Vol. 61 No 03 (239) 2021
DOI: https://doi.org/10.5564/pmas.v61i03.1818

PMAS
Proceedings of the Mongolian Academy of Sciences

ARTICLE

Science policy at the crossroads of global change research: Mongolia

Enkhamgalan Damiran[1,4], Tsevelmaa Khyargas[2], Nymadawa Pagbajabyn[4] and Shairii Batsukh*[3]

[4] Department for Research and Planning, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia,

[2] Department of Economics, National University of Mongolia, Ulaanbaatar, Mongolia

[1] Department Public administration, National Academy of Governance, Ulaanbaatar, Mongolia

[4]Mongolian Academy of Medical Sciences, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

---

ARTICLE INFO: Received: 19 Feb, 2021; Accepted: 22 Sep, 2021

Abstract: *In the last more than half a century, the science policies of countries have been interchanging in a cyclical manner between science, technology and innovation policies. In the early period of the evolution of the science policy, priority attention was given to policy matters, and the process of new knowledge generation proceeded at a rapid pace. Highly industrialised countries directly linked science policy with the growth and development of industry, and innovation gradually became the key catalyst of industrial development. But in the developing countries, science policy had a mixed impact on the process of industrialisation, where decision making by the Government had had a powerful impact on their science policy. Science is involved in the introduction and domestication of new knowledge in the education sector, experimentation and application of technology in local development, and guiding the government on its decisions that are economically efficient, environmentally safe, and promotes equality in the society. In this sense, if we regard scientific research as the key resource of "research industry," then countries need to define a science strategy and policy that would meet this supply and demand, identify and apply the competitive edge of science. The main objective of this study is to evaluate the science policy of Mongolia in the last 50 years in the context of global change based on facts, and to compare it with the historical experience of science policy development in industrialised countries.*

Keywords: *science policy; technological evolution; study of global changes; trends; impacts and outcome;*

INTRODUCTION

Science policy is a cross-cutting subject of study embracing policy study, scientific research, management science etc. Is there production in the branch of science? If so, what changes have undergone its supply and demand, competitiveness, strategic policy, planning and coordination?

***corresponding author: batsukhshairii@gmail.com** **https://orcid.org/0000-0002-0441-4994**

The Author(s). 2021 Open access This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made.

Vol. 61 No 03 (239) 2021
DOI: https://doi.org/10.5564/pmas.v61i03.1818

The question of science policy boils down to adequate distribution of resources for science, their rational utilisation, and their application for the overall welfare of the society. Science and technological policy, in the beginning, was predominantly directed at building the economic competitive advantage of such branches as defence, space research, electronics, transportation etc. [1] The importance of inter-disciplinary scientific research grew significantly especially following the adoption of the "Sustainable Development Goals 2030," a global agenda that is designed at mitigating the negative impact of climate change, focusing on global issues, such as depletion of natural resources, rising level of poverty and inequality, and promoting mutually complementary development of the economy, and the environment. Science has a special role in accomplishing the Sustainable Development Goals, and also guaranteeing social and economic growth of developing countries.[2]

As regards scientific management, one of the most difficult challenges is to define the strategy [3] of creating, basing on innovation and social values in the industrial sector that would facilitate the improvement of the closely interconnected and mutually dependent business. Porter [4] found it challenging to promote cooperation between the government, research institutions and the public sector in the developing countries, where industrialisation is regarded as the foundation of growth and development. We must, therefore, find solutions to this challenge. One such solution is to view science, technology and innovation as an integrated and mutually inter-connected unit of science policy, and better understand reality by way of inter-changing historical circumstances with historical international development and juxtaposing the science policies. Better we understand the changes, better there would be the opportunity to create new knowledge, expose the hidden knowledge and substantiate it with experiments, and improve the dynamics of the growth process. [5]

It has been proven by historical experience of highly industrialised countries that the rate of industrial development of countries speeds up when hard science (physics, chemistry, biology etc.), and soft science [6], (social, humanitarian science, philosophy, sociology etc.), technology and innovation are substantiated and confirmed by research and experiments. The development trends of science policies of different countries have not been the same, depending on the branch of science, the level of its growth, its role as an adviser or a connecter between industry and state services, or a combination of both. Gluckman [7] states that science has had a much closer link with the Government, and so it had been primarily functioning as an adviser.

Science seeks justifiable financial support from the government, on the one hand, and on the other, scientists reject government control, but strive to back government decisions with science, make effort to convince the citizens, and try to shape science according to their own interests. [8]

If we summarise the historical development of science policy, we find that works defining science policy appeared in England and in the United States in the second half of the 20th century. After the Second World War, the world was focused on post-war reconstruction and economic growth, and science began to make a breakthrough when it was supported and backed by policy.

Starting from the 1950s "creative destruction" of neo-Schumpeterian [9] economy had a powerful impact on overhauling the structure of industry. Economic influence was not only very powerful in most of the research that was carried out in the Western countries, but evolutionary trends started emerging in economics, and such branches as evolutionary economics and industrial innovation economics were established (Nelson and Winter 1982; Freeman 1982). At this time, the term "policy" was rarely used, while science policy was mainly used as "research policy" and the link between technology and innovation was defined in this context. What's more, most of the researchers focused on research and development (R&D), technology and innovation management, and judging by the research works, we find that an elaborate network of "policy, management, and economy" had emerged.

Beginning from the 1960s, countries started promoting science policy in close link with industrial and economic growth.

Furthermore, the arms race and space research in countries that were wrangled in the *Cold War* contributed to the rapid development of science, and budgetary outlays for R&D were also increased. Science became much narrower with the development of the science sector, it grew and spread out into different branches and accordingly, there arose the need to collect and report data on research and experimental development, and accordingly, the Frascati Manual was first published in 1963 [10].

From the 1970s, priority attention was given to the technological policy of broadly introducing knowledge and technology into industry and economy; scientific research became increasingly narrow and complicated, embodying in themselves many important elements of innovation. Starting from this period onward, the importance of strategic management grew in connection with R&D, technology and innovation, such as the development of economic and business history, for instance, technology and innovation history; innovation and industrial sector growth and industrial sector research development; new product study; technological and innovation management; and knowledge management. Technology policy’s relative focus was on national interests and economic growth, covering activities related to technology development to marketing, which grew and expanded. [10]

In the 1980s, a new trend emerged, which focused on creating and investing in new knowledge and technology, and applying created knowledge and technology into practice, and the innovation policy was launched. Starting from this period, such terms as engineering, research and development became narrower, and the combination of science, technology and innovation began to grow and expand. Breakthroughs in information technology started penetrating in a strong manner into the financial sector, and economic activities gained momentum. Although innovative actions were increasingly assigned to science sector, participants and factors in this area expanded gradually, and from the late 1980s, the concept of innovation system evolved, which laid the foundation for the formation of the science and technological policy. [1]

Beginning in the 1990s, when innovation started reflecting the key qualities of science, the use of the two terms - science and technology, increased and the Oslo Manual was first issued in 1992, which was a guideline for collecting and interpreting technological innovation data. [10] In reality, innovation became the central and key indicator of competitive advantage in the industrial sector in the Western countries, and consequently, a historical transition was made from technological and innovation link to scientific and technological link.

Since the 2000s, when the scope of global changes expanded, developed countries that had made progress with the help of science policy were increasingly pushing for international coordination of science, technology and innovation [6], while the developing countries were applying science policy in a quite diverse manner. To illustrate, after the end of the Second World War, developing countries like India, Brazil, Pakistan and Iraq invested millions upon millions of dollars in nuclear energy, electronics, pharmaceutical industry, and space study, but scientists who had been educated in natural science in the developed countries brought about variegated solution and outcome to speed up their respective country’s development. However, Goldemberg [11] argues that in actual reality when the science policy of these countries began leading the process of development, there was a growing demand for an integrated agro-industrial system, and progress in the education sphere. Accordingly, the rationale for facilitating new knowledge and its outcome are quite different in the developing countries in terms of supply on the part of science.

With the onset of the 21st century, science policy not only focused on economic growth, development and competitive advantage indicators, but also looked for solutions to many challenges in the society, for example, it increasingly sought to preserve and protect environment from climate change. Science, technological and innovation policies of countries around the world became much more open, they were directed towards promoting sustainable development goals, they became trans-disciplinary and more digitised.

Vol. 61 No 03 (239) 2021
DOI: https://doi.org/10.5564/pmas.v61i03.1818

In terms of policy research, if we look at the evolution and changes in the science policy and innovation research [12] we find that science, technology and innovation are being perceived as one whole under the umbrella of science policy, and in the last more than half a century, it had undergone through the process of evolution as one branch of science, and in this respect, take the example of England. However, researchers are divided on the idea of "science policy" as an independent branch. To illustrate, in the USA research policy, "competition" is central, whereas the United Kingdom has already started a debate around promoting the branch of "science policy" after having thoroughly analysed the science research system. But in the developing countries, research into science policy is almost non-existent.

Regarding changes in science research, we find that the study into Global changes is gaining momentum. International experience shows that in order to understand the global changes, inter- and trans-disciplinary trends are being applied in natural, social and humanitarian sciences [13] and a much more thorough and extended studies are being carried out, an example of which is the "sustainable development" [14]. Such an approach is defined as a radical - and trans-disciplinary [15] environment. This approach has different impacts on expanding the scale and scope of a research institution's fundamental and trans-disciplinary science. Information data system related to the nature, environment, technology, society, economy and humans are becoming inter-dependent, and the environment of global change research is changing suddenly. Although an independent sector science research continues to remain strong, there is a growing tendency towards better understanding the changes on the whole, and there is a higher demand for inter- and trans-disciplinary research, and the issue of sustainable growth of the science sector is now being studied.

The nature of science is changing and at a very fast pace. It is switching from linear to the non-linear model, from one science to a multi-faceted, interdisciplinary science system, from concrete to probability, where complexities in reality are acknowledged, where the impact of big data, and the data from artificial intelligence are being applied. Consequently, the mutual inter-dependency of science and the society is changing, and an evolutionary change in the passage of "sustainable" policy is occurring at the crossroads where "science, policy and society" intersect with each other.

Science is becoming increasingly dependent in a very complicated manner, hidden data have not been identified, and they also remain unclear, while unidentified objects are too numerous, but what is clear is that no time can be lost in taking a decision with regard to science policy. A science policy is invaluable and its composition is numerous, and although their value is controversial, they do not come without a cost [12]. In science policy research, similarly like in other branches of science, collection of data, information, and documents, and basing on them, the possibility of conducting analysis of the inter-dependence of science is limited, hence, efficiency is being interpreted holistically basing on quality research, and in this respect, perspective method is being widely applied. In this manner, it can be concluded that during the course of almost six decades, science policy has been making a transition from "policy, management and economics" to "science, policy, society".

Statistics show that the cost of R&D in the developing countries is expected to grow slowly but gradually [16], and also that the citation from published works by scientists, including from works on social and humanitarian science [17] is increasing. Judging by the experience from developed countries, there are many foundations that support R&D, thus giving a competitive edge to scientific research and what's more, the issue of R&D financing is addressed by linking it to production. The experience of industrialised nations shows that heavy investment in science and technology, and stable and balanced growth of the economy, society, nature and environment can bring about big success.

DOI: https://doi.org/10.5564/pmas.v61i03.1818

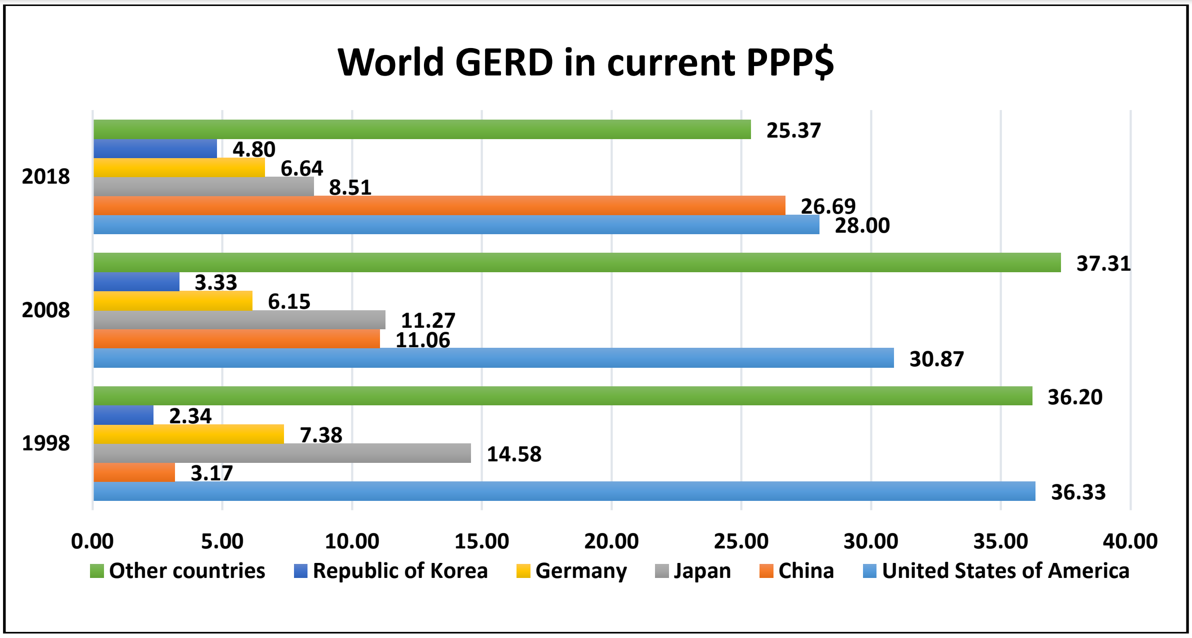

Figure 1. Gross Expenditure on R&D by countries

Source: UNSECO institute for Statistics. Science, technology and innovation: Gross domestic expenditure on R&D (GERD).

In 1998, five countries, such as the United States, People's Republic of China (PRC), Japan, Republic of Korea and Germany accounted for 63.8 per cent of the total global expenditure on R&D, while other countries accounted for the remaining 36.2 per cent only. People's Republic of China expenditure on R&D in 1998 was 3.2 percent, which grew to 26.7 percent in 2018, that is, an eight-fold increase during the period from 1998 to 2018. As a result, as of 2018, these five countries accounted for 74.6 per cent or three fourths of the global expenditure on R&D. The share of the PRC has been growing, while the share of other countries has been decreasing (Figure 1).

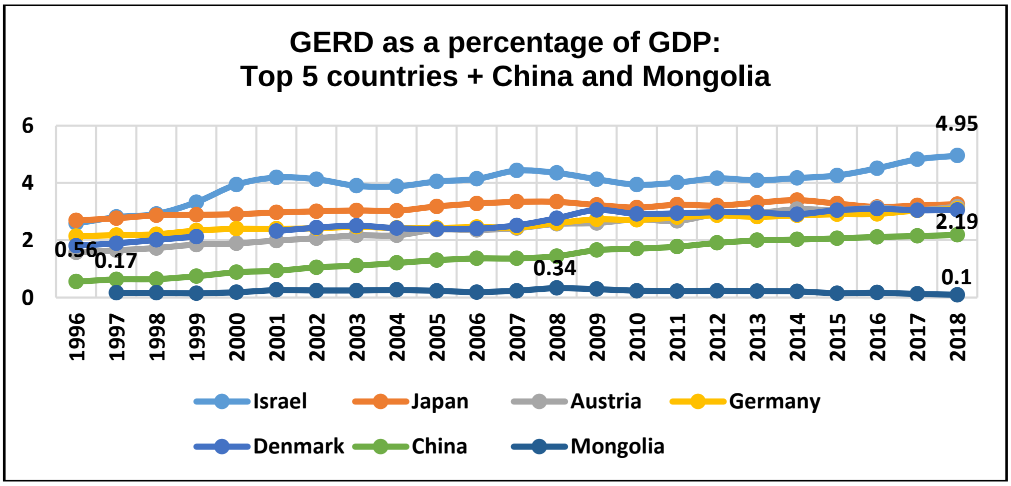

Figure 2. The share of R&D expenditure in GDP (By countries)

Source: UNESCO institute for Statistics. Science, technology and innovation: GERD as a percentage of GDP.

Global trends indicate that the share of expenditures on R&D in the GDP of countries in 2018 was 4.95 per cent in Israel, 3.26 per cent in Japan, 3.17 per cent in Austria, 3.09 per cent in Germany and 3.06 per cent in Denmark, and the highest showing was more than 3.0 per cent. Comparatively, the percentage of total expenditure on R&D in terms of GDP in the People's Republic of China grew rapidly, which was 0.56 per cent in 1996 and which grew continuously to reach 2.19 per cent in 2018. (Figure 2)

UNESCO statistics show that the size of funds allocated for research and development (R&D) in Mongolia between 2013 and 2018 was relatively different. In 2018, compared to 2018/2013, the size of the budget allocated for R&D in Mongolia had shrunk by almost 25 per cent. (UNESCO, 2020)

However, if we were to consider the matter from the standpoint of science policy, it has been found that technology transfer and innovation, as compared with the creation of new knowledge in the industrial sector (scientific research), has increasingly switched towards new market, new technology and new product manufacture.

Under such circumstances, the role of science as an adviser to the Government has changed to become a linking element between the Government and the private sector with science, technology and innovation.

MATERIALS AND METHODS

The study of science policy at the "sectoral" level has a powerful role to play in the national growth and prosperity of the developing countries. Within the framework of science policy, while considering scientific R&D (the process of developing new knowledge), processing (the process of experimenting new technology and innovation) and experimentation from an integrated historical perspective, attempts will be made to reveal the realities of the scientific branches by relying on historical sources and documents.

While drawing up a general trend of science and technology policy, it is important to consider, apart from the national policies of countries, the science and technological policies, guidelines and recommendations of international organisations as well. This is because, the science and technology policies being implemented by the governments of different countries are of a mixed nature and embrace, besides national security, socio-economic growth and development, national reputation and cultural values. [10] But such international organisations as the UN Education, Scientific and Cultural Organisation (UNESCO), United Nations Conference on Trade and Development (UNCTAD), the International Science Council (ICS), and the Organisation of Economic Co-operation and Development (OECD) compare the policies and actions of the governments of different countries, search and find constructive solutions to common issues of globalisation, define effective models of cooperation, and coordinate national and international policies, and are major sources making open and accessible data and information on science, technology and innovation, and are major platforms, which regularly and openly publish new and latest information. [10]

Overall outcome and impact, general trend and perspective of R&D in Mongolia's science have been defined in a general framework by Elsevier's Scopus (www.scopus.com), Web of Science of Clarivate Analytics (www.clarivate.com) using peer-reviewed scientific papers, published since the 1960s, and citation database. Since there aren't sufficient data for evaluating policy in the scientific field, basing on historical documents, and confirming their effectiveness, their logical inter-dependency has been studied using qualitative research or the perspective method. The evaluation of the impact of R&D through citation through such a paid and closed portals as Web of Science and Scopus is although not a correct approach, but the quantitative indicator for its justification has not reached the appropriate level.

Given the insufficiency of database evaluating the policy of Mongolia's science policy and its impact, the logical interdependency of research and development, processing and experimentation has been considered in perspective. While taking up the historical path of development of science policy, one can try to understand only the science branch, and consider in a historical perspective the inter-dependency of research and development, processing and experimentation in the field of science.

The history of the development of science branch of the countries around the world shows that in every country, the influence of the Government was very strong.

Vol. 61 No 03 (239) 2021
PMAS
DOI: https://doi.org/10.5564/pmas.v61i03.1818
Proceedings of the Mongolian Academy of Sciences

Scientific and technological policy pursued by the Government conversely impacts R&D, processing and experimentation in the sphere of science. This would help get a better understanding of the historical factors and impact of science policy. The historical methodology of studying the science policy, its changes and the recommendations and conclusions by researchers to streamline research methodology have been taken on the example of Mongolia based on the lessons learned by the developing countries in their science policies and related documents.

Science policy reform and paradigm

Scientific research is impacted by both external and internal factors, which change its trend and tendency, making the outcome and impact relatively different. With regard to external factors, countries around the world have started giving special attention to intensifying research and study relying on scientific database. In scientific research, both the inter- and intra-dependency of environmental, social and humanitarian sciences is being studied, and research and study is being increasingly deepened. In the research into different branches of traditional science, one science, for example, the science of economy was very close to other sciences, but in the radical inter-trans environment, the application, experimentation and outcome of different sciences are more effective, for example, management science and psychology together are much more effective and directed towards the society.

Radical interdisciplinary and transdisciplinary research

Different disciplines of science co-exist in an identical axis, mutually generate new knowledge in their own disciplines, through which control and monitoring are created in the labour market, contributing to a special methodology of inter-disciplinary study. [18] With the replenishment of R&D in one discipline with the strengths of other discipline, inter-disciplinary study is increasing in the modern world. Inter-disciplinary study contains the science knowledge of two or more science disciplines and methodologies of other branches are applied in this study. This kind of research is called integrated study method that analyses and coordinates the knowledge of different disciplines of science as one whole. [13] Although inter-disciplinary study can be both theoretical and consumer study, it is mostly directed towards consumer study, and in the academic framework, different disciplines of science merge with each other, jointly carrying out studies, and since the role of behavioral economics [19] and neuroscience [20] is growing in the society, inter-disciplinary study helps find solutions and answers to chronic problems related to behaviour and changes of people adapting to market system and the society, as a whole.

Academic and non-academic branches can be both involved in R&D, which makes it possible to cooperate directly with stakeholders when producing and applying knowledge outside of the academic domain. This is called trans-disciplinary study, which is not only responsible for concrete outcome, but also for creating opportunities for promoting mutual trust and future cooperation between different disciplines. [13] If extra-scientific actors can be drawn into R&D in non-disciplinary issues, then only can it become a trans-disciplinary study. [18] Trans-disciplinarity is a notion that includes in itself inter-disciplinary study, and researchers hold the view that it has an important role in making social and environment studies much more effective. Stakeholders, not only from the science field, but also from politics, civil society, private sector and the industrial sectors can be unified, but it is never easy to get an immediate result. Therefore, it is vitally important to strengthen the study links and ties between different disciplines, and in this respect, openness is central to making the study useful and accessible. Openness is the heart and soul of an activity in the field of science, and it is a knowledge, which is based on evidence, and whose logics have been confirmed.[21] In order to ensure openness of science, it is extremely important to promote an open database of knowledge of science, and to develop open platforms.

Openness in sciences

All the knowledge, goods and the data produced by science must be open and reusable. In order to ensure the applicability of data, data must be collected and processed according to the established model, which forms the bedrock of Artificial Intelligence and technology, whereby it becomes possible to apply data and strengthen the system of data management and monitoring. [21] This is why, collection and reporting of scientific, technological and innovation information help improve statistical comparison, which facilitates the progressive development of the structure of global statistical data of relevance to researchers and decision-makers, [20]. For example, it is believed that management methods have a big impact on the trends and tendencies of research being conducted by science institutes and universities, that is, the management skills of the heads of department's impact the work of the relevant department, while the sector of an institute is dependent on the management skills of the sector director. Although ensuring regular funding of research work is important, it is becoming a growing trend to collect, within a regular frequency, indicators of the sectors of institute and departments of universities, policy indicators of institutes, and indicators of individual researchers, and assess them, make them open and apply them in the decision-making process. [21]

If scientific knowledge is made accessible to the public, knowledge that has been published can be further developed, and basing on this, different and new knowledge can be generated. Creation of open database, and promotion of open access should be based on technological progress, including digital technology, and collecting and processing date in a proper manner will make it possible to disseminate knowledge, and openness can lead to effective cooperation. [22]

These digital technologies in the era of the Fourth Industrial Revolution, besides expediting the process of identifying solutions to social development issues, is also adding substantial impetus to the development of the science sector. [23] Digital technologies, which are products of R&D, have become important tools that stimulate the development of science, that is, governance, monitoring and outcome evaluation in the field of sciences.

The governance of an organisation, in terms of funding, is moving towards a model where multi-disciplinary study is carried out instead of focusing on just one sector, and it is becoming increasingly solution oriented.

The Government supports public sector institutes (PSI) to carry out study and research complying to the needs and demands of national and local development, and accordingly, it has become important to direct technological progress, private sector participation and investment to addressing social, economic and environment-related problems and challenges.

Science policy was overwhelmingly directed at increasing the national economic growth and competitiveness, and switching towards knowledge-based economy, whereas now, it is directed more at finding a way out and seeking solution to pressing challenges facing the entire world. Given such changes, many different non-academic social sectors are involved, more than the scientific institutions, in R&D and they are working in close collaboration with each other, which is proving extremely beneficial to the society. [22]

Science sector funding:

R&D can be funded primarily in two ways. First, through competitive project funding, second, through non-competitive institutional funding. The Government is becoming interested in defining the priority areas and their executors, and allocating them long-term non-competitive funding and in other cases, granting competitive funding to project units and institutions. The government system of R&D funding has become complicated and mixed, such as competitive and non-competitive, institutional funding and excellence funding. [24]

Highly developed countries are pursuing a policy of supporting and increasing private sector funding in R&D, whereas the developing countries are trying to increase budgetary investments. [22] Take for example the successful Los Alamos Laboratory, Project Y on nuclear weapons development in the United States, which have proven that investments in technological development, fundamental and consumer science can help address many critical problems. [6] R&D expenditure is growing further as a result of growth in innovation and economy, social needs and demands, while budgetary spending is likely to decrease. Within this framework, the private sector and businesses in the developing countries are being drawn into research

DOI: https://doi.org/10.5564/pmas.v61i03.1818

activities, and there is a growing tendency for the private sector to support R&D. [25]

In general, science, technology and innovation policies are inseparably connected with each other and the innovation policy defines the objectives, goals and players in the technological policy, and the technological policy defines the science policy objectives, goals and players. [10] Science, technology and innovation policies cut across the policies of many different sectors, such as science and technology, industry, trade, foreign investment, entrepreneur, finance and economic growth planning, and mutually determines agriculture, industrial, energy, transportation and health sector policies. Such a cross-cutting policy is coordinated and promoted under the Prime Minister in such industrialised economies as the Republic of Korea and Finland. [1]

Faster the new scientific knowledge is assimilated and adopted in the industrial, agricultural and education spheres, the faster new value-added products will be produced and sectoral values will strengthen accordingly. A proof that innovation is successfully penetrating into science branches is evidenced by the rapid and balanced penetration of low and high technology, and sustainable innovation in major trans-continental, trans-national, regional and national manufacturers, thus further strengthening the mutual dependence of science and social relations. The process of improving, acclimatisation and renovation, substitution and replacement of innovation at small and medium enterprises is proceeding at a rapid pace in the developing countries.

A holistic cognition of science, technology and innovation policies within the framework of perspective method is vitally important for defining, redefining and changing the long-term strategy of science policy.

RESULTS AND DISCUSSION

Scientific research in Mongolia and evolution in the policy since 1959

The foundational base of Mongolia's economy - animal husbandry and veterinary research, gained momentum, and by the beginning of the 20th century, a favourable environment had been created for exploiting untapped internal resources, and conducting research and studies. Priority attention was given to the study of linguistics, literature, history and economy, natural sciences, and medical science in order to add scale and scope to research work with due consideration of the country's development policy.

Agricultural science, compared to other science branches, was given special attention, focusing on scientific research, experimentation and application of new technique and technology. As a result, an integrated research database was created, which not only included research and studies showing all the qualities of highly productive livestock animals, but also included studies designed at increasing the yield of animal-origin produce. Veterinary research became more intensive, which contributed to determining the stages in the development of animal diseases, developing ways and means of fighting them, and retaining the weight gains and the productivity of livestock animals. Together with this, studies into plants, pastures and animal fodder, and land farming increased in scale and scope, making it possible to transfer important know-how into production.

Beginning from the second half of the 20th century, research in natural sciences, such as geography, geology, astrophysics, meteorology, zoology, physics and chemistry, became more developed in Mongolia, and the Institute of Higher Education of Science was established in 1957 for the purpose of improving the link and coordination between science and human resources training. Many research works were produced, which had carried out in-depth study into the natural regions of Mongolia, the frequency and status of earthquakes, animal, plant and economic geography, business location of economic zones, the perspective of their development, chemical composition of minerals etc.

Also priority was given to medical science research, for instance, comprehensive research was conducted into the symptoms of some diseases that erode human health and labour competency, ways and methods of their treatment and prevention, covering different

DOI: https://doi.org/10.5564/pmas.v61i03.1818

areas of traditional medicine, public health, hygiene and sanitary conditions. What's more, research into infectious diseases and tuberculosis was scaled up, anti-TB mobile teams were mobilised, thanks to which fourth generation sexually transmitted diseases were eradicated. As a result, the health of the population improved, which was accompanied by higher birth and lower mortality rates, and such a situation created favourable conditions for an unprecedented growth of the population, which can rightly be defined as a health evolution. Joint Mongolian and Soviet teams, from 1980 to 1985, carried out comprehensive study into the health and morbidity status of the country's population, which was one of the major accomplishments of those times. [26] Alongside this, study into animal reproduction was deepened, and totally new experiments and research were conducted into the productivity, physical growth, care and breeding of sheep and goats, as a result of which fine fleece sheep breeds were developed anew and their farms were set up. The country also carried out research into the development of technology for new strains and varieties of wheat, improving the cultivation technology, as a result of which, a new strain of wheat was developed.

In social sciences, research into Mongolia's history, archaeology and ethnography picked up pace, and extensive work was done towards protecting cultural heritages, facilitating archaeological excavation work, and promoting Mongol studies around the world. Researches on different branches of the national economy, increasing their profitability and labour productivity, national income, economic laws and legislation in the period of transition are being conducted. However, the country has not yet been able to carry out a broad-ranging, systematic study into the industrial, transportation and trade sectors of the economy. [27]. Therefore, from the stand point of international standards, the subject of study or the science policy of the country had been agriculture, rather than the industrial sector.

There was a growing need for studying agricultural resources and raw materials, including the network, machinery and technology for diverting and supplying them to the industrial sector at a low cost, and also the infrastructure, logistics innovation and technology of companies, and research into easing intensity of labour and trade in the agriculture sector. The country also needed to carry out research that would help create favourable environment for attracting direct foreign investment, which would facilitate technology transfer from the industrial to the agriculture sector, and improve innovation competitiveness.

To look at the development of Mongolia's science branches in terms of the number of publications, it can be divided into two periods: pre- and post-1990. Until 1990, Mongolia had followed the path of socialist development for about 70 years and developed a science policy with Soviet influenced model. In 1990, the social transition to democracy and openness to the outside world led to changes in scientific environment as well. Due to the changes in society and economy, we find that 125 publications were produced in the country by Mongolian scientists in the period from 1957 to 1990, which increased 41.6 fold to reach 5,246 in the period between 1991 and 2019, according to the Scopus database.

Many factors influenced this dramatic increase in the number of scientific publications. As regards the internal factors, prior to 1990, Mongolia's science policy was predominantly focused on medical sciences (22.2%), agriculture (11.1%) and natural sciences (over 50%) such as physics and astronomy, mathematics, geology, earth science, and chemistry, according by publications in Scopus. (Figure 3)

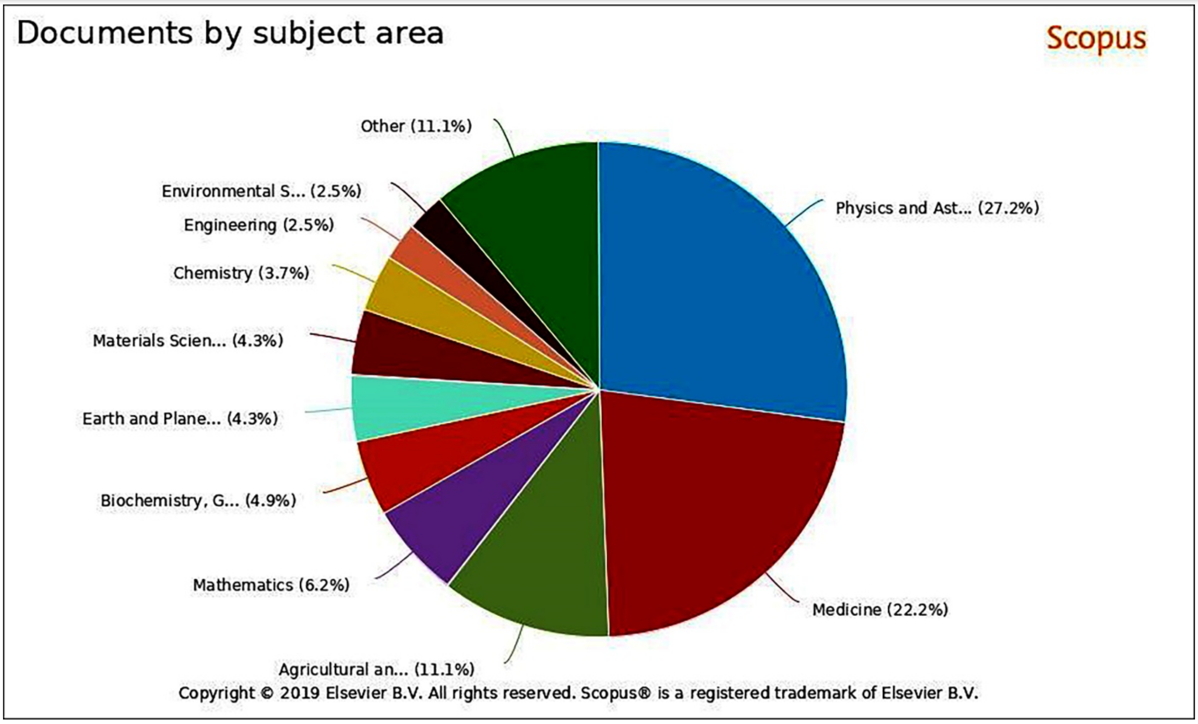

Figure 3. Publications by branches of sciences (1957-1990)

Source: (Date of searching: 17/07/2019, Scopus)

Although, since the 1990s, the government's attention and support on science have waned, but R&D has become more open in almost all the branches of science. It should also be noted that investment in science is still limited due to government budget deficits and foreign debt. Regarding external factors, since the 2000s, indirect impact of collaboration and support of foreign research institutes and universities has opened up broader opportunities for Mongolian scientists to publish papers in both hard and soft sciences. As a result, scientific papers have become equally competitive both inside and outside of the country. Since the 1990s, the social, computer, environment, and engineering sciences have evolved and similarly, the number of publications has increased. Due to the increase in the number of publications in these fields and the decrease in direct support of government to natural sciences, the share of natural sciences in the total number of publications has decreased, such as physics, astronomy, mathematics and materials science. (Figure 4)

Vol. 61 No 03 (239) 2021
DOI: https://doi.org/10.5564/pmas.v61i03.1818

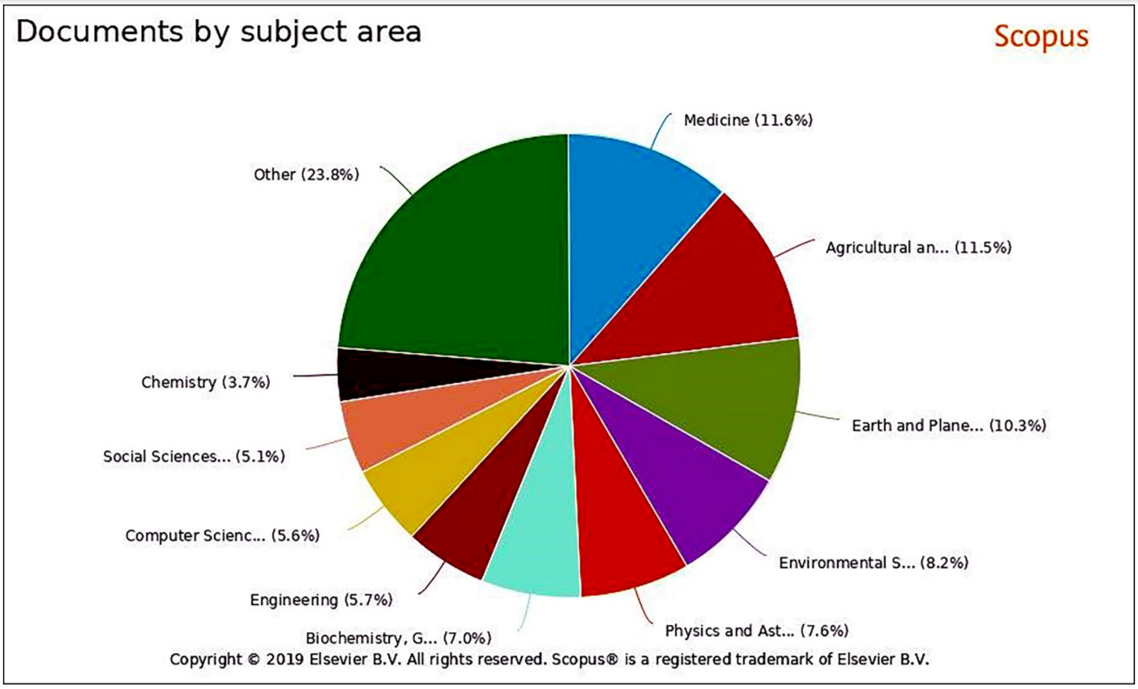

Figure 4. Publications by branches of sciences (1991-2019)

Source: (Date of searching: 17/07/2019, Scopus)

Although scientific papers tended to increase gradually in number in the period between 1957 and 1990, there was much fluctuation when it came to publishing them. If we look at the papers published between 1991 and 2000s, their rate of publication was slow, which, however, changed and began to increase rapidly especially after 2006. There are a few institutions that have been playing an important role in increasing the number of publications, such as Mongolian Academy of Sciences, National University of Mongolia, Mongolian University of Science and Technology, and Mongolian National University of Medical Sciences.

Mongolia is recognised for its research in the area of natural sciences, and this status should be further strengthened and maintained, and we are aware that research in the area of social science is not up to the desired level.

The Council of Ministers of the Mongolian People's Republic in 1985 adopted a Programme of Developing Science and Technology of Mongolia up to the year 2005, which was not implemented because of the regime change in the country. Legal regulation has a direct impact on the environment of science policy. In 2016, the State Great Khural – Parliament of Mongolia, adopted "The Concept of Sustainable Development of Mongolia – 2030.". Today, such documents as the Law on Science and Technology (2006), Law on the Legal Status of the Academy of Sciences (1996), Law on Technology Transfer (1998), Law on Innovation (2018), Master Plan on Developing Mongolia's Science and Technology from 2007 to 2020 (2007), Priority Areas of Developing Mongolia's Science and Technology from 2015 to 2020 and the List of All Technologies (2015), State Policy on Science and Technology (2017), State Policy on Innovation (2018), National Programme of Developing Science, Technology, Innovation and Human Resources (2015) are in force [28] in the country.

Scientific research, technology and innovation experiments and their transfer demand heavy capital investment. If we look at the existing situation in the country, we can observe that R&D in the production sphere of the science sector is primarily based on budget financing, and fundamental research works are given higher priority and significance.

PMAS
Proceedings of the Mongolian Academy of Sciences
Vol. 61 No 03 (239) 2021
DOI: https://doi.org/10.5564/pmas.v61i03.1818

Table 1. R&D projects funded from government (2015-2020)

	R&D	2015	2016	2017	2018	2019	2020
1	Fundamental research projects	159	163	182	186	215	196
2	Science and technology projects	40	69	92	95	98	90
3	Innovation projects	81	74	80	60	73	46
4	Priority areas and key technology projects	8	8	8	7	4	1
5	Post-Doctoral Grant projects	65	67	76	42	54	65
6	Projects with foreign partners and organisations	68	74	77	65	89	71
	Total	**421**	**455**	**515**	**455**	**533**	**469**

Source: Reports of Mongolian Foundation for Science and Technology

Fundamental research projects have the highest percentage for the six-year average, that is, they account for 38.7 per cent of all the funded projects during this period. Although innovation projects, which were funded from 2015 to 2020, had decreased one fold, and science and technology projects had grown by one fold, their impact on industrial production, human resources and transportation were not evaluated and analysed.

From 1960 to 1990 Mongolia's science policy was heavily focused on research designed at improving management, intensifying research work in compliance with practical work, that is, it gave priority to research in agricultural, natural and medical sciences, while the intensity of research in the social and humanitarian sciences, as well as economic science, was weak.

The science policies of industrialised nations in the 1950s and 1960s were focused on promoting scientific research, similarly, Mongolia also attached important significance to scientific research by linking it with practice. Scientific research in the industrialised countries was developing and progressing rapidly in all directions, but up until 1960, Mongolia's scientific research was predominantly in the natural science branch. The foundation of Mongolia's science policy, for the most part, was directed at maintaining economic balance and stability. This is precisely why scientific research was stepped up in the natural science branch, and research organisations and management were gradually developed by improving them in a step-by-step manner. [26]

Although the number of humanitarian science papers and works had increased at the international level since 2006, the impact of scientific research, technology and innovation on the development and growth of the industrial sector of the country continues to remain relatively different. Under such circumstances, it is imperatively important to make innovation projects, designed at intensifying economic activities, making them much more competitive in keeping with international standards, and creating a mechanism that would make the bidding of such projects more open and accessible to the public. Alongside this, further improvement of the legal environment of non-budgetary, multiple source funding, such as research grants by major corporations and companies, foundations and special science funds would be in compliance with the global trend.

It has been observed that the quality of research work has been improving significantly since 2015, and there is increasing and quicker transfer from R&D to actual processing and experimentation. Although competitiveness in Mongolia's science branch is becoming stronger, the country is still in dire need of reforming the strategy, policy, management and funding in order to ensure a sustainable growth and development of science.

As of 2020, total budget earmarked for R&D in Mongolia accounted for 0.2 per cent of the GDP and the outlay for research to study the procurement capacity parity was 72,619.2 thousand US dollars. 4.9 per cent of this spending was from the private sector, almost 83.0 per cent by the Government and 12.1 per cent was by private universities and research institutions. [29]

DOI: https://doi.org/10.5564/pmas.v61i03.1818

CONCLUSIONS

One conclusion that can be drawn from the experience of scientific research development in the last half a century is that it is extremely important to switch over to the implementation of innovation-based scientific and technological policy, as the impact and efficiency of science policy is directly dependent on the level of innovation. This is why, science policy is simultaneously performing the role of an advisor and a link in ensuring sustainable development of the nature, environment, society and the economy.

Long-term development impact is not the same in some developing countries, where R&D has been directly applied, which has become an experience and a learning for other developing countries. In our view, there are many internal factors that can have an impact on the "factory" of science in Mongolia. Therefore, there is an imperative need to improve Mongolia's science policy strategy in line with the changing global science policy and its achievements. Opportunities come up when the challenges are dealt with.

REFERENCES

1. UNCTAD, *A framework for Science, Technology, Innovation policy reviews.* 2019, United Nations Conference on Trade and Development: Geneva.
2. UNESCO. *Medim-Term Strategy 2014-2021. in UNESCO General Conference, 37th*. 2013. Paris.
3. Porter, M.E., C. Ketels, and M. Delgado, *The Microeconomic Foundations of Prosperity: Findings from the Business Competitiveness Index.* The global competitiveness report, 2007. 2008: pp. 51-81.
4. Porter, M.E., *What Is Strategy?* Harvard Business Review, 1996. 74(6): pp. 61-78.
5. Porter, M.E., *The Competitive Advantage of Nations* Harvard Business Review 1990: pp. 72-91.
6. Attri, V.N., *A Perspective on Science, Technology and Innovation Policy: Need for International Coordination, in Global Sustainable Development Report,* UN, Editor. 2016: New York.
7. Gluckman, P., *The art of science advice to Government.* Nature, 2014. 507: pp. 163-165.
8. EU, *Global Governance of Science. Report of the Expert Group Global Governanace of Science to the Science, Economy and Society Directorate, Directorate-General for Research, European Commision.* 2009, European Research Area: Belgium.
9. Schumpeter, J.A., *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle.* 1934, Piscataway: Transaction Publishers.
10. Lunddvall, B.-A., S. Borras, and R.R. Nelson, *Science, Technology and Innovation Policy, in Innovation Handbook,* J. Fagerberg and D.C. Mowery, Editors. 2005, Oxford University Press: Oxford. pp. 599-631.
11. Goldemberg, J., *What Is the Role of Science in Developing Countries?* Science 1998. 279(5354): p. 1140-1141.
12. Martin, B.R., *The evolution of science policy and innovation studies. Research Policy,* 2012. 41: pp. 1219–1239.
13. Toomey, A.H., et al., *Inter- and Trans-disciplinary Research: A Critical Perspective in Global Sustainable Development Report.* 2015.
14. Stock, P. and R.J.F. Burton, *Defining Terms for Integrated (Multi-Inter-Trans-Disciplinary) Sustainability Research.* Sustainability 2011. 3: pp. 1090-1113.
15. Klein, J.T., *Prospects for transdisciplinarity.* Future, 2004. 36: pp. 515-526.
16. OECD, *Main Science and Technology Indicators.*

DOI: https://doi.org/10.5564/pmas.v61i03.1818

https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB. 2020.

17. Medoff, M.H., *A Citation-Based Analysis of Economists and Economics Programs*. The American Economist, 1996. 40(1): pp. 46-59.
18. Maasen, S., M. Lengwiler, and M. Guggenheim, *Practices of transdisciplinary research: close(r) encounters of science and society*. *Science and Public Policy*, 2006. 33(6): pp. 394-398.
19. Hausman, D.M. and B. Welch, *Debate: To Nudge or Not to Nudge. The Journal of Political Philosophy*, 2010. 18(1): pp. 123–136.
20. Dolan, P., M. Hallsworth, and a.a. David Halpern, *MINDSPACE Influencing behaviour through public policy*. 2010, Institute for Government.
21. ISC, *Open Science for the 21st Century*. 2020, International Science Council. p. 28.
22. UNESCO, *UNESCO Science report: towards 2030*. 2015: Luxembourg p. 794.
23. WEF, *World Economic Forum | Annual Report 2019-2020*. 2020.
24. OECD, *OECD Science, Technology and Innovation Outlook 2018*. 2018.
25. OECD. *Science and Innovation Policy. Key Challenges and Opportunities. in OECD Committee for Scienctific and Technological Policy at Ministerial Level*. 2004. Paris.
26. Boldbaatar, J., et al., *XX zuuny Mongol: Bolovsrol, soyol, shinjlekh ukhaany khugjlyin tuukh [Mongolia in the XX Century: History of Education, Culture and Science Development]*. 2020, Ulaanbaatar: Udam soyol LLC.
27. Sereeter, C., K. Tserev, and B. Chadraa, *Mongol Ulsyn Shinjlekh Ukhaany Akademyin Tuukh [History of Mongolian Academy of Sciences]. 2002*, Ulaanbaatar: Shinjlekh Ukhaany Akademyin khevlekh uildver.
28. MECSS, *Shinjlekh ukhaan, tekhnologi, innovatsyin bodlogo, erkh zui, statistikyin emkhetgel [Science, technology, innovation policy, legal and statistical information]*. 2019: Ulaanbaatar. pp. 26-27.
29. UNESCO, Science, Technology and Innovation. Research and experimental development (full dataset). 2020. UNESCO. Institute for Statistics. http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS&lang=en#