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Advancing Science, Technology, and Innovation Policies: A Comparative Analysis of Turkey, Iran, and Pakistan with a Focus on Improvement Dimensions

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Abstract:

This research is set in exploring in detail the Science, Technology, and Innovation (STI) policies of both Turkey and Iran; aiming at identifying and probing directions for improvement within Pakistan's STI framework. The research seeks to critically examine the STI policies of these states in order to contribute to the body of knowledge that explains what works and what doesn't work in Pakistan. The research will exploit through Omar's six components and a 22-indicator assessment matrix in order to measure and validate the efficacy of current STI policies in the country. Furthermore, the study will be able to indicate the areas that need some improvements. The methodology covers comparative analysis of STI policies for the needs of the research. The analysis of historical development, policy implementation and outcomes in terms of innovative output, economic growth and human capital development is included. The conception of underscored aspect is the NASTIC (Need Assessment of Science, technology, and Innovation Cycle) framework. This framework is designed to be unique and to solve the problem areas that were discovered in STI in Pakistan, providing a way for the improvement of policies through structure. These finding has the potential to be proved of worthy by the decision makers, researchers and the stakeholders of the Ministry of Science and Technology (MoST) in Pakistan. Through underlining the fields of future development of the science, technology and

innovation (STI) policy measures in Pakistan and submitting the plan for the policy enhancement this research is aiming to add some extra weight to the studies that deal with the STI policies analysis, drawing attention to the comparative analysis and policy improvement as the methods that can give impulse to science and technology in the country.

Keywords: STI policy, Turkey, Iran, Pakistan, Omar framework, policy responses, NASTIC framework, sustainable development.

Introduction:

The advancement and expansion of Pakistan's economy are dependent upon science, technology, and innovation (STI) (Nations, 2015). Keeping this quote in mind the first chapter of this thesis is beginning with offering an overview of science, technology, and innovation in Pakistan. Pakistan has created research facilities and academic institutions that should conduct scientific research for the economy's prosperity. It is evident that the non-functionality of these facilities is due to the lack of an action plan & the policies made. Organizations, even with the available funding, are not able to produce the results. While Pakistan has made some progress in science, technology, and innovation (STI), the sector is still not as developed as in neighboring countries. STI plays a critical role in economic growth, yet Pakistan has been facing numerous challenges in promoting research and innovation. Overview of the current state of science, technology, and innovation in Pakistan reveals various limitations that need to be addressed:

Pakistan has established some research institutions, but facilities and funding remain limited compared to regional competitors. While the government supports cooperation between organizations, connections between academia, industry and government are still weak. The information technology sector has grown but high-tech industries driven by domestic R&D are lacking. Biotechnology shows promise but commercialization is slow. Renewable energy development has taken place but is not rapid enough to meet demand. Space capabilities are nascent compared to other countries. Startups have increased but the overall entrepreneurial ecosystem is underdeveloped. Science education receives attention, but human resource development needs more investment. International partnerships exist but are not extensive enough to leverage global knowledge. Overall, while progress has been made, funding shortages, infrastructure gaps, weak collaborations and a shortage of specialized talent are impeding

Pakistan's full realization of STI's potential for development. This study aims to address these gaps.

The Pakistan Vision 2025 placed a strong emphasis on innovation, research, and technology but did not develop targeted actions to track progress. As a result, Pakistan has fallen short of improving its technological prowess and supporting innovation-driven industries as envisioned. Similarly, the National STI Policy and National Innovation Policy aimed to strengthen academic-industry linkages and encourage entrepreneurship. However, without dedicated implementation roadmaps, partnerships and an innovation culture have not been effectively fostered.

Initiatives by HEC provided funding and support for research but lacked coordination with industry needs. Consequently, research commercialization could not be enhanced. The IT policy strived to expand access to technology, but clear directives and resource allocation were missing. The space policy sought to boost capabilities but lacked implementation directives. The renewable energy regulations also failed to accelerate adoption due to the absence of an action framework. The country's recent policy priorities have heavily emphasized STI, and the government has put in place policies to encourage entrepreneurship, increase investments in research and development, and promote technology. Turkey has actively sought out international partnerships and collaborations in science and technology. Pakistan can gain by working with Turkish institutions and academics, especially in fields like agriculture, information technology, and renewable energy.

Scientific prowess: Iran has advanced significantly in improving its scientific prowess, especially in areas like nuclear technology, biotechnology, and space exploration. In these areas, Pakistan can investigate possible collaborations with Iranian organizations and scientists. Economic restrictions against Iran have had an influence on its advancement in science and technology. However, the nation has proven to be resilient and has continued to invest in a few crucial industries. Pakistan might think about ways to cooperate and transfer technology that are compliant with international laws and steer clear of any potential legal or diplomatic issues.

While Pakistan has achieved strides in the fields of STI, there are still several obstacles and gaps that must be closed to realize STI's potential as a tool for national development. One major obstacle is a lack of funds for R&D. In comparison to other nations, the amount of funding

allocated for STI initiatives, such as research grants and infrastructure development (Ozkaya et al., 2021) is quite low. To support scientific research, innovation, and technological commercialization, enough funding is essential. Collaboration between academia, industry, and government is crucial for turning theoretical research into real-world applications and fostering businesses that are driven by innovation. In Pakistan, there is frequently a communication and coordination gap between these industries (Lundvall, 2016). It's crucial to fortify connections and establish efficient platforms for the transmission of knowledge and technology.

Research Objectives:

- To compare the STI Policies of Turkey, Iran, and Pakistan through six components of Omar and explore dimensions of improvement for Pakistan.
- To measure the extent of the Policy responses through 22 indicators in an assessment matrix of the Science Technology and Innovation Policy for validating dimensions of improvement in Pakistan.

This chapter presents the concept of Science, Technology and Innovation policy and its need for meeting the societal development challenges for socio-economic upbringing of country like Pakistan. The overview of Turkey and Iran is presented with a proposal of devising implications for Pakistan. At the end, the chapter presents the research question to be answered by this thesis.

Literature Review:

STI and SDGs are closely related. Since STI is essential to accomplishing the SDGs and in 2015 United States were established 17 sustainability development goals and these goals are intention of solving multiple issues related with social, economic, environmental in direct to achieved sustainability development by the years 2030 (*Pakistan's Implementation of the 2030 Agenda for Sustainable Development Goals: Voluntry National Review. SDG Section, Ministry of Planning, Development and Reforms, Government of Pakistan, Islamabad.*, 2019).

No Poverty: By fostering inclusive economic growth, job creation, and marginalized populations' access to technology and financial services, STI can contribute to the development of novel strategies for reducing poverty. Zero Hunger: STI can raise agricultural productivity, create sustainable farming methods, and better food delivery networks, which will increase food

security and nutrition. Good Health and Well-Being: STI helps to create innovative medical technology and therapies, improve illness surveillance, and advance health education and awareness. Quality Education: STI supports the development of cutting-edge learning technology, the advancement of educational methodologies, and access to high-quality education so that people can gain knowledge and skills. Gender Equality: STI may advance gender equality through eliminating prejudices against women in research and innovation, providing opportunities for women in STEM professions, and utilizing technology for women's empowerment.

Clean water and sanitation: For everyone to have access to clean water and sanitary facilities, STI makes it possible to create cutting-edge water treatment technologies, effective water management systems, and sustainable sanitation solutions. Affordable and Clean Energy: STI supports the transition to sustainable and clean energy systems by assisting in the development and uptake of renewable energy technology, energy-efficient solutions, and enhanced energy access. Fair Employment and Economic Growth: Instigating economic growth, employment creation, and sustainable industrial development, STI promotes innovation, entrepreneurship, and technological developments. Infrastructure, Industry, and Innovation: By encouraging inclusive and sustainable industrialization, assisting in the development of infrastructure, and encouraging innovation across industries, STI plays a crucial part in achieving this objective.

Reduced Inequalities: STI can aid in closing the digital divide, lowering disparities in knowledge and technology access, and fostering inclusive innovation ecosystems that are advantageous to all facets of society. Sustainable Cities and Communities: STI supports the development of innovative infrastructure and transportation systems, smart city solutions, and sustainable urban planning to make cities more resilient and sustainable. The transition to sustainable consumption and production patterns: It is made possible by STI's promotion of resource-efficient technologies, eco-innovations, and sustainable manufacturing methods. Climate Action: STI supports international efforts to combat climate change by promoting the development and application of clean technologies, climate adaptation plans, and mitigation techniques.

Life below Water: STI supports initiatives to maintain marine ecosystems through sustainable fishing, ocean-related technology, and marine research, monitoring, and conservation. Life on

Land: STI promotes biodiversity monitoring, the conservation, restoration, and sustainable management of terrestrial ecosystems, as well as the creation of novel strategies for sustainable land use. Peace, Justice, and Strong Institutions: By utilizing technology for effective and inclusive public service delivery, data-driven decision-making, and strong institutions, STI can improve governance, transparency, and access to justice. Goal: Partnerships to Achieve the Goals: In order to successfully partner, share information, and build capacity, governments, universities, businesses, and civil society must work together. STI is a key enabler for these activities.

STI is a potent instrument for fostering creativity, addressing difficult issues, and attaining sustainable development in a variety of fields. It aids in social advancement, environmental sustainability, and economic growth, ultimately assisting in the achievement of the SDGs. Policies of Iran and Turkey are reflected in terms of STI with a question of what effects they might have on Pakistan STI system. This literature review is to enhance this understanding and is based on details that were current as of September 2021.

Turkish Government's Science, Technology, and Innovation Policy:

Turkey has been working to improve its STI capabilities and create a knowledge-based economy. The nation has put in place several programs and policies to support innovation, technological advancement, and scientific research. The following are some significant facets of Turkish STI policy: National STI Strategy: Turkey's national strategy for advancing science, technology, and innovation explains its objectives and action plans. The plan focuses on issues including boosting R&D spending, enhancing university-industry cooperation, encouraging entrepreneurship, and creating STI-related human resources. R&D and Innovation financing: To promote R&D initiatives and innovation projects, the Turkish government has established several financing sources. Grants, loans, tax breaks, and venture capital funds are among examples. Public-private partnerships are also encouraged by the government to promote innovation and the commercialization of research findings.

Research and Development Centers: To promote collaboration between academia, industry, and the government, Turkey has developed research and development centers and technology parks. Infrastructure, resources, and assistance are provided by these centers for research and

innovation initiatives. Education and the development of human resources: Turkey understands the value of trained labor in STI. The nation has been making investments in raising the quality of science and technology instruction at all levels, promoting STEM (Science, Technology, Engineering, and Mathematics) fields, and fostering researcher mobility and international collaboration. Relevance for Pakistan: Pakistan may be able to learn from Turkey's STI policy measures. Knowledge exchange and commercialization, collaborative research and development initiatives, and capacity building of human resources can result from cooperation between the two nations in the field of STI. Pakistan might also investigate collaborations with Turkish research institutes, make use of financial sources, and absorb Turkish knowledge on the creation of technology parks and encouraging industry-academic cooperation.

Iran's Science, Technology, and Innovation Policy: Iran has actively pushed STI to advance economic growth and lessen reliance on oil earnings. To improve its scientific and technological capabilities, the nation has put in place several projects and policies. Iran's STI strategy has several important facets, including: Vision 2025: Iran's Vision 2025 is a long-term strategy plan that places a strong emphasis on STI's contribution to economic growth and sustainable development. The strategy has objectives that include boosting R&D spending, enhancing the standard of academic inquiry, encouraging technological transfer, and encouraging innovation and entrepreneurship.

National invention System: Iran has established a National Innovation System (NIS) that intends to involve a variety of actors, such as academic institutions, businesses, and government organizations, in the invention process. The NIS framework promotes teamwork, information sharing, and the monetization of research findings. R&D Investments: Both the governmental and commercial sectors of Iran are making more R&D investments. Through grants, loans, and tax incentives, the government offers financial assistance for R&D initiatives. An effort is being made to develop technology parks and scientific cities and draw foreign investment to high-tech enterprises. Human Resource Development: Iran lays a lot of focus on STI's development of human resources. The nation has been making investments in science and technology education, boosting the number of STEM graduates, and offering Iranian researchers financial aid and scholarships to pursue postgraduate degrees overseas.

Relevance for Pakistan: Pakistan can look for possibilities for STI cooperation with Iran. Both nations face similar problems and stand to gain from knowledge exchange, collaborative research and development efforts, and technology transfer for commercialization. Pakistan should gain insight from Iran's experience in creating a national innovation system that is integrated and luring international investment into high-tech sectors. Additionally, collaboration in educational exchange programs and human resource development can improve both nations' STI capacities.

WTO and STI link with Iran, Turkey, and Pakistan

Iran was anticipated to develop more knowledge after the Iran Deal boosted its access to global markets and improved its economic performance. The more actively Iran participates in international economic connections, the more its specialists might contribute to the global scientific community and Iranian start-up enterprises might be able to access a wider market. There may still be a number of big political issues to be handled, though (Weinhardt & Schöfer, 2022). Even though sanctions have been lifted and great progress has been made, many Iranians are still baffled as to why American, European, and even Asian institutions aren't explicitly stating that they are providing banking services in Iran.

Thus, one of the initial barriers to corporate activities is the transfer of funds. Of the countries that have not ratified the World Trade Organization (WTO), Iran has the largest economy. Iran has been stuck in observer status at the WTO since 2005 as a result of pressure from the United States and its use of its veto power in the WTO Council (Hopewell, 2022). Partnerships between small and medium-sized knowledge-based businesses and massive corporations, whether domestic or foreign, are crucial to their success. Iran may be able to receive the major financial aid it needs to modernize its domestically significant companies and increase foreign investment inflows by joining the WTO and international banks.

The Iranian leadership is quite concerned about the number of manufacturing jobs that multinational companies might add. This is the only way to address the enormous problem of unemployment. The innovative policies Iran has put in place to encourage knowledge-based SMEs will have a long-lasting impact on the economy of the country if large firms adopt technical breakthroughs made possible by SMRs and increase production efficiency. Iran may

someday grow to be a regional hub for higher education now that the nuclear accord has offered Iran some political stability. Iran might be a desirable site for its neighbors due to its low commodity prices, huge admission capacity, and affordable tuition costs. If Iranian S&T results are broadly disseminated among international students, their number of citations may increase. All of this is dependent on Iran forging friendly ties with its neighbors. In terms of international trade and economic development, there are connections between the World Trade Organization (WTO) and Science, Technology, and Innovation (STI). Let's examine the relationship between the WTO and STI in relation to Pakistan, Iran, and Turkey:

The WTO and STI in Iran:

Iran has been a WTO member since 2005. Iran has access to the WTO as a forum for trade negotiations, participation in international trade debates, and gainful participation in a multilateral trading system that is governed by regulations. Iran understands the value of innovation and technical progress for economic growth in terms of STI. To encourage domestic R&D, technological transfer, and entrepreneurship, the nation has put measures into place. Iran's STI initiatives can help it become more competitive in international trade and adhere to WTO rules.

The WTO and STI in Turkey:

Turkey joined the WTO in 1995. Turkey's accessions to international markets and absorption into the world trade system have been made possible by its WTO membership. Regarding STI, Turkey has emphasized the contribution of invention and technical advancement to its economic expansion. The nation has put rules into place to encourage R&D, industry-academia collaboration, and entrepreneurship. Turkey's emphasis on STI can improve its ability to compete in global trade and allow it to adhere to WTO rules and regulations.

The WTO and STI in Pakistan:

In 1995, Pakistan joined the WTO. Pakistan has been able to trade internationally, take advantage of chances for market access, and take part in international trade talks because to its WTO membership. Regarding STI, Pakistan acknowledges the value of innovation and technical progress for economic growth. The nation has taken actions to foster technology transfer,

advance R&D, and create a knowledge-based economy. The WTO's principles and regulations can be complied with while also increasing Pakistan's competitiveness in international commerce. WTO offers a framework for its participants, including Iran, Turkey, and Pakistan, to engage in global trade, assure fair and predictable trade practices, and advance economic development. By promoting innovation, technical advancements, and knowledge-based economies, STI plays a critical role in improving these nations' competitiveness in international trade. These nations can use their scientific and technical capabilities to promote sustainable economic growth and fulfill their WTO commitments by integrating STI policies with them.

Asian STI policy comparison

Investment in science, technology, and innovation (STI) must be the cornerstone of a productivity-driven economic recovery and sustainable growth. Despite tremendous advances in productivity over the past few decades, developing economies in Asia and the Pacific have witnessed economic expansion that has been predominantly fueled by factor accumulation. The current economic slump has been exacerbated by this, and efforts to effectively promote the 2030 Agenda for Sustainable Development may be jeopardized. One of the keys to the rise in productivity is a workforce with a high level of expertise (*Pakistan's Implementation of the 2030 Agenda for Sustainable Development Goals: Voluntry National Review. SDG Section, Ministry of Planning, Development and Reforms, Government of Pakistan, Islamabad.*, 2019).

The good news is that the Asia-Pacific region already has some of the most dynamic and innovative economies in the world. It also leads the world in complex scientific research, cutting-edge corporate environments, and socially inclusive government initiatives. Several Asia-Pacific economies are among the top in terms of research spending as a percentage of GDP, with the Asia-Pacific region accounting for around 43% of global research and development (R&D) investment. In just 2013, rising Asian economies spent more than $650 billion on research and development. Meanwhile, only a small number of economies have experienced these amazing advancements. For instance, 95% of the researchers in the region reside in just five countries. To meet the objectives of the 2030 Agenda, the Asia-Pacific region will need to make the most of all its potential resources, with a focus on broadening the STI network. The least developed countries (LDCs) should give this consideration. Business as usual is not an option if the region

wants to properly use STI to achieve the Sustainable Development Goals. Due to the size and complexity of the Goals, significant advances in science and technology are also required, coupled with a fundamentally novel and innovative strategy.

The region's scant STI achievements, however, won't be sufficient to ensure that the Goals will be accomplished in the ensuing 15 years. Particularly with relation to LDCs, four issues require immediate attention: We must first develop a common and useful conceptual framework for STI to make it more economically and socially accessible and enhance climate resilience and the reduction of carbon emissions. Such a system requires reliable institutions, a sound digital infrastructure, appropriate legal and regulatory frameworks, a dedication to and encouragement of investment, as well as a workforce prepared for the future.

Governments will also need to implement extensive and forward-looking STI policies that entice investors and businesses to support the economic, social, and environmental sides of sustainable development to carry out the Goals. As a result, any reporting criterion must expressly take into consideration all three outcomes. Third, to achieve sustainable development, STI policies and strategies need to be inclusive, open, and collaborative. It will be crucial to innovate inclusively, involve vulnerable people in the process, and develop technologies that are affordable and available to those who live in poverty if we want to make sure that no one is left behind. Regional STI collaboration has a lot of space to grow throughout Asia and the Pacific. The challenge is to create tangible and sustainable opportunities for innovation and technology sharing to close the gaps that still exist, iv - Policy Approaches for Least Developed Countries to enable countries at all levels of development to benefit from available technologies, and to develop a strong regional innovation culture. Regional cooperation will be crucial for exchanging best practices and addressing the opportunities and challenges that this quickly changing topic provides. The benefits of a larger STI net are inextricably tied to the accomplishment of the 2030 Agenda.

Challenges in Science, Technology, and Innovation and Major Development

It is impossible to measure and manage modern life without technology. Technology has altered how we communicate with one another, life, work, travel, play, and even perform religious duties and rituals. Every aspect of life in the modern world is impacted by technology in some

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way. According to the National STI Policy 2022 of Pakistan, meeting basic human needs, attaining rapid economic growth & development, boosting quality of life, and strengthening governance are the four key societal challenges, like many other emerging nations, and therefore must be addressed with appropriate STI policy (Figure 2.1). These challenges are also reflected by UN through Sustainable Development Goals (SDGs) and therefore also proves the relationship between SDGs and STI. It is only technological breakthroughs and innovation which can significantly help address all these challenges.

Figure 2.1. Science, Technology & Innovation and Key Societal Challenges in Pakistan

Source: National STI Policy (2022)

Technology is the systematic implementation of science, which is the fundamental understanding of nature. Innovation, on the opposing hand, is the application of knowledge to practical problems. In every nation, maintaining national security and improving the standard of living are the main goals of governance. Additionally, these need to be interpreted broadly. Through economic and military power, science, and technology (S&T) plays a crucial role in both fields and has disruptive effects. Some technologies can even disrupt the exiting systems in countries and can cause economic impacts e.g. damaging business and eliminate job etc. (Mclaren & Kattel, 2022). Therefore, state structures must adapt to S&T advancements to handle social issues and challenges. Considering this, STI policy and practice are crucial, and state and local governments must all be involved. STI occurs in a multi-player national ecosystem (Lytras et al.,

2022). Governments and corporations have provided spending for science and technology, built institutions, and implemented policies. S&T knowledge today comes from people working in the public and private sectors. S&T and information in general depend heavily on human resources. Technology has a disruptive effect that can alter the distribution of power and the economic activities within nations, which can exacerbate inequality and lead to job losses and job displacement (Balakrishnan, 2010).

Methodology:

Researchers that use a mixed technique often gather and evaluate qualitative and quantitative data both which may be from surveys, observations, interviews, document analysis, or statistical data. Depending on the research objectives and design, different methodologies may be used in a specific order. The following are some essentials of mixed methods research: In mixed methodology research, qualitative and quantitative data are combined, frequently by combining, connecting, or contrasting the results from each methodology. This fusion can take place at various points, as during data gathering, processing, or interpretation. Research topics that cannot be fully investigated by a single approach can be addressed by combining mixed methodologies. While quantitative approaches allow for generalization, statistical analysis, and numerical representation of data, qualitative methods offer in-depth insights, examine complicated social phenomena, and capture rich contextual information. Research using multiple methodologies might be carried out sequentially or concurrently. In a sequential design, one technique is put into practice first, then another.

The data collection procedure used in mixed methodology research frequently combines qualitative and quantitative techniques. The steps in data collection utilizing a mixed methodology approach are as follows: Specify the research objectives: The objectives of the research are clearly stated in chapter 2. The research question of the study calls for a mixed methods approach. It is desired to discuss what specific data or insights, from both qualitative and quantitative perspectives, are required to be collected. A research framework is created in figure 2.1 that specifies the general layout of research investigation, considering the ordering and fusion of qualitative and quantitative approaches. A sequential design is to discuss two different sorts of data gathered and analyzed.

Choose population: For comparing the STI policies, Turkey and Iran are selected as the study's target. For interviews, participants are selected from three countries including Pakistan. Depending on the research objectives, the purposive sampling and convenience sampling are adopted in this research. Collecting qualitative data: Complete activities for qualitative data gathering include focus group discussion, interviews, and content analysis of STI policies and the interview transcripts. These qualitative data collection tools produce rich, contextual data and are in line with Science, Technology and Innovation Policy of Turkey, Iran and Pakistan. Collecting quantitative data: The data is collected through a questionnaire designed as a quantitative tool to be analyzed statistically for gaining numerical insights. It covers a critical issue for many developing nations, such as Pakistan, who are attempting to improve their capacities in science, technology, and innovation to promote economic growth and development. Valid insights are gained from a comparison of Turkey's and Iran's STI policies since it is showing how their tactics, strategies, and results differ and overlap in important ways that Pakistan can learn from. Understanding how respective STI policies interact and influence one another is important from a regional development viewpoint given the proximity of Turkey, Iran, and Pakistan.

The comparison between Turkey and Iran specifically, two nations with different sociopolitical, economic, and technological circumstances, is interesting. A study that compares how different STI policies affect Pakistan provided a novel insight. Then evaluating these STI policies through the OMAR framework of six components and 22 policy responses is itself a novelty. When the issue focuses on how Pakistan may apply successful aspects of the Turkish and Iranian governments' policies to its situation, it becomes more original. This study includes proposals that go beyond simple policy analysis. The study is providing fresh perspectives and reflect the current situation if it considers the most recent events and policy modifications in Pakistan, Iran, and Turkey.

Analysis:

In order to response to this objective, all the policy documents mentioned in the literature review chapter for Turkey, Iran and Pakistan are classified by mapping their policy statements against the six components of the STI Policy by Omar. Each policy document titled in the previous

chapter has multiple policy statement e.g. the National Science, Technology and Innovation Policy (2022) available at most.comsatshosting.com/Policies/NSTPolicy2022.pdf has nine chapters and under these nine chapter 61 policy statements are proposed. The content analysis is done to explore the frequency of these policy statements in accordance with the six components related to the theory of Omar. The six components are already discussed in the previous chapter. The frequency of these six components is given in table 4.1.

Table 4.1. Pakistan, Turkey and Iran policy statements illustrating presence of six STI policy components.

	Pakistan	**Turkey**	**Iran**	**Total**
International collaboration in STI	1	3	1	5
Policy for STI	16	19	19	54
STI and Community	4	7	8	19
STI and Governance	1	4	6	11
STI and Private sector	0	1	1	2
STI for Policy	21	10	9	40
Total	53	44	44	131

Above table is showing the comparison between Pakistan, Turkey and Iran with respect to the six components of the STI policy. It is found that for international collaboration Pakistan has made only 1 policy, Turkey has made 3 policies and Iran made only 1 policy. It shows that Turkey has more focus on international collaboration for STI in their country whereas Iran and Pakistan are at same level. For Policy for STI Pakistan has made 16 policies, Turkey has made 19 policies and Iran has made 19 policies, which shows that Turkey and Iran are more focused towards Policy for STI compared to Pakistan. For STI and community Iran has made highest number of

polices which is 8, turkey has made 7 which is almost close to Iran and Pakistan has made only 4 policies. It shows that Iran and Turkey are paying more attention to developing STI for their community in their country whereas Pakistan is very steady in the race of creating this STI community.

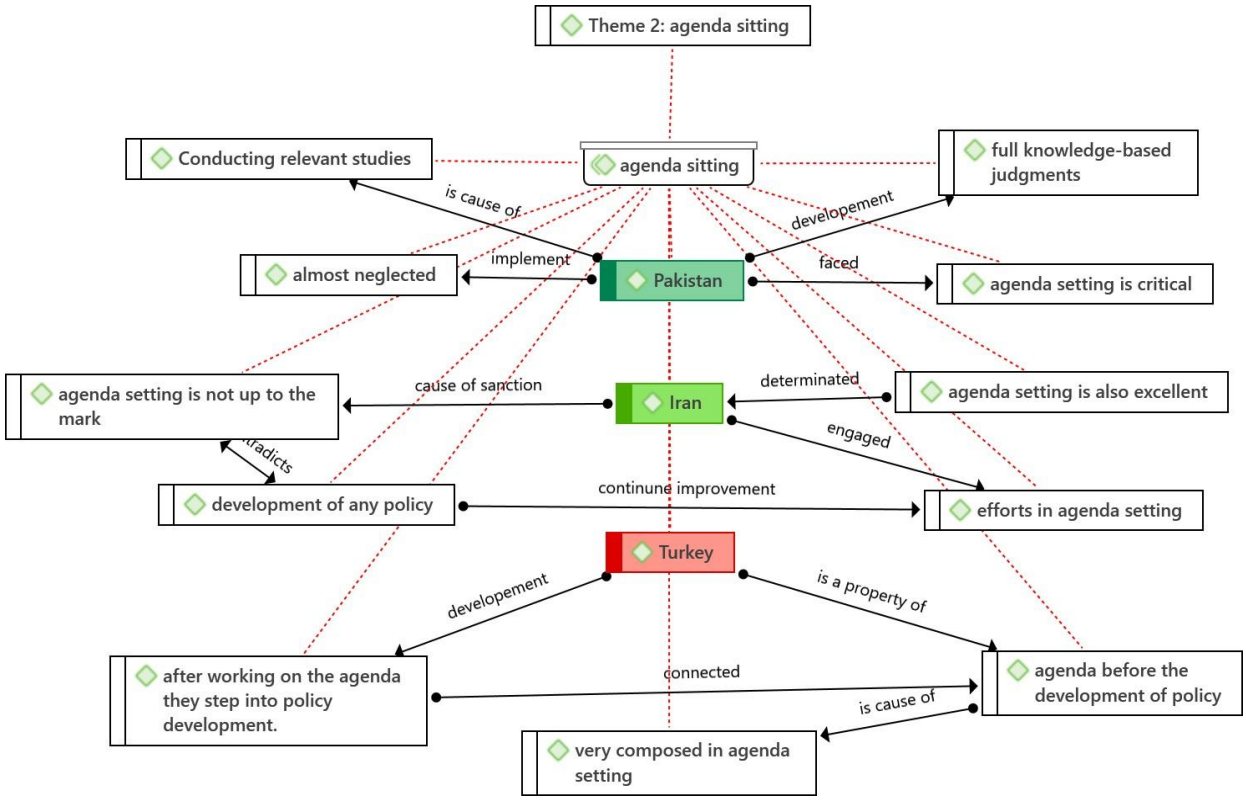

Figure 4.1: Lessons learned based on content analysis supported by statements of focal persons for the agenda setting stage of policy life cycle.

Lessons explored through analysis for Pakistan:

No periodic evaluations of the STI policy's efficacy and applicability is observed: This stage is usually a part of review and revision of STI policies in Pakistan. This assessment entails assessing the degree to which the policy objectives have been met, finding any gaps or difficulties, and making the required corrections to address new priorities and changes in the STI environment. These reviews and changes are carried out by the Ministry of Science and Technology in coordination with the pertinent parties, however there is no consistency being observed in these actions.

Lessons explored through analysis for Turkey:

Some consistency is observed: To ensure its efficacy and responsiveness to changing demands, the STI policy in Turkey goes through periodic evaluations and adjustments. In these assessments, the effectiveness of the policy's execution is evaluated, the effects of the actions taken are evaluated, and potential improvement areas are noted. Along with other important stakeholders, the Ministry of Industry and Technology is crucial to conducting these evaluations and updating the policy as necessary.

Lessons explored through analysis for Iran:

Special initiatives are taken: To adapt to shifting conditions and be in line with the nation's development objectives, the STI strategy is reviewed and revised in Iran. These procedures entail assessing the results and effects of the policy, determining its strengths and shortcomings, and making the required adjustments to increase its effectiveness. The evaluation and revision processes are coordinated by the Ministry of Science, Research, and Technology with assistance from other pertinent organizations. In all three nations, the review and revision procedures frequently entail meetings with a wide range of stakeholders, including governmental bodies, academic institutions, business representatives, research institutions, and civil society. The purpose of these consultations is to collect opinions, suggestions, and feedback from many viewpoints to inform the policy review and modification process.

Table 4.2 reliability of Ranking of effectiveness of the six stages of the policy life cycle in Pakistan

Variables	Rank	Cronbach's Alpha
Problem Identification	12.9	0.73
Agenda Setting	15.3	0.74
Policy Development	9.05	0.76
Policy Adoption	8.62	0.75
Policy Implementation	6.34	0.85
Policy Evaluation	4.51	0.70
STI policy system	3.45	0.82

The table 4.2 reveals ranking of all the six components of the STI policy life cycle in terms of its existence in the STI policy system in Pakistan. The performance of the STI policy system as a separate variable is measured to observe the overall ranking. The four stages are encountered by future problem identification (12.9), agenda setting (15.3), policy development (9.05), and policy adoption (8.62). According to the data collected from the 18 institutions, it is observed that government of Pakistan is not appropriately addressing the weaknesses of policy implementation (6.34) and policy evaluation (4.51) in STI policy system. In addition, the overall performance of the STI policy system is weak (3.45).

An evaluation of the consistency or reliability of a measurement or test is done using a statistics reliability table, which is part of above table. It offers details on the internal consistency or stability of the data gathered and aids in determining how error- and inconsistency-free the measurements are. Cronbach's Alpha is a widely used indicator of reliability and internal consistency. It evaluates how well a test or questionnaire's items or variables reliably reflect the same underlying construct. Higher numbers indicate greater reliability. Cronbach's alpha has a range from 0 to 1. The table shows the range from 0.70 to 0.85 and therefore adds the credibility of the questionnaire shared with the participants from the 18 institutions.

Table 4.3 Correlation amongst six stages of the policy life cycle

Pearson correlation	Problem Identification	Agenda Setting	Policy Development	Policy Adoption	Policy Implementation	Policy Evaluation
Problem Identification	1	-0.274	0.539	0.339	0.165	0.207
Agenda setting	-0.274	1	-0.509	-0.33	0.021	0.009
Policy Development	0.539	-0.509	1	0.24	-0.051	0.128
Policy Adoption	0.339	-0.33	0.24	1	0.049	0.113
Policy Implementation	0.165	0.021	-0.051	0.049	1	-0.001
Policy	0.207	0.009	0.128	0.113	-0.001	1

Evaluation						
Sig. (1-tailed)						
Problem identification	.	0.055	0	0.023	0.172	0.116
Agenda sitting	0.055	.	0.001	0.026	0.451	0.478
STI policy development	0	0.001	.	0.082	0.384	0.232
Policy adoption	0.023	0.026	0.082	.	0.389	0.258
Policy implementation	0.172	0.451	0.384	0.389	.	0.497
Policy evaluation	0.116	0.478	0.232	0.258	0.497	.

Table 4.3 displays a correlation matrix with significance levels for every correlation, as shown by the scores. The relationships between the many stages of the policy process—problem identification, agenda setting, policy development, adoption, implementation, and evaluation—appears to be represented by this matrix. Agenda setting and problem identification have a negative correlation (-0.274). Agenda framing and policy creation have a negative correlation of -0.509, respectively. Policy implementation and policy evaluation have a negative correlation of -0.051 and -0.001, respectively. Adoption of policies and problem identification are significantly correlated (0.023); agenda-setting is significantly correlated (0.001) with both policy creation and adoption (0.026). The collective data indicates that agenda-setting is not regarded as highly significant when it comes to problem identification, policy development, and adoption. Similar to this, Pakistan's STI policy system's policy implementation and policy evaluation do not complement one another. The Pakistani government did not adequately create and implement the STI policy system during the six stages of the policy life cycle.

Table 4.4 Model summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics			
					R Square Change	F Change	Sig. F Change	

1	.433	0.632	0.679	4.77630	0.232	0.584	0.020

a. Predictors: (Constant), policy evaluation, policy implementation, agenda sitting, policy adoption, problem identification, policy development

b. Dependent Variable: STI policy system in Pakistan

Table 4.4 presents the key conclusions and statistical data from a regression analysis of the correlation between the independent and dependent variables. The specific contents of a model summary can vary depending on the statistical package or program being used, but they often include the following components: 0.632 is the R-squared (R2) value evaluates the proportion of the variance of the dependent variable that can be explained by the independent variables. Higher numbers, which range from 0 to 1, suggest a better fit. The number of predictors in the model is taken into account by the adjusted R-squared value, which is 0.679. It provides a more reliable measure of model fit and penalizes the inclusion of unnecessary variables when comparing models with different numbers of predictors. The overall significance of the regression model is assessed using the F-test. The null hypothesis, which states that all regression coefficients are equal to zero, is only broken by the intercept. A significant value of 0.020 on the F-test suggests that the model provides a superior fit compared to the null or empty model. The results of the regression model indicate that the variance in Pakistan's STI policy system can be largely explained by the combination of predictors (policy assessment, policy execution, agenda setting, policy acceptance, problem identification, and policy formulation).

Table 4.5: ANOVA

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	79.979	6	13.33	0.584	0.007
Residual	638.764	28	22.813		
Total	718.743	34			

a Dependent Variable: STI policy system in Pakistan

b Predictors: (Constant), policy evaluation, policy implementation, agenda sitting, policy adoption, problem identification, policy development

Table 4.5 shows the ANOVA (analysis of variance). An estimate of the typical variance for each source of variation is given by F-statistic (0.584) with significant p-vale (0.007) representing significant effect and stronger evidence against the null hypotheses. Therefore, null hypothesis is

rejected and alternative hypothesis showing impact of six stages of life cycle on the STI policy system is accepted. To understand the impact of every stage of the life cycle on the STI policy system in Pakistan table 4.12 offers the details of coefficients. Coefficients: For every independent variable in the model, the estimated regression coefficients (sometimes referred to as parameter estimates) are shown in this section. The coefficient value, standard error, t-value, and p-value are all included.

Table 4.6. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	10.892	12.105		0.9	0.037
	Problem Identification	0.308	0.239	0.293	1.289	0.020
	Agenda Setting	0.206	0.193	0.229	1.064	0.02
	Policy Development	0.045	0.291	0.037	0.156	0.877
	Policy Adoption	0.09	0.258	0.069	0.35	0.729
	Policy Implementation	-0.35	0.524	-0.123	-0.668	0.51
	Policy Evaluation	-0.162	0.349	-0.085	-0.464	0.646

a Dependent Variable: STI policy system in Pakistan

Overall analysis of the lessons learned in the context of Pakistan clearly highlights the existence of the STI system, in the form of ministries and other institutes. However, it is also reflected that human capital that works in these institutions are not aligned with the stages of policy life cycle and therefore further exploration at the level of HUMAN CAPITAL is desired to be considered as one of the important dimensions for Pakistan to grow for the STI Policy. Secondly, it is also observed that in the case of Turkey and Iran, much emphasis is given on alignment of R&D with national objectives and on entrepreneurship. Therefore, RESEARCH AND DEVELOPMENT and ENTREPRENEURSHIP, both are also highlighted as important dimensions of improvement for Pakistan to grow in the STI policy of policy life cycle. To measure the extent of the Policy

responses through 22 indicators in an assessment matrix of the Science Technology and Innovation Policy for validating dimensions of improvement in Pakistan

In order to meet this goal, an assessment matrix, shown in table 4.13 below, is mapped to the 22 elements of the Omar theory. Similar to goal 1, the policy papers are assessed using content analysis to see whether or not these responses are included in the policies of Iran, Pakistan, and Turkey. The table's right side presents conclusions from content analysis, while the left side examines 22 policy responses. The first objective's interpretation led to an investigation of three crucial areas Pakistan should focus on: entrepreneurship, R&D, and human capital. This goal will assist in confirming whether or whether responses are generated along these three dimensions, or whether they remain poor in policy responses as well. Overall analysis of the lessons learned from Turkey and Iran for Pakistan still reflect the same dimensions of improvement which need concentration and effort to work upon. One of the dimensions highlights as the results of 22 policy responses is “capacity building”. The same dimension is explored through the objective one which is now validated here and emphasizes much on the need of HUMAN CAPITAL. Another policy response mentions the RD&C which is an acronym of research, development and commercialization. Therefore, two more proposed dimensions of improvement earlier, RESEARCH AND DEVELOPMENT and ENTREPRENEURSHIP, are also considered as the outcome of objective 2. Therefore, in objective 3, these three dimensions will be explored in detail for exploring the performance of different policy making institutes in the context of Pakistan.

Conclusion and Recommendations

Conclusion

The first chapter set the stage for the research by outlining the importance of STI for economic development in Pakistan. It provided an overview of the country's research institutions and discussed their roles in conducting scientific research. However, limitations like lack of funding, weak collaboration between sectors, and shortage of specialized talent that impede performance were highlighted. The chapter also analyzed STI policies of Turkey and Iran. It noted opportunities for Pakistan to collaborate with and learn from Turkey's actively engaging in international partnerships and knowledge sharing approaches. Insights into Iran's focus on self-

reliance despite sanctions could also inform Pakistan's strategies. By introducing the research objectives to evaluate STI policies, explore gaps, and propose solutions, this chapter established the scope and direction of the entire study. The introduction effectively laid the groundwork to delve deeper into evaluating Pakistan's STI landscape.

This second chapter analyzed the STI frameworks and initiatives globally as well as in other countries in thorough detail. It provided an in-depth comparison of approaches taken by dominant players like the EU nations alongside emerging economies of Asia including Turkey, Iran and Pakistan. A close examination of Pakistan's national STI policies spanning 1984, 1993, 2012 and 2022 aided in understanding evolution of the country's innovation agenda over time. This helped establish linkages between STI and economic well-being, social advancement as well as national development – thereby emphasizing STI's vital role. By reviewing a wealth of literature, this chapter formed a solid foundation to benchmark best practices and critically analyze the current realities of Pakistan's STI ecosystem. It facilitated identification of viable strategies, opportunities and gaps to be explored.

The third chapter methodically outlined the mixed research approach adopted, delving into quantitative and qualitative data collection steps individually. It clearly defined research objectives, identified the target population, and discussed appropriate sampling techniques. Data collection tools including surveys and interview guides were described along with management and analytical procedures for quantitative and qualitative strands respectively. By laying out the systematic methodology in a step-by-step manner, this chapter provided a robust structure to rigorously execute the primary and exploratory research as intended. It ensured collection of credible evidence to fulfill research aims.

The fourth chapter evaluated the four objectives of this research. The first and second objectives used the Omar method of six components and 22 policy responses. The policymaking process by outlining the standard policy cycle framework is also evaluated. A thorough analysis of each stage – from problem identification to evaluation – was conducted. Gaps like lack of coordination, limited stakeholder engagement and deficiencies in proper development, adoption and implementation of policies across stages were identified. This highlighted the urgent need for Pakistan to methodically work through the entire policy lifecycle approach. The findings are

then evaluated through human capital, R&D projects and entrepreneurship opportunities in the third objective. The results demonstrated clear shortcomings in institutionalizing established processes – thereby impeding optimal translation of innovation agenda into tangible outcomes. The analysis underlined reforms required across Pakistan's policymaking system. Finally, the objective four the NASTIC framework is proposed as an outcome for the knowledge contribution of this study. This chapter delved into the significance of robust R&D infrastructure for high-impact research and innovation. It acknowledged infrastructure development and capacity augmentation needs prevailing within Pakistan's research organizations.

The fifth chapter then emphasized the findings and discussions and propose for strengthening industry-academia linkages through collaborative platforms and attracting global talent. It argued that targeted investments are crucial to empower researchers with state-of-the-art infrastructure, foster knowledge exchange networks and uplift socioeconomic progress. Continued prioritization of infrastructural growth was proposed vital to enable evidence-based decision making, problem-solving and long-term competitiveness of Pakistan's STI sector.

Recommendations

A comprehensive and multifaceted approach is needed to bridge gaps in Pakistan's Science, Technology, and Innovation (STI) policy concerning the dimensions of improvements including human capital, Research and Development (R&D), and entrepreneurial opportunities. Making R&D investments in cutting-edge fields like renewable energy, biotechnology, nanotechnology, and artificial intelligence must be a priority but keeping in mind that how these ubiquitous technologies will help in meeting the key societal challenges. Creating research facilities and partnerships to remain at the forefront of developments around the world is important but keeping in mind the exact requirements of Pakistan and its existing strengths and weaknesses. Promoting applied research, strengthening connections between academic institutions and business sectors, promoting collaborative efforts, internships, and initiatives for technology transfer, all are important steps towards progress. Creating innovation hubs and clusters to connect research institutions, startups, and well-established businesses along with an atmosphere that rewards experimentation and taking risks. Investing in research and development pertaining to data privacy and cyber-security to guarantee the safety of digital assets and providing a

framework for the ethical and responsible application of developing technology, both are important actions.

The following suggestions are extracted from this study after taking into consideration the comparisons of Pakistan, Turkey and Iran in terms of addressing key societal challenges fostering science, technology, and innovation (STI) system:

1. Research and development (R&D) spending should be increased in Pakistan to promote creativity and technological development. An increase in the national budget's R&D spending will improve research capacity, encourage academic-industry cooperation, and foster innovation-driven growth to meet the key societal challenges.

2. Strengthening Universities and Research Institutions: Pakistan should put emphasis on bolstering universities and research institutes by giving sufficient financing, facilities, and resources are proposed by the National STI Policy 2022. This will support multidisciplinary research, recruit and keep brilliant researchers, and foster information sharing with other countries' institutions.

3. Supporting Startups and Entrepreneurship: It's crucial to foster an environment that encourages entrepreneurship. To support businesses and give them access to capital, mentorship, and business growth possibilities, Pakistan can set up entrepreneurship centers, incubators, and hubs for innovation. Collaboration between startups, business, and academics will promote economic development and innovation in the fields proposed by SFIC and other institutions.

4. Strengthening Industry-Academia partnership: For technology transfer and the commercialization of research findings, industry and academic partnership must be strengthened. Pakistan should set up systems to encourage collaborations, shared research endeavors, and knowledge exchange between academic institutions, research organizations, and business sectors.

The STI growth is a global phenomenon, however, countries need to develop STI policies and proposals which are customized to their national requirements and goals because each nation, region and sector has different challenges and contexts. The NASTIC framework suggested through this study, however, can serve as Pakistan's springboard for strengthening its STI

capacities, addressing social issues, and absorbing lessons from Turkey, Iran, and other nations through six components and 22 policy responses, well designed to achieve STI goals.

By focusing on inclusion, diversity and sustainability in the STI system, Pakistan may harness its human capital and technological advances to create an equal and prosperous society. To ensure that the benefits of STI reach all segments of the population, it is necessary to review progress on a regular basis, solicit feedback from all stakeholders, and alter techniques.

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Annexure A

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