United Arab Emirates

Measuring innovation and R&D in the UAE

INSEAD, Innovation and Policy Initiative
28 March 2012

What are R&D and innovation?

Innovation is the creation of better, more effective products, or new services, technologies, or ideas that are accepted by markets, governments and society

According to the Oslo Manual (2005), innovation is "the implementation of products or production and delivery processes with new or significantly improved characteristics"

Research and development (R&D) is the process of discovering new ideas or products, often whose benefits are not immediately realised

According to the Frascati Manual (2002), R&D "comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications"

Is innovation and R&D always beneficial?

- Innovation is not always necessarily beneficial to society (e.g. CDOs). Likewise, the benefits of R&D must be weighed against the time and resources it consumes, especially as R&D often may not bear any fruit
- However, innovations and R&D expand the consumption possibilities of society either directly (e.g. new products) or indirectly through making more efficient uses of resources, technologies and processes
- Information, knowledge, and other intangibles power economic prosperity and wealth creation, so it is imperative to be patient and have a long-term perspective with regards to R&D

UAE Vision 2021

United in knowledge

A competitive economy driven by knowledgeable and innovative Emiratis

A diversified and flexible knowledge-based economy will be powered by skilled Emiratis and strengthened by world-class talent to ensure long-term prosperity for the UAE

Characteristics of innovation

1. Innovation involves the combination of inputs in the creation of outputs
2. Inputs to innovation can be tangible and intangible
3. Knowledge is a key input into innovation
4. The inputs to innovation are assets
5. Innovation involves activity for the purpose of creating economic value
6. The process of innovation is complex
7. Innovation involves risk
8. The outputs of innovation are unpredictable
9. Knowledge is a key output of innovation
10. Innovation involves research, development, and commercialisation

Adapted from "Frameworks for measuring innovation" (Science and Technology Institute)

Defining research and experimental development (R&D)

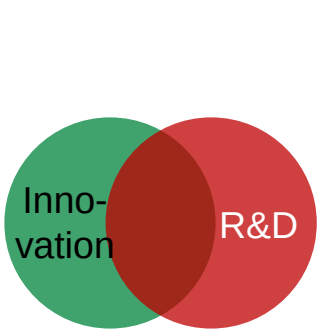
Technical definition (Frascati Manual (2002))

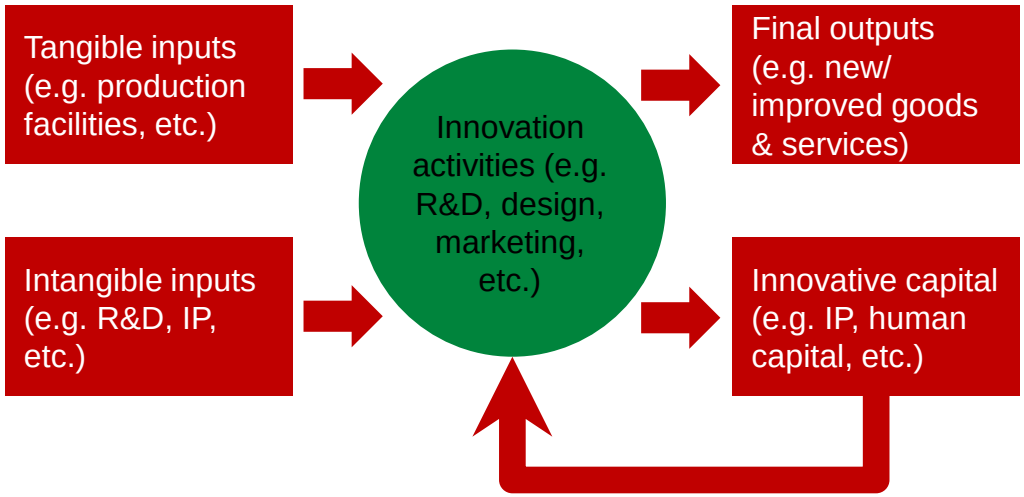
- "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (Frascati Manual (2002))
- "R&D covers both formal R&D in R&D units and informal or occasional R&D in other units" (i.e. there are likely many people performing R&D who are not aware of their doing it, and vice-versa)
- "R&D must be distinguished from a wide range of related activities with a scientific or technological basis. These other activities… must be excluded when measuring R&D"
- There are three forms of R&D: (1) basic research, (2) applied research, and (3) experimental development

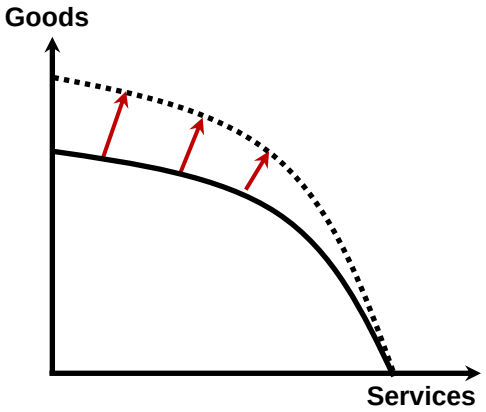
1. **Basic research**
   - No particular application or use in view (e.g. much of university research, especially in the non-technical and theoretical fields)
2. **Applied research**
   - Directed primarily towards a specific practical aim or objective (e.g. investigating the effects of using saline water to hydrate desert plants)
3. **Experimental development**
   - Directed towards producing new materials, products or devices (e.g. developing plants that can grow in the UAE using saline water hydration)

The linkages between innovation and R&D

- Innovation and R&D are often spoken in the same breath and also often confused. Although they are similar concepts they differ in several regards, mainly that R&D is systematic and novel, while innovations are always associated with an output whereas R&D may fall short in producing a result
- Innovation and R&D overlap with each other and the OECD/Unesco take great care in separating the two (as well as with science and technology); the Oslo Manual (2005) is dedicated to defining innovation (to facilitate international comparisons) while the Frascati Manual (2002) does the same for R&D
- Innovation allows society to expand its set of consumption possibilities by either creating new goods and services, or by making more efficient uses of existing resources. Such innovations are often the result of R&D and the benefits and byproducts of the innovation spill over to society
- The process of innovation is like a funnel that takes in many ideas and uses R&D (amongst other things) to produce finished outputs



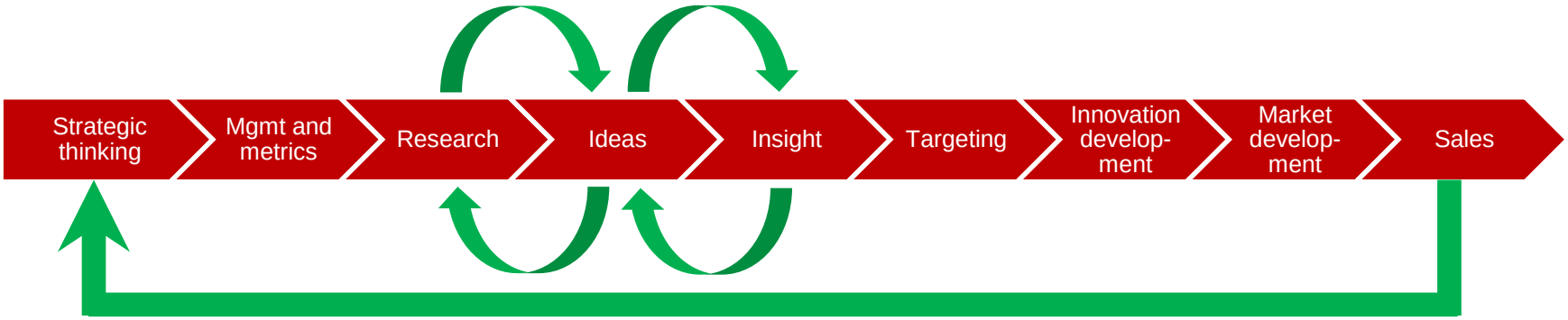




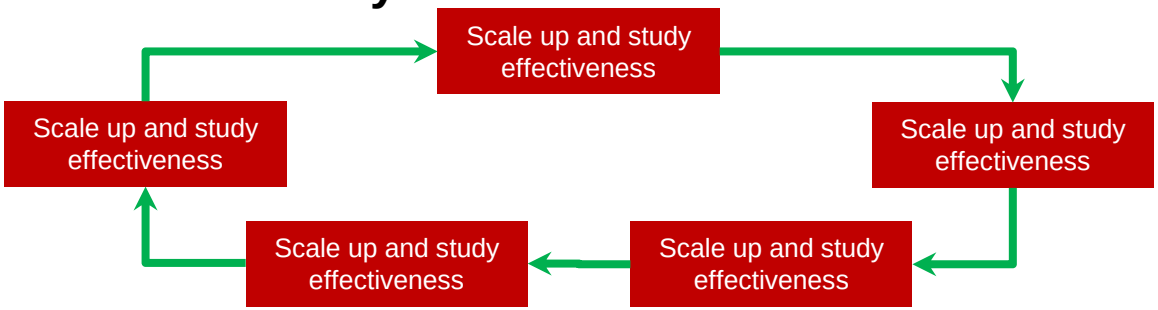
Life cycles of commercial innovation and R&D

- Most people envision innovation and R&D as taking place in a laboratory performed by people in white lab coats. However, the truth is that innovation and R&D can be found in all sectors of the economy, in both private and public organisations, and at enterprises of all sizes
- The below diagrams show the life cycles of innovation and R&D that have a commercial focus:

Life cycle of commercial innovation



Life cycle of commercial R&D



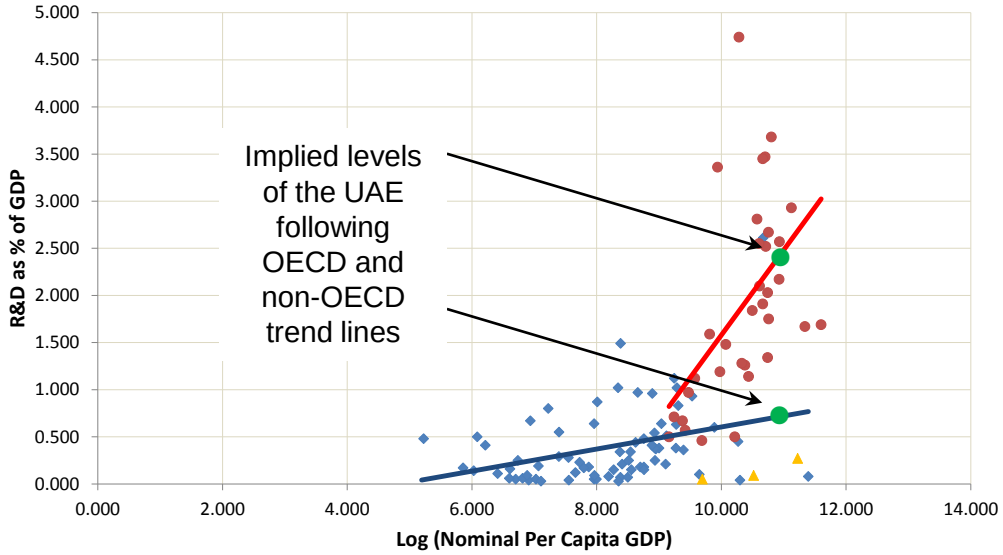
R&D expenditure levels: GERD as percentage of GDP

- Gross (domestic) expenditures on R&D (GERD) is typically normalised by expressing it as a percentage of GDP, and this measure is highly positively correlated the level of economic development of a country. The relationship is stronger for OECD nations versus non-OECD nations
  - The overall average level of R&D expenditures in OECD countries is 1.98%
- The UAE is not an OECD country, a group that is commonly referred to as the "rich countries club". However, the UAE is richer than most OECD countries (as such it is classified as a high-income non-OECD country)
- However, both the data infrastructure and the state of R&D is less highly developed than in OECD countries with comparable per capita income
- As the UAE diversifies from hydrocarbons it is focusing on developing its R&D to increasingly important role in its growth

R&D expenditures as a percentage of GDP

#	Leading countries	R&D % of GDP
1	Israel	4.74
2	Sweden	3.68
3	Finland	3.47
4	Japan	3.45
5	Korea	3.36
6	Switzerland	2.93
7	Iceland	2.81
8	USA	2.67
9	Singapore	2.61
10	Denmark	2.57

Arab world	R&D % of GDP
Tunisia	1.02
Morocco	0.64
Jordan	0.34
Qatar	0.27
Kuwait	0.09
Algeria	0.07
Saudi Arabia	0.05
UAE (non-OECD)	0.72
UAE (OECD)	2.45



Blue triangles = Non-OECD; red circles = OECD; yellow triangles = GCC; green dot = UAE

Sources: Unesco; Qatar data from IMD; UAE data from ECC calculation

Innovation captured in IMD's World Competitiveness Yearbook and the WEF's Global Competitiveness Report

There are two internationally acclaimed reports on national competitiveness: The Global Competitiveness Index (GCI) and the World Competitiveness Yearbook (WCY)

- The IMD's World Competitiveness Yearbook (WCY) is a derived from a set of 331 indicators, of which 248 are used in the WCY index
- There are 46 science and technology indicators in the WCY, of which 42 are used in the WCY index, accounting for 10% of the index score

Number	Sub-pillar	Pillar	Indicator	Score	Rank	Weight
4.2.01	Technological infrastructure	Infrastructure	Investment in telecommunications (%)	0.2	56	0.27%
4.2.02	Technological infrastructure	Infrastructure	Fixed telephone lines	339.0	31	0.27%
4.2.03	Technological infrastructure	Infrastructure	Fixed telephone tariffs	0.0	17	0.27%
4.2.04	Technological infrastructure	Infrastructure	Mobile telephone subscribers	2,321.0	1	0.27%
4.2.05	Technological infrastructure	Infrastructure	Mobile telephone costs	0.1	4	0.27%
4.2.06	Technological infrastructure	Infrastructure	Communications technology	7.6	39	0.15%
4.2.07	Technological infrastructure	Infrastructure	Connectivity	7.8	35	0.15%
4.2.08	Technological infrastructure	Infrastructure	Computers in use	0.1	50	0.27%
4.2.09	Technological infrastructure	Infrastructure	Computers per capita	287.0	41	0.27%
4.2.10	Technological infrastructure	Infrastructure	Internet users	736.0	24	0.27%
4.2.11	Technological infrastructure	Infrastructure	Fixed broadband tariffs	40.6	53	0.27%
4.2.12	Technological infrastructure	Infrastructure	Broadband subscribers	84.9	45	0.27%
4.2.13	Technological infrastructure	Infrastructure	Internet bandwidth speed	17.6	34	0.27%
4.2.14	Technological infrastructure	Infrastructure	Information technology skills	7.4	38	0.15%
4.2.15	Technological infrastructure	Infrastructure	Qualified engineers	6.9	32	0.15%
4.2.16	Technological infrastructure	Infrastructure	Technological cooperation	6.0	22	0.15%
4.2.17	Technological infrastructure	Infrastructure	Public and private sector ventures	6.4	24	0.15%
4.2.18	Technological infrastructure	Infrastructure	Development and application of technology	6.7	25	0.15%
4.2.19	Technological infrastructure	Infrastructure	Funding for technological development	6.2	19	0.15%
4.2.20	Technological infrastructure	Infrastructure	Technological regulation	6.1	33	0.15%
4.2.21	Technological infrastructure	Infrastructure	High-tech exports ($)	29.0	58	0.27%
4.2.22	Technological infrastructure	Infrastructure	High-tech exports (%)	3.2	54	0.27%
4.2.23	Technological infrastructure	Infrastructure	Cyber security	[illegible]	[illegible]	0.15%
4.3.01	Scientific infrastructure	Infrastructure	Total expenditure on R&D ($)	N/A	N/A	0.31%
4.3.02	Scientific infrastructure	Infrastructure	Total expenditure on R&D (%)	N/A	N/A	0.31%
4.3.03	Scientific infrastructure	Infrastructure	Total expenditure on R&D per capita ($)	N/A	N/A	
4.3.04	Scientific infrastructure	Infrastructure	Business expenditure on R&D ($)	N/A	N/A	0.31%
4.3.05	Scientific infrastructure	Infrastructure	Business expenditure on R&D (%)	N/A	N/A	0.31%
4.3.06	Scientific infrastructure	Infrastructure	Total R&D personnel nationwide	N/A	N/A	0.31%
4.3.07	Scientific infrastructure	Infrastructure	Total R&D personnel nationwide per capita	N/A	N/A	0.31%
4.3.08	Scientific infrastructure	Infrastructure	Total R&D personnel in business enterprise	N/A	N/A	
4.3.09	Scientific infrastructure	Infrastructure	Total R&D personnel in business per capita	N/A	N/A	
4.3.10	Scientific infrastructure	Infrastructure	Science degrees	13.0	39	0.31%
4.3.11	Scientific infrastructure	Infrastructure	Scientific articles	214.0	53	0.31%
4.3.12	Scientific infrastructure	Infrastructure	Nobel prizes	0.0	27	
4.3.13	Scientific infrastructure	Infrastructure	Nobel prizes per capita	0.0	27	0.31%
4.3.14	Scientific infrastructure	Infrastructure	Patent applications	78.0	57	0.31%
4.3.15	Scientific infrastructure	Infrastructure	Patent applications per capita	1.0	57	0.31%
4.3.16	Scientific infrastructure	Infrastructure	Patents granted to residents	22.0	47	0.31%
4.3.17	Scientific infrastructure	Infrastructure	Number of patents in force	0.0	N/A	0.31%
4.3.18	Scientific infrastructure	Infrastructure	Scientific research	4.7	34	0.17%
4.3.19	Scientific infrastructure	Infrastructure	Researchers and scientists	4.6	30	0.17%
4.3.20	Scientific infrastructure	Infrastructure	Scientific research legislation	5.1	33	0.17%
4.3.21	Scientific infrastructure	Infrastructure	Intellectual property rights	5.6	36	0.17%
4.3.22	Scientific infrastructure	Infrastructure	Knowledge transfer	5.3	26	0.17%
4.3.23	Scientific infrastructure	Infrastructure	Innovative capacity	5.4	33	0.17%

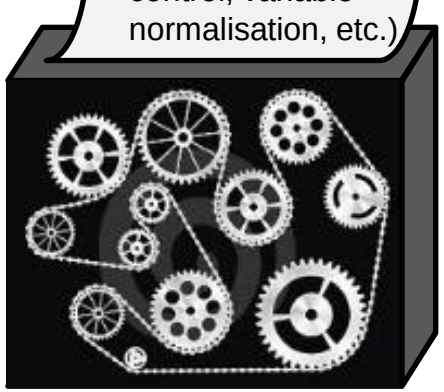
- The WEF's Global Competitiveness Report (GCR) is derived from a set of 111 indicators, all of which are used in the GCR index (GCI)
- There are 13 innovation and technology indicators in the GCI accounting for over 21% of the index score

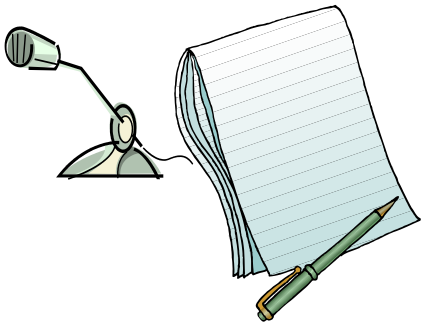
Number	Indicator	Pillar	Score	Rank	Weight
9.01	Availability of latest technologies	Technological readiness	6.1	25	1.54%
9.02	Firm-level technology absorption	Technological readiness	5.9	16	1.54%
9.03	FDI and technology transfer	Technological readiness	5.5	10	1.54%
9.04	Internet users/100 pop.*	Technological readiness	78.0	19	0.93%
9.05	Broadband Internet subscriptions/100 pop.*	Technological readiness	10.5	49	0.93%
9.06	Internet bandwidth, kb/s/capita*	Technological readiness	26.6	28	0.93%
12.01	Capacity for innovation	Innovation	3.8	32	2.00%
12.02	Quality of scientific research institutions	Innovation	4.2	40	2.00%
12.03	Company spending on R&D	Innovation	4.1	24	2.00%
12.04	University-industry collaboration in R&D	Innovation	4.2	37	2.00%
12.05	Gov't procurement of advanced tech products	Innovation	4.8	5	2.00%
12.06	Availability of scientists and engineers	Innovation	4.9	18	2.00%
12.07	Utility patents granted/million pop.*	Innovation	1.5	50	2.00%

How data is used in national competitiveness rankings

Rules

- Economic and competitiveness theory (growth, clusters, market efficiency, etc.)
  - Report specific
  - Statistical methods (sampling, quality control, variable normalisation, etc.)





Statistics and data (hard indicators)

- Macroeconomic data: GDP, inflation, unemployment, etc.
- Microeconomic data: infrastructure, industry data, labour costs, etc.
- Social data: health, education, values, etc.
- **Innovation and R&D indicators**
- Other hard data (e.g. word citations)

Interviews and surveys (soft indicators)

- Subject-matter experts and practitioners
- Executive opinion survey (preferably a sample representative of the economy)
- Random-sampling polling
- Media and public perceptions
- Other soft data (e.g. perception-value scores)

Score and rank

The importance of innovation and R&D for a knowledge-based economy and how to encourage its creation

- Innovation and R&D are the engines that produce intangible assets that fuel a knowledge-based economy
- Intangible assets – worker skills and know-how, informal relationships that feed creativity and new ideas, high performance work organisations, formal intellectual property, and brand names, etc. – are the new keys to competitive advantage in economically mature nations
- The knowledge economy depends on the ability to structure information and act upon it in clever ways

Keys for encouraging a knowledge-based economy

Government	• Government intervention to promote key sectors • Create attractive environment for business and foreign talent • Offer financial and non-financial incentives to grow clusters
Collaboration	• Collaboration between the public and private sector • Collaboration within the private sector • Collaboration between higher education and industry
Talent	• Develop workers with world-class skills • Develop world-class universities to train labour force with world-class skills • Encourage the inward migration of talent
Cluster development	• Encourage cluster development • Promote highly specialised clusters • Remove barriers to competition

The importance of talent in attracting capital and being a driver of competitiveness

- "Talent attracts capital far more effectively and consistently than capital attracts talent… A city that wants to attract creators must offer a fertile breeding ground for new ideas and innovations…Diversity breeds new ideas and new innovations." *Michael Bloomberg, mayor of New York City*
- "Competitiveness is a holistic concept… [that includes] the ability to attract capital, business, talent and visitors." *Benchmarking global city competitiveness*, EIU 2012

Aspects considered in the EIU's assessment of global city competitiveness

Adapted from "Benchmarking global city competitiveness" (EIU, 2012)

The foundation of a knowledge-based economy is a culture of data

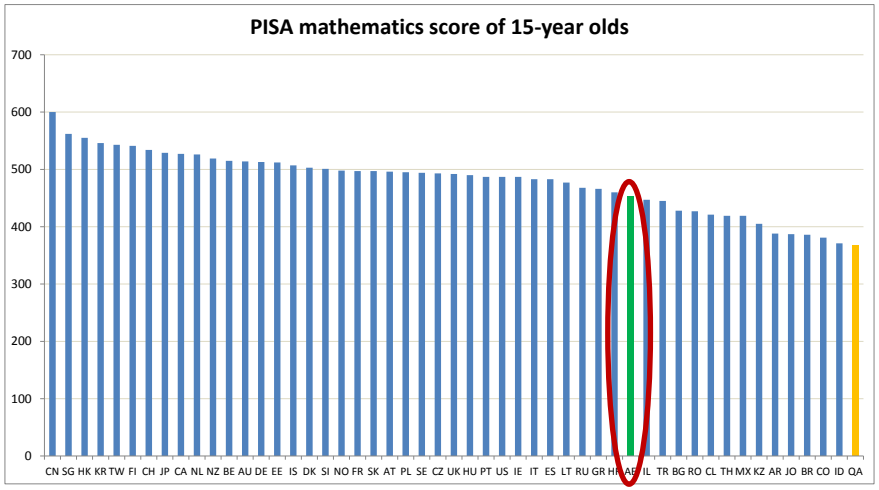
Beyond capturing data, there also needs to be an ability to interpret, play with and feel at ease with data. Currently the UAE is working to strengthen its capacity in this area.

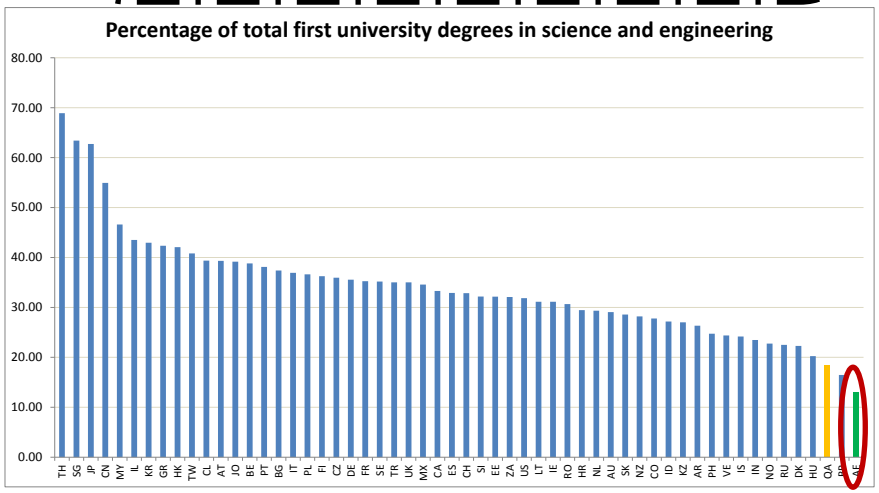
Performance in math & sciences

- In an international standardised test of mathematics for 15-year olds (PISA) the UAE scored 453, placing it in the bottom third of the sample
- Only 13 percent of UAE university graduates earn science degrees

Consequence

- Not possible to build up a comprehensive data infrastructure without a labour force versed in mathematics and statistics
- Agencies tasked with collecting and disseminating statistical data might not have all the full competencies required to adequately execute operational plans

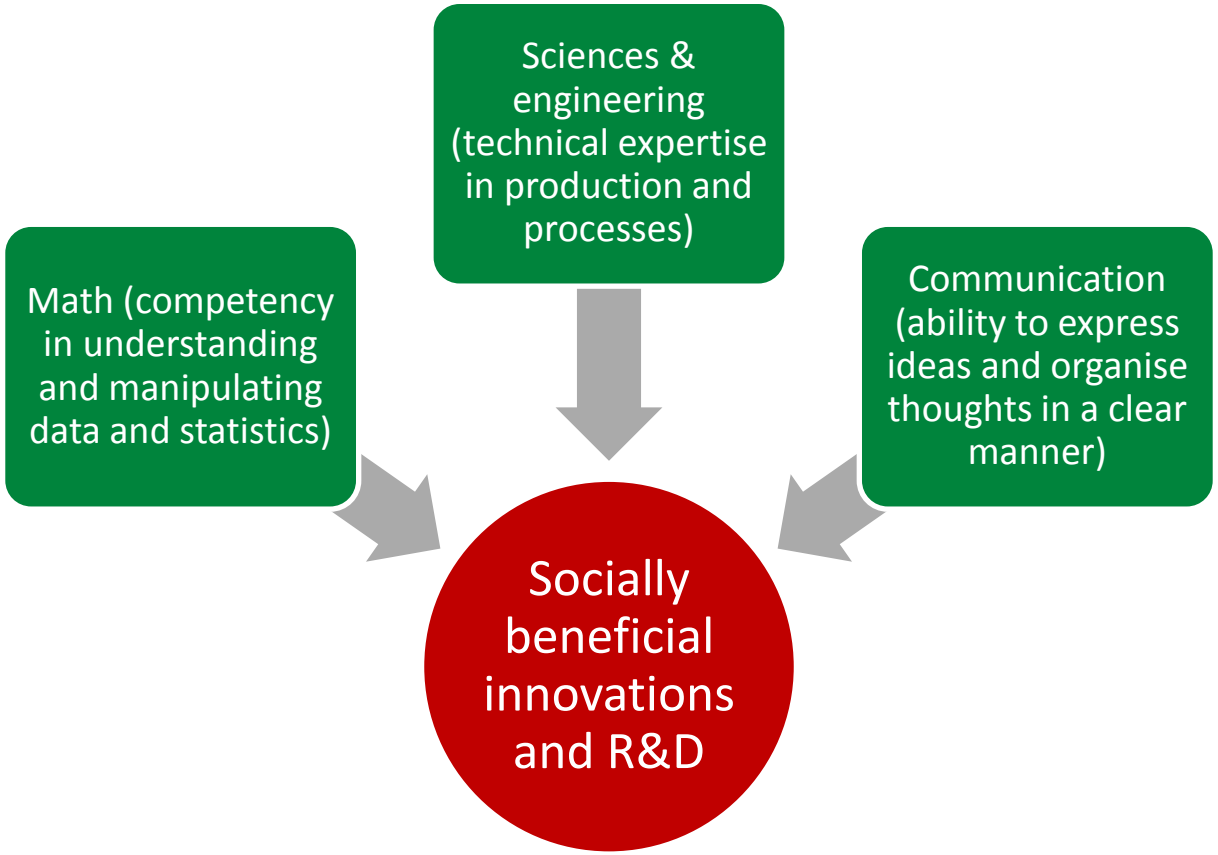




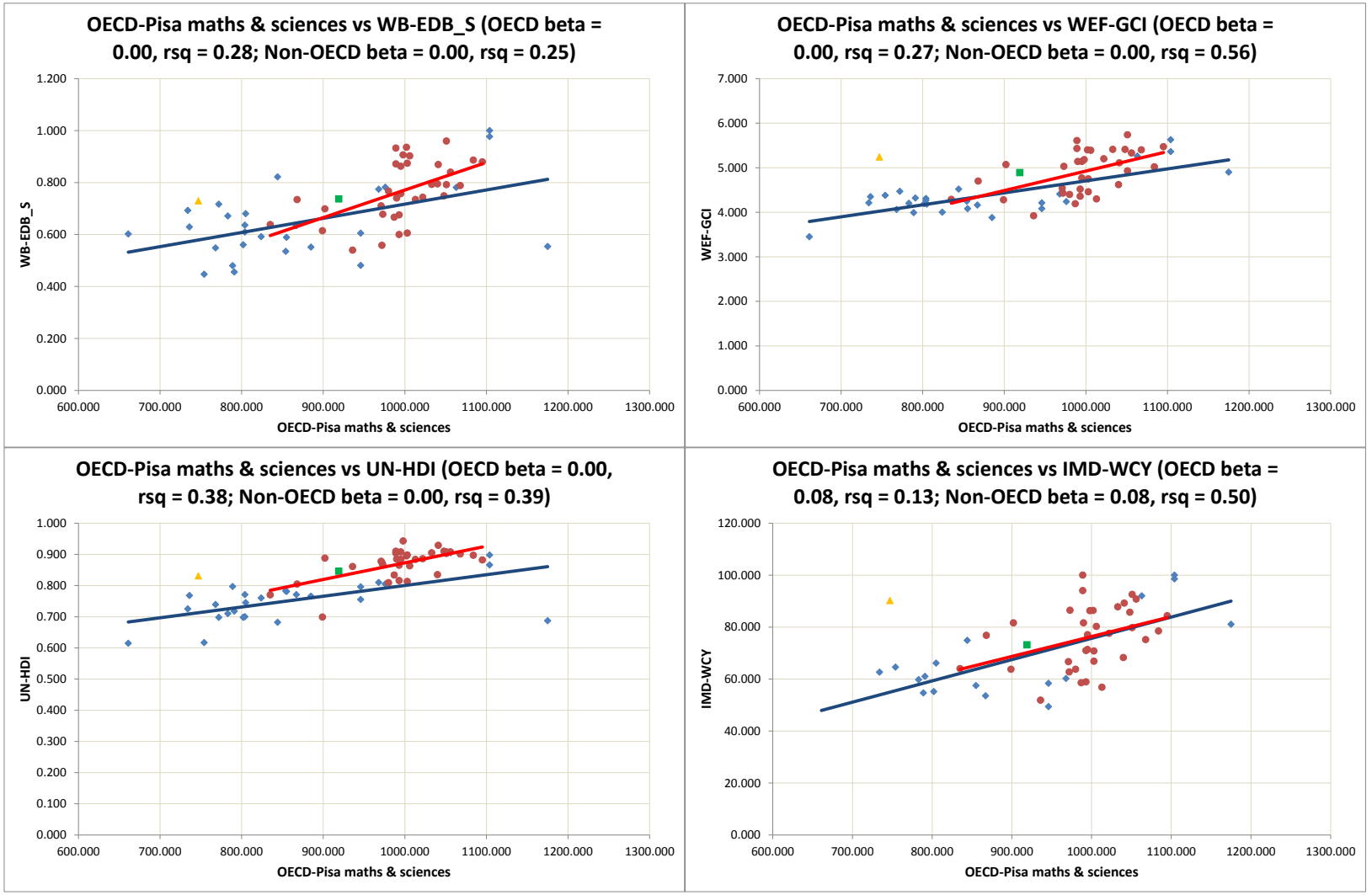
Sources: National Science Foundation, OECD, PISA (as reported in the IMD-WCY)

The skills required in the labour force to develop a knowledge-based economy

A knowledge-based economy is predicated upon a highly educated workforce. This entails competency in math, sciences and soft skills to understand problems and synthesize solutions, which often require the ability to educate and lead others



Competency in maths and sciences a key to national competitiveness



*Although relationship is bi-directional, competency in the maths & sciences **is** a driver of competitiveness*

Sources: IMD, IMF, OECD, PISA, WB, WEF

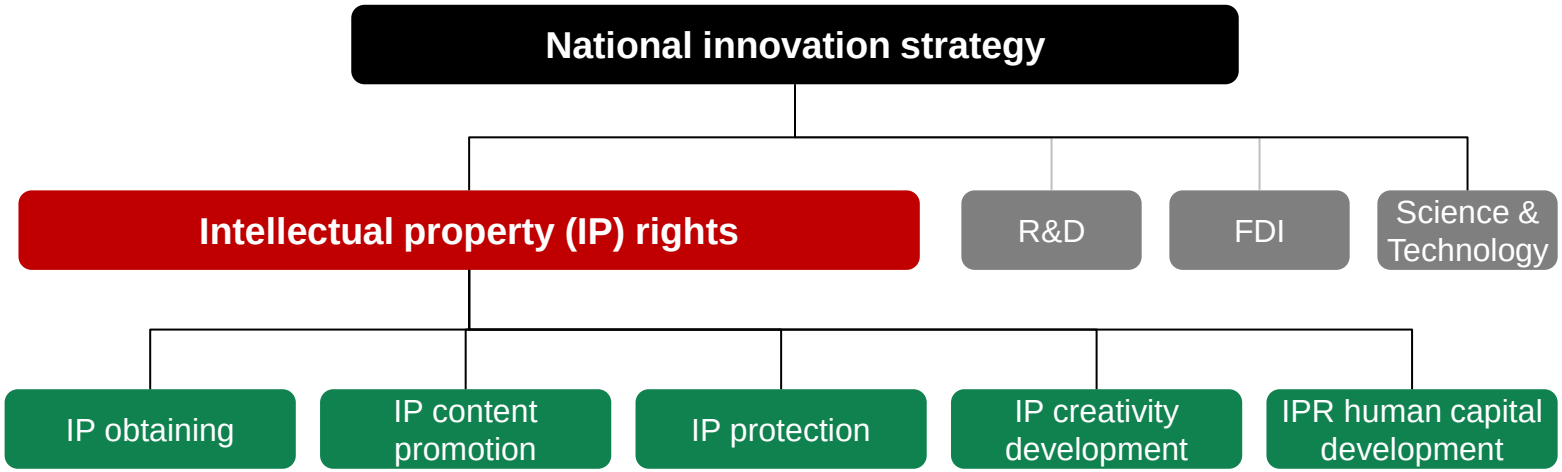
What the UAE is doing to achieve its goal of becoming a knowledge-based economy

Steps

- Develop intellectual property rights (IPR) strategy
- Develop ICT strategy
- Develop S&T strategy
- Develop clusters and encourage investments
- Enhance higher education

Goal / Progress

- IPR strategy study undertaken (see below)
- ICT Fund fostering growth in ICT sector
- Create body to advocate S&T at the highest level
- ATIC, Masdar, Mubdala, etc. laying foundations
- Over 70 universities in the UAE (e.g. Insead)



Countries with national IPR strategies

Brazil	UK	EU	Finland	Germany	Australia	China
Canada	Hungary	India	Jamaica	Japan	Cuba	Czech R.
Sweden	New Zealand	Philip-pines	Romania	South Africa	Denmark	USA

Measuring innovation and R&D

- Measuring innovation is not a straightforward exercise; often the measurable aspects of innovation (e.g. spend, patents, etc.) do not reflect the true extent of benefit to society
- Measuring R&D is fraught with challenges its collaborative nature risks double counting of the activity
- To measure innovation and R&D requires a sophisticated and expansive data capture at the enterprise level and a coordinated reporting structure to a relevant aggregating body at the emirates and federal levels
- Innovations and R&D can be measured both in terms of their inputs and outputs

Method	Indicators	Method	Indicators
1 **1st generation indicators (1950s-60s)**	▸ R&D expenditures and personnel ▸ S&T personnel ▸ Capital ▸ Technology intensities	2 **2nd generation indicators (1970s-80s)**	▸ Patents ▸ Publications ▸ Products ▸ Quality change
3 **3rd generation indicators (1990s)**	▸ Innovation surveys ▸ Indexing ▸ Benchmarking innovation capacity	4 **4th generation indicators (2000+)**	▸ Knowledge & intangibles ▸ Networks & demand ▸ Clusters ▸ Management techniques ▸ Risk/return

Adapted from "Frameworks for measuring innovation" (Science and Technology Policy Institute)

Frameworks for measuring innovation and R&D

1 **Measuring innovative activity**

- Focuses on measuring intangible capital, which can be categorised into three buckets: (1) human capital, (2) intellectual capital, and (3) organisational capital

2 **Measuring investments**

- Focuses on the investments that are likely to generate innovation and R&D, of which these investments can be partitioned into three groups: (1) human capital, (2) technical knowledge, and (3) ICT infrastructure

Asset versus capital approach for measurement

Type of asset	Type of capital
Human capital: Knowledge and skills possessed by individuals	Human capital: Embodies education, training, etc.
Intellectual capital: Technical inputs to the innovation and R&D processes	Technical knowledge: R&D patents, trade secrets, etc.
Organisational capital: Business models and processes, networks, alliances and special	ICT infrastructure: Allows people to collaborate and communicate across distances and in real time

Challenges encountered in measuring R&D in the UAE

- The UAE is a unique country with regards to its economic development – it is rich country that has progressed in a very short period of time, but where the data infrastructure is not very well developed
- The UAE does not have corporate taxes, thus obviating the need for enterprises to keep track of their activities in as much detail as in other countries
- The absence of taxes also means that there are no tax-incentives (or subsidies) to encourage and prod R&D activity
- Currently are relatively few organizations and foundations that fund R&D
- Because of the aforementioned reasons hard data on R&D is scant, necessitating statistical and benchmarking techniques to come up with a national measure for R&D

Recommendations

1. Increased coordination between federal and local entities in data sharing, esp. across the various statistics bureaus

2. Implementation of regular R&D surveys covering both private and public enterprises for firms of all sizes

3. Development of national innovation and R&D policy with coordination between the government and private enterprises; create national body to fund national industrial R&D

4. Encourage data collection and educate enterprises that decisions without data is groping in the dark; tie collection of high-calibre data in meaningful way to enterprises to internalise high-quality data management

Capturing innovation and R&D data is relevant to all sectors of the economy and across all sizes of enterprises

One of the foundations of a knowledge-based economy is a culture of data

- As the UAE strives to be a global leader gathering innovation and R&D data (and data in general) is critical. This means following international best practices for data collection and reporting. Within the context of innovation and R&D data this means:

1. Enterprises identifying their innovation and R&D projects (Frascati Manual (2002) gives guidance on what types of activities qualify as R&D)
2. Enterprises identifying their innovation and R&D personnel (level of education can be used as a proxy; personnel directly supporting R&D personnel also count towards headcount)
3. Purchase software or implement time-use surveys to track expenditures and use of time for R&D activities (i.e. track R&D expenses (accounting standards) and full-time-equivalent headcount of R&D staff)
4. Hire staff that can help overcome data challenges
5. Sharing data with the relevant statistics bureau and collaborating with the bureau to ensure timely, adequate and appropriate information exchange

- Collecting and reporting data will help all organisations better understand their internal structures, strengths and weaknesses
- All organisations need to be able to benchmark their performance
- All organisations need to measure innovation and R&D else it cannot be managed
- Governments need timely and accurate data (as well as staff that can work with numbers) to make informed policy decisions
- Big enterprises need R&D data to monitor a part of their organisation which is a source of their competitive advantage
- Small enterprises can move quickly but need data to act

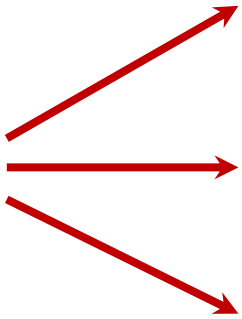
The UAE encourages its stakeholders to take the challenge and invest in and perform R&D *in the country*

The UAE is a very ambitious country and we are aiming to be amongst the most competitive innovations and R&D country as part of Vision 2021

The Economist Intelligence Unit has already stated that the Middle East is at a juncture ready to become a global innovation and R&D hub*

We challenge enterprises in the UAE to help us become a global R&D player in the coming years, to push your own firm to its boundaries and to help us all reach our potential

UAE (2021)



R&D expenditures as a percentage of GDP				
#	Leading countries	R&D % of GDP	Arab world	R&D % of GDP
1	Israel	4.74	Tunisia	1.02
2	Sweden	3.68	Morocco	0.64
3	Finland	3.47	Jordan	0.34
4	Japan	3.45	Qatar	0.27
5	Korea	3.36	Kuwait	0.09
6	Switzerland	2.93	Algeria	0.07
7	Iceland	2.81	Saudi Arabia	0.05
8	USA	2.67		
9	Singapore	2.61		
10	Denmark	2.57		

** Laying the foundations: A new era for R&D in the Middle East (EIU, 2011)*

Thank you

شكرا