Proceedings of the Australasian Conference on Business and Social Sciences 2015, Sydney
(in partnership with The Journal of Developing Areas)
ISBN 978-0-9925622-1-2

A SCIENCE AND TECHNOLOGY ROAD MAP FOR DEVELOPING COUNTRIES: NATIONAL INITIATIVES IN THE UNITED ARAB EMIRATES AND JORDAN

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ABSTRACT

Cultural and economic globalization and the rise of strongly developing economies has created tremendous pressure on developing countries which are striving to change their economic conditions in many different avenues. This stems from socio-economical and geo-political forces in a world that is becoming increasingly global. This paper creates a practical "road map" that serves to guide an educational aspect of that transformation, and examines the roles that may be played by collaboration between academia, industry and government, also referred to as the Triple Helix. Then a number of initiatives that the United Arab Emirates and Jordan have started will be discussed and are showed to be very effective in realizing the intended transformation towards more knowledge-based economies. Whilst these two countries are in a state of transformation, their initiatives may serve to kick-start programs in other economies which are at the same stages of development, and like the UAE and Jordan, look towards making socio-economic progress.

JEL Classifications: G28, O32, O33

Keywords: Science, Technology, Developing Countries

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I. INTRODUCTION

Education, science, technology and commerce continue to develop many countries around the world into becoming international industrial leaders. In 1995, Etzkowitz and Leydesdorff promulgated the Triple Helix concept in which the triadic combination of university-industry-government could be concerted to become the source of innovation and economic development in a knowledge society. Such a triad was examined as a future source of knowledge generation and innovative applications.

Following that, successive researchers investigated its possibilities in other countries and developing regions, such as Mello and Rocha in Latin America (2004), and Luna and Tirtido in Africa, (2008). (Cited in triplehelix.stanford.edu). The university was seen as a potential agent of commercialization, with research being applied to socio-economic development, including knowledge transfer and entrepreneurship. Further related research followed: Vongpivat (2002) focused on the Thai national innovation system concept that examined interactive influences on technological development; and Wonglimpiyarat (2014) on operations of university business incubators to support innovation and entrepreneurship in Thailand. In the same light, Vrgovic, Vidicki, Glassman and Walton (2012) opined that government agencies could support innovation hubs, and help SMEs to connect in order to initiate more innovation practices in developing countries.

This paper specifically identifies the Middle East region where there is a considerable gap in the knowledge, and will focus on the UAE and Jordan as cases. This gap is at the present time also being addressed by the Science Technology and Public Policy (STPP) Program of the Belfer Center for Science and International Affairs at the Harvard Kennedy School. Referred to as “Assessing and Strengthening University-Industry Collaborations,” this proposed two-year study commencing in 2015, will focus on a comparative analysis of Jordan, the UAE and Saudi Arabia. This research intensification within the wider region then places Etzkowitz and Leydesdorff into a new geography in which the research on the university-industry-government nexus is rapidly progressing in order to provide base-line data that is anticipated to result in the expansion of innovation, entrepreneurship and socio-economic development. Complementing the STPP Program, this paper postulates that a “road-map” can provide developmental routes for both the UAE and Jordan which will firstly expand the dearth of research in the Middle East, and secondly, that this can have beneficial applications for the region and other developing countries as well.

Road-mapping creates connections between points that are related. Moghaddam, Baheri and Mahdi road-mapped university, industry and government in 2010, when they connected science and technology in relation to the Iranian petrochemical industry.

Entrepreneurs are a very important source for innovation-based startups on the scale of small and medium enterprises (SMEs). However, in conservative, low risk-taking cultures, such as those typified by countries in the Middle East, a critical mass of entrepreneurs that would change the economic topography does not yet exist. Therefore, education systems should have priority in the transformation process that could gradually modify the traditional mentality into a more business-oriented one, in which greater risk-taking capacity must become an every day characteristic. El-Khasawneh (2008) discussed a methodology that higher education systems could adopt to enhance the entrepreneurial abilities of students and faculty.

The business environment has changed dramatically in the last few years, especially for developing countries, with the United Arab Emirates and Jordan comprising two such countries. In this work, they will serve as case-studies because their progress has to date been laudable – although far from complete in any sense. Many factors have been introduced into the equation of national development in the global economy, but most of them have not been in favor of entrepreneurship and SMEs. Many SMEs would not be able to handle the dynamics of the new competitive climate because those might lead to their bankruptcy; others are struggling with no clear survival plan. Very few seem able to transform the challenges into opportunities and come out beyond the nascent stage of commercial development. (Kuratko, 2009). This paper addresses the state of the university-industry-government triad at the present time and promotes a road-map as a means of carrying forward developmental intention to reality.

The technological divide between developing countries and developed countries has never been wider. That divide has implications not only on the gross national product of these countries, but also on education, research, and even society's image of itself. There are ways in which the road-map delineated in this work may be financed, although it is not the intention of this paper to examine financial possibilities in depth. However, the authors acknowledge that a road-map cannot have viability unless it be funded, and so the authors include a discussion at the end of the paper that focuses on two sources: the World Bank, and innovation licensing through established hubs which could expand to international locations. Whilst, road-map precedents exist, the technological divide cannot be bridged overnight due to a number of existing challenges such as:

- Political will: This cannot be underestimated. Political will can create the right vision and align initiatives to support higher level ambitions. Lack of this support will lead to disorganized and even conflicting efforts that may lead to nowhere or even make conditions worse, and would inevitably be non-conducive to technological enhancement. Therefore, the political will is a necessary condition but by itself it is insufficient to produce effective transformation. Providing the needed resources and ensuring the right implementation of the right initiatives is of equal importance.

- Financial resources: Bringing about a major transformation of national science and technology status requires major investments. Therefore, enough and sustainable funding should be allocated for the "road map" which will be discussed in detail. Otherwise, the nation ends up with unfinished projects, unproductive wastage and no success stories leading to loss of credibility and popular support.

- Human resources: The prime mover for the proposed technological change is not only highly skilled scientist and engineers, but also operators and technicians. The competition for a skilled workforce has ceased to be confined within any one country, it is now regional. With flows of information, ease of transportation, and social mobility, mass flow of the workforce across borders is a daily phenomenon. The brain drain from developing countries is a major concern that will not be resolved unless there is an institutional effort to absorb these capabilities, compensate them fairly and utilize them effectively.

It is extremely important to recognize the impact of innovation on the sustainability of economic prosperity and growth. As supported by the Triple Helix Research Group, for innovations to be realized they need innovators and a catalytic environment that provides proper tools, space, culture, incentives, and funding. Most of the aforementioned conditions need capital, which is why industrialized nations invest more in research and development, (De Jong and Vermeulen, 2006). Indeed, Hidalgo et al. (2010) demonstrated with good evidence that technology derived from innovations and patents helped in the industrialization process of each country under study. Srinivasa and Sutz (2008) discussed scarcity-induced innovation frameworks and showed how this could shape institutional developments and planning. One of the innovation tools is product innovation management (PIM) shown by Cormican and O'Sullivan (2004). Bates et al. (2009) discussed how manufacturing plants competing in global industries are continually faced with pressures to make changes within their internal environments due to changes within the external environments in which they operate, so they must innovate to survive. At the national scale, Wonglimpiyarat (2010) provided ambitious initiatives and discussed strategic implications to promote innovation of the economy.

This paper discusses a science and technology transformation road-map. The design of this map is impacted by the three pillars which are discussed in detail:

1. Industry, entrepreneurship, innovation and IP roadmap (Section II)

2. Government Role (Section III)

3. Academia and Research Centers' Role (Section IV)

As well as these important pillars, an assessment of performance can be more objective with the use of indicative key performance indicators. A number of KPIs are listed and explained in Section V. Section VI is concerned with the two specific cases, Section VII with accessing Finance, Section VIII is the conclusion and Section IX comprises the recommendations.

This road map is intended to enhance the status of science and technology in developing countries. The United Arab Emirates (UAE) and Jordan are given as examples for this transformation. Section (VI) of this paper discusses Emirati and Jordanian initiatives that have already succeeded in boosting science and technology in many different ways and could be used as a guide for other countries on the roads to their own individual development. But it should also be made clear that the article does not wish to be prescriptive. Accessing resources to implement the road-map will vary from one developing nation to another, however, two sources of funding will be examined.

This road map is very practical and could be a recipe for reaping considerable benefits for an economy, albeit in the medium to long-term.

II. INDUSTRY, ENTREPRENEURSHIP, INNOVATION, AND IP ROAD MAP

Diversification of developing countries' economies is extremely important to ensure sustainable growth and lower economic risk. One of the drivers for developed countries' economies is innovation and entrepreneurship. Small businesses act as experimentation labs for high risk ideas. In the USA, small business constitute 99.7% of the total number of businesses and one third of the exporting value, and they employ half the high technology personnel. This shows the significance and value of small businesses. However, this does not arise without important contributing factors: education, training, access to funding, and an encouraging culture are the drivers behind this trend. Entrepreneurship traits and innovative thinking are developed through cultural drivers, systematic approaches, and scientific frameworks. This is of even higher importance within conservative cultures in which secure jobs within their governments are perceived as more highly desirable, concomitant with low risk taking, because that has become the main stream thinking of youth entering the workforce, particularly in the Middle East. The following is a set of actions that this paper recommends to promote entrepreneurship and innovation and to protect the output of intellectual property by creating an innovation eco-system in which a number of "living" forms have to coexist and synergize into a new dynamic.

i. Reform the education system to promote scientific enquiry, critical thinking, hands-on soft skills, team work, and innovation leading to enabled innovators and entrepreneurs

Development of appropriate thinking skills and scientific enquiry should start in the K-12 system. The focus on this should be the grass roots for any future development plans in any country. Nurturing the hands-on skills, team work and soft skills is also very important to produce a balanced student, employee and citizen. Well-rounded students should be any academic institution's goal. Changing the developing economic landscape necessarily needs a critical mass of entrepreneurs transforming creative ideas into small businesses. Thus, a paradigm shift in the way our citizens think is highly needed, and that cannot be obtained without focused entrepreneurial training to school and university students so that they become more confident in taking calculated risks and realize the advantages of creating such businesses. As for the training in innovation, it is a very important tool to create innovative and viable ideas in a systematic and productive methodology.

ii. *Establish excellence centers, technology incubators and techno-parks in universities and research centers.*

Excellence centers are of immense importance for developing the right skills, motivation, and sense of direction for both students and faculty. It is an exchange and learning platform between the three most important players within a country; namely, government, industry and academia. The excellence centers reduce the risks with maximum benefit to all involved. Business incubators and techno-parks drive knowledge economies and create business and technical dreams for participants and aspirants. This process is "incubation" and it is a mechanism that acts as a social and technological haven within a conservative culture in which risk-taking is highly feared and discouraged. Within this mechanism the cultural constraints and bounds are relaxed and people think in a completely different paradigm.

iii. Create funding mechanisms to support knowledge-based and high tech start-ups

Financial support for startups is one of the main challenges in developing countries. This is particularly true for challenged economies in which the individual and the state incomes are impecunious. Financial institutions should be encouraged to provide loans for these startups with the state as the guarantor of such loans. Financial institutions need to develop maturity and encourage an environment of trust, so that they can then develop towards accepting innovative ideas and feasible business plans as their loan collateral. The state could and should initially act as a facilitator, but at a later stage would only act as an advisor at most, or a regulator if the need were to arise.

iv. Provide and fund patent registration services

Creating a knowledge economy needs a catalyst to encourage and promote intellectual properties (IP), innovation creation and patent registration. Changing a culture to one that appreciates and creates technology is a difficult task. This is different from having a technology-using society. Therefore, any action that encourages a technical society to create IP should be encouraged and that includes facilitating, even subsidizing patent registration services. Again, like "government will" mentioned above, this is necessary but not sufficient in itself, since creating a technologically transformed society requires a critical mass of innovation underscored by registering patents.

v. Launch a widespread awareness campaign to encourage innovation and increase the drive toward S&T

In popular culture, there is a lack of appreciation for scientists and engineers. A widespread campaign should be launched in different media outlets including social networks to give science and technology its due attention and respect. This would build a new set of dreams for up and coming youngsters which would be the engine for change within developing countries. This media effort would boost the morale of entrepreneurs, scientists and researchers leading to positive impact on their research productivity and intellectual curiosity. However, this would not happen without fair monetary compensation for scientists and researchers. It has to be noted that 40 percent of the Arab world population is below the age of 15 years, which implies that this could be a very positive indicator for a different and better future with these youngsters acting as prime movers and change agents. It should be noted that this young generation, if not employed appropriately, may equally turn into a generation of the disaffected with the result that they might become social, economic and political burdens on their governments.

vi. Leapfrog to a high-technology and brain-intensive economy without undermining the manufacturing and agricultural sectors.

The high technology revolution has not yet fully taken place in the developing world and once realized, it would result in proliferation of a big number of high-technology businesses such as in Dubai and Abu Dhabi. This should be an integral part of educational planning, the research agenda, and funding priorities. Nevertheless, this should not undermine the manufacturing industry.

III. GOVERNMENT ROAD MAP

Governments should act as a facilitator between all contributors in their countries. The following are a suggested government work plan:

i. Facilitate consortia for different industrial sectors and academic institutions

ISBN 978-0-9925622-1-2

Trust-building between academia and industry in developing countries requires a process during which confidence-building is established between both parties. Governments should act as a facilitator and orchestrator between academia and industry to maximize their interaction and create the right synergy. Bringing the two ends of the spectrum, academia and industry, as in theory and practice, around a table or through a consortium format in which both would interact and identify areas of common interest would leverage efforts and maximize benefit to participants. This will move science and technology forward and as a result establish businesses that are able to create jobs and pay taxes to close the economic cycle.

ii. Build a data bank to accurately assess the status quo of science and technology based on a number of key performance indicators (KPIs) and publicize them

The traditional key performance indicators related to science and technology comprise mainly the following: research expenditure relative to GDP, the number of scientists and engineers relative to population, journal publication in absolute numbers and per scientist, and the scientific citation index. These indicators are not positive in developing countries. But publicizing those data will create an implicit pressure on decision makers, scientists, funding agencies, and innovators to enhance their status quo. It will create the right drivers for all involved to address the issues that will impact these KPIs. That will make what is really important to the country a well-known fact. Over time, this will help in improving the KPIs for individuals, institutions, and eventually the country's economy. Decision-makers need such statistics and KPIs to make informed decisions and later for others to be able to measure the impact of these decisions on the status of national S&T.

iii. Develop legislation that promotes investments in advanced technologies and high investment companies

This is of major importance since advanced technology companies are associated with high risk and volatility. Therefore, to reduce that risk and provide them with a safety cushion, a set of legislation and taxation provisions could encourage entrepreneurs and investors to explore such technologies due to the attractions associated with them. Some may argue that in an ideal setting this is not needed; however, developing economies are far from being ideal. They need immense effort to get to the critical mass of high technological businesses, and only then, will the system take care of the growth and sustainability of such industries.

iv. Create national science and technology priorities that get pre-eminence in funding and support and ensure that all initiatives are aligned with them.

It is always beneficial to have a national forum that sets the national science and technology priorities. Without specific goals and clear directions in a number of desirable areas, the effort will be diluted. Additionally, it is of vital importance for the sustainability of science and technology development to see direct influence from local priorities and concerns. Otherwise, public funding will be questioned regarding the viability and impact on the local economy and development. Establishing a national research agenda with priority in funding and support is also highly needed to ensure focused effort on national needs. Defining the national scientific priorities should be a serious effort developed by all national stake holders: government, research institutions, academic institutions, industry, politicians and the business communities. A road-map for industrial and academic strategy should be developed based on national scientific priorities. This road-map should be developed to ensure that all initiatives are aligned with them. This will lead to a national road map in which a clear vision with the expected science and technology key performance indicators (KPIs) have been accurately and methodically identified. A realistic expectation should be set, and a road map for expectations, concerning who, what, where, when and how should be identified. This will ensure that all national effort is managed in a direction that will serve the overall good of the people and the nation concerned.

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v. Orchestrate the different funding mechanisms to echo national priorities and avoid duplication

Usually, developing countries have a good number of funds that support science, technology and industrial development. However, they rarely leave a permanent mark or sustainable impact. Therefore, what is needed at the national level is to have a set of funds that complement each other, orchestrate their activities, and avoid duplication. These national funds should be driven by the national priority agenda mentioned earlier and should be shaped by an impact factor on a national set of key performance indicators (KPIs). The system of these national funds should be steered on the national level by a high-level independent authority.

vi. Increase the governmental spending on research and development

There is a huge discrepancy in research spending relative to the GDP on research and development between the industrial world and developing countries. This difference is 10-30 fold. However, for the developing countries it is not a matter of spending more. Increasing the spending should be done with a more definitive purpose; namely, to improve the local economy. Hence, spending on R&D should be driven by national priorities with the highest priority given to its applied research programs. This increase in spending should be according to a well-developed road-map. Developing countries need to build research capacity which takes a lot of effort and time. There should be no short-cuts in this activity. Sudden growth will lead to superficial and unsustainable activities with a shallow impact, which has to be avoided. The aim of doing quality research is to impact industrial activities and local social and economic development.

vii. Transform the brain-drain to brain-gain and talent-magnet economy

Transforming developing countries to become attractive to their scientists and scholars abroad once again is a major dilemma that these countries should embark on. It is not only a monetary issue for those abroad, but it is also the absence of a system that can transform their intellectual abilities into scientific research programs that could benefit these developing countries.

viii. Give priority for home grown technologies even if it means longer lead-times

It is always easy and tempting to procure turn-key technologies. However, it is not in the national interest to do so. Developing countries need to build confidence in their technology development capability. Of course, one of the better platforms to do so is large infrastructure projects needed by the country, which are of importance for its development, and are sizeable and would keep a good number of scientists and engineers engaged for a lengthy duration with clear objectives. Large projects set the rhythm for scientists and engineers and act as a technological focus for the country. Reduction of risk is attained by assigning non-critical components of these large projects to local high technology start-ups/companies and research/academic institutions.

ix. Create legislative and taxing umbrellas to encourage S&T within the industrial sector

Make industry expenditure on research, human/product development, and education tax deductible. This will send the right message and enhance the industrial sector's investment in new products and technologies.

IV. ACADEMIA AND RESEARCH CENTERS ROAD MAP

i. Appoint university and research centers' leaders based on merit and vision

Leadership of these institutions have a tremendous burden on their shoulders because they have to provide vision and direction for their institutions and transform them into havens of thought where inspiration and societal change begin. Naturally, this requires managerial skills and vision as well. This traditional scheme has caused many of these

ISBN 978-0-9925622-1-2

institutions to live in a managerial vacuum. A better approach is to appoint these leaders based on their managerial and leadership abilities, experience, their business networks, and their transforming vision. Such well-rounded leaders will be able to fulfill the technical and financial needs of the institution, resulting in a clear direction for academics and staff.

ii. Upgrade the research infrastructure within universities and research centers to be of international standards through accreditation.

Conducting proper research requires adequate and well equipped laboratories. This infrastructure is a prerequisite for any significant scientific advancement and research accomplishments. Many developing countries are economically limited; therefore, providing such an infrastructure should be based on the priorities set forth by the national agenda. However, the scientific infrastructure should be viewed at the national level, to avoid duplication of expenses, and the definition of expensive should be a local threshold.

iii. Transform universities into havens which are autonomous, imbued with a positive, creative, and productive atmosphere

By definition this should be the state of any university; however, in developing world the status quo of many universities is far from such a glory perspective. Therefore, to have creativity and innovation, the prerequisite is an atmosphere that is free from ideological pressure. The environment should be one that promotes freedom of expression and encourages exchange of ideas.

iv. ***Establish a robust merit-based pay-scale and reward system***

Accomplishing good quality research and innovation requires from faculty a state of mind that is free from financial and social security burdens. While many of the researchers and innovators in most developing countries have income that is barely acceptable, it is unrealistic to assume that they will be able to introduce change while struggling. Having a fair, merit-based pay scale system will motivate the scholars to commit all their effort.

v. Encourage academics to provide technical consultations to the developing industrial base

Encouraging academics to provide technical consultations to the developing industrial base is a necessary step before getting a maturing industry. Technical assistance to the local industry from public universities which are tax-payer funded, should not be an optional service; rather, it should be requested by the tax payer. This has two implications, from industry's side: they feel they are implicit partners with these public institutions, and from the academics' perspective they feel they are committed toward improving their industrial environment. This will lead the research to be more applied and the scholars to be more attentive to the local concerns and challenges.

vi. Transform teaching to a project-based style so as to couple knowledge and its application

Project-based learning is an effective method of development because it transforms students into active and interactive learners. They develop skills to identify and define the technical challenge, and map the components into solving the challenges. Additionally, soft skills and team work may be improved this way by transforming students into articulate observant thinkers with well structured streams of thought.

vii. Assess national needs to accentuate the most vital university disciplines, and then guide prospective students of their viability

A national outlook center should identify the technical and non-technical gaps that the region needs. Short, medium and long term needs should be identified. Based on these well detailed studies, planning becomes much more viable. The findings for such studies should be publicized so that academic institutions and individuals alike could make informed decisions regarding their future planning.

ISBN 978-0-9925622-1-2

viii. Publicize industry projects' success stories to develop credibility and strengthen industry-university ties leading to increased funding of applied and industry-driven research

These projects are important since they bridge academia and industry which will in the mid-term impact local economic growth and job creation. Additionally, there is a certain lack of trust and confidence in academia's ability to improve and solve industrial challenges; hence, this platform, and these projects will create the type of atmosphere needed to shift applied project support within academia from the government to the private sector.

V. SCIENCE AND TECHNOLOGY KEY PERFORMANCE INDICATORS (KPIS)

Below are some of the important KPIs for science and technology which either feed into science and technology processes or become an output of that process:

1. Economic KPIs

- Growth in productivity/economic outputs is the result of high-tech investment (output): The growth of the high tech sector would mirror the success of the technological transformation plan.

- Cost savings/gains due to industrial collaboration with academia (output): Academia is usually an underutilized resource for talents and solutions. Hence, as a result of improved collaboration with academia, some of the industrial challenges would be resolved. This would result in financial gains for the industry.

- Jobs created due to academia initiated startups or their collaboration with the industry (output): An extension to the previous point, increased collaboration will likely result in creating new job opportunities. Additionally, startups spinning out of universities would create new jobs as well.

2. Technological KPIs

- A number of patents and patent applications (output): Patent applications are filed worldwide through the Patent Cooperation Treaty or with a national patent office for exclusive rights for an invention - a product or process that provides a new way of doing something or offers a new technical solution to a problem. A patent provides protection for the invention to the owner of the patent for a limited period, generally 20 years. (The World Bank, 2014)

- A percentage of funding going to applied research relative to total research funding and a number of applied research projects (input): The applied research carried out in national universities and research centers have better odds in being transformed into a business compared with abstract research. Therefore, monitoring the number and status of such projects will help in the transformation process.

- The number of engineers (input): Engineers are the engines for industrial companies, without whom progress is limited and growth could not be accurately predicted. Therefore, qualified engineers in the local market would encourage business community to venture into industry.

- The number of startups spinning out of academic and research institutions (output): Transforming the university graduates from job seekers to job creators has huge economical and psychological impact on the society. This potentially could change the topography of the local economy.

3. Scientific KPIs

- The number of journal papers (output): Scientific and technical journal articles refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences. (The World Bank, 2014)

- The number of scientists working in the research and development (input): Researchers in R&D are professionals engaged in concept development or the creation of new knowledge, products, processes, methods, or systems and in the management of the projects concerned.

- Industrial investment in scientific research (excluding technical assistance) (input): When the industry is more mature, and with established credibility of the local scientific community, the industry would be willing to invest in the local scientific endeavors. This would be a reflection of positive relations and outcome between academia and industry.

VI. CASES: NATIONAL EFFORT IN SCIENCE AND TECHNOLOGY

As has been discussed, science and technology transformation for developing countries is extremely important since it has huge implications in economic and political dimensions. Two developing countries who are working actively to improve their entrepreneurial and technological landscapes are the United Arab Emirates and Jordan. A number of initiatives are described here from both countries which could assist other developing countries in forming their own road-map.

1. The United Arab Emirates (UAE)

The United Arab Emirates as one country united in 1971 out of seven separate political entities, has a very progressive development plan with an appropriate political and economic vision. It has dedicated enough human and financial resources toward creating an excellent eco-system and healthy economy that has sustainable growth, largely because of diversification rather than purely being fossil-fuel dependent for its exports. Many initiatives were created to promote education, science, technology and business. The following are a number of the ongoing initiatives in the UAE as examples of what is possible in developing economies:

- ABU DHABI Vision 2030: This vision is based on the principles laid out in the Government's Policy Agenda published in August 2007. The "Abu Dhabi Economic Vision 2030" is a roadmap for this particular Emirate's economic progress. This vision defines the strategic areas that have priority in support and funding. In the given time frame, the economy should be transformed in to a diversified and manufacturing-based one.

- Abu Dhabi Technology Development Committee: the United Arab Emirates as a country is working actively to diversify the economy to create a sustainable growth pattern. Human resource development is a major effort in this country to enable what is known as the knowledge economy. According to the Abu Dhabi Technology Development Committee, "Abu Dhabi will be an Emirate in which the benefits of Science and Technology pervade every aspect of life; empowering the Nation, transforming the economy, and inspiring the people." (Technology Development Committee, 2014).

- National Research Foundation (NRF): This foundation was founded in March 2008 to help build a competitive knowledge economy in UAE and be a key element in the UAE national innovation system. There are three interdependent components of the national innovation system: (i) knowledge production; (ii) knowledge application; and (iii) knowledge diffusion. (National Research Foundation, 2014). Khalifa Fund: It was launched in June 2007 to help develop local enterprises in Abu Dhabi, with a total capital investment of AED 2 billion. The Fund aims to create a new generation of Emirati entrepreneurs by instilling and enriching the culture of investment amongst young people, as well as supporting and developing small to medium-sized investment in the Emirate. (Khalifa Fund, 2014)

- INJAZ-UAE: It is a member of Junior Achievement (JA) Worldwide. It is a partnership between the business community, educators and volunteers — all working together to inspire young people to dream big and reach their full potential. Junior Achievement Worldwide is the world's largest and fastest growing organization dedicated to educating students about workforce readiness, entrepreneurship and financial literacy through experiential, hands-on programs - reaching over 10.6 million students a year. In the UAE, INJAZ-UAE reached 15,000 students since 2005, through 1,500 volunteers at 43 schools and universities - and growing. INJAZ-UAE connects corporate volunteers to mentor youth (ages 11-24) through JA programs. (Injaz UAE, 2014)

- TAKAMUL: The Takamul (the Arabic word for "Integration") Program is a national innovation support program developed and operated by the Abu Dhabi Technology Development Committee (TDC). The program was created to facilitate the integration of each stage of the innovation cycle, from the generation of ideas to the practical and commercial application of these ideas into products, solutions and services. (Takamul, 2014).

- MUBADALA: This is an investment and development company supporting the diversification of the UAE by investing in key social infrastructure and creating globally integrated industry sectors in Abu Dhabi. In 2002, Mubadala (the Arabic word for 'exchange') was established by the Government of Abu Dhabi as a principal agent in the diversification of Abu Dhabi's economy. His Highness Sheikh Mohamed Bin Zayed Al Nahyan, Abu Dhabi's Crown Prince and Deputy Supreme Commander of the Armed Forces, is its Chairman of the Board of Directors, to emphasize its importance. Mubadala is mandated to strengthen Abu Dhabi's growth potential. Focused on investment and development across multiple sectors, Mubadala's portfolio is valued at more than US $55 billion. (Mubadala, 2014).

- MASDAR CITY: Masdar (Arabic word for 'source'), is a model for sustainable urban development regionally and globally, seeking to be a commercially viable development that delivers the highest quality living and working environment with the lowest possible ecological footprint. Masdar operates through five integrated units, including an independent, research-driven graduate university, and seeks to become a leader in making renewable energy a real, viable business and Abu Dhabi a global center of excellence in the renewable energy and clean technology category. The result is an organization greater than the sum of its parts and one where the synergies of shared knowledge and technological advancement provide this commercial and results-driven company with a competitive advantage that includes an ability to move with agility and intelligence within an industry that is evolving at great speed. (Masdar City, 2014)

- SILICON OASIS: This was established in 2004, Dubai Silicon Oasis Authority (DSOA) (Dubai Silicon Oasis Authority, 2014) is wholly owned by the Government of Dubai providing both a living and working integrated community. Silicon Oasis is a Free Zone Authority and provides free trade zone incentives and benefits to companies operating within the tech park. Here, there is no company taxation. Dubai Silicon Oasis' (DSO) spans 7.2 km². The Authority has made a large capital investment in its infrastructure to cater to the need of high-tech industries in the free zone, ranging from advanced telecommunications, a fibre optic network, tier 3 data center with 120 high capacity racks, and a high-tech utility infrastructure with eight power stations with a capacity of 1600 MW. (Silicon Oasis, 2014).

- In October of 2014, the Dubai government announced that it would soon be commencing the construction of a new US $1.3 Billion Innovation Hub, to be sited in the Free Zone of Internet City, on Dubai's southern edge. The aim is to create significant advances in innovative technologies to serve both the Emirates as

ISBN 978-0-9925622-1-2

well as the wider global economy. This initiative is expected to accommodate 10,000 companies in jobs in technology, engineering, development, patent services as well as in support administration. The total number of employees expected to work there is anticipated to be in the vicinity of 100,000. (*Gulf News*, 28 October, 2014, p.1).

2. Hashemite Kingdom of Jordan

Jordan has a developing economy. Therefore, science, technology and entrepreneurship are seen as economic survival tools. Jordan has qualified human resources who are capable of executing the desired technological and economic transformation. The following are some initiatives being executed in Jordan:

- Higher Counsel of Science and Technology (HCST): This is a governmental institute that has the mission of coordinating and promoting science and technology in Jordan. The HCST has a specific fund to support local industries through projects championed by faculty from academia. (Higher Counsel of Science and Technology, 2014).

- The Scientific Research Support Fund (Scientific Research Fund, 2014): It was established by the ministry of higher education and scientific research and aims at increasing the expenditure on scientific research. The private sector in Jordan spends less than 3 percent of the total R&D expenditure compared to 7 percent in the Organization for Economic Co-operation and Development (OECD) countries (UNESCO, 2003). Therefore, the above initiatives are intended to convince the industry with the academia abilities and establish trust and credibility between them. Only then will the private sector fund higher percentages of R&D, because they know of its impact on operations and profitability.

- National Research Priorities Initiatives: This was a project funded by the scientific research support fund and the Higher Counsel of Science and Technology (HCST). The purpose of this project was to develop research priorities in 13 theme areas. This was done through a painstaking process in which teams of experts representing academia, industry and government met, discussed and decided on the priorities. The end result was a list of research priorities in these theme areas that will steer the funding priorities for research projects in Jordan in the future.

- Jordan Education Initiative (JEI): It was launched in June 2003 and is now supported by 45 organizations, including local and international companies, Jordanian government departments, global government donors, and nongovernmental organizations. The goals of JEI are to enhance the quality of education through the effective use of information and communications technology, build the capacity of the local technology industry and create a global education program model to be replicated in other countries. (Jordan Education Initiative (JEI), 2014).

- The Jordan Innovation Centers (JIC): The Jordan Innovation Centers Network (JICs) has under its umbrella eight different incubators focused on a number of topics such as agro-industry, IT, and engineering solutions. The iPark is one of these incubators and is technology centered (iPark, 2014). The Jordan Innovation Centers (Jordan Innovation Centers, 2014) is another example and serves underdeveloped areas of Jordan.

- The Queen Rania Center for Entrepreneurship (www.qrce.org): this encourages and prepares the young generation to be entrepreneurs, and holds an annual competition named the Queen Rania Entrepreneurship Competition which is supported partly by some multinational companies such as Microsoft. (Queen Rania Center for Entrepreneurship, 2014).

- The Jordan Enterprise Development Corporation (JEDCO): Is one of the funding agencies that provide grants to startups and SMEs in addition to providing them with technical assistance. (Jordan Enterprise Development Corporation (JEDCO), 2014).

TABLE 1: COMPARATIVE INTERNATIONAL INDICATORS

Country	GDP - real growth rate:	GDP - composition by industrial sector	Industrial production growth rate	Labor force - by industrial occupation	Inflation rate (consumer prices)	#of Journal papers	Total number of patents
UAE	4%	61.10%	3.30%	15%	1.30%	7559	138
Jordan	3.30%	29.90%	2.80%	20%	5.90%	23,485	39
Brazil	2.30%	26.40%	3%	13.30%	6.20%	715,178	3373
China	7.70%	43.90%	7.60%	30.30%	2.60%	2,579,863	41247
South Korea	2.80%	39.20%	2.50%	23.60%	1.10%	712,559	127992
Czech republic	-0.90%	37.30%	0.50%	37.40%	1.40%	193,116	950
Singapore	4.10%	29.40%	1.70%	18.60%	2.40%	178,722	7986
USA	1.60%	19.50%	2.50%	20.30%	1.50%	9,879,915	2715390

1. References taken from cia factbook. All figures taken up to 2013. https://www.**cia**.gov/library/publications/the-world-**factbook**/
1. Retrieved from http://apps.webofknowledge.com.ezproxy.kustar.ac.ae 7 February 2015.

2. Retrieved from http://www.uspto.gov/we/offices/ac/ido/oeip/taf/cst_all.html 7 February 2015.

The sample of countries in this table were selected on the basis of their varying stages of development which forms a comparative platform. This table is indicative of the nascent stage of scientific and technological development in the UAE and Jordan. The total number of journal papers and patents point to growth in these nations and an awareness of the need to meet specific transformational requirements in the future. Those indicators are provided by more developed nations such as South Korea, Singapore and the USA.

VII. ACCESSING FINANCE

Road-maps are intended to have practical applications; they must have financial means in order to be implemented. The authors put forward two means from among many other possibilities which could assist implementation. The first is accessing the resources of the World Bank, and the second is to propagate the entrepreneurial processes already in practice by institutions like the Pedro Nunes Institute (PNI) in Portugal, and the proposed hub in Dubai. The PNI has strong connections with Coimbra University in the Portuguese city of Coimbra where expertise and funding methods harmonize successfully.

Firstly, in an interview with the President of the World Bank, Mr. Jim Yong Kim, reported in *Foreign Affairs* (Sept.Oct. 2014), Mr. Kim revealed important information which could significantly impact the road-map's viability. One of the Bank's priorities is to invest more heavily in "social protection." By lending more than $60 billion in 2014 alone, a figure that is also indicative of its future resourcing, it is clear that the World Bank may be accessed. (Ibid. p.70). Whilst admitting that global education is challenging, Mr. Kim contends that it is the World Bank's intention to assist in opportune circumstances and work with the governments of developing nations, "when it comes to development for any given country, the most important thing is to get the government to buy into the plan." (Ibid. p.72). His approach is collaborative, "We've got to move from a siloed system, where everyone is afraid to take risks and everyone pushes the decision up to the next level because they don't want to get in trouble, to one in which everyone sits at the table and we actually collaborate." (Ibid. p.73). In this way, his approach might also be described as visionary, viable, and sustainable. It will become sustainable when its investments eventually become profit-bearing, which under sound and robust management they would do. The ultimate aim would be for investments to lead to self-sustaining industrial entities.

The second means is for existing innovation and entrepreneurship hubs, such as the one mentioned above, planned for Dubai within the next two years, to become more outward looking, and share expertise. Whilst its prime focus will be development of the UAE, it might also consider the advantages of providing facility development and expertise propagation in countries with which it presently only has trade relationships. It could provide India, Pakistan and other nations with negotiation, contracts and licenses which would enable relationships and connections in innovation to be strengthened, much according to Cox's comment in the introduction of this work. By investing some of the Dubai hub's revenues from innovation and entrepreneurship into developing nations, it could then charge for licenses and eventually for a percentage of royalties once those nations' developing industries begin showing a profit over time. Of course, such investments are medium to long-term; they will not bear fruit instantly.

VIII. CONCLUSION

This paper provides a number of recommendations that could establish a road-map for science and technology transformation. The technological divide between developing and developed world has never been wider. Nevertheless, with determination and political will, that gap can be bridged. There are a number of examples for economies that were transformed successfully. China, India, Brazil, and others are living witnesses for measures of transformation in relatively short time-frames. Therefore, proper planning and execution, clear and transparent goals, in addition to dedicating sufficient national resources are seen to be primarily conducive to successful implementation. Focused effort in a concerted fashion between industry, government and academia would lead to synergies that amplify outcomes and technological leaps. The United Arab Emirates and Jordan have number of initiatives that qualify as prime building blocks for developing their respective knowledge economies.

In summary, this paper provides a set of initiatives distributed between a critical triad: academia, government and industry. Through such a network a leap in scientific and technological advancement can be achieved. Finally, this road map is coupled with a set of key performance indicators to assess both the status quo and work in progress because the things that can be measured are the things that get done.

By using the resources and willingness from large financial institutions such as the World Bank and propagating the expertise from existing innovation hubs like the one in Dubai, the authors contend that the road-map may be implemented by various regions because vital financial means are available.

IX. POLICY RECOMMENDATIONS

The authors make the following recommendations, that

1. The triad between universities, industry and government be seen as a viable means by which to encourage socio-economic development in developing regions;

2. Governments make funding available for university research programs and entrepreneurial start-ups to help kick-start underdeveloped economies;

3. Practical university research be supported in order to implement development programs;

ISBN 978-0-9925622-1-2

4. Road-maps be devised based on creating an alignment between cultural and commercial considerations to provide regions with the means towards socio-economic progress;

5. Key-performance indicators be implemented periodically to evaluate progress and that corrective action be taken wherever it is required.

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