

Commercializing University Research Outcomes: A Sri Lankan Experience

Aruni Nisansala^{#1}, Maheshya Weerasinghe^{#2}, Damitha Sandaruwan^{#3}, Chamal Perera^{#4}
Chamath Keppitiyagama^{#5}, Nihal Kodikara^{#6}, Ranjith Senadheera^{*7}

[#]*School of Computing, University of Colombo*
35, Reid Avenue, Colombo 7, Sri Lanka

¹asn@ucsc.cmb.ac.lk

²amw@ucsc.cmb.ac.lk

³dsr@ucsc.cmb.ac.lk

⁴clp@ucsc.cmb.ac.lk

⁵cik@ucsc.cmb.ac.lk

⁶ndk@ucsc.cmb.ac.lk

^{*}*Colombo Dockyard PLC, Sri Lanka*

⁷senadheera@cdl.lk

Abstract— Sri Lankan government has taken a policy decision to develop the country as a knowledge hub in Asia. Universities have a pivotal role in realizing this goal and they have the responsibility to contribute new knowledge, through innovation and research, towards the economic development. Research culture in the Sri Lankan universities is gradually developing and there have been several research projects that resulted in commercializable innovative outcomes. However, commercialization is a challenging task due to several reasons and only a few significant outcomes of the university research have been successfully commercialized. Commercialization challenges are an integral part of the universities and research institutes and they are looking for pragmatic solutions.

In developed and industrialized countries, it is now widely accepted that the research outcomes of universities plays an important role in the economic development and it is quite common for the industry to work in collaboration with the universities to innovate and find solutions to their problems. However, this is not the case in Sri Lanka and due to this there is a large gap between the university research outcomes and industry expectations.

In this paper, as a case study, we present our experience in taking the outcome of a university research project and adapting it to solve a problem faced by two entities responsible for handling maritime traffic in Sri Lanka. We have productized the research outcome to a large extent and deployed it to handle a real world problem. While we cannot claim that it is fully commercialized yet, we have bridged the gap between the expectations of the real world users and the researchers at the university. Also, in this paper we explore how other countries have handled the problem of commercializing research projects as well as the Sri Lankan effort in this regard.

Keywords— Commercialization; Research Innovations; Strategies; Developing Countries;

I. INTRODUCTION

Universities are the main knowledge hub where number of innovations originate and spread worldwide. In every year vast numbers of research projects are being carried out covering each and every aspect of science, medicine, mathematics, computer technology and etc[1]. Universities are providing a considerable freedom in research

& development their underlying phenomena other than the industry level researches. Academic research projects are devoted to the innovation process. Hence universities are considered as a significant source of knowledge leading platform where the future technologies built up. When it comes to the smaller companies they do not have the resources or the manpower to carry out the research work. Larger companies are less keen on investing in technologies that are in an early and often uncertain stage of development. Specifically, the transfer of knowledge and technology between universities and companies has been broadly discussed[2].

Even though the academic research does not started to fulfill industry requirements, successfully completed research work has the ability of creating a new market trends in the relevant market segment. Generally the market strategies can be made once there is a business valued product. It doesn't depend on how the market behaved until now without the product[3]. When innovative product is introduced to the prevailing market it'll create its own trend. Not only in science, even in the entertainment market it's a proven fact[3]. In spite of that belief commercializing researches always have been a difficult process with lots of challenges. Not only Universities as well as research centers, R&D centers are facing the same issue[4]. There are plenty of university research outcomes which were disseminated around the world and dominated the existed products or technologies[5]. For instant, SUN was a graduate student project which was designed for the Stanford University Network communications project as a personal CAD workstation and then it became popular and a worldwide product[6]. The basic idea was laid with a university level research base project. The initial discovery of the recombinant DNA was also conduct at the Stanford University and the University of California[7]. Then the research was continued and many more successful outcomes were made along with the initial basic discovery.

The process of getting patent for the initial discovery and the problems which were occurred during that process were rarely investigated. Behind the each success story there is a process which should be analyzed to check the external internal factors that universities facing during the research commercialization process. This paper aims to come up

with crisis the universities face in commercializing their research outcomes. The successful seeds should be taken care and should be well protected with proper licensing and all. The connection between universities and the industry is heavily affected with this process. So how the industry and universities should collaborate to overcome the challenges and barriers in commercialization process is also reviewed in this paper.

When concerning the marketing patterns and current market it is clear that developed countries has come up with vast number of innovative ideas while the contribution of the developing countries is low. Countries which are having lower living stands; lower industry development and lower Human Development Index are called developing countries[8]. Albeit developing countries are showing lower contribution to the global technical view, their universities are also conducting research covering various technical fields. So the real problem lies between the university outcome and the business model. This paper aims to clear up the strategies which were used in developed countries commercialized the research outcomes with a proper business model and analyze the feasibility of applying them in the developing countries.

Generally computer literacy of developing countries is lower than the others[9]. Even though Sri Lanka is a developing country it has achieved a high literacy rate. In 2012 the average literacy rate was 92.0[10]. In context of globalization the knowledge and technology innovations have increased competitively result in a significant higher rates in higher educational fields. In this paper it is aimed to have a quick review on the strategies which are used in Sri Lankan universities to commercialize their research outcomes and how successful those strategies with compared to the developed country strategies. To ease the discussion, Siyara VTMS - a novel ICT based approach towards the vessel traffic monitoring/management[11] is used as an example to find the major challenges in the process of commercialization of university researches and innovations in developing countries. Siyara is a research outcome of university of Colombo school of computing[11] and it was recognized by industry and academia through several awards and publications.

II. RESEARCH COMMERCIALIZATION

Research commercialization is a complex and heterogeneous concept, requiring complicated interactions between research providers, the companies wishing to exploit the research, and - in any cases - the investment sector. Taking laboratory level experiments into the development production level and deliver it to the consumers is the process which involved in commercialization. This laboratory to market procedure is the main feature of the commercialization. Intellectual Property rights, licensing, supporting body, portioning economic benefits are the sub processes with related to the project commercialization. This process is complex and also costly. It has indicated that only one in one hundred of prospective research outcomes investigated for investment purposes can be successfully commercialized[12]. So this process has to be done with care and with minimum number of inconsistencies.

Knowledge transferring between private and public sectors is the bridge to the commercialization process.

Strategies used to transfer this knowledge base are different from region to region. Legislative acts have been issued to decrease the gap between the industry and university knowledge transferring and research commercializing[13]. Individual level technology transfer has focused on patenting, licensing and invention disclosures to university technology transfer offices[14]. So the basic architecture is always twisting around the university technology transfer offices.

III. RESEARCH COMMERCIALIZATION PROCESS IN DEVELOPED COUNTRIES

A. American & Europe Approach

As the importance of technology transfer have been widely address by policymakers. Various programs have been introduced to facilitate this technology transferring process. United States of America has the most successful history of transferring knowledge into industrial outcome. With the Bayh-Dole Act, US has established a strong national technology licensing infrastructure. Stanford University, MIT, Columbia University and the University of California are some of the successful institutes which follow this infrastructure[13]. Guidelines for patenting, licensing, equity ownership, copyright, consulting and contract with industry are done through these liaison offices. Policies were made to ensure the core academic value and to protect the researches rights.

USA knowledge and technology transferring process can be categorized under Funding technology transfer, Intellectual property policy, Entrepreneurship and education, Small business policy and programs, other government initiatives and programs. Government has set up laws and acts to support this process. Also the entrepreneurs use various strategies to keep early stage projects alive. They use contract work, income from licensing patents, sale of spin-off firms and angel investments backed by bank debt, university and corporate equity investments. So this process goes hand in hand with the support of the government as well as the entrepreneur. Industry university cooperative research centers are the most fruitful strategy which is established by USA government. This was specified in the Federal Technology Transfer Act of 1986. This University-Industry cooperative research centers are administrated by the National Sciences Foundation.

Sweden is the most knowledge based economy in the world. It is one of the countries which adopted the USA commercialization strategy[14]. It is one of the significant knowledge hubs which own giant companies such as Ericsson, Volvo, AstraZeneca etc. European countries such as Sweden are also lack in early stage venture capital[13]. So this is a common phenomenon in all R&D areas in all over the world. Europe proposed a national structure for incubators which could be run with private and public money. Incubators are joint offices which help newly established companies and institutes. As the next option they suggest testbeds co-located with the incubators and other structure as universities and institutes. The governments have a tax reforming plan which will encourage external bodies to invest in university research in its very early stage. This trend of knowledge based

economic value adding has spread over the Europe adopting the USA research commercialization approach.

B. Australian Approach

In generally research originate with a concept which has neither marketing nor business value. But ultimately knowledge gathered in this research will produce an economical valued product which should be commercialized with care. So the universities are the significant pillars which holds the knowledge and the external factors should be concern about the core idea behind the university research before bring it to the commercial market. As discussed above American and the European continent are successfully handling these twisted paths with care and finally gain maturity. Outside these regions New Zealand and Australian approaches can be analyzed further to identify the commercialization process of Australian continent.

New Zealand government has three principal areas of activity that influence the university commercialization practices.

1) *Legislation*: Patent Act(1953); Copyright Act (1994); Trade Marks Act(2002); Designs Act (1953); Plant Varieties Rights Act(1987); Layout Design Act(1994) are the acts which were passed to protect the intellectual property

2) *Fiscal*: Influencing the industry to undertake such activities such as research, commercialization and linkages. Treasury, the Ministry of Economic development encourages the industry to attend the above matters. Investing to commercialization is indirectly has benefited the industry in taxation.

3) *Policies*: Policies were structured, reviewed, developed and implemented through Ministry of Research, Science and Technology and in some cases by the Ministry of Education.

Following the above three strategies the continent was able to improve, encourage the innovation, firm internationalization with globally contribution towards linked business and improving investment environment[15].

C. Eastern Asian Approach

Over the past 40 years Korea has also shown a remarkable economic growth with rapid changes in technology transfer and technology commercialization strategies. Investing in large -scale facilities, development of infrastructure and aggressive acquisition of the most advanced technology in global marketplace. Technology Transfer Promotion act in 2000 was the turning point of the commercialization process in Korea. According to the act the researches were funded by the government funding and government act as the anchor of commercialization and market the product in international market. Technology transfer offices were established within universities and public research institutes premises. This can be defined as an adoption of the USA Bayh-Dole Act. This has diverse the country economy to the top rate within few years. Basic idea behind the Korean commercialization process was to maintain the focus on commercialization oriented policy and systems to determine the results with the utilization in

industry. The government emphasizes small & medium enterprises to solve technical barriers onsite by the utilization of the local university technology development support, and constructing autonomous joint industry-university technology development systems. And for the regional IT universities, joint area industry-university technology development consortia are being designated and supported actively[16]. The commercialization funding was maintained with the government departments, venture capital and angel investment funds. Especially the KTTC has played the linkage role so that the universities were free to focus on their innovation and not to worry about the marketing or the intellectual property violation issues.

D. Israel Approach

Israel can be identified as a country which achieved a high development within few years. When analyzing the economy of Israel it can be seen this country has invest lots of money and resources in research and technology development relative to other countries. Israel was established in 1948 and from the starting governments was enthusiastically participated in identifying a proper educational strategy[17]. As a result of this tremendous effort they have become the fifth in scientific publications all around the world and continue average of 5.57 citations per paper[18].

Financial support for academic, basic research, conducting programs to bridging the gap, setting up a proper legal infrastructure are some primary duties which carried out by the government. Every university has its own TTC which act as the intermediate person of the industry and the university. There are main common principles which university and the researchers should follow. They are;

- If the research has a commercial value researcher should disclose it to the university.
- Service Invention/ institute invention intellectual property is owned by the university.
- TTC is the solely distributor of the university research/inventions.
- Commercialization revenue are distributed between the university and the inventors by 40-50% or 50-60%
- If TTC is not interest in patenting the product innovator can do it at their own cost.

This TTC program was a bottom-up approach, but in 21st century Israel has introduced a top-down approach[19]. It applies their best practices, tools in other potential knowledge or technology resources.

IV. RESEARCH COMMERCIALIZATION PROCESS IN DEVELOPING COUNTRIES

Developing countries have lots of challenges to overcome in the process of research commercialization with compared to the developed countries. But in this era this crisis has become a significant topic for the both developing and developed countries. Today the country economy is depending on the knowledge that country possess[20]. It does not confined to one field, no matter whether the expertise lies on agriculture, nuclear, electronic or the computer field. So the present day knowledge holds demanding value. Universities are the main infrastructure which holds unlimited knowledge of each society. No

matter the developing status of the country most innovations are founded in the universities or in the research institutes.

A. Indian Approach

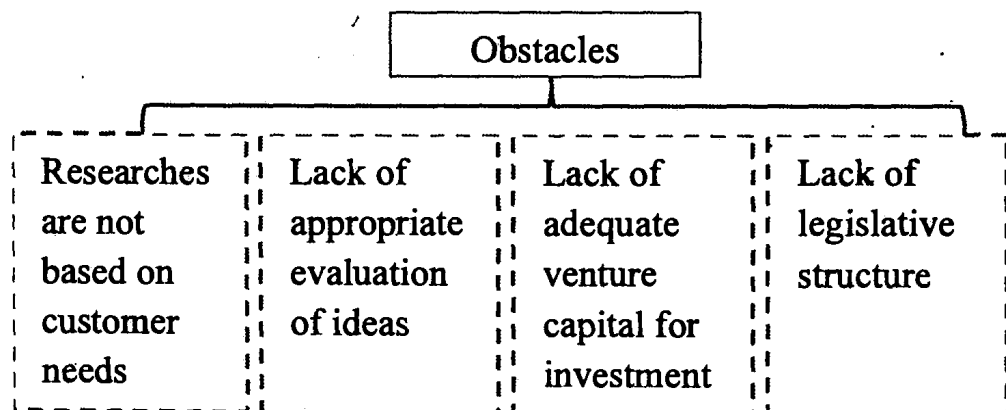
India claimed that they have a highly advanced higher education sector compared to its neighboring countries [21]. India has enacted the protection and utilization of public funded intellectual property bill in 2008 following the USA Bayh-Dole act. These Indian acts prioritize two main features which are[22];

- Maximize the protection of IP and provide a policy environment that guarantees the domestic commercialization, serves public interest.
- Raise the GDP for science and technology by two percent with the help of the industry.

So this bill will cover the most critical steps in commercialization process which are the structuring legislative structure and the funding. With this proceedings India was succeed to patent 21% share of the patent granted to Indians during 2010-2011 at the Council for Scientific and Industrial Research (CSIR)[22].

B. Iranian Approach

Iran government spends between 4 to 5.5% of the GDP on the education. In 2004 parliament passed a law which had the primary goal of developing the science and technology sector and domesticating import technologies[23]. Even though this caution was taken, country is facing the issues in research commercialization. According a research conducted by D.Tanha et al, It has found following major obstacle to commercialization of researches and innovations in Iran[4]. That summarization can be shown as follows,



C. Eastern Asia – Chinese Approach

China is one of the countries which attained a high development rate within a considerable time period. In this process of seeking knowledge for the growth of the nation, universities act as the base operating hub of the technical revolution. So the china has proposed a strong industry university relationship which interrelated in this commercialization process. University-industry cooperation (UIC) in research is an important vector of innovation and growth, the cooperation ecosystem of interconnected institutions, persons, and policies that are necessary to propel technological and economic development is commonly referred to as the Chinese innovation ecosystem [24]. China has invested more than 1% of GDP in research and development sector during the past decade. It is relatively high percentage with the other developing countries.

Due to the market oriented reform, decision on reforming science and technology was issued with the objective of reducing the government funding on university research and encourage them to increase their funding by commercializing the research outcomes. This policy caused the deficiency of the productive link between the university and the industry. This encouraged the universities to bias towards the commercialization of technologies that would benefit business quickly [25]

This Chinese strategy was adopted from developed countries. Research institutes, colleges and universities were the key forces to conduct projects nationwide under the supervision of the state. This allowed universities to do more than basic research and became early driving forces for commercial adventure in high tech sectors. Technology diffusion was initiated with university spin offs, science and technology development corporations and high-tech development committees [25].

D. Sri Lankan Approach

New policies have been presented to preserve Sri Lanka’s cultural values and traditions while developing a knowledge-based economy with better living standards for everyone. Sri Lanka was able to get the HDI value of 0.7151 in 2012, the highest in south Asia [26]. This indicates the high literacy rate, relatively lower poverty, high social and health conditions. Technology, innovation, research and development are highly related to each other’s serving the purpose of elimination of poverty [27]. Hence, with these two hypotheses analyse can be done to investigate the current research, innovation and commercializing process do behaves in Sri Lankan context.

First attempt on improving the local technology was started with the establishment of the Ceylon Institute of Scientific and Industrial Research (CISIR). But this was a failure which leads Sri Lankan government to commence the Industrial Development Board (IDB) in 1966. Publications supposed this failure was due to limited number of staff, lack of research groups and lack of linkages with industry [28]. After 1977 policy reform private sector showed a positive growth in R&D which was proceeding up until 1983 [27]. So with this history Sri Lanka was not successful in R&D sector while the other part of world was leading to a promising technical revolution in technology.

In the present day Sri Lanka has 15 state universities and 3 campuses covering performing art, technology, medical, engineering and R&D fields [29]. But comparing to the university graduates and the successful research outcomes it has a lower rate. Universities have no dedicated funds for research and development. GDP on research and development in Sri Lanka was 0.16% (2010) [30]. This indicates Sri Lanka is still struggling to achieve even a 0.2% ratio. This is far below than the recommended 1% for the developing countries. National Science Foundation (NSF) [31] and the National Research Council (NRC) [32] and Lankan Angel Network (LAN) [33] are few bodies which act as angel investors in R&D sector. With the above small capital investments, these organizations are struggling over the survival of R&D in Sri Lanka. World Bank has also funded for the growth of the research in Sri Lanka context in some extent. Researches have been carried out in several universities under the World Bank funding. University of

Colombo [34], University of Moratuwa [35] and University of Ruhuna [36] are some of those research centers.

NSF is a state funded foundation which handled by under the Ministry of Technology and Research, established in 1998. This body has a vast structure on funding researches. Competitive research grants, Postdoctoral research scientists, research scholarships, research fellowships, research equipment, research spare parts are some areas which NSF has allocated funding resources. NSF is also facilitating the technology transfer unit in Sri Lanka domain. IP protection and awareness is one of major responsibility of this council [31].

NRC has three main programs in favour of researches which are mainly focus on funding researches [32]. 'Target-oriented multi-disciplinary research projects' is one of the programmes conducted by the NRC. Isolation of research will cause the duplication of same effort. So the main objective of this program is to create the linkage of research projects. 'Private-Public Partnership Program' aims in building a local strength by connecting the researches and the industry sector within the local premises in order to achieve a global exposure. 'Research Grant Program' is to provide fund for research projects which are initiate at the Universities and affiliated colleges and any governmental or semi-governmental organization.

University Grant Commission (UGC) and the Ministry of Higher Education jointly have launched a new research grants to promote the innovation of the academic staff. This Research Grant Scheme (RGS) aims at forming a nourishing research culture in higher education institutes of Sri Lanka. Innovative Research Grant is one of the grants which formed under this scheme. This grant is focussed on high impact innovative research. Among the applicants it selects the richest innovative concepts and permits the grant. Under the scheme it is proposed to provide funds in commercializing the research outcomes with utility value. Publications, capacity building and development of inter institutional and international cooperation and collaboration are the other aspects which would be facilitated by this grant. Instead of the Innovative Research Grant UGC provide Postgraduate Research Grant and a Start-Up Research Support Programme (SRSP) benefiting the local higher educational institutes. This SRSP intend to provide the start-up funding's for high quality research concepts [37].

The Ministry of Technology and Research has a number of institutions formed to direct and form a national strategy for the science and technologies. The National Science and Technology Commission (NASTEC), National Science Foundation (NSF), Industrial Technology Institute (ITI), Arthur C. Clarke Centre for Modern Technologies (ACCIMT), National Engineering Research and Development Centre (NERD), Institute of Fundamental Studies (IFS), National research Council (NRC), Sri Lanka Standards Institute (SLSI) and the Sri Lanka Accreditation Board for Conformity Assessment (SLAB) and the Sri Lanka Inventors Commission (SLIC), Sri Lanka Institute of Nanotechnology (SLINTEC) are the institutes which are governed by the Ministry of Technology and Research [38].

Sri Lanka has IP laws to protect the innovators rights. This intellectual property act is issued in 2003 [39]. This

legislative structure matters when it come to the research commercialization process.

Although the research grants are been established, laws and regulations are enacted, the gap between the industry and the universities has been an obstacle when it comes to the research commercialization. Since lack of funds and extra resources universities havenot yet introduced a business product with a proper business plan. Since most of the research concepts are end up as a proof of concepts or a prototypes [40].

SLINTEC is one of the success stories in Sri Lanka research commercialization context. This was established as public private sector collaboration in advancement of the nanotechnology. Five leading private companies joined with the government in investing for the SLINTEC. This is specialized in research and development and adding value to natural resources. SLINTEC has acquire five patents during the its very first ten months proving the excellency of the collaboration [41].

V. MAJOR STRATEGIES IN RESEARCH COMMERCIALIZATION

By comparing the above developed country approaches toward the university research commercialization, here it is aimed to check the feasibility of adopting those strategies to the developing country background. When analyzing the different part of the world few common strategies can be condensed as follows.

A. Setting up a Knowledge Transfer Unit:

According to the above case studies it can find almost all the countries which achieved a high technology, knowledge transferring has set up this infrastructure to act as the linker of the university and external environments. Developing countries such as Sri Lanka has no structured body which will act as the intermediate person between the academic and industry knowledge transferring process. This knowledge transferring mechanism can be varying from consultancy, service provision, joint venture of R&D, licensing processor to contract research. Advantages of this body to the university can be identifies and briefed as follows [42].

- Addressing the needs of economy and to develop its activities accordingly through income from the sales of technology
- Opportunity place students in the industry environment rather than giving all the theoretical knowledge.
- Access to industry, potential market in a smoothly way through the recognized body.
- Creating goodwill and providing the service in a proper way. Reach out the potential clients in a credential way.
- Establishing the intermediate body will affect to the university and that body as well as to the country economy too. Since the interaction is heightened innovation, addressing of the potential issues will be effective. So this will mutually benefit to the economy and the technical sectors.

B. Setting up Proper Legislative Structure on Innovations, Patent, Intellectual Property Laws:

Since the blurring edge of academic and corporate worlds crisis has arisen. Commercialization process has compromised the openness of the academic research. It had the trend of openness and sharing the result. So to maintain this boundary legislative system has enacted during the past decades. Patenting and the licensing is the basic approach to protect the intellectual property rights. Developed countries have the knowledge transferring bodies to process the IP on research materials and outcomes, protecting the academic values of the research outcome. Professional bodies such as Ministries, science and technology department setup rules according to the current social status. Developing countries has also enacted those IP laws. But the issue is that there is no methodology to protect the educational value of the research outcomes.

C. Funding the University Research from the Very Early Stage:

Generally government plays the significant role to ensure the funding procedure to be carried out properly. Expenditure for the research and developing category can be shown according to the world bank records. After analyzing the graphs it is clear that the developed countries are allocating higher percentage for the research and developing category than the developing countries. It is true that developing countries cannot allocate the same amount of money for this category but they should at least follow similar percentage rate considering to the developed countries. But there is a visible difference between the developed and developing country resource allocation. Following graphs shows the differentiation of the both parties with some examples.

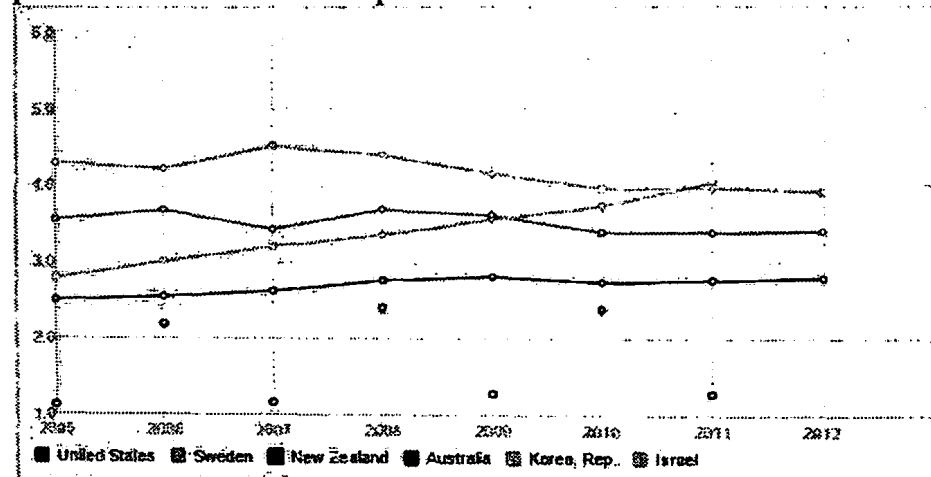


Fig. 2 Research and development expenditure - developed country (% of GDP)[30]

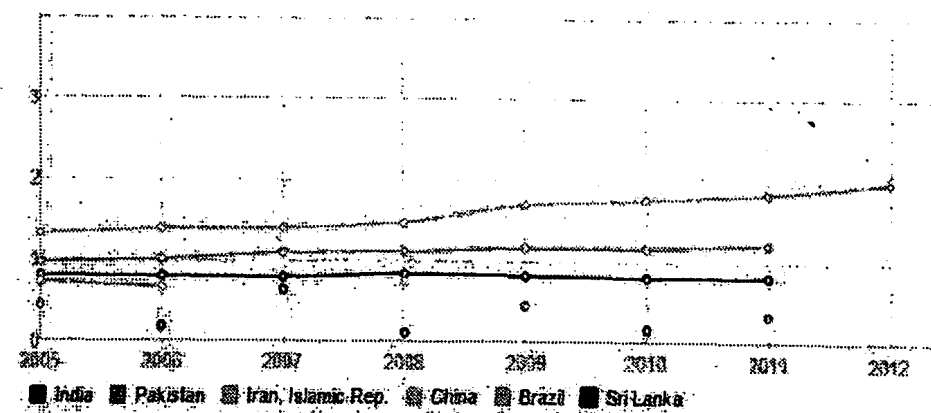


Fig. 3 Research and development expenditure - developing country (% of GDP)[30]

D. Encourage the External Bodies to Fund, Cooperate and Promote Innovations:

In USA and Europe there are laws which have passed on taxation methodology of the private sector industries which encourage the research facilitation. By this approach external bodies are encourage to build up the supporting backbone to the researches. But in developing world countries it doesn't have any infrastructure to encourage the external industrial people to encourage the research section. It is not like the developing countries are lack of innovations or innovative ideas but the lack of concern and the prioritization from the outside industries.

E. Reduce the Industry-University Gap

The first country that realized the importance of the reducing the gap between the university and industry and successfully do so was the United States, more than three decades. This was due to the free market economy. Then Europe and the UK adopted this approach. But even after three decades developing countries have failed in adapting to this process[43]. For the eras research was the monopoly of the university whilst development was the monopoly of the industry. But with this strategy research and development has combined together and so as the universities and the industry should come under the same shade. Reducing this gap can be achieved through establishing the bridge intermediate body as described earlier.

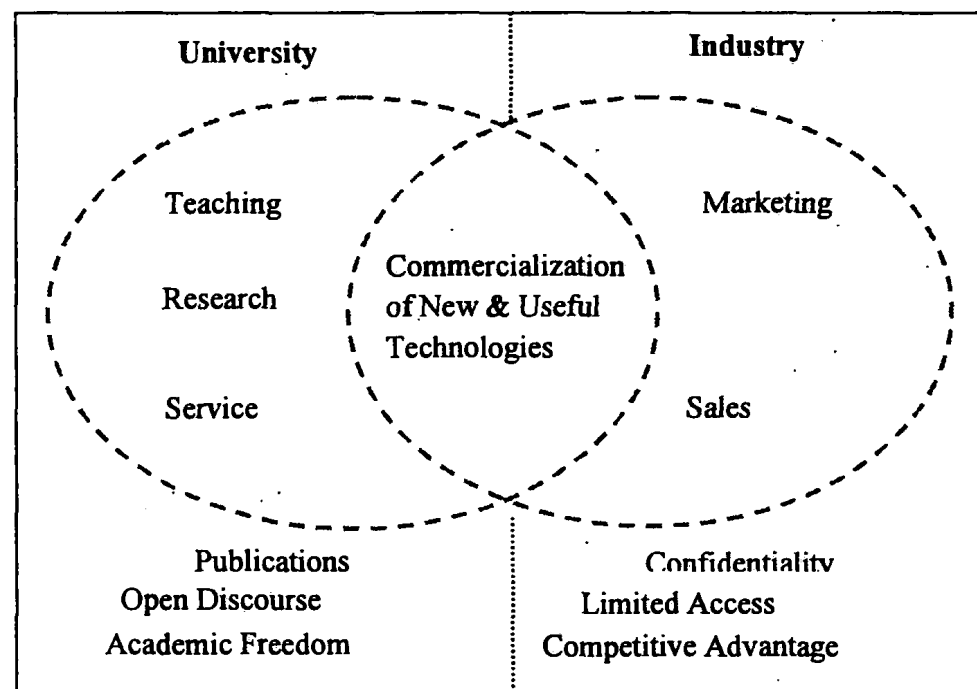


Fig. 4 Intersection of Universities & Industry tech transfer

VI. CASE STUDY WITH SIYARA VTMS

Siyara VTMS[44] is an innovation concept originated at the University of Colombo school of Computing[11]. Sri Lanka is a developing country with high diversity of technical innovation concepts. Universities conduct various researches and numbers of successful undergraduate and postgraduate research are being published every year. But only limited numbers of successful research are available at the market as a business product/service. Here it is intended to verify the facts which were discussed in previous section with related the commercializing of Siyara VTMS.

Almost all the busiest ports are facing the issue of monitoring and management in channel traffic. Mostly VTMS systems has the two dimensional charts to plot the ship path and locations. The leading maritime solution provider Transas has introduced a three dimensional VTMS

to the market[45]. But this is an expensive commercial product with annual licensing fee. GeoVs[46], VisSim[47] and Signalis[48] some of the major VTMS software solution providers in the maritime field and GeoVs also introduced 3D VTMS to the current market. Siyara is a university research outcome which successfully addressed the vessel management activities and a combination of almost all the features in other commercial products[49]. So the Siyara VTMS has a potential market and this research is driven with customer based requirements. Sri Lanka Port authority (SLPA)[50] and Sri Lanka Navy (SLN)[51] provided requirements at the development stage of the Siyara.

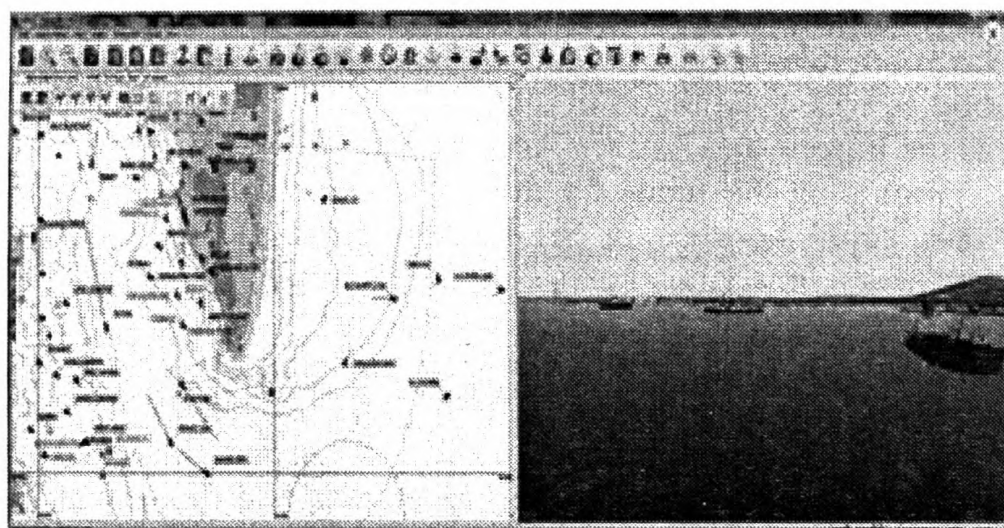


Fig. 5 Screen shot of Transas 3DVTS



Fig. 6 Screen shot of GeoVs – cartographic VTM

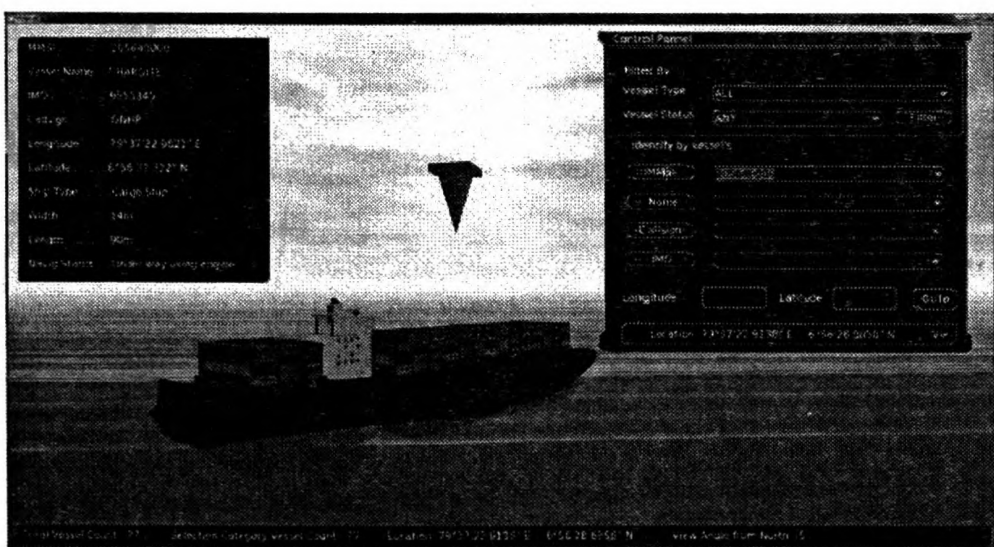


Fig. 7 Screen shot of Siyara VTMS

Table I shows a briefing of the features in Siyara VTMS combatively the products which are available in regions. This indicates the Siyara is a successful outcome with competitive features and functionalities. But the University

had to face lots of challenges during the launching of the product to the market. This model is demonstrated to the real users and the expertise in the naval and military contexts. According to their feedbacks Siyara VTMS can be deployed in the real time environment. It was recognized by the industry and academia through wards and publications[11][44].

TABLE I
COMPARISON OF KEY FEATURES

Features of Siyara	Availability of Similar Product		
	Local Context	Asia Pacific context	Global context
2D Pc Based VTMS view	NO OTHER SIMILAR PRODUCTS IN LOCAL CONTEXT.	YES	YES
3D VTMS view		NO	YES
2D mobile view with Management info:		NO	NO
Sensors for operational Boats.		NO	NO
Radar Compatibility		YES	YES
FAL Automation		NO	NO

As classified in above section lack of proper link between the university and the industry caused several issues in the Siyara commercialization process. In developed country approach, universities are there to conduct, deploy and implement the solution while the knowledge transfer office do the licensing, promoting and creating a market to the outcome. But here in a developing country such as Sri Lanka does not have that privilege. So after publishing the innovation and ensuring the IP of the outcome it has to create its own strategy to enter to the industry and the market. Since the university is not always capable of providing the strong service/maintenance structure that the client requires and it caused high percentage of projects to fail in the market.

Obtain the required funding the early stage of the research is one of the major requirements which favor in a successful outcome. But in this case it was a very time consuming and tiresome process to find an external body to support the funding process. The implementation was a costly process due to Hardware cost and development cost. Once the project is completed for a domain it need new hardware and labor cost to duplicate the project in some other environment. Siyara VTMS was initially set up at the Colombo port and given free of charge service for day today activities. But next University had no resources to duplicate the environment at the other potential places.

The project was funded by the NSF and supported by the HETC (Higher Education for Twenty First Century) project at the later part of the project[52]. Usually all governments should allocate some amount of money for the university research out of the GDP per year. In developing countries the percentage which is allocated is very low with relative to the developed countries. Even though the difference between the GDP is high when taking the percentage it should be vary in an average rate. But as shown in the previous section Sri Lanka has a lower rate on research and development section.

University has to get the support of private sector in commercializing the Siyara VTMS. This is where the intermediate body should be appeared and links the industry and the university. As the Sri Lanka lacks of this knowledge transferring/commercialization units, University had to find a venture itself. Under the HETCW4 Higher Education for Twenty First Century project encourage to established such units to link the industry and the university[52].

Product certifications are one fact that builds up the confidence of the client over the product. So a product which enters to the competitive market should own some of industry recommended certifications to entrust their customers. These certificates are the one which certify that the product has gone through a proper quality assurance tests and performance tests. But Siyara VTMS could not posse any certification due to the lack of proper infrastructure. Universities have lack of expertise and experience in the process of certification and also there is no proper link with the legal bodies to support in this process.

Even the Siyara VTMS has potential and competitive product with the recommendation of filed expertise; it was not 100% successful in achieving the market basis. So during the process of research and development, deployment and launching as a business product there were lots of challenges to overcome. Even in this case all the commercially successful VTMS are marketed by the developed countries. Even they are not the universities, some of those projects were funded and carried out under the supervision of industrial bodies and successfully dominated the global market. In developing countries such as Sri Lanka will have to take a lot of effort in establishing in even its own market. So as the paper suggests.

VII. CONCLUSIONS

Setting up a knowledge transfer unit, setting up a proper legislative structure, funding the research from the beginning and reducing the industry university gap are the major strategies in commercializing the university research outcomes. Developed countries have followed those phases properly and gradually have obtained a successful commercialization in universities.

When comparing to the strategies of the developed countries it is found four major steps which follows by the technology knowledge transferring experts. Those steps were compared and contrast in the above section. After analyzing those procedures following strategies were extracted out of them as the best strategies which can be adopted in developing country research commercialization.

Ensure and tighten the corporation between the university and industry is the first step which can be applied in the developing country market. Most of the university commercialization has been conducted at the national or organizational levels. So minimize the gap between the universities or the academia and the potential industry needs is the best scenario which can lead the knowledge transfer to a better position.

Establish a proper merchant community around the university research groups. This will reduce lots of efforts; university has to endeavor in entering or addressing the potential market issues.

Establish a proper funding strategy for the very first stage of the research; this should be initiated with the support of public and private sector. If government can apply some taxation relaxation on funding research projects external bodies will encouraged in investing the ongoing researches as the Europe and Eastern Asia strategy.

Providing the funds for the startup research is essential. This could be seen in Sri Lankan context. The lack of sufficient encouragement in commercialization is the limitation where Sri Lanka should act with care. After achieving a high quality research outcome the next goal should be exposing it to the industry. This commercialization process needs a strong knowledge transferring unit between the universities and the industry. Establishing a strong knowledge transferring unit, funding research until the outcome goes to the industry and all the discussed steps for a better commercialization will mutually benefit to industry, government and academia.

VIII. REFERENCES

- [1] Friedrich, Thomas Brenner Dornbusch, "Universities as local knowledge hubs under different technology regimes: New evidence from academic patenting.", 2013.
- [2] T. Nikulainen, "The outcomes of individual-level technology transfer and the role of research collaboration networks," in *ETLA discussion paper*, 2010.
- [3] Eric Von Hippel, "Lead users: a source of novel product concepts.," in *Management science* 32.7, 1986, pp. 791-805.
- [4] A. Salamzadeh, Z. Allahian and Y. Salamzadeh D. Tanha, "Commercialization of university research and innovations in Iran: Obstacles and solutions," , pp. 126-146.
- [5] Christoph, and Heide Fier Grimpe, "Informal university technology transfer: a comparison between the United States and Germany.," *The Journal of Technology Transfer* 35.6 (2010), pp. 637-650., 2010.
- [6] Sun Microsystems. [Online]. http://en.wikipedia.org/wiki/Sun_Microsystems
- [7] Sally Smith Hughes, "Making dollars out of DNA: the first major patent in biotechnology and the commercialization of molecular biology," in *Isis*, 2001, pp. 541-575.
- [8] Steven M. Sheffrin and Arthur Sullivan, "Economics: Principles in action," New Jersey, ISBN 0-13-063085-3, 2003.
- [9] Menzie D. Chinn and Robert W. Fairlie, "The determinants of the global digital divide: a cross-country analysis of computer and internet penetration.," in *Oxford Economic Papers*, 2006.
- [10] Central Bank of Sri Lanka. [Online]. <http://www.cbsl.gov.lk>
- [11] Damitha Sandaruwan et al., "Low Cost Immersive VR Solutions for Serious Gaming," *IGI Global*, pp. 407-429, 2012.
- [12] "Research in the national interest: Commercialising university

- research in Australia," Commonwealth Information Services, Australian council report ISBN 0 642 23984 3, 2000.
- [13] Karlsson Magnus, "Commercialization of research results in the United States—an overview of federal and academic technology transfer," , 2004.
- [14] D. Nordfors, J. Sandred, and C. Wessner, "Commercialization of academic research result," VINNOVA Forum – Innovation Policy in Focus VFI 2003:1, ISBN: 91-89588-94-0/ISSN: 1651-3541, 2003.
- [15] Alan Collier and Brendan Gray, "The commercialisation of university innovations—A qualitative analysis of the New Zealand situation," Centre for Entrepreneurship School of Business University of Otago, Research report 2010 May.
- [16] Young Roak Kim, "Technology commercialization in republic of Korea," Korea Technology Transfer Center(KTTC), 2001.
- [17] Israel. [Online]. <http://en.wikipedia.org/wiki/Israel>
- [18] "Report of the Committee for the Assessment of the State of Biomedical Research in Israel," The Israel Academy of Sciences and Humanities, Jerusalem, Committee Assessment Report 2008 November.
- [19] Brent Goldfarb and Magnus Henrekson, "Bottom-up versus top-down policies towards the commercialization of university intellectual property," *Research policy*, vol. 32, no. 4, pp. 639–658, 2003.
- [20] United Nations Economic Commission for Europe, "Towards A Knowledge Based Economy," United Nations, New York and Geneva, Assessment Report 2002.
- [21] Government of India Planning Commission, "Report of Steering Committee on Science and Technology," Office of the Principal Scientific Adviser to the Government of India, New Delhi, Committee Assessment Report 2006 December.
- [22] Pradeep Srivastava and Sunita Chandra, "Technology Commercialization : Indian University Perspective," *Journal of Technology Management & Innovation*, vol. 7, no. 4, pp. 121-131, December 2012.
- [23] Ahdol S. Soofi, Sepehr Ghazinoory, and Sanam Farn, *Science and Innovations in Iran: Development, Progress, and Challenges.*: Palgrave Macmillan, 2013.
- [24] Jin-fu Wang, "Framework for university-industry cooperation innovation ecosystem: Factors and countermeasure," *Challenges in Environmental Science and Computer Engineering (CESCE)*, vol. 2, pp. 303-306, 2010.
- [25] Yang Chen, Richard Sanders, and Jinmin Wang, "The commercialisation of Chinese universities and its effects on research capacity," , 2006.
- [26] UNDP. About Sri Lanka. [Online]. <http://www.lk.undp.org/content/srilanka/en/home/countryinfo/>
- [27] Sarath Dasanayaka, "Technology, poverty and the role of new technologies in eradication of poverty: The case of Sri lanka.," *South Asia Conference on Technologies for Poverty Reduction*, vol. 10, October 2003.
- [28] ROB Wijsekara, "Scientific Research in a Small Developing Nation – Sri Lanka," *Economic Review*, vol. 2, no. 3, pp. 9-13, 1976.
- [29] Univeristy Grant Commission. [Online]. <http://www.ugc.ac.lk/>
- [30] World Bank. Research and development expenditure(%of GPD). [Online]. <http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS/countries>
- [31] National Science Foundation. [Online]. <http://www.nsf.ac.lk/>
- [32] National Research Council of Sri Lanka. [Online]. <http://www.nrc.gov.lk/>
- [33] Lankan Angel Network. [Online]. <http://www.lankanangelnetwork.com/default.php>
- [34] University of Colombo - HECT Projects. [Online]. <http://www.ucsc.cmb.ac.lk/node/387>
- [35] University of Moratuwa - HETC projects. [Online]. <http://www.mrt.ac.lk/web/hetc>
- [36] University of Ruhuna - HETC Projects. [Online]. <http://www.ruh.ac.lk/Uni/hetc/>
- [37] University Grant Commission - Sri Lanka. [Online]. <http://www.ugc.ac.lk/en/dric/research-grants.html>
- [38] Ministry of Technology and Research. [Online]. <http://www.motr.gov.lk/web/index.php?lang=en>
- [39] National Intellectual Property Office Sri Lanka. [Online]. <http://www.nipo.gov.lk/>
- [40] Malik Ranasinghe, University Research and Commercialization.
- [41] Sri Lanka Institute of Nanotechnology. [Online]. <http://slintec.lk/>
- [42] M Esham, "Strategies to develop university-industry linkages in Sri Lanka," *National Education Commision Sri Lanka Study Series No. 4*, 2008.
- [43] A. A. Zaky and M.M.El-Faham, "The university-industry gap and its effect on research and development in developing countries," in *Frontiers in Education Conference, 1998 28th Annual, IEEE*.
- [44] University of Colombo School of Computing. UCSC - Siyara VTMS. [Online]. <http://www.ucsc.cmb.ac.lk/node/357>
- [45] Transas 3DVTMS. [Online]. <http://www.transas.com/products/3DVTS>
- [46] GeoVS Limited. [Online]. <http://vimeo.com/geovs>
- [47] VisSim - Vessel Traffic Management System. [Online]. <http://www.vissim.no/products/vessel-traffic-management>
- [48] Signalis - Vessel Traffic Services. [Online]. <http://www.signalis.com/produits/vessel-traffic-services/?L=1>
- [49] C. Keppetiyagama, N. Kodikara, R. Senadheera, P. Samarasinghe, R. Abeyakone , R. Ariyaratna, P. Dabare, K. Zoysa, A. Silva, D. Attygalle, K. Dias, R. Rosa, C. Perera and D. Lakmal D. Sandaruwan, "Real-time 3D vessel traffic monitoring system for com,".
- [50] Sri Lanka Ports Authority. [Online]. <http://www.slpa.lk/>
- [51] Sri Lanka Navy. [Online]. www.navy.lk
- [52] Ministry of Higher Education. Higher Education for Twenty Century. [Online]. www.hetc.lk