Technology and Innovation, 2016.

A Tentative Model Application ; R&D personnel and researchers

- **Demand was analyzed by examining the current status of researchers employed in different sectors. Past trends and productivity are to be considered.**
  - **The number of researchers required in the each R&D sector was computed using R&D investment and research's productivity.**
  - **The total number of researchers was computed by projecting future R&D expenditures by extrapolating previous sectroal R&D level multiplied by the employment coefficient, which is the reciprocal of labor productivity.**

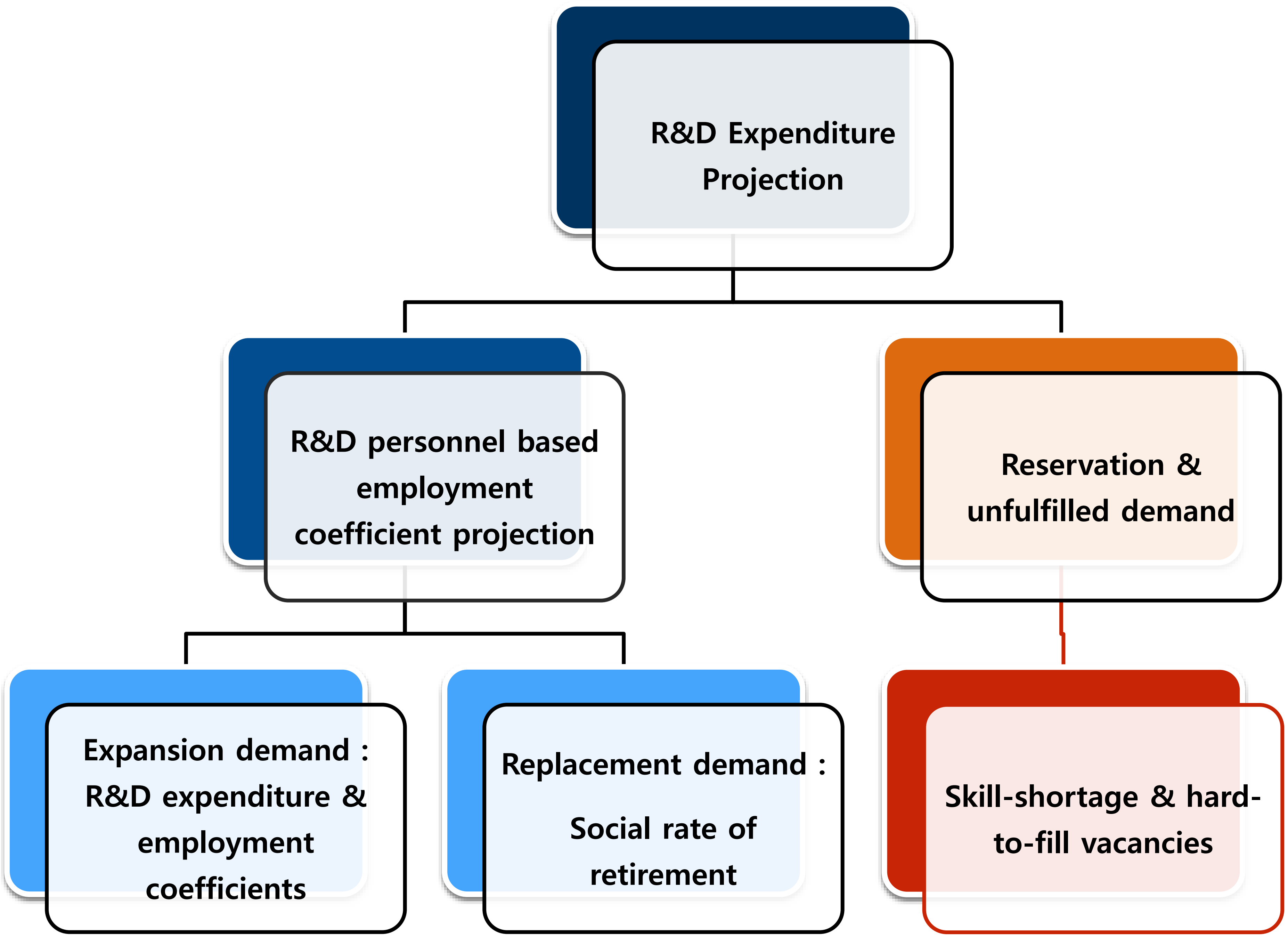
A Tentative Model Application ; R&D personnel and researchers

- **Three major components make up the supply: current supply, future increments, and projected loss. The current supply has two sub-components:**
  - **(a) researchers who are currently employed in various sectors and**
  - **(b) personnel with appropriate degrees who are unemployed, or engaged in activities other than research.**
  - **Future increments were analyzed by examining the total number of students enrolled in education programs and the number of graduates left unemployed.**
- **Projected losses were determined by analyzing the deaths, retirements, and emigrations.**

A Tentative Model Application ; R&D personnel and researchers

- **A summary of the supply and demand projections for the projection periods is provided here.**
  - **These projections yield the relationship between the supply of qualified personnel and the demand for researchers.**
  - **Supply-to-demand ratio is an indication of proficiency of education and training system as well as research productivity which is related to the national level of total R&D expenditures and the structure of research areas.**

STEPI Framework ; Demand Projection



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STEPI Framework ; R&D expenditure in Costa Rica, 2010-2020 ($ million)

Country	2010	2011	2012	20013	2014	2015	2016	2017	2018	2019	2020
R&D expenditure in Costa Rica, 2010-2020 ($ million)											
Costa Rica	189	209	233	262	294	331	372	418	467	521	579

Source: Author's calculations using data from MICITT, 2016

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STEPI Framework ; R&D personnel based employment coefficient projection in Costa Rica, 2010-2020 (per $million)

Country	2010	2011	2012	20013	2014	2015	2016	2017	2018	2019	2020
R&D personnel based employment coefficient projection in Costa Rica, 2010-2020 (per $million)											
R+D Personnel	32.53	36.85	27.78	27.48	21.64	19.61	17.78	16.16	14.70	13.39	12.21
Researchers	17.88	18.98	14.63	14.84	12.83	11.81	10.87	10.00	9.20	8.47	7.79
Doctorate Candidates	0.98	1.99	0.93	1.55	1.01	1.01	1.02	1.03	1.03	1.04	1.05
R+D Technical Support Personnel	13.67	15.88	12.23	11.09	7.81	6.79	5.90	5.13	4.46	3.88	3.37

Source: Author's calculations using data from MICITT, 2016

STEPI Framework ; R&D personnel projection based employment coefficients in Costa Rica, 2010-2020

Country	2010	2011	2012	20013	2014	2015	2016	2017	2018	2019	2020
R&D personnel projection based employment coefficients in Costa Rica, 2010-2020											
R+D Personnel	6,156	7,708	6,483	7,193	6,370	6,493	6,620	6,745	6,863	6,971	7,067
Researchers	3,384	3,970	3,414	3,884	3,776	3,910	4,044	4,175	4,298	4,410	4,511
Doctorate Candidates	185	417	216	407	296	335	380	429	483	542	607
R+D Technical Support Personnel	2,587	3,321	2,853	2,902	2,298	2,248	2,196	2,141	2,082	2,018	1,950

Source: Author's calculations using data from MICITT, 2016

STEPI Framework ; Expansion & replacement demand for R&D personnel in Costa Rica, 2010-2020

Country	2010	2011	2012	20013	2014	2015	2016	2017	2018	2019	2020
Expansion & replacement demand for R&D personnel in Costa Rica, 2010-2020											
Expansion											
Researchers	-	586	-556	470	-108	134	135	130	123	113	100
Doctorate Candidates	-	232	-201	191	-111	39	44	49	54	59	65
R+D Technical Support Personnel	-	734	-468	49	-604	-50	-52	-55	-59	-64	-69
Total	-	1,552	-1,225	710	-823	123	127	125	118	108	96
Replacement											
Researchers	135	159	137	155	151	156	162	167	172	176	180
Doctorate Candidates	7	17	9	16	12	13	15	17	19	22	24
R+D Technical Support Personnel	103	133	114	116	92	90	88	86	83	81	78
Total	246	308	259	288	255	260	265	270	275	279	283

Source: Author's calculations using data from MICITT, 2016
Note: … = data not availble.

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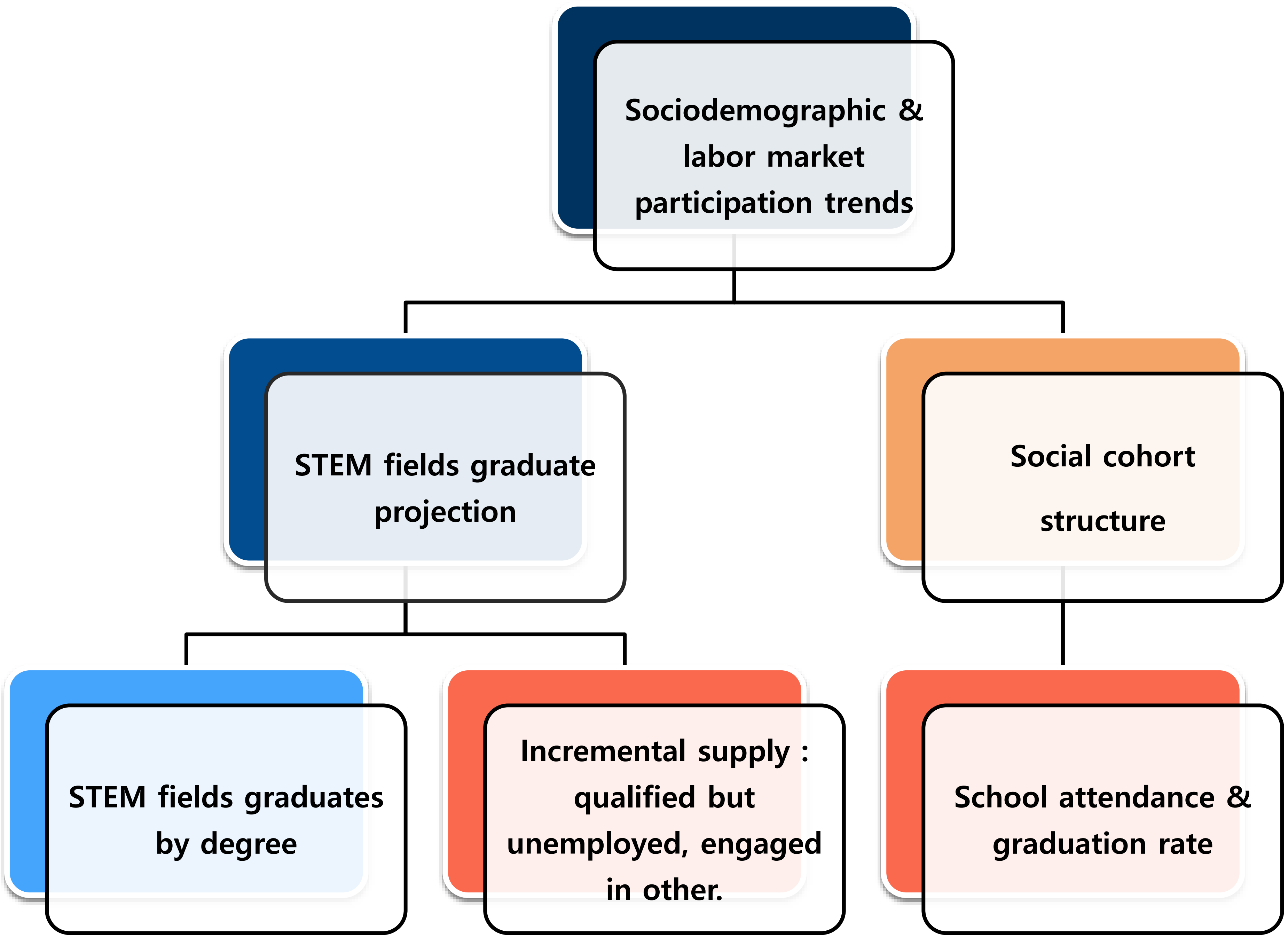
STEPI Framework ; Recruitment demand for R&D personnel in Costa Rica, 2010-2020

Country	2010	2011	2012	20013	2014	2015	2016	2017	2018	2019	2020
Recruitment demand for R&D personnel in Costa Rica, 2010-2020											
Recruitment											
Researchers	-	745	-419	625	43	290	296	297	295	289	281
Doctorate Candidates	-	249	-192	207	-99	53	59	66	74	81	89
R+D Technical Support Personnel	-	867	-354	165	-512	40	36	31	24	17	9
Total	-	1,860	-966	998	-568	383	392	395	392	387	379

Source: Author's calculations using data from MICITT, 2016
Note: … = data not availble.

STEPI Framework ; Supply Projection



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STEPI Framework ; STEM fields graduates in Costa Rica, by sub-field, 2010-2020

Country	2010	2011	2012	20013	2014	2015	2016	2017	2018	2019	2020
Costa Rica STEM fields graduates iby sub-field, 2010-2020											
Agricultural Science	408	383	532	510	461	475	490	506	522	538	555
Natural and Exact Science	980	995	1,286	1,708	1,165	1,235	1,309	1,387	1,470	1,558	1,652
Medical Science	2,342	2,975	3,507	4,020	5,084	5,597	6,161	6,783	7,467	8,220	9,050
Technology and Engineering	3,488	3,769	3,945	4,268	5,086	5,629	6,230	6,895	7,632	8,446	9,348
Total	7,218	8,122	9,270	10,506	11,796	12,936	14,191	15,571	17,091	18,763	20,604

Source: Author's calculations using data from MICITT, 2016
Note: … = data not availble.

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STEPI Framework ; Distribution of degrees obtained by STEM professionals in Costa Rica, all areas, 2000-2020

Country	2010	2011	2012	20013	2014	2015	2016	2017	2018	2019	2020
Costa Rica STEM fields graduates iby sub-field, 2010-2020											
Doctorate	0.3%	0.5%	0.5%	0.5%	0.4%	0.44%	0.47%	0.46%	0.45%	0.44%	0.45%
Masters	10.1%	7.4%	7.7%	6.1%	5.0%	7.26%	6.69%	6.55%	6.32%	6.36%	6.64%
Professional specialization	2.4%	3.0%	3.0%	3.4%	2.3%	2.82%	2.90%	2.88%	2.86%	2.75%	2.84%
Licenciate	55.4%	55.8%	51.8%	49.2%	47.0%	51.84%	51.13%	50.19%	49.87%	50.01%	50.61%
Bachelors	31.8%	33.2%	36.9%	40.8%	45.3%	37.60%	38.76%	39.87%	40.47%	40.40%	39.42%

Source: Author's calculations using data from MICITT, 2016
Note: … = data not availble.

STEPI Framework ; STEM fields graduates in Costa Rica, by degree, 2015-2020

Country	2015	2016	2017	2018	2019	2020
Costa Rica STEM fields graduates by degree						
Doctorate	57	66	72	78	83	93
Masters	939	950	1,020	1,080	1,194	1,368
Professional specialization	365	412	449	489	517	586
Licenciate	6,706	7,255	7,816	8,523	9,383	10,427
Bachelors	4,864	5,500	6,209	6,916	7,580	8,122

Source: Author's calculations using data from MICITT, 2016

STEPI Framework ; STEM fields graduates and recruitment demand comparision in Costa Rica, by degree, 2015-2020

Country	2015	2016	2017	2018	2019	2020	Sum(15-20)
Costa Rica STEM fields graduates by degree							
Doctorate	57	66	72	78	83	93	450
Masters	939	950	1,020	1,080	1,194	1,368	6,551
Professional specialization	365	412	449	489	517	586	2,818
Licenciate	6,706	7,255	7,816	8,523	9,383	10,427	50,111
Bachelors	4,864	5,500	6,209	6,916	7,580	8,122	39,191

Source: Author's calculations using data from MICITT, 2016

Country	2015	2016	2017	2018	2019	2020	Sum(15-20)
Costa Rica STEM fields graduates by degree							
Researchers	290	296	297	295	289	281	1,748
Doctorate Candidates	53	59	66	74	81	89	422
R+D Technical Support Personnel	40	36	31	24	17	9	157
Total	383	392	395	392	387	379	2,328

Source: Author's calculations using data from MICITT, 2016

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Preliminary Conclusions

- Overall, the supply of Doctorate in Costa Rica for STEM fields is expected to be a significant constraint to effectively carry out research needs by 2020.
- If researchers all mean Doctorate holders, then we can expect a considerable supply shortage in the near future.
  - For researchers, there will be no significant change from 290 in 2015 to 281 in 2020, with 1,748 demand expected during this period.
  - However, Doctorate supply is expected to be only 450 during this period.
  - On the other hand, if the qualification required for a researcher is met with a master's degree - in terms of the content or difficulty of the study - at least in terms of quantity, the supply may be considered sufficient.

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Preliminary Conclusions

- **It can be concluded that the supply of Doctorate Candidates is also not sufficient to perform stable R&D in Costa Rica.**
  - **Demand for Doctorate Candidates is expected to be around 422 in 2015-2020 and is on the rise.**
  - **Assuming that the dissertation preparation is required for 3 years after the doctorate student has successfully completed the final qualification exam and proposal process, assuming that (2/3) of them successfully graduate, 900 Doctorate Candidates will be supplied.**
  - **When comparing these two figures, supply is about twice the demand.**
  - **There is no exact figure, but the concluding a half of Doctorate Candidates will participate in R&D is excessive.**

Preliminary Conclusions

- What is worrying more than anything is that the demand-supply gap will increase if it is subdivided by sub-major even if the aggregate supply and aggregate demand seem to be fairly balanced.
  - This level of doctorate supply is likely to experience a serious supply shortage in the sector, particularly in areas where demand for R&D is growing.

- Fortunately, the supply of R+D Technical Support Personnel seems to be no problem when looking at the masters, Professional specialization, Licenciate and Bachelors graduates - at least quantitatively.

Obstacles and Challenges to be Overcome

- The supply and demand forecasts go through a number of stages of estimation, and the data-binding problem at each stage undermines the model's coherence.
- There's a foundational limitation, which is the lack of a centralized body that processes data and keeps it updated, coordinating with government and public institutions, private sector representatives or chambers and the heads of the higher education institutions (public and private).
    - Costa Rica lacks an entity like the Korean Employment Information Services (KEIS) that centralizes relevant functions and operates autonomously.
    - It should also be accomplished through a national policy for R&D funding may be corresponds the needs of industries as well as HEIs.

Obstacles and Challenges to be Overcome

- **The main obstacle and limitation is the lack of current and up-to-date information; in some cases, the lack of information at all.**
  - **Despite the role of MICITT as the central institution in the subjects of science, technology and innovation, its operating capacity is far from optimal regarding the collection, systematization and dissemination of data in these areas.**
  - **This leads to an atomization of data that follows different standardization and methodological goals, making it more complicated to obtain and analyze.**
  - **Especially, private organizations, on the other side, are more secretive, with limited channels of communication and little cooperative nature, despite clarifying the objective and nature of the research.**

Policy Recommendations

- The first step is to collect and integrate data on STEM fields enrollments and graduates from public and private universities and to establish and operate a small research group that will conduct analysis related to demand-supply forecasting from the most basic stages.
  - In the case of Korea Employment Information Service (KEIS), the Employment Information Research Division is conducting labor market analysis, employment forecasting, panel surveillance as well as monitoring of policy.
  - Korean Education Development Institute (KEDI), serving as a leading institution in educational policy development and its implementation since 1972, has been providing Korea Education Statistics Service.
  - KEDI has one of its subsidiaries, the Education Survey and Statistics Research Division, which includes the Office of Survey and Data Analysis and the Center for Educational Statistics, which allow for organic investigation and analysis.

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Policy Recommendations

Organization Chart

The Korea Employment Information Service :
the organization both labor and management smiling together

- Organization: 3 Division, 1 Office, and 25 teams

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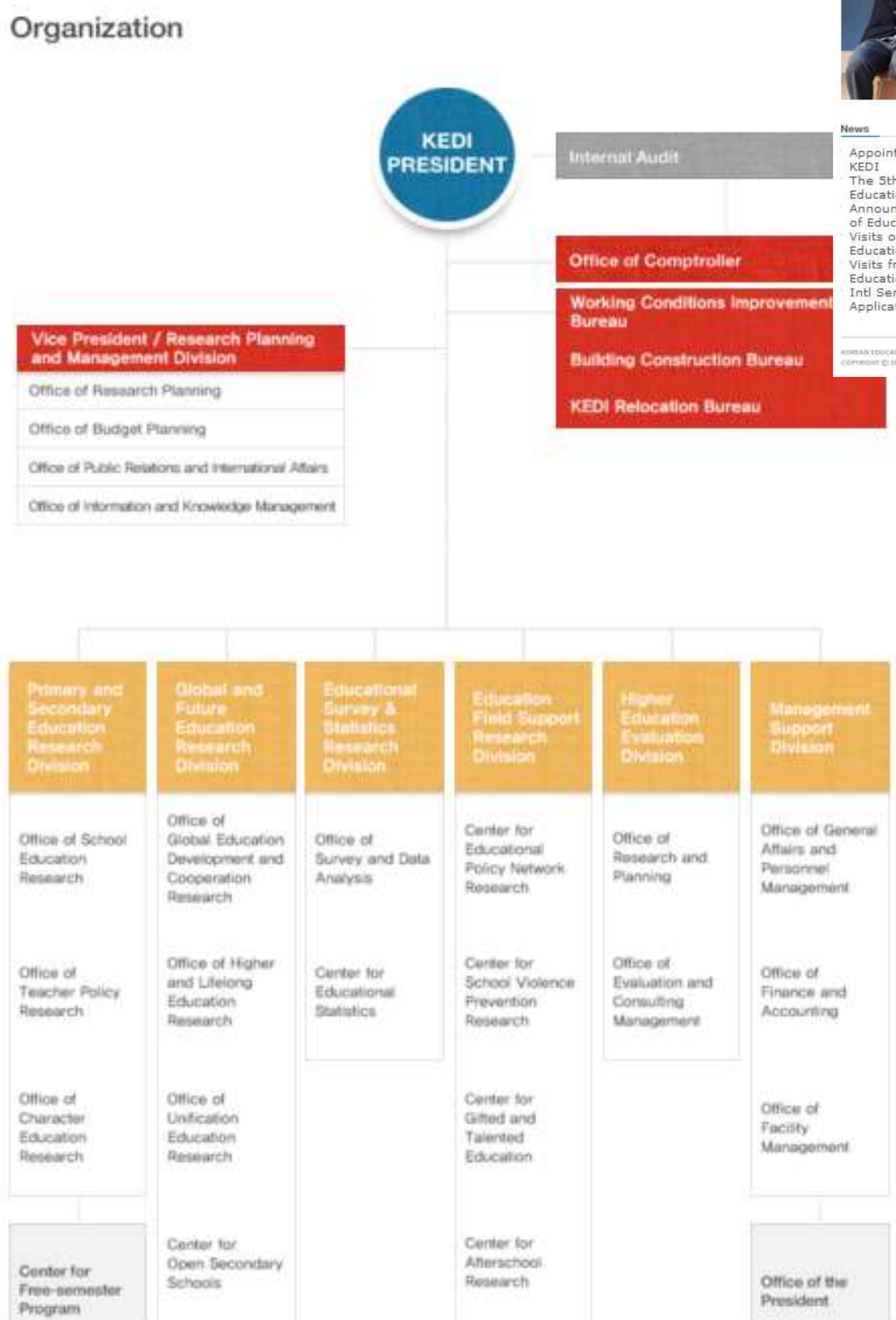
Policy Recommendations



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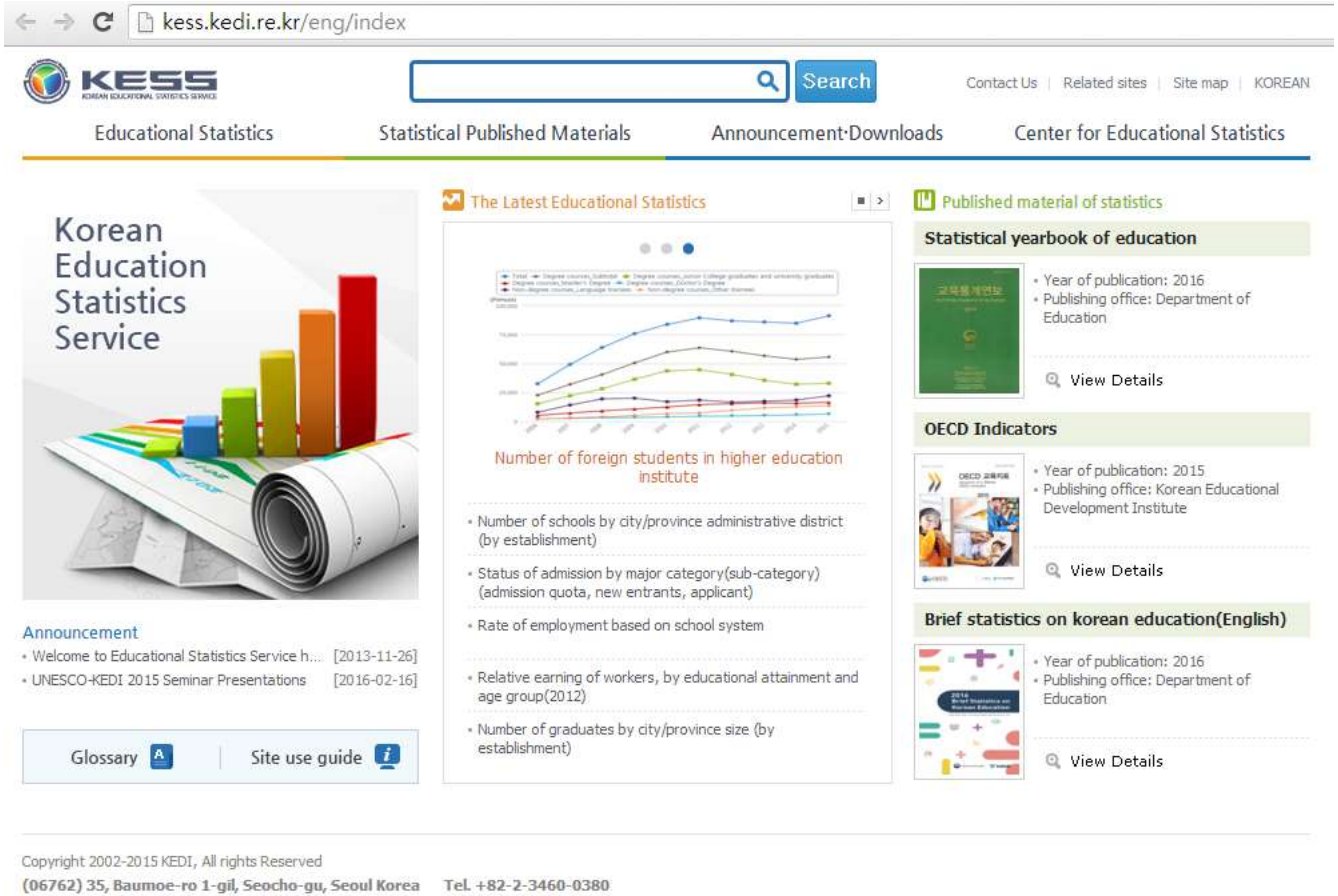
Policy Recommendations



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Policy Recommendations

- **To build demand and supply forecast models for STEM fields graduates, it is necessary to establish a mid- to long-term roadmap.**
  - The roadmap needs to be structured in four broad areas.
  - The first is to identify the statistical requirements for the supply and demand forecasts and to design specific surveys to collect such data, and to develop questionnaires.
  - The second is to identify the functions needed to complete the supply and demand forecast and select the institutions to participate. In particular, it is necessary to allocate and assign the functions to the participating organizations, to set the sequences and processes, and to designate the person in charge. Above all, it is also necessary at this stage to establish a supervising body or supervisor to coordinate this process.

Policy Recommendations

▶ **To build demand and supply forecast models for STEM fields graduates, it is necessary to establish a mid- to long-term roadmap.**

- The third step is to secure a budget and identify it as a government task and assign it to a specific ministry. In the case of Korea, each ministry independently undertook supply-demand forecasting, but eventually, even if not successful, the Prime Minister's Office was trying to coordinate those functions.
- The fourth step is to create a research networks in which experts participate. In Korea, the Ministry of Education, which was the deputy prime minister at the time and was responsible for human resources development policy, supported creating a network of researchers who were responsible for the supply and demand forecasts through affiliated research institute such as KRIVET(Korea Research Institute for Vocational Education and Training).

Policy Recommendations

- **In order to develop a demand-supply forecasting model for STEM fields graduates, and to develop surveys and analytical techniques, it is necessary to nurture and secure experts.**
  - **In Korea, mostly labor economists and econometricians were involved in model development, and statisticians participated in the survey.**
  - **In addition, the contribution of macroeconomists and industrial economists was needed to forecast GDP growth and industry-specific growth rates, which are fundamental data for supply and demand forecasts for STEM fields.**
  - **Above all, the most effective way to develop a supply-demand forecasting model is to start with a relatively simple model and build up experience. In this regard, it is important to complete the supply and demand forecast for research personnel which has been conducted through this KSP project.**

Further Suggestions in A Broader Context

- The advantages to be achieved by organizing committees as the heads of relevant ministries and agencies, and by forming task forces with those responsible for their work are significant.
  - Supply and demand forecasts are based on the ability to cooperate with various organizations and create governance, though they will be carried out at a single project level.

- A structured and multi-level national qualifications system, Professional Engineers (PA) at its highest level - is most effective way Korea successfully executed to provide high-quality technicians and engineers for fast growing industry promptly.
  - The functioning of higher education systems, particularly universities, may be limited in fostering sufficiently large-scale qualified technicians and engineers.

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Further Suggestions in A Broader Context

Classification		Number of items	Remarks
Total		3,437	
National qualifications	Sub-total	644	
	National technical qualifications	512	Technicians, engineers etc
	National professional qualifications	132	licensed customs agents etc
Private qualifications	Sub-total	2,793	
	Authorized private qualifications	84	Chinese characters proficiency test, etc.
	Registered private qualifications	2,600	After school instructors, etc.
	In-house qualifications	109	KT in-house qualification, etc.

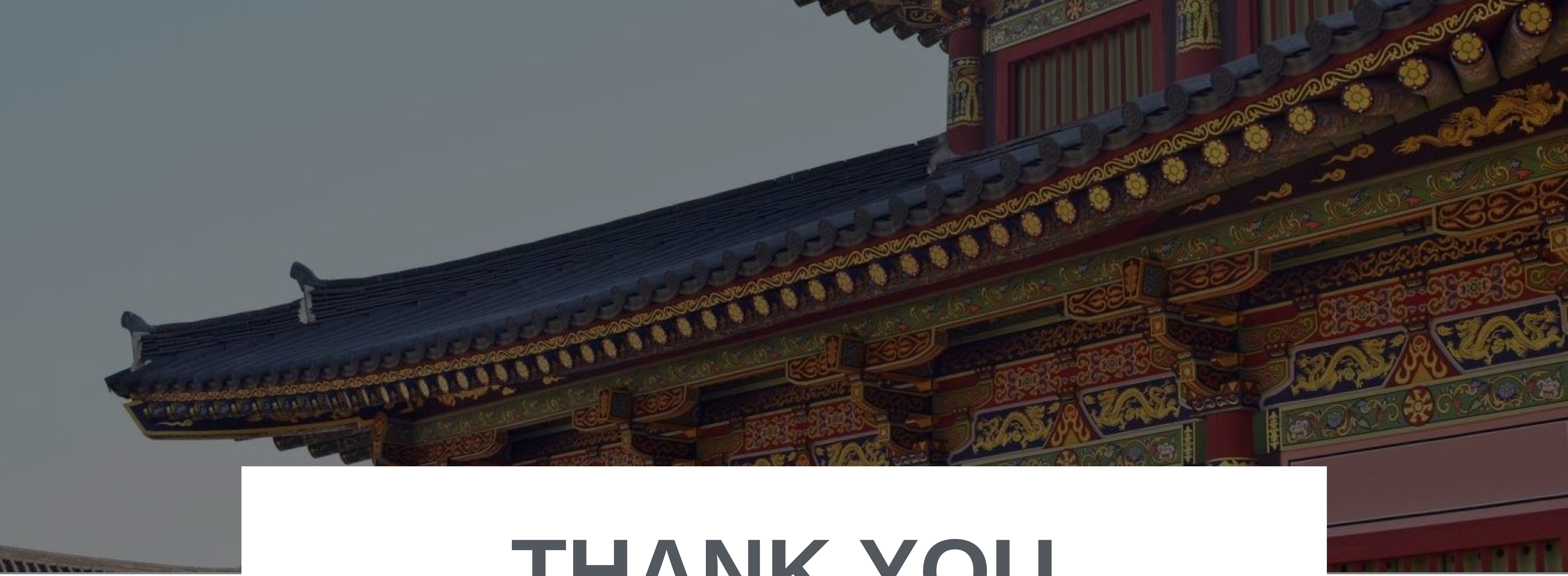
* * HRD Korea operates national qualifications (Technical qualifications 467 items, professional qualifications 36 items) and supports in-house qualification recognition

Further Suggestions in A Broader Context

- It is recommended that a top decision-making body, chaired by the president who coordinates policies on science, technology and innovation among the ministries and allocates the budget, is a successful example of Korea's experience.
  - Korea has a long history of running the National Science and Policy Council(NSTC) as the chief decision-making body with the President as its chair.
  - At the same time, the Presidential Advisory Council for Science and Technology(PACST) was also run to advise the President on science and technology policy.
  - In 2004, the Korean government made the Ministry of Science and Technology a deputy prime ministerial department, not only reviewing and allocating the R&D budget of all ministries.

Further Suggestions in A Broader Context

- **There is a need for an active solution on how to overcome under-investment of R&D and university STEM fields.**
  - **The growth of ICT technology in Korea was possible because of bold R & D investment, which was made possible by government policies that allowed a portion of sales to be spent for R&D.**
  - **In 2005, the Ministry of Science and Technology, as a deputy prime minister, issued scientific and technical bonds to promote more bold R&D.**
  - It can be said that Korea's ICT technology and industry actually started from a single successful R&D project. It was an electronic telephone switch, which later created a chain reaction leading to consumer electronics - semiconductors – communications.
  - The companies that participated in this electronic telephone exchange at the time grew into conglomerates, which are all called chaebol, and one of them is Samsung Electronics.



THANK YOU