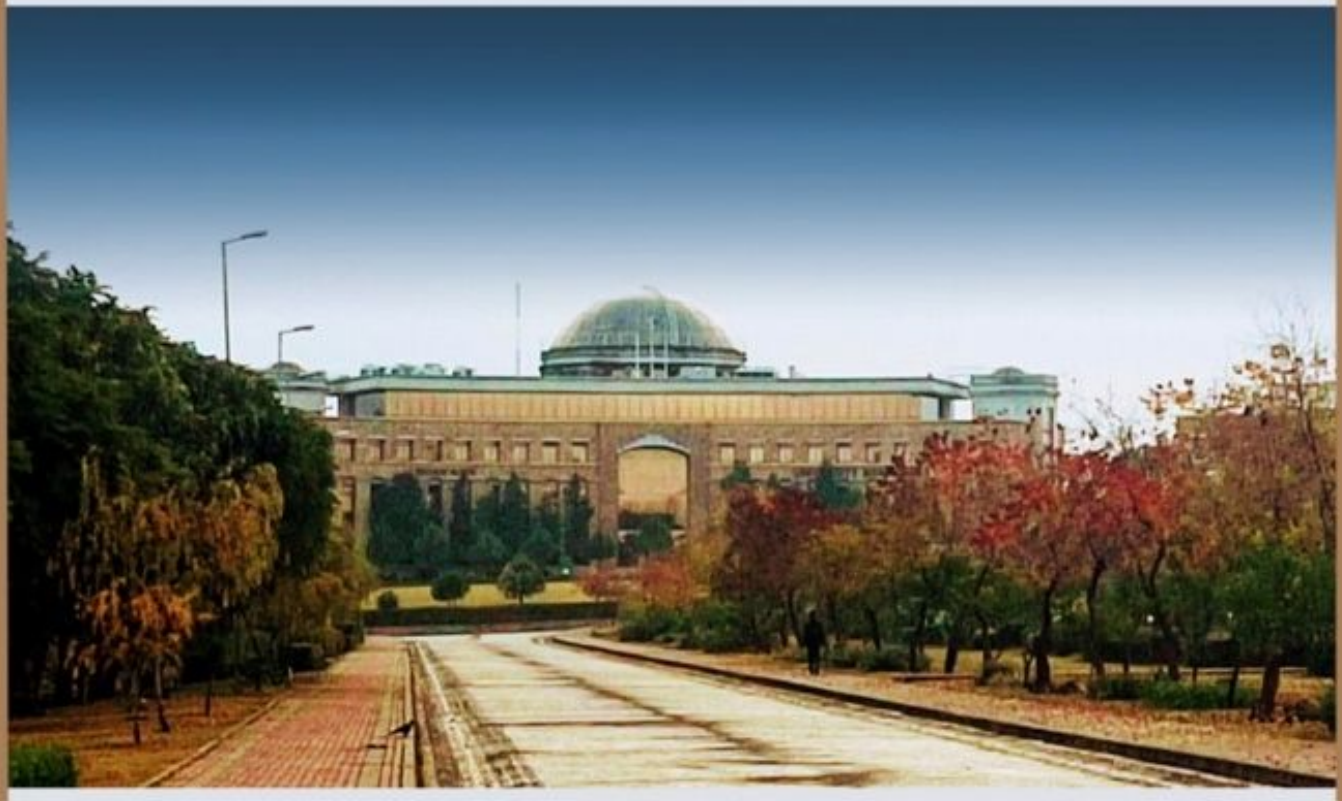
The Role of S&T Universities in Promoting National High-Tech Growth



NUST Institute of Policy Studies

The Role of S&T Universities in Promoting National High-Tech Growth

NUST Institute of Policy Studies

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The views presented here are solely of the participants of the webinar and do not represent the position of NUST and NIPS.

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Executive Summary

NUST Institute of Policy Studies (NIPS) organized the high-level webinar on the role of S&T universities in promoting national high-tech growth on Thursday, July 6, 2021. The webinar brought together a distinguished panel of senior policymakers, university and science park leaders, experts, academics, and scholars from China, Pakistan, and the United Kingdom to discuss various facets of the role played by universities in driving national high-quality high-tech growth in which science, technology, and innovation serve as strategic support force. The webinar focused on the role of universities in producing nation-building human capital, that is, highly qualified R&D and S&T talents. The discussion also focused on the participation of leading universities in science-based regional development consisting of new industrial cluster development, including science and technology parks and the importance of the overall context of regional growth and development for the rise of world-class universities. Experts highlighted the importance of positive international S&T collaborations as the driving force behind the globalization of scientific research as part of the broader agenda of higher education internationalization. The importance of social capital for domestic, regional, and global knowledge-based networking was underscored. The webinar also stressed the regular and collaborative organization of university-based technology foresight exercises as a way for setting the agenda for the comprehensive promotion of innovation, regional development and S&T-led growth.

This report is a substantive critical account of the issue, and represents the collective views of the experts put forward during the webinar. Five appendices have been placed at the end of this report to provide complementary material on the topic. Appendix I consists of the remarks made at the webinar by Honorable Shibli Faraz, Federal Minister for Science and Technology. Appendix II consists of the welcome remarks delivered at the webinar by the Director General NIPS. Appendix III carries the recommendations of the national seminar on knowledge economy, organized by NIPS in March 2020. Appendix IV consists of the recommendations of the webinar on the role of science and technology for growth and competitiveness, held by NIPS in July 2020. Appendix V carries a recent op-ed (July 21, 2021) by Prof Atta-ur-Rahman, published in one of the leading daily English-language newspapers of Pakistan.

The following recommendations were derived from the webinar deliberations:

i. The government should declare a 10-year long educational emergency to revamp and renew primary, secondary, technical and vocational, and higher education systems on war footing. The proposal is under consideration by the government and decision may be taken in due time.

ii. The government should focus on the development of at least 3 to 5 world-class universities figuring in the top 100 universities of the world till 2030. This goal should drive the national higher education agenda. In this regard, at least 10 top national universities should be selected. These universities should be provided with sufficient resources to help them achieve the proposed target within the proposed time frame. The government should create a triple-helix taskforce to prepare a roadmap for this proposed 5-in-100 vision.

iii. The totality of goals and objectives of universities should be both self-determined as well as laid down by the government in a manner that universities can respond to different demands of each stage of national growth and domestic development.

iv. Universities should collectively consider the possibility of tertiary unemployment, oversupply of graduates in a certain field, devaluation of university degrees, diminishing returns of university qualifications, and brain drain, and recommend proposals and strategies for addressing these risks without waiting for the market to correct these distortions on its own.

v. Universities should be incentivized to produce a critical mass of highly qualified professionals in disciplines of the future. In this regard, at least ten to fifteen advanced disciplines should be identified and selected as part of the strategic national plan for higher education and university development between 2022 and 2040. These fields should be advanced natural sciences, engineering, and new social sciences.

vi. Pakistani universities, individually or through a consortium of universities, should offer degree-level courses in science, technology and innovation (STI) management in collaboration with leading universities of the advanced countries and newly industrialized countries. In this regard, leading universities should establish centers of excellence for STI development management focusing on an interdisciplinary education and training consisting of management studies, cybernetics, design thinking, futures studies, and STI policy studies.

vii. The potential of universities to act as nodal points in science-based regional development should be developed and maximized. In this regard, universities should participate actively in the development of new industrial clusters in their regions. Among different types of these clusters, universities should focus specifically on the development of science and technology parks. The approvals and procedures required for this form of development should be rationalized and simplified, to be preferably dealt with via a hassle-free time-saving one-stop shop. Budgetary concessions, tax rebates, educational subsidies, financial grants, soft loans, etc., should be made available for universities to participate in new industrial cluster development. International financial organizations like the Asian Infrastructure Investment Bank (AIIB), Silk Road Fund, World Bank, and the Asian Development Bank should be approached in this regard.

viii. Big domestic and global business, industrial, and financial corporations should be incentivized to invest in leading national industrial clusters under development. These incentives can include tax holidays, first-mover concessions, and other forms of preferential treatment to stimulate science park formation movement and S&T market development in Pakistan.

ix. The government should consider the establishment of a national science park development fund to be managed jointly by the Prime Minister's Taskforce on Technology-Driven Knowledge Economy, Prime Minister's Taskforce on Science and Technology, the Higher Education Commission and the Ministry of Science and Technology.

x. University-Industry collaboration should be based on achieving pro-poor market outcomes and poverty alleviation results in the context of Pakistan. Universities and their science parks should, therefore, among on other things, focus on locally designed affordable agricultural technologies, alternative and more sustainable forms of energy, smart agricultural extension service platforms, e-health, affordable decent housing, urban and rural transportation, and educational technologies. Universities should also focus on providing smart agricultural extension and industrial training services.

xi. Universities should cooperate as much as they compete with each other. The sub-optimal state of inter-university collaboration in Pakistan should be addressed through sharing knowledge resources, joint use of laboratories, sharing maintenance of large national research infrastructures, scientific mobility, joint research, and joint policy advocacy.

xii. Science popularization campaigns should be made a part of strategic communication and outreach plans of universities.

xiii. Pakistani universities should revise and adapt their teaching, research, and curricula to the UN Sustainable Development Goals (SDGs). The comprehensive research agenda of Pakistani universities should reflect the synergy of various development visions like the domestic development vision, Belt and Road development vision, CPEC development objectives, SDGs, 14th Five-Year Development Plan of China, and other relevant regional development visions.

xiv. Pakistani universities should encourage and organize regular technology foresight exercises and establish departments of futures studies offering courses, degrees, and certifications in the field. As part of inter-university collaboration, rounds of technology foresight exercises on an annual basis should be held with several sessions hosted by various universities.

The Role of S&T Universities in Promoting National High-Tech Growth

1. Introduction

Science and technology, higher education, human capital formation, research and development, and innovation and entrepreneurship have been established as the fundamental pillars of contemporary growth and development. Nations desirous of forging ahead in the global race for competitiveness prioritize the concerted development of these key pillars. Leading universities act as institutional forms best suited for the purpose. Their diversity and dynamism allow them to become avenues where different institutional actors from different sectors, domains, and areas can come together. This convening power allows leading universities to simultaneously seek and evolve omnidirectional linkages with the state, government, market and economy, industry and business, society and communities, and people and households. This multidirectional and multifaceted interaction enables universities to utilize existing competencies, develop new ones, and leverage the particular strengths of other sectoral, institutional, and domain stakeholders, thereby becoming a nodal point for driving economic growth, social development, social change, cultural evolution, political participation, scientific discovery, and technological change. This process is neither straightforward nor a historical given, but rather needs careful curation by national policy. Contribution of universities to high-quality growth is not a linear process, but rather one that presupposes the need for the concomitant use of both vertical and horizontal development approaches, guided respectively by the strategic direction of overall national development and the structure of regional demand for innovation, as well as societal, community and firm-level tolerance and appetite for technological change and scientific development.

2. Brief Historical Perspective: Industrialization, Modernization and Higher Education

The modern experience of industrialization and modernization during the last 250 years consistently reveals the role of the visible and reconstructive hand of the state and government in organizing and facilitating national and regional conditions for innovation and technological growth.

The first wave of industrialization and modernization, known as the Industrial Revolution, occurred in England in the late eighteenth century. This first wave was a relatively spontaneous process begun largely through

private initiative without state support. It was based on relatively crude and simple techniques in modern terms, much amenable to use by a workforce that lacked any formal scientific or technical training and engineering education. Its relative independence from state backing incidentally became a building block of laissez faire or free-market philosophy and practice. However, during the last quarter of the nineteenth century, the development of an elaborate but a restrictive national system of higher education and scientific research in the United Kingdom plugged the gap between private initiative and public support for the enterprise of scientific research and development.

The second wave of industrialization in North America, Western Europe and Asia Pacific between the third quarter of the nineteenth century and the first quarter of the twentieth century was premised from the beginning on the establishment of the basic infrastructure of public higher education and scientific research, literacy campaigns, and focused improvement in the technical skills of the workforce. Industrial development of the United States, Prussia and later Germany, and Japan were representative of these trends.

The third wave of industrialization consisted largely of fast-paced but traumatic development of Soviet Russia between 1930 and 1950 consisted in the extensive state state-led promotion of the selfsame trends at a more frenetic pace covering an extensive geographical area in a much shorter span of time.

The ongoing fourth wave of industrialization and modernization in South Korea, Brazil, Russia, Singapore, Turkey, Indonesia, and China has also been driven by massive investments in all levels of education and research. This fourth wave is also characterized by the increasing transformation of advanced economies into postindustrial societies with greater play given to innovation and entrepreneurship.

It is noteworthy that with each successive wave, the importance of universities for growth and development rose rather than plummeted. This increased significance owed itself to the expansion of the role of universities in growth and development from being adjunct institutions to becoming progressively central organizations. The so-called three or four generations of university growth and evolution capture this evolutionary path succinctly.

3. Overview of Worldwide Higher Education and Scientific Research

There are over 25,000 universities around the world. According to a 2018 paper by Angel Calderon, titled, "Massification of Higher Education

Revisited," the total number of students in higher education was projected to reach almost 380 million by 2030, 472 million by 2035, and almost 600 million by 2040. The global average of expenditure on higher education as a percentage of government expenditure is 22 percent. According to UNESCO's Global Education Monitoring Report 2019, annual spending on education worldwide in 2019 was USD 4.9 trillion, with USD 3 trillion, constituting 65 percent of the total, spent in high income countries, and USD 22 billion, making up 22 percent of the total, spent in low income countries. Total global spending on research and development reached USD 2.23 trillion in 2018, whereas it was USD 500 billion dollars in 1996. According to the Congressional Research Service analysis of the data of the Organization for Economic Development and Cooperation (OECD), the United States and China were the two biggest spenders on R&D in 2018 at USD 581.6 billion and 554.3 billion, respectively. Published scientific journal articles worldwide were estimated to be 2.22 million in 2018. Bibliometric analysis undertaken by Lutz Bornmann of Max Planck Society and Ruediger Mutz of the Swiss Federal Institute of Technology has estimated that the global scientific output doubles every nine years. In so far as university-based intellectual property creation was concerned, the University of California filed 559 international patent applications globally in 2020, the highest in the world followed by Massachusetts Institute of Technology (MIT) and Shenzhen University.

4. Development of High-Quality R&D and S&T Human Capital

Top universities have historically played a leading role in training high-quality R&D personnel and S&T human capital. Human resource development has been the most time-honored function of universities. Provision of highly qualified human capital has made possible qualitative changes in the production function and the social organization. The transformation of quantity into quality in terms of manpower, ideas, processes, and products has been possible only as the result of the sustained functioning and continuous advancement of universities over a long period of time as sites of production of knowledge professionals and R&D personnel.

Universities exist as particular institutions that function at the intersection of state, market, industry, and society. Their role of human resource development and training manpower continues to be adjusted as reflected in the regular revision of curriculum, research agenda, pedagogical priorities, reorganization of disciplines, and increased interdisciplinary, and multidisciplinary endeavors. Universities focus on ensuring the sufficient supply of trained manpower in core disciplines and technologies with direct

impact on growth and development. Diversification of teaching, research, and disciplines reflects the advanced stage of evolution of universities on the one hand, and the increased complexity of societal evolution, on the other. Producing diverse mass technical competencies to perform increasingly complex functions of national and regional growth and development drives universities during different stages of economic and social development in line with the demands and needs of each particular stage of development.

Unchecked production of trained manpower without any attempt to create reliable mechanisms for addressing market failure and development bottlenecks will result in risks of tertiary unemployment, devaluation of university education, diminishing returns of university qualifications, and eventually brain drain from one area to another, and from one country to another.

While capital in any free market economy, whether developed or developing, would be allocated through market mechanisms and the operation of market forces, it is imperative from the standpoint of a developing country S&T development that highly qualified R&D manpower and technical personnel are consciously formed and allocated through enabling state intervention strategies that help universities produce a sufficient number of highly qualified professionals required for staffing cutting-edge disciplines and industries of the future. 10 to 15 advanced disciplinary fields should be identified and selected as part of the strategic national plan for higher education development between 2022 and 2040, such new materials, new ICTs like the internet of things, big data analytics, quantum computing, Artificial Intelligence, new manufacturing like additive manufacturing, complex demographics and new forms of urban design, new forms of energy, new types of automation and robotics, advanced agricultural applications, space science and technology, new social sciences, and converging sciences. It is encouraging to note that this disciplinary development is part of the focus of activities of the Prime Minister's Taskforces on Technology-Driven Knowledge Economy, and Science and Technology. The leading universities of the nations should be given the responsibility and resources for acquiring the critical mass of highly trained personnel, R&D capabilities, and dissemination strengths in these strategic fields.

Advanced social sciences should be encouraged on a priority basis because only social sciences would provide breakthrough solutions and answers for resolving social contradictions embedded in Pakistan's social formation. Unless these contradictions are overcome, development cannot take place

consistently. New social sciences will also be required to understand the social impact of the introduction of new fields and technologies, since social change will inevitably occur side by side with technological change.

Leading universities would need to institute advanced science and technology management and innovation management courses in collaboration with leading universities in advanced countries like the U.S., China, Japan, Germany, South Korea, etc. Such education is extremely important because S&T and innovation management professionals tend to be as important as R&D personnel for the process of innovation-led growth and development. Leading universities like NUST can take the initiative of establishing centers of excellence for S&T development management and innovation promotion training and research. Such centers will focus on creating a multidisciplinary national corps of professional equipped with leading concepts, techniques, and applications in fields like management, innovation, cybernetics, design thinking, social science, etc., for managing strategic interactions between S&T, industry, and society.

Modernization of the national higher education sector, including its governance and management, is critical for creating strong inventive and innovative impulses in national S&T, management and social science graduates and students that would induce them to not only transfer existing value from one sector to another, but also to create new socioeconomic value. National socioeconomic modernization should be the root of the national higher education modernization. Unless this larger modernization takes place, the future challenges of population growth, demographic shifts, urbanization, progressive technological change, continuous social change, climate change, and the globalization of talent markets cannot be overcome.

National University of Sciences and Technology (NUST), the University of Science and Technology of China (USTC), and the University of Surrey provide good models of successful university development in three different national contexts, namely, developing country (Pakistan), newly industrialized country (China), and developed country (United Kingdom). USTC, founded in 1958 by the Chinese Academy of Sciences (CAS), is ranked 98th by the 2022 QS World University Rankings. USTC trains premier S&T talents of China, and is home to 12 national research institutes, 4 major national scientific research infrastructures, and 62 major provincial research institutes. The University of Surrey, founded in 1891, is a leading public research university in England. In 2018-19, the University of Surrey generated a total of 1.8 billion pounds in gross value added and almost 20,000 jobs

across the United Kingdom. NUST is the top university of Pakistan with 7 campuses in 5 cities. NUST graduates have a 93 percent employability rate one year after graduation. NUST was ranked 1st in Pakistan by the Times Higher Education SDG Impact Rankings in 2021. NUST houses more than 300 laboratories and centers with 4 major national research centers. It houses Pakistan's first university-based science and technology park, namely, the National Science and Technology Park (NSTP).

The establishment of the Pak-Austrian University of Applied Sciences and Technology in Haripur, Khyber Pakhtunkhwa, Pakistan, is a recent initiative that will prove to be of far-reaching significance for the development of knowledge economy in country. The university is already working in collaboration with eight foreign universities, of which five are from China and three are from Austria. The university entails three clear innovation-led streams of functions and operations. The first stream focuses on imparting advanced technical and engineering education at graduate level. The second stream is dedicated to promoting post-graduate research by means of the establishment of the centers of excellence in a range of advanced S&T fields like advanced agriculture, biomedical engineering, advanced railway engineering, and others. Human capital development also involves training of faculty, researchers, and students at foreign partner universities, leading to the eventual grant of dual degrees, duly accredited by accreditation authorities in Austria and China. The third stream consists of the university-affiliated technology park which involves the ongoing development of a range of S&T-based products for commercialization. The technology park will promote new technology-based firm creation. The university is in the process of founding a business development services to provide innovation and entrepreneurship support services to technology park tenants. The success of the university will be appraised on the basis of the quality of the graduates, the number of research publications, and the creation of intellectual property and commercialization of R&D products. Plans are afoot to develop two other similar universities, one in Islamabad and the other in Sialkot.

5. Integration of Universities into the Regional Economic Structure

Integration into the regional economic structure allows universities to act as nodal points in regional economic development. The dominant contemporary form of this integration is the famous triple-helix model of collaboration between the university, industry, and the government. This presupposes a continuous feedback loop between the local firms and research

and development taking place at the universities. In order to be successful, this collaboration must be sensitive to the major growth imperatives of each stakeholder. Any one-sided interaction in which one party tries to pursue its own objectives to the exclusion of the goals of other parties will not be sustained over time. Technology transfer from the university to industry forms just one part of this feedback cycle.

In order to be comprehensive, the university-industry interaction will have to explore new or hybrid avenues of cooperation beyond technology transfer and the employment of university graduates. Similarly, integration of universities cannot be sustainable unless the universities, industry, and government work together around creating a conducive policy environment for innovation and entrepreneurship. A higher education institution will not become an entrepreneurial university merely because it has good record of collaboration with industry and government. The larger context of national or regional economic development will need to be present and provide robust performance objectives to the universities for them to become entrepreneurial.

A region beset with stagnant growth and unaddressed development disparities will not produce a leading or world-class university. Absence of adjustment and adaptation to changes in regional and local industrial and firm profile will also cause universities to fall behind the trend of regional development, leading to diminished efficacy or academic ossification. In this regard, it is imperative that universities keep abreast of and stay relevant to changes in regional comparative advantages and regional factor structure. Universities in developing countries will have to decide in consultation with other major stakeholders in national and regional development, whether any given university will only complement the regional factor structure and comparative advantages, or instead focus on their transformation.

6. Universities as Nodal Points in Science-Based Regional Development

One of the major physical settings and institutional tools for changing the comparative advantages and factor structure of regions is the phenomenon of new industrial clusters as part of science-based regional development. This has been a rising global trend over the last 50-odd years. It has placed universities squarely at the center in their role as a powerful driver of science-based regional development. New industrial clusters include science and technology parks, research parks, business incubators, innovation districts, technology development zones, innovation cities, different types of special economic zones, and areas of innovation. Whether hosting science parks on

their own premises, or providing cases of successful academic entrepreneurship for tenancy in other science parks, universities promote the development of different types of new industrial clusters in order to maintain a competitive technological edge, financial sustainability, and industrial impact. To achieve this goal, universities channel their traditional strengths in concentrating human resources, technological resources, communication resources, and financial resources toward new industrial cluster development. The commitment of universities to develop them can be attributed to the role of these new type of clusters as sites of innovation, new technology-based firm creation, and gateways to global hubs of knowledge, technology, and talent. These new industrial clusters tend to have both a local and a global orientation.

It has to be recognized that in most developing countries, science-based regional development, predicated on knowledge-based use of land, is not at a premium. Prime land in any typical developing city would be devoted to non-innovation and non-entrepreneurial, mainly residential and commercial, development. From the standpoint of Pakistan, considerable improvement has been made in moving toward the development of new industrial clusters, but still overall the process remains in its infancy. Knowledge-based land use and development should be given priority over other uses, and science-based land use should be given priority among different forms of knowledge-based uses. In this regard, policy instruments should be used for encouraging the development of university-based and non-university-based science parks. It means enabling the universities to allocate and devote their prime land portions to the development of science parks. The approvals and procedures related to such development should not be time-consuming, and should be preferably entertained at a one-stop window dedicated to national science-based regional economic development. Universities should receive budgetary concessions, tax rebates, educational subsidies, financial grants, concessional loans, and funding support for science park development in return for submitting themselves to clear, precise, and verifiable performance indicators to ensure that they are in fact using the proposed discretionary land use privileges to develop science parks rather than utilizing funds to support other forms of infrastructure development and university development initiatives. There is also a need to encourage private developers to participate in new industrial cluster development on competitive terms.

The government may consider devising a uniform system for public and private development of new industrial clusters. For instance, in the case of

science parks, a two-tier system may be developed consisting of a government grants facility reserved for public and private universities and research centers that want to develop science parks, and a soft loans facility reserved mainly for non-university private science park developers. The soft loans facility may also be availed by universities as a supplementary funding option. Developing country governments should negotiate for concessional infrastructure development loans from international financial institutions like the World Bank, Asian Development Bank (ADB), Asian Infrastructure Investment Bank (AIIB), Silk Road Fund and other relevant organizations and programs for new industrial cluster development, especially, science park developments. Universities should be dedicated beneficiaries of these international soft loans. Government should also leverage its bilateral science and technology protocols with various countries for the purpose.

Big domestic and global business, industrial, and financial corporations should be incentivized to invest in leading national industrial clusters under development. These incentives can include tax holidays, first-mover concessions, and other forms of preferential treatment to stimulate science park formation movement and S&T market development in Pakistan. Getting big domestic and international players interested in Pakistan's nascent but potentially big S&T innovation market should be treated as a priority of government's business promotion and investment attraction efforts and policies. To convey that government is serious in promoting science park development, matching investment should be offered for international expressions of interest in Pakistan's science parks. Becoming leading players in global academic tourism and providing world-class venues for meetings, conventions, and expos can help universities attract global attention, cooperation, and investment. New industrial cluster development should be aligned with the goals of environmental sustainability and climate change mitigation commitments and aspirations of international organizations, donor governments and agencies, and global corporations. The possibility of an indirect tax or levy can be explored to harvest funds for science park development both at the initial stage of land development and the later stages of new technology-based firm creation. The establishment of a national science park development fund may also be considered to be run jointly by the Prime Minister's Taskforce on Technology-Driven Knowledge Economy, Prime Minister's Taskforce on Science and Technology, the Higher Education Commission (HEC) and the Ministry of Science and Technology.

Universities also play an important role in sustainable and ecological infrastructure development. In terms of infrastructure development alone, they provide direct opportunities for business generation for an array of companies involved in design and construction, technical instalment, maintenance service, etc. These opportunities have increasingly been indexed to environmental standards and green infrastructure development.

As mentioned above, universities take a leading part in the development of new technology-based firms and new social business firms. They act as both regional innovation organizers (RIO), "providing convening capabilities" and regional innovation initiators (RII) commanding "sufficient prestige and authority to aggregate resources and initiate an enterprise," as explained by Henry Etzkowitz in his book, *Triple Helix* (2008).

While local governments have played an active part in facilitating science-based regional development in China, Europe, Japan, and South Korea, in Pakistan local governments and authorities have been virtually inert in this regard. As a result, universities in Pakistan have failed to get the right kind of support from their city governments and local authorities that they would have required for science-based regional development. In this regard, there is an urgent need for local governments at district level in Pakistan to work closely with the universities. In this regard, district education offices should be revamped completely to align with the function of S&T modernization and innovation promotion. This coordination can be set up in the form of advisory services given to local governments jointly by universities and industry to shift the concern of local governments from proto-industrial concerns to innovation promotion. This coordination can focus on giving full play to the potential innovation capacity of universities in Pakistan's key cities, especially those located in renowned urban industrial centers. City governments of these industrial districts should encourage active exchanges between industrial and business clusters and universities within their jurisdiction.

In this regard, universities may consider the development of regional institutes for technical and vocational education as part of their industrial extension services to ensure a steady supply of skilled technicians for the local industry in urban industrial clusters. Universities may also consider hosting institutes for metrology and testing facilities for the local industry to help the enterprises with issues of standardization. As part of their extension services, Pakistani universities can also offer training courses aimed at technical,

industrial and management workforce, especially with a view to national SME development.

Considering that Pakistan is a typical developing country with typical developing country problems and challenges, universities of the country and science parks affiliated with them would have to retain a strong focus on social innovation and social entrepreneurship for creating pro-poor market mechanisms and service delivery for addressing various types of asymmetries in our society. The challenge of university-affiliated science parks in Pakistan for some time to come will be how best to integrate the objectives and effects of new technology-based firms and new social business firms into a unified open innovation platform.

Technology development and commercialization should be organized to yield poverty alleviation outcomes precisely as has happened in the course of poverty alleviation in China. University-affiliated science parks should, therefore, focus on locally designed affordable agricultural technologies, alternative and more sustainable forms of energy, smart agricultural extension service platforms, e-health, affordable decent housing, urban and rural transportation, educational technologies, etc. Government should offer major incentives to universities engaged in R&D for poverty alleviation.

It would be instructive for universities already running science parks, or planning to host science parks to study the development history of Surrey Research Park affiliated with the University of Surrey, the United Kingdom. The park, established in 1985, is now a global success case of science park planning, development, and management. Similarly, the National Science and Technology Park (NSTP) hosted by NUST should be a good case study of a science park successfully developed by a leading university in a developing country context.

7. Universities as Knowledge Economy Microcosms

Universities tend to be perhaps the only contemporary institutional form that serves as the perfect microcosm of knowledge economy capable of simultaneously promoting the development of its four key pillars, namely, favorable economic and institutional regime, high-quality human resource development, national system of innovation, and advanced information and communications technologies. Universities, thus, may be seen as the contemporary leading organizations of knowledge economy.

However, this central technical role exists in inverse proportion to their political influence in the developing world. While in advanced economies,

newly industrialized countries, and even major emerging economies, senior university managers, top professors, star researchers and ace experts increasingly go on to perform leadership and senior management roles in government in addition to professional politicians and corporate executives, in most developing countries, university leaders continue to occupy peripheral positions in terms of national leadership.

Developing country universities need to find ways to create greater correspondence between their actual role in growth and development and their representation in political, economic, and social governance and leadership.

In addition, the tradition of inter-university collaboration in Pakistan is somewhat weak. Universities exist in a competitive resource-constrained world and try to maximize outcomes by focusing by and large on their own development to the exclusion of devising collective and collaborative strategies for the above-mentioned modernization of the national higher education. Greater inter-university collaboration structured around S&T development and innovation promotion can enable individual universities to overcome their resource constraints.

In a developing country context, pooling of resources is a viable strategy for overcoming various types of shortfalls for key S&T interventions and projects. This form of collaboration will allow universities to not only develop and sustain big S&T infrastructures, undertake largescale projects, but also enable them to improve the institutional environment in which universities interact with government and industry. Increased university-to-university collaboration would ease pressure on performance and improve their survival outcomes.

Exchange of trained human resource according to different short- to medium-term arrangements will address manpower and quality shortfalls in the overall national higher education system. Similarly, joint use of critical S&T and R&D infrastructure and equipment will save operational costs for their maintenance.

University-to-university collaboration will accordingly provide a good example for deepening and broadening linkages in the national innovation system. Knowledge economy will develop faster if universities cooperate with each other at the same intensity at which they compete with each other. A policy mix approach should be utilized for increasing investments in knowledge economy.

8. Universities as Drivers of Win-Win International S&T Collaborations

Globalization has entailed the internationalization of scientific research and practice in the last half century. Leading research in various natural science and social science disciplines takes place in the form of international or multi-country research groups. The physical location of leading global hubs of knowledge creation organized around top universities in a handful of advanced countries and newly industrialized nations has not only led to S&T agglomeration in these countries, but has also promoted S&T development in other parts of the world. Increased scientific and student mobility in the last 50 years is one of the most significant outcomes of this agglomeration and diffusion. International science-based associations and organizations have also encouraged the trend of internationalization of research as part of the broader agenda of the internationalization of higher education.

The peaceful development of China since the beginning of the reform and opening up in the early 1980s has given an extraordinary impetus to global higher education and international research cooperation, just as it has led to the advancement of the scale and multiplication of the types of new industrial clusters. Universities are playing an important part in knowledge diplomacy and science diplomacy. This role emphasizes peaceful relations among nations.

However, the fact cannot be denied that at the same time that S&T collaboration is increasingly globalized, the contribution of S&T at a national level helps increase the overall national power and influence of countries and improves their standing in global interstate relations. However, increased national power may either reinforce or undermine peace depending upon the overall strategic orientation of specific countries.

9. Universities as Social Capital Trusts

Social capital can be defined as shared activities, practices, resources, and values that help develop mutual trust and encourage reciprocity among people engaged in a collective pursuit of common goals for mutual interest, organizational development, and societal benefit.

Universities serve as massive social capital trusts, as higher education, by its very nature, tends to be a sociocultural enterprise, presupposing technical and social division of labor. Knowledge production is inextricably linked with networking, which in turn acts as potent enabler of social capital. Universities provide conditions in which there is a combination of individual initiative of scientific research and discovery and the group incentive of the

advancement of the frontiers of knowledge. This occasions the faster accumulation of social capital, and in situations in which more social capital is present, financial and human capital will be maximized with more enhanced outcomes than in those in which there is minimal trust in the common enterprise. In the context of creating new industrial clusters, especially university-hosted science parks, Pakistani universities can come together to create an All-Pakistan association of universities already running science parks or desirous of developing on-campus science parks for learning by doing and learning by sharing.

On the other hand, the government, in view of the critical importance of science-based regional development to national high-quality growth, can consider creating a national science park development committee and staff it with competent and well-trained professionals drawn from different government bodies, private businesses, and universities. One aspect of universities functioning as units of social capital accumulation is to increase the societal and community relevance of science, technology, and innovation so that the physical and social contexts within which universities function can improve as a result of research and entrepreneurial activities. This, among other things, calls for sustained engagement channels for involving people and communities in science, teaching, and research as a special form of social enterprise.

10. Universities and Foresight

Scientific research is in part also a predictive, anticipatory, and forecasting enterprise aimed at enabling people, society, and government to understand not only current problems but also those of the future. It also means imagining ways in which we would prefer social change to unfold and then carefully taking appropriate actions and steps in the present to move toward the preferred future. There is a strong orientation toward future in the very act of new technology creation as such endeavors tend of necessity to be driven toward future.

Universities are well-positioned to promote technology foresight and futures studies as an organized discipline of collaborative inquiry. Universities around the world are increasingly engaging in foresight exercises. This is an area where triple-helix collaboration between universities, industry, government, and even civil society can deliver positive social impact. In Pakistan, universities have generally lagged behind in realizing the importance of organizing foresight exercises as a way of delivering technological, economic, and social value. Inter-university collaboration for

organizing technology foresight exercises can engage different stakeholders meaningfully and help deliver a common vision of national high-tech growth. As a well-developed field of study and practice, the introduction of foresight and the institutionalization of futures studies as a recognized field of research and practice will introduce an elaborate body of methodologies, tools, and techniques for scientific analysis, scholarly exchange, and socioeconomic transformation.

11. Recommendations

Following recommendations emerged from the deliberations of the webinar:

i. The government should declare a 10-year long educational emergency to revamp and renew primary, secondary, technical and vocational, and higher education systems on war footing. The proposal is under consideration by the government and decision may be taken in due time. The educational emergency should involve massive channeling of funding and resources, among other things, to address the gaps and ensure a rationalized national education system geared to the needs of growth and development.

ii. The government should focus on the development of at least 3 to 5 world-class universities figuring in the top 100 universities of the world till 2030. This goal should drive the national higher education agenda. In this regard, at least 10 top national universities should be selected. These universities should be provided with sufficient resources to help them achieve the proposed target within the proposed time frame. This funding should be indexed to clear performance indicators. The government should create a triple-helix taskforce to prepare a roadmap for this proposed 5-in-100 vision. The taskforce should study the more traditional world-class universities of the advanced world as well as the growth and development trajectories of the top universities of China, South Korea, Japan, Singapore, and Malaysia for learning lessons that could prove useful in engineering the rise of domestic universities.

iii. The totality of goals and objectives of universities should be both self-determined as well as laid down by the government in a manner that universities can respond to different demands of each stage of national growth and domestic development. This should involve a categorization of general and specific objectives as well as constant and variable goals. During each stage, universities should be ready to function as institutions capable of addressing S&T and innovation-related market failure and development bottlenecks through specially tailored interventions.

iv. Universities should collectively consider the possibility of tertiary unemployment, oversupply of graduates in a certain field, devaluation of university degrees, diminishing returns of university qualifications, and brain drain, and recommend proposals and strategies for addressing these risks without waiting for the market to correct these distortions on its own.

v. Universities should be incentivized to produce a critical mass of highly qualified professionals in disciplines of the future. In this regard, at least ten to fifteen advanced disciplines should be identified and selected as part of the strategic national plan for higher education and university development between 2022 and 2040. These fields should be advanced natural sciences, engineering, and new social sciences. The focus should be on new materials, big data analytics, quantum computing, Artificial intelligence, new manufacturing, complex demographics, new urban design, new forms of energy systems, new types of automation and robotics, new nuclear energy, advanced agricultural technologies, new multimodal transportation and connectivity, space science and technology, biotechnology, and converging sciences.

vi. Pakistani universities, individually or through a consortium of universities, should offer degree-level courses in science, technology and innovation (STI) management in collaboration with leading universities of the advanced countries and newly industrialized countries. In this regard, leading universities should establish centers of excellence for STI development management focusing on an interdisciplinary education and training consisting of management studies, cybernetics, design thinking, futures studies, and STI policy studies.

vii. Universities should seek to integrate dynamically and sustainably with the regional economic structure. Government should provide policy guidelines and support in this regard. Triple helix collaboration between universities, industry, and government should take the lead in this regard.

viii. The potential of universities to act as nodal points in science-based regional development should be developed and maximized. In this regard, universities should participate actively in the development of new industrial clusters in their regions. Among different types of these clusters, universities should focus specifically on the development of science and technology parks. Investments in knowledge-based and science-based land use and development should be incentivized both at the government and the university level. The approvals and procedures required for this form of development should be rationalized and simplified, to be preferably dealt

with via a hassle-free time-saving one-stop shop. Budgetary concessions, tax rebates, educational subsidies, financial grants, soft loans, etc., should be made available for universities to participate in new industrial cluster development. International financial organizations like the Asian Infrastructure Investment Bank (AIIB), Silk Road Fund, World Bank, and the Asian Development Bank should be approached in this regard.

ix. Big domestic and global business, industrial, and financial corporations should be incentivized to invest in leading national industrial clusters under development. These incentives can include tax holidays, first-mover concessions, and other forms of preferential treatment to stimulate science park formation movement and S&T market development in Pakistan.

x. The government should consider the establishment of a national science park development fund to be managed jointly by the Prime Minister's Taskforce on Technology-Driven Knowledge Economy, Prime Minister's Taskforce on Science and Technology, the Higher Education Commission and the Ministry of Science and Technology.

xi. University-Industry collaboration should be based on achieving pro-poor market outcomes and poverty alleviation results in the context of Pakistan. Universities and their science parks should, therefore, among on other things, focus on locally designed affordable agricultural technologies, alternative and more sustainable forms of energy, smart agricultural extension service platforms, e-health, affordable decent housing, urban and rural transportation, and educational technologies. Universities should also focus on providing smart agricultural extension and industrial training services. Considering the state of stunted industrial development in the country, universities should play a viable part in providing technical and vocational training services and metrological and testing services to industry. University-based new technology-based firm creation and new social business firm creation should be synergized for pro-poor goals.

xii. Universities should cooperate as much as they compete with each other. The sub-optimal state of inter-university collaboration in Pakistan should be addressed through sharing knowledge resources, joint use of laboratories, sharing maintenance of large national research infrastructures, scientific mobility, joint research, and joint policy advocacy. Inter-university cooperation should be channeled to enable universities and their leadership to play a leading and directive role in national STI and multi-sectoral policymaking.

xiii. Pakistani universities should participate actively in win-win international S&T collaborations. Such collaborations should, at the same time, deliver public good and demonstrate local social impact. The elitist tendencies inherent in scientific research should be addressed through focusing research on societal goals. Diversity and inclusiveness should not only be research topics but also research values. Universities should play an active part in conducting and promoting knowledge diplomacy and science diplomacy.

xiv. Universities should seek to maximize social capital to encourage mutual trust within universities, among universities, and between universities, society, and industry. Sustained engagement channels should be developed to communicate the relevance and benefits of science, teaching, and research for people, communities, and society. Science popularization campaigns should be a part of strategic communication and outreach plans of universities.

xv. Pakistani universities should revise and adapt their teaching, research, and curricula to the UN Sustainable Development Goals (SDGs). Greater multi-disciplinary initiatives should be encouraged on the basis of SDGs. The comprehensive research agenda of Pakistani universities should reflect the synergy of various development visions like the domestic development vision, Belt and Road development vision, CPEC development objectives, SDGs, 14th Five-Year Development Plan of China, and other relevant regional development visions.

xvi. Pakistani universities should encourage and organize regular technology foresight exercises and establish departments of futures studies offering courses, degrees, and certifications in the field. As part of inter-university collaboration, rounds of technology foresight exercises on an annual basis should be held with several sessions hosted by various universities. Universities can also pool resources to hold futures studies conference on an annual basis focusing on key domestic, regional, and global development challenges.

About the Speakers

Honorable Syed Shibli Faraz

Senator Syed Shibli Faraz is the Federal Minister for Science & Technology, Pakistan. He is one of the most seasoned members of Pakistan Tehreek-e-Insaf (Pakistan Movement for Justice), the currently ruling political party of Pakistan. Before S&T, he was the Federal Minister for Information and Broadcasting. A senior statesman, he has been the member of Senate of Pakistan from Khyber Pakhtunkhwa since 2015. He was previously the Leader of the House for the Senate from 2018 till 2020. He is an investment banking expert and has been a commercial pilot as well. Senator Shibli Faraz is the son of Ahmad Faraz, one of the most acclaimed poets of Pakistan.

Professor Atta-ur-Rahman FRS, N.I., H.I., S.I., T.I.

Professor Atta-ur-Rahman obtained his Ph.D. in organic chemistry from Cambridge University (1968). He has 1232 publications in several fields of organic chemistry including 771 research publications, 45 international patents, 70 chapters in books and, 341 books published largely by major U.S. and European presses.

He is the Editor-in-Chief of eight European Chemistry journals. He is Editor of the world's leading encyclopaedic series of volumes on natural products "Studies in Natural Product Chemistry" 64 volumes of which have been published under his Editorship during the last two decades.

Professor Atta-ur-Rahman is the first scientist from the Muslim world to have won the prestigious UNESCO Science Prize (1999) in the 35-year old history of the Prize. He was elected Honorary Life Fellow of Kings College, Cambridge University, U.K. in 2007. TWAS (Italy) Prize for Institution Building was conferred on him in October 2009 in recognition of his

contributions for bringing about revolutionary changes in the higher education sector in Pakistan.

The Austrian government has honoured him with its highest civil award ("Grosse Goldene Ehrenzeischen am Bande") (2007) in recognition of his eminent contributions. He is President of Network of Academies of Sciences of Islamic Countries (NASIC). Professor Atta-ur-Rahman is the recipient of the International Scientific Corporation Award by Chinese Academy of Science (CAS) for building scientific collaborations between China and Pakistan (2014).

In 2020, President Xi Jinping conferred on him the prestigious International Science and Technology Cooperation Award of the People's Republic of China. Professor Atta-ur-Rahman is currently the Chairman of the Prime Minister's Task Force on Science and Technology, and the Vice Chairman of the Prime Minister's Task Force on Technology-Driven Knowledge Economy.

Professor David Sampson

Professor David Sampson is the Pro-Vice-Chancellor, Research and Innovation at the University of Surrey, U.K. He is a member of Council, director of the University of Surrey Seed Fund and of SETsquared Limited, serves on the board of the Surrey Research Park, the editorial board of The Conversation (U.K.), and on the boards of SETsquared Partnership, and SPRINT.

Previously, David was with the University of Western Australia (UWA), Perth, Australia. David is heavily involved in the global optics & photonics community, serving as an elected Director of the SPIE – The International Society for Optics and Photonics (2017-2019).

He is a fellow of the optics societies, SPIE and OSA, and the electrical engineering society, IEEE. He serves on various society committees and editorial boards, including currently as adviser to the Board of Directors of SPIE.

Dr Malcolm Parry

Dr Malcolm Parry is the Visiting Member of Staff at University of Surrey, U.K. He is a chartered biologist and a long standing member of the Biology Society. He received his PhD in Life Sciences from the University of London in 1977. In 2006, he was awarded an OBE by HM Queen Elizabeth II for his services to business and education.

Dr Parry was the Founding Chief Executive of the Surrey Research Park. Prior to the establishment of Research Park in the early 1980s, he was a member of Faculty at the University where he ran a commercially funded research team. He has sat on the IASP Board and its Advisory Council, and also now works with UNESCO and the UN Economic Commission to Europe as an expert in relation commercialization and innovation strategies. He has worked in many countries advising both governments and other organization on the planning, development and operation of science and technology parks. Dr Parry is one of the founders of the UK Association of Science Parks (UKSPA). He has edited and contributed to two UKSPA books on this subject. He has also written and spoken extensively on the topic of Science and Technology Parks.

Air Vice Marshal Dr Rizwan Riaz SI (M)

Air Vice Marshal Dr Rizwan Riaz is the Pro-Rector for Research, Innovation & Commercialization at the National University of Sciences & Technology (NUST). He brings with him extensive experience of academics, research and technology management.

Dr Rizwan Riaz has over a decade of experience in R&D, project management, organizational R&D policy, and academia-industry linkage development. An avid proponent of applied research, Dr Rizwan has been part of national projects which have won him laurels and saved the nation millions in foreign exchange. He recently led the

establishment of the NUST Interdisciplinary Cluster for Higher Education (NICHE), a cutting-edge first-of-its-kind interdisciplinary research initiative in Pakistan. In recognition of his meritorious services, he has been awarded Sitara-i-Imtiaz (Military).

Dr Ashfaque Hasan Khan

Dr Khan is the Director General of NUST Institute of Policy Studies (NIPS). He is serving as the Principal and Dean of School of Social Sciences and Humanities, NUST. He has served as the Special Secretary Finance/Director General, Debt Office and Economic Adviser, Ministry of Finance, Islamabad, Spokesperson of the Government of Pakistan on Economic Issues, Director and Vice Chairman of the Saudi-Pak Industrial and Agricultural Investment Company Ltd. and Director of the United Bank Limited and Pak-Libya Holding Company. Dr Khan is one of the leading economic experts of Pakistan. He holds PhD in economics from the Johns Hopkins University, U.S.A. In recognition of his outstanding contribution to the field of economics and public policy the President of the Islamic Republic of Pakistan conferred the award of Sitara-i-Imtiaz to Dr Khan in 2005 and the Economic Cooperation Organization (ECO) also conferred him the ECO Excellence Award 2010. Dr Khan was also a member of the Prime Minister Imran Khan's Economic Advisory Council.

Gallery


Recording


中国科学技术大学

Appendix I

Remarks of the Honorable Federal Minister for Science & Technology

Webinar on

The Role of S&T Universities in Promoting National High-Tech Growth

NUST Institute of Policy Studies (NIPS)

Tuesday, July 6, 2021

Respected Speakers and Participants,

Ladies and Gentlemen,

Assalaam o Alaikum:

1. In the first place, I want to thank Rector NUST for inviting me to speak this afternoon on a topic of great importance, "The Role of S&T Universities in Promoting National High-Tech Growth".
2. Ever since the dawn of the modern industrial age in the late eighteenth century, there has been a direct and positive relationship between technological development and the wealth of nations. What clearly distinguishes the earlier stages of industrialization from the ongoing fourth industrial revolution is that, in the present stage, higher education institutions, especially S&T universities, have become the major sites of scientific and technological breakthroughs and innovations.
3. Leading universities around the world are now driving the global STI agenda. They help generate new socioeconomic value by acting as sites of knowledge production and transfer. They promote high-quality domestic and global scholarly exchange, brain circulation, and dynamic scientific mobility.
4. They help incubate not only new technologies and businesses by means of science and technology, research parks, and other vehicles of innovation, but also become the places for policy and governance innovation that helps raise the quality, scope, and coverage of the social contract. Seen in this light, leading universities have an important role to play in maintaining social stability.

5. Indeed, contemporary leading universities are also main actors in science diplomacy and knowledge diplomacy. They are helping shift the focus of the world slowly but gradually from geopolitical competition to knowledge-based cooperation. In today's world, there is an urgent need to promote peace-enhancing diplomacy rather diplomacy driven by war and conflict.

Ladies and Gentlemen,

6. The government is keenly aware that long-term high-quality national development depends on the successful development of the national systems of innovation and a mature knowledge economy based on a favorable economic and institutional regime, high-quality human resource development, multi-type innovation driven by science and technology, and promotion and utilization of advanced information and communications technologies.

7. The government is also cognizant that world-class universities provide perhaps the most comprehensive institutional form which can promote all these major pillars of knowledge economy at the same time.

8. While, Pakistan possesses more or less all the elements involved in S&T-based development and modernization, it has not been possible for the country historically to promote sustainable and durable collaborative linkages and flows among these elements. The development of world-class universities as the functional core of our S&T-based modernization should hopefully provide the motivation for the development of such linkages after all.

9. The government is fully devoted to the promotion of high-tech growth. The presence of the eminent national and international speakers in today's webinar will surely help us in understanding the right way forward. The attendance of international experts in the domain of S&T will also be a rich experience.

10. In the end, I hope that this webinar will lead to fruitful deliberations and look forward to the recommendations.

    Ladies and Gentlemen, I thank you all.

Appendix II

Welcome Remarks of Director General NIPS

Webinar on

The Role of S&T Universities in Promoting National High-Tech Growth

NUST Institute of Policy Studies (NIPS)

Tuesday, July 6, 2021

Respected Speakers, Experts, & Participants,

Ladies and gentlemen,

Assalam o Alaikum:

1. I welcome all our distinguished participants at todays' webinar arranged by NUST Institute of Policy Studies on a significant subject of national development. My special gratitude to the esteemed speakers and participants for sparing time for us from their extremely busy schedules. Their contributions for the progress of tech-based landscape of their countries are indeed admirable and we look forward today to learning from their wisdom.
2. Science, technology and innovation, as we all know, are transforming the world and ways of life. Being the basic constituents of a state's path to inclusive growth and modernization, tech-driven undertakings have gained a substantial momentum around the globe.
3. Cutting edge innovations in frontier technology are paving the way for nations to grow and modernize sustainably besides providing better living standards to their people.
4. In order to benefit from the unprecedented surge of ideas and cross-sectoral interdependence in a high-tech global environment, countries require massive restructuring of mechanisms and reskilling of higher value work roles. Around 85% of employments have changed in the Asia Pacific only due to new trends introduced by digital economy and artificial intelligence.
5. In this regard, the role of science and technology in competitiveness and growth is most suitably described by the concept of knowledge economy

which aims at the creation of national systems of innovation through favorable economic and institutional regime, human resource development, innovation, and advanced ICTs.

6. This model allows diverse spaces of innovation driven by a variety of actors, including universities and science parks.
7. Together with other areas of innovation, universities have a special role to play in promoting the national objective of high-tech growth, within the broader context of socioeconomic development.
8. In addition to creating knowledge and adding skilled labor, they can be the fulcrum of in-house R&D arranging responses to the changing requirements of markets.
9. The intertwined triple helix of university-industry-government relations has an important role in the creation of a knowledge-based networked economy.
10. These actors can jointly work on high-tech manufacturing and information technology service industry. The task is challenging but can inspire an era of development. Through the intellectual nexus present within their domains, universities can build trust, based on free and objective enquiries and scientific facts, and promote open ideas and solutions. Placing value on their diversity, universities can work for the common good.
11. The value of such interfaces is the ability to swiftly adopt knowledge and share information. These trends spurred the development of high-tech regions such as the involvement of Stanford University in the growth of Silicon Valley and the influence of the MIT on the growth of high-tech industry along Boston's Route 128.
12. Furthermore, the entrepreneurial role of universities as 'regional innovation organizers' and their pro-active engagements address needs of labor markets, and orient research activities towards local industries by means of dedicated research centers and mechanisms to transfer knowledge and technology. Working as special areas of innovation, they can redirect their science and technology education and research programs for national development.
13. As Pakistan springs up the growth spectrum, a stable knowledge- and tech-based economic evolution will offer promising avenues for

advancement of competitive strengths to complement the country's distinct geographical advantages and vast human resource.

14. Each actor in the knowledge economy has to factor in the calculus. The future strategic plan must encompass massive-scale investment in new technologies. The patterns of high-tech economies are worth following, which owe most of their development to institutional and industrial restructuring.

15. According to the latest information available with UNESCO on gross domestic expenditure on R&D by countries in 2017, the United States and China spent approx. 543 billion and 500 billion dollars, respectively, while India and Turkey spent around 50 billion and 20.5 billion dollars, respectively. In Pakistan's case, it was only 2.5 billion dollars. The relevant stakeholders thus have to synergize and perform to catch up fast.

Ladies and Gentlemen,

16. I take this opportunity to share that as the leading S&T university of Pakistan, NUST has been making a conscious effort to be at the forefront of S&T-based national development and modernization through its well-placed knowledge ecosystem. With a 93% employment rate of our graduates, NUST hosts national centers of excellence on significant subjects of high-tech growth, including artificial intelligence, robotics, and automation. Our N-ovative Healthcare Technologies is the first facility in Pakistan for indigenous production of cardiac stunts. Pioneering university-based incubation, the entrepreneur ecosystem at NUST has engaged 1300 plus knowledge workers, and contributed around 8 million dollars to the national economy. Moreover, the National Science and Technology Park at NUST has 60 hi-tech companies on board and 10 international tenants from 7 countries. Having been awarded the high-tech special economic zone (SEZ) status in 2020, our journey towards excellence continues, Insha'Allah.

17. At the end, I would like once again to extend my thanks to the Honorable Minister and worthy experts. We look forward to their seasoned insights on the subject.

Thank you.

Appendix III

Recommendations of the NIPS National Seminar on Knowledge Economy: The Path to Speedy and High-Quality Growth[1]

1.1. Favorable Economic and Institutional Regime

1.1.1. Create ease of doing business and improve incentives for economic agents playing a leading role in knowledge-based economic activity like innovators, entrepreneurs, researchers, etc.

1.1.2. Promote supportive government action to prevent market failure, especially in terms of cushioning technology-based startups and firms from economic shocks and market crashes.

1.1.3. Establish a clear legal system of intellectual property rights based that takes cognizance of the global regime of trade-related intellectual property rights.

1.1.4. Discourage rent-seeking behavior, increase institutional transparency, and promote greater trust between government and innovation agents and actors.

1.1.5. Enhance the competitiveness of the economy and focus on increasing the investment rate of 20%-25% and saving rate to at least 10%-15%.

1.1.6. Promote concerted science-based regional urban development based on the comprehensive development of new industrial clusters like business and technology incubators and accelerators, research parks, science and technology parks, special economic and technology zones and innovation areas.

1.1.7. Increase the intensity of the innovation function in the economy defined as the relationship between aggregate innovation and gross knowledge endowments denoted by the quantity of R&D spending and the number and quality of R&D personnel.

1.1.8. Promote and protect the new technology-based startups as well as technology-based small and medium enterprises integrated with the domestic production networks of major domestic public and private

[1] The National Seminar on "Knowledge Economy: The Path to Speed and High-Quality Growth" was organized by NIPS on March 3, 2020.

corporations as global supply chains come to be disrupted and economic decoupling hits local enterprises in the wake of coronavirus outbreak.

1.1.9. Promote and increase the levels of domestic scientific mobility and science-based social mobility with prosperous life outcomes for the agents of knowledge economy.

1.1.10. Just as the dominant principle of the agricultural age was extraction and envy and that of the industrial age was competition and conflict, so the dominant principle of the post-industrial knowledge-based age is cooperation and collaboration. In Pakistan however, the envy characteristic of the agricultural age and conflict characteristic of the industrial age thwart the development of collaboration characteristic of the knowledge economy. Triple helix collaboration should be promoted in letter and spirit to outgrow the stage of envy and competition if the transition to knowledge economy is to take place.

1.1.11. In order to promote knowledge economy in, a policy mix approach should be adopted for that is based upon building complementarities upon various policies like the education policy, S&T policy, social policy, labor policy, legal policy, monetary policy, and fiscal policy.

1.1.12. Economic structure of Pakistan needs to be transformed to increase the share of industry and high-end services with high technology quotient each to at least 40% of GDP.

1.1.13. Overall macroeconomic stability characterized by medium to high output growth, low unemployment rate, and reasonably low inflation rate should be achieved since innovation and entrepreneurship are influenced by the overall health of the economy.

1.2. High-Quality Human Resource Development

1.2.1. Move toward the massification in higher education system in the next 10 years with tertiary enrolment approximating at the least the levels of South Korea or Turkey, i.e., 3-4 million.

1.2.2. Increase the public spending on education to at least 5% of GDP by 2025 and 7%-8% by 2030.

1.2.3. Increase the public spending on R&D to at least 1% of GDP by 2025 and at least 2.5-3% by 2030.

1.2.4. Increase by 2030 the number and quality of total R&D personnel per million inhabitants comparable to Turkey, i.e., between 2500 and 3000 R&D personnel per million inhabitants.

1.2.5. Increase by June 2020 both the recurring grant and development budget of HEC to come closer to the projected requirements of HEC.

1.2.6. Help promote the fourth-generation function of universities of sustainable regional (sub-national and supra-national) socioeconomic development as well as the knowledge and science diplomacy potential for peace among nations of the leading universities of Pakistan characterized by internationalization of higher education and global scientific mobility.

1.2.7. Select, support, and fund 3 top universities of Pakistan with the objective of their ranking amongst the top 100 universities of the world within the next 10 years.

1.3. Building Dynamic National System of Innovation

1.3.1. Increase and intensify between government, universities, and industry based on mutual trust and common problem identification.

1.3.2. Intensify the R&D intensity of industrial production together with increased public and private spending on R&D for increased scientific and technological output. Increase the high-technology exports to form at least 15% of manufactured exports by 2030.

1.3.3. Increase the absorptive capacity of the national system of innovation through the rapid development of S&T infrastructure in Pakistan leveraging the China-Pakistan strategic cooperation including the utilization of the key provisions of the Belt and Road Science, Technology, and Innovation Cooperation Action Plan announced by President Xi Jinping during the First Belt and Road Forum (BRF) for International Cooperation in May 2017.

1.3.4. Link the approval of all foreign assistance and FDI projects to mandatory knowledge transfer, so that at least 5% of the cost of such projects is set aside for training and indigenous capability development, leading to national self-reliance.

1.3.5. The elaborate system of S&T execution and facilitation under the umbrella of MoST should be provided adequate resources and funding.

1.3.6. The priority areas of the Task-Force on Technology-Driven Knowledge Economy should be adopted as the public and private national R&D agenda.

1.3.7. Regular foresight exercises be conducted focusing on the objective of enabling the transition to knowledge economy should be conducted by the Ministry of Planning, Development and Special Initiatives. These exercises should be duly indexed to the SDGs.

1.3.8. The key prerequisite for developing knowledge economy in Pakistan is the establishment of an overarching strategic outfit – an authority or a think tank. It will provide an anchor for the ongoing useful but scattered attempts of strengthening the KE landscape in Pakistan. Select experts may steer through production of workable concepts and implementable strategies.

1.4. **Advancement of ICTs**

1.4.1. Software exports should be increased to US$10 billion by 2030.

1.4.2. The construction of the 40-acre software city in Islamabad should be promoted as an integrated national plan for developing new industrial clusters.

1.4.3. Digital Pakistan Vision should be realized on priority basis. The strategic objective of building the national digital economy with 1 million jobs should be achieved in a smart manner concomitantly with improvement and upgradation of the secondary, vocational, and higher education in the country. This job creation should also co-occur with the increase in the number of new technology-based startups and technology-based small and medium enterprises if the economy were not to run the risk of getting stuck in the low middle income band.

Appendix IV

Recommendations of NIPS Webinar on the Role of Science and Technology for National Progress, Growth and Competitiveness[1]

1. S&T should be considered a strategic priority for national development and growth. As a strategic priority, at least 5-7 percent of GDP should be spent on S&T development including education.
2. A whole-of-system approach or the methodology of national system of innovation should be adopted for S&T development. Under this approach developing the individual elements and their mutual linkages should be equally important.
3. A 5-in-1 model of S&T development consisting of five key elements should be adopted, that is, according central position to S&T in national development planning and governance, promoting independent research and development, orienting S&T to directly support economic and social development, creating a strategic national S&T force consisting of the national academy of sciences, public research entities, and universities, and keeping pace with global S&T developments.[2]
4. Comprehensive multi-domain, multi-sectoral, and multi-disciplinary national S&T development should be considered focusing on increasing both the quantity and quality of S&T talent in the country.
5. The number of R&D and S&T personnel per million of population should be increased on urgent basis. The base salaries of young engineers, doctors, scientists, researchers, and technicians should be increased to make S&T an attractive career for the youth.
6. Strategic approach to university development should be prioritized. At least three top Pakistani universities should be selected for inclusion among the top 100 universities of the world by 2030.

[1] The Webinar on "The Role of Science and Technology for National Progress, Growth, and Competitiveness" was organized by NIPS on July 28, 2020.
[2]This model was presented by Prof. Kang Dachen, a senior academician at the Chinese Academy of Sciences (CAS), during his keynote address at the webinar.

7. R&D promotion should become a top priority focusing on the promotion of high-quality basic research, the development of core technologies, and the enhancement of innovation performance, and increase in the quantity and quality of innovations. The national R&D agenda should include priority areas like IT-related technologies, mineral processing and natural resources, emerging technologies, industrial biotechnology, nanotechnology, new energy storage systems, supercomputing and quantum computing, new nuclear energy systems, geothermal energy systems, synthetic biology, Artificial Intelligence (AI), robotics, etc. National R&D agenda should be promoted through prudent public-private partnerships.
8. Existing S&T infrastructure should be upgraded and new one should be developed. This should also include the development of national large research infrastructures.
9. Integrated development of new industrial clusters like technology and business incubators, research parks, science and technology parks, high technology development zones, innovations districts, industrial parks, special economic zones should be prioritized and developed. Science-based development of national regions should be utilized to address various disparities and asymmetries.
10. Social capital creation for S&T development based on trust-based networks of creative reciprocity should be promoted to foster local scientific mobility and inland brain circulation.
11. Policies and initiatives across domains and sectors should be aligned and coordinated to reinforce S&T development.

Appendix V

Quality and Innovation[1]

By

Professor Atta-ur-Rahman

Recently a brainstorming session was held in the Ministry of Science & Technology to consider the draft of the National Science, Technology and Innovation Policy.

The efforts of the Ministry of Science & Technology to introduce a new policy need to be applauded. Innovation is essential not only for industrial growth but for the survival of our nation. Therefore, public policy must focus on creating demand for innovation and indigenous technology capability building. Our efforts are often supply driven, rather than being demand driven, which leads to failure

The three major players in the promotion of innovation and the development of a knowledge economy are universities, industry and enabling government policies. All three players thrive on the extent of merit-based competitiveness that needs to be in-built into the systems and on the efficiency of interaction among all these three key players. The development of a knowledge economy requires a thorough understanding of the dynamic interplay between research, invention, innovation, and economic growth.

An important question raised in the brainstorming session was why our education system is not producing thinkers and innovators. There are several facets to this problem. First, our school system has gone from bad to worse over the last several decades. Massive cheating is a norm, more in board exams in Sindh and also in other provinces. There is a huge drop-out rate with about 20 million out-of-school children. The quality of teachers is very poor in government schools and so the wrong mind set is being created during the 12 years of schooling. Students who enter colleges have thus been brainwashed into accepting mediocrity. Rote learning has become a habit and moral values have eroded. College education again is a disaster, as there are hardly any facilities and so the erosion continues.

The 10-12 years of poor school and college level education can hardly be compensated by 2-4 years of university level education. So, if we need to

[1] The article was published in *The News on July 21, 2021 and is available at https://www.thenews.com.pk/print/866890-quality-and-innovation.*

improve the quality of the output of students from our universities, and promote a culture of innovation and entrepreneurship, we must do so by bringing about major changes in our entire educational system at school, college and university levels. Mere tinkering will not work. To tackle these challenges, I have presented a comprehensive plan involving declaration of a National Education Emergency.

When I took over as chairman HEC, our primary focus was on quality of higher education, rather than churning out large numbers of incompetent students, ill prepared for the market needs. All curricula were therefore revised and updated in consultation with relevant stakeholders in industry, agriculture, medicine, and academia. The revised curricula introduced were geared to meet the demands of the international and local market. New books were introduced, and a digital library established under the Pakistan Educational Research Network (PERN) that provided free access to 65,000 text books and 25,000 international journals. A culture of quality research was introduced by training a large number of our brightest students at the world's leading universities and attracting them back to Pakistan through vastly improved salaries under a new Tenure Track Salary structure, jobs on arrival, liberal research funding and access to sophisticated instrumentation.

While research was encouraged in universities through massive research grants, establishment of central instrumentation laboratories and establishment of Quality Assurance units in all universities, some of the specific measures taken to improve quality were that all PhD theses were evaluated only by eminent foreign scientists. All PhD thesis and research papers were checked for plagiarism by introducing a powerful software (iThenticate or Turnitin) which brought a complete halt to the menace of plagiarism. Punitive action was initiated by the HEC when this was detected.

Some 11,000 students were sent abroad to leading universities for PhD level training and they were absorbed as faculty members on their return, leading to a huge improvement in educational standards and increase in research publications. The criteria for appointments and promotions at faculty positions were toughened and linked to international stature of the applicants as judged from their international publications, patents and citations. Quality Enhancement Cells were established in all universities for the first time in the history of the country.

Criteria for minimum requirements of faculty, facilities and infra-structure for establishments of new universities were approved by the cabinet and

enforced before giving charters to new universities. The mushrooming of substandard universities and university campuses was stopped.

The results of these measures were astounding. We had never had a single Pakistani university in the top 500 of the world during 1947-2002, according to the Times Higher Education (UK) rankings. By 2008, within a short six-year period, we had several universities ranked in the top 300-500 of the world, and numerous reports were written by neutral international experts calling 2002-2008 "the Golden Period" for higher education in Pakistan. This was made possible by the tremendous support to the higher education and science sectors from president Musharraf and the hard work of my colleagues at the HEC.

The emphasis of quality education and research was applauded internationally as well. In an analysis of scientific research productivity of Pakistan, in comparison to Brazil, Russia, India and China, Thomson Reuters acknowledged that Pakistan had emerged as the country with the highest increase in the percentage of highly cited papers in comparison to the BRIC countries.

Unfortunately, the governments that followed the Musharraf government drastically slashed higher education budgets and even tried to destroy the HEC by fragmenting it into pieces, a move that was blocked by the Supreme Court of Pakistan on my petition. A revival has at last now begun but much damage has been done, particularly after 2018 due to misguided HEC policies with the mushrooming of 35 new universities and campuses in the last three years without availability of funds or faculty, and the numbers of students sent abroad for PhD level training. As a result, quality has nose-dived.

It is time to start again and rebuild. Our future lies in unleashing the creative potential of our children.

The writer is Chairman PM National Task Force on Science and Technology, former minister, and former founding chairman of the HEC.

The Role of S&T Universities in Promoting National High-Tech Growth

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