How Does the Evidence-Based Approach Contribute to Ethical Policy-Making in Science and Technology?

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Abstract: Evidence-based policy-making is a continuous process of collecting valid and ethical information, intelligently analyzing it, and effectively communicating the findings to policymakers at the operational level in a controlled manner. This approach enables policymakers to take a proactive stance toward the consequences of science and technology (S&T) and develop ethical policies to achieve favorable economic and social outcomes in the S&T field. The purpose of this research is to describe how the evidence-based approach contributes to ethical policy-making in science and technology (S&T). To achieve this goal of explaining the evidence-based policy-making approach, the concept of strategic intelligence in policy-making has been utilized to elucidate the theoretical foundations of the research. The ethical components of evidence-based policy-making are then identified from relevant resources and documents through a documentary study. To classify the ethical components of evidence-based policy-making, identify the relationships between them, and formulate the framework for evidence-based ethical policy-making, a thematic analysis method inspired by the 7-step approach of Noblit and Hare (1988) has been used. Based on the results of this research, the steps of evidence-based ethical policy-making include the identification of information sources, the use of analytical tools

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for strategic intelligence in policy-making, policy intelligence, and ethical policy formulation. Also, in all these steps, policymakers must adhere to ethical principles of politics, which include participation, objectivity, methodicality, and learning.

Keywords: Evidence-based Approach, Ethical Policy-making, Strategic Intelligence, Science and Technology, Intelligence Tools

1. Introduction

Although scientific and technological developments are necessary for economic development and the overall well-being of society and humanity, some of them may have negative consequences. The negative consequences of scientific and technological developments are at the origin of important and urgent ethical questions in the fields of "the effects of science and technology (S&T) on social norms", "how to control the effects of new technologies" and "consultants in the field of the effects of new technologies" (Van Est et al., 2014, Ladikas et al., 2015). In recent decades, these questions and many other questions have led to the expansion of ethical debates around S&T, and in addition to experts, many non-experts also engage in ethical debates in the field of S&T to express their opinions, which means the intensity and the majority of voices in the society are around these fields. Because, people are afraid of the negative consequences of S&T and want to protect social values against the influence of new values that have emerged through the development of S&T, which seem to show less respect and attention to living beings (Bovenkerk, 2012).

Ethical discussions about S&T as a form of social interaction and a platform of consultation and dialogue, which is influenced by the values and socio-cultural norms of the society, is an important input for S&T policy-making and in many cases, it determines the mandatory or non-mandatory policy actions and policy orientations (Ladikas et al., 2015). This has led to a significant integration of morality in S&T policy-making. As a result, many scientific journals now discuss the ethical aspects of S&T policy-making, including issues such as privacy, intellectual property rights, access, equality, and inclusion. These topics have garnered the attention of scientists and researchers. Although ethics is an independent concept, the incorporation of ethics in policy-making does not happen alone, rather it is also influenced by various factors involved in policy formulation, such as culture, values,

history, official government structures (government institutions involved in policy-making), informal structures, etc., all of which affect the expression and orientation of ethical issues (Burgess, 2014). In addition, one of the prerequisites of ethical policy-making is that policymakers pay attention to S&T policies as a pre-hand tool that must have sufficient insight into the impact of scientific and technological developments on the social, economic, and moral structure of society (Brom et al., 2015). This issue explores the concept of strategic intelligence in policy-making. Strategic intelligence supports policymakers by offering early warnings, minimizing risk and uncertainty, and providing policy recommendations (Evans, 2012; McKie & Heath, 2016; Kuosa, 2014; Cagnin et al., 2008). Strategic intelligence emphasizes the importance of multidisciplinary aspects in policy-making, which include social, political, economic, defense and security, geography, logistics and communications, and government and diplomacy variables. Because attention to multidisciplinary aspects and strategic information can help governments to maximize national interests. Therefore, strategic information, which is called evidence in this research, can provide accurate considerations for policy making (Salya, 2022).

Evidence-based policy-making cycles can show the effects of strategic intelligence in policy-making (Georghiou & Keenan, 2006). Evidence-based policy-making, while creating a kind of strategic intelligence in the policy-making process, helps to formulate effective and informed policies by placing accurate and valid evidence at the heart of the policy-making process. According to the characteristics of this policy approach, it seems that its application can provide a platform for developing ethical policies (Miri Rami, 2022). Although Evidence-based policy-making is the subject of discussion in many policy studies, there are practical challenges associated with this policy approach. One of the most important challenges is the lack of agreement on the nature and types of evidence suitable for S&T policymaking. However, for evidence to have a greater impact on policy and practice, a key requirement is agreement on evidence that can be applied to S&T policy (Boaz & Davies, 2019; Nutley et al., 2002). Moreover, policymakers are often surrounded by a lot of evidence (Pittore, et al., 2017). However, evidence is not used in policymaking due to several obstacles. Some of these are lack of evidence access mechanisms, policymakers' ignorance of the importance of using evidence in policymaking, lack of support for the production

of effective research evidence for use in policymaking, policymakers' suspicion of the validity of research evidence, insufficient technical skills of policymakers in the use of evidence, and lack of guidance for the use of evidence in policymaking (Namdarian & Rasouli, 2021; Punton, 2016).

In this regard, the main questions of the current research are (1) how evidence-based policy-making helps to formulate ethical policies? (2) What are the most important sources of evidence for S&T policymaking? (3) What are the most important policy tools that provide the evidence needed for S&T policymaking?

To answer these questions, the second section of this paper deals with the theoretical backgrounds of the research, the third section with the methodology, the fourth section with the data analysis and the statement of the findings, and finally the fifth section with the discussion and conclusion.

2. Theoretical background

2-1. The evidence-based approach in policy-making

In the evidence-based approach, along with experiences, expertise, and individual and collective judgments, quality evidence is used in the formulation of policies through a detailed process (Antunes et al., 2022). This approach, by following the ethical principles of unbiasedness and methodicality (Leir & Parkhurst, 2016; Gray, 1997), largely prevents the entry of untested views of individuals or groups, ideological views, prejudices, or speculation into policy-making. "Unbiasedness" emphasizes the absence of bias and prejudice in the creation, selection, and interpretation of evidence (Leir & Parkhurst, 2016), and "methodicality" emphasizes that any perception, understanding, and the process of achieving the truth must be systematic (Hafner-Zimmermann, 2007, Tübke et al., 2001). For types of evidence, there are different categories such as official and unofficial statistics, university research results, expert opinions, survey results, attitudes and values (mentality), and findings based on monitoring and program evaluation (Arcos, 2016).

In many past studies, stakeholder participation has been recognized as a key factor in improving policy evidence (Caginin et al., 2008; Ghrbanizadeh et al., 2021; Hutler & Barnhill, 2021). In general, in cases where different values and beliefs, conflicting opinions, and interests of stakeholders and decision-makers are taken into consideration and approved for formulating policy recommendations,

the legitimacy of the evidence is more. The role of the participative approach in strengthening the legitimacy of the evidence can be explained in different ways: first, the participative approach eliminates the gap between the issues defined by scientific investigations and the experiences, values, and actions of the actors who are the main element in solving such issues; Second, participation helps identify differences, disagreements, perspectives, and interests related to issues; Thirdly, participation facilitates the definition of the problem and fourthly, participation increases the learning of the participants and in this way helps to improve the quality of decision making. In general, the perspective of evidence validity emphasizes the importance of integration and integration of stakeholders' knowledge and participation in creating accurate and correct evidence for policy making (Evans, 2012).

Various types of patterns and models have been presented for evidence-based policy-making, such as the triple flow model of Kingdon and Stano (1984), the evidence-based policy cycle of Hornby and Perera (2002), the policy development framework of Edwards (2005), Young and Quinn's (2002) policy cycle, and O'Dwyer's (2004) evidence-based policy-making process. Namdarian (2016) tried to provide a comprehensive framework for evidence-based policy-making based on these patterns and models using the meta-synthesis qualitative method and survey. This framework, which includes the features of existing models, is as follows:

Step 1. Problem identification: specific problems are brought to the attention of policymakers and given priority.

Step 2. Information gathering and information feeding of the policy-making process: obtaining information from all available information sources.

Step 3. Technology forecasting and assessment, policy advice and policy formulation: transforming knowledge from technology forecasting and assessment or results from collective processes into policy options that can be defined jointly with policymakers.

Step 4. Policy implementation: establishing procedures, writing guidance documents, or issuing grants to initiate policy-making work. In this phase, activities can be adapted to different policy-making bodies as well as other organizations and companies.

Step 5. Policy evaluation: To determine whether the policy has addressed the problem and whether the policy has been well implemented, it may be necessary to review the agenda, formulated, or implemented policy.

2-2. Information sources of ethical policy decisions

It should be noted that providing accurate and relevant information to policymakers helps them formulate more informed policies that enable society to reap the benefits of S&T. However, it is a mistake to think that information and statistics are the only factors that matter in making policy decisions related to information dissemination. These sources of information are necessary, but not sufficient. Some other information sources required for the policy-making process, which provide the foundation for formulating ethical policies, are described below.

2-2-1. Evidence from systematic research

Research evidence, sometimes referred to as scientific evidence, consists of factual or numerical (quantitative) and descriptive (qualitative) information. Research evidence can be obtained from various sources, such as performance monitoring, research studies, surveys, and evaluations. In general, the more a well-known and valid method is used in the design of research or an evaluation, the more convincing the resulting evidence will be. In any case, when preparing a document, it is important to use the “best available research evidence” (SPERU 2018). The necessity of using research evidence has been emphasized in the studies of Orem et al. (2012), Apollonio and Bero (2017), Nabavi and Jamali (2018), and Burns et al. (2022). The sources of research evidence and their definitions, advantages, and disadvantages are as follows:

- ◇ Systematic review: It is a systematic attempt to identify, evaluate and synthesize all empirical evidence (especially evaluations) that uses appropriate and predetermined criteria to answer a specific research question. A systematic review is a rigorous and reproducible method that produces a rapid, high-quality, and unbiased summary of a complete body of evidence. However, doing so may take a long time, so it may not be able to answer policy questions on time (SPERU, 2018).
- ◇ Randomized Control Trials (RCTs): A comparative study between two or more groups of eligible individuals. This study provides a very powerful answer to

the causal questions. It is often used in medical and health studies. Using this method on social issues is very complicated and difficult (SPERU, 2018).

- ◇ Delphi technique/expert panel: A group, who are experts on the subject, are asked to express their expert views and answers to the question through an iterative process. After each round of distribution of questions, the answers are summarized and published for discussion in the next round. This process is repeated until the consensus of the experts is reached. Although the process of this type of study is transparent and accurate, it requires a high level of motivation for the participation of experts. In addition, the quality and accuracy of the answers depend on the quality of expertise of the participants involved (SPERU, 2018).
- ◇ Case studies/focus groups: In case studies and focus groups, evidence is collected using surveys of users and service providers based on their experience. These methods help to get valuable insights from people (users), especially about the accessibility of services and their effectiveness. However, in these methods, group thinking or bias toward the status quo can affect the results (SPERU, 2018).
- ◇ Survey: A technique for collecting the opinions or experiences of a group of a larger population, to whom a summary of the results is presented. It can be multidimensional and cover a wide range of topics and subjects. If the survey is repeated at regular intervals, it can identify trends. However, survey data are not evidence in itself but must be analyzed. In addition, the survey sample can be too small to draw valid conclusions about the target population of the study (SPERU, 2018).
- ◇ Big data: Policymakers can utilize big data from social networks, cloud applications, software, social media, data warehouses, appliances, technology networks, legal documents, online business websites, meteorological data, and sensor data. Big data is a social phenomenon that can be used as an instrument and method of analysis in solving public problems (Supriyanto & Saputra, 2022).

Meanwhile, systematic reviews are very important in evidence-based policy-making because they not only provide a rigorous method for finding relevant and

high-quality studies but also integrate the findings of these studies to form a clear picture. Provide a more comprehensive presentation of a topic. This category of studies can provide the best policy solutions (Goughs et al., 2013). On the other hand, surveys and case studies have moderate effectiveness in policymaking and lead to relatively good policy solutions (Phillips et al., 2009).

2-2-2. Local and indigenous knowledge

Regarding the social challenges of S&T, different groups are in very different relationships with scientific, political, and policy processes. Gaps and inequalities of power and resources are among the reasons for the deep differences between these groups, their voices being silenced, or their withdrawal from the regimes of knowledge and politics. However, it should be stated that it is important to pay attention to the situation of indigenous people and more generally local and indigenous knowledge. Indigenous people have a unique perspective compared to other groups because of their cultural knowledge and their approach to engaging with contemporary S&T. This enables them to contribute to the identification and distribution of the “risks and benefits of S&T” and to anticipate how S&T will impact their society. Neglecting local and indigenous knowledge can be threatening when power relations are highly instrumental and unequal due to the technoscientific worldviews of policymakers. The importance of this issue is so significant that it has prompted the international community to make decisions aimed at promoting the value of local and indigenous knowledge and supporting the rights of indigenous and local people (COMEST, 2015).

2-3. Ethical Evidence-based policy making support methods and tools

In addition to information sources, suitable analytical methods and tools also play a significant role in formulating wise policies by policymakers. In this section, analytical methods and tools that support ethical policy-making are introduced.

2-3-1. Public perception research

The term “ethics” is debatable because what is considered an ethical issue by some people may be considered an economic issue by others; Sometimes it is difficult to separate prejudice and opinion from religious prescriptions in the case of ethics. Therefore, the influence of cultural norms on ethical issues is the main and undeniable issue. ethical beliefs are not empty and upbringing plays an important

role in shaping the notions of “right” and “wrong” (Sanderson, 2009). Emphasizing the “perception of right and wrong” requires accepting the importance of public perceptions in ethical discussion, regardless of their value origin. Therefore, public perception research, whether with quantitative or qualitative methods, is an integral part of the ethical debates surrounding any development of new S&T. Public perception surveys about S&T are important sources of feedback and information for policymakers. The widespread use of such surveys allows for direct comparisons between countries and cultures (Chaturvedi et al., 2015).

2-3-2. Technology assessment

Although technological innovations can bring enormous benefits in terms of material well-being, they can also create national security and moral dilemmas, all of which raise complex questions that policymakers must be prepared to consider with vigilance (Graves and Cook-Deehan, 2019). Therefore, one of the key challenges facing policymakers is how to better understand the negative or unintended social and economic consequences of technological developments and innovations (Tubke et al., 2001). Technology assessment is a tool that helps policymakers achieve such understanding. The US Congress definition of technology assessment is: “The process of objectively examining the consequences of technological change. This process includes examining the short-term benefits of technology in the economy, but it generally goes beyond this and identifies the influential parties and unintended consequences of technology in a broad and long-term manner, and examines both the favorable and unfavorable consequences of technology, because missing a golden opportunity is as harmful to society as facing an unforeseen danger” (Hetman, 1974).

Ethical criteria of various groups that are related to technology are influenced by technology and influence its formation whether they like it or not. Because of this, technology has become a focus for ethical conflicts between different groups. On the other hand, problems of technology legitimacy arise when the distribution of technological advantages and disadvantages is unequal. For example, depending on the place that is considered for the construction of a nuclear power plant or a waste recycling factory, or a chemical factory, those who are in the neighborhood of these industries have to bear more complications than others. In these cases, policy decisions are often not agreed upon by the affected people

or the general public. All these cases indicate the complexity and uncertainty in technology policy-making and the necessity of applying technology assessment results in technology policy-making. The new concept of technology assessment emphasizes the better connection between technology assessment and technology policy and helps to formulate inclusive and ethical technology policy (Tubke et al., 2001, Kaplan et al., 2021). Technology assessment in the modern sense has a more interactive nature than its previous forms and is presented as a process of studies and discussions that are in parallel and in close relation with decision-making processes. Participatory technology assessment reduces inequality and injustice by considering the plurality of views and values in society and involving them in policies. The task of participatory technology assessment is to create social groups (such as lobbies, influential citizens, professionals, and the general public) to participate in the technology assessment process and its consequences (Hennen, 1999).

In general, it can be said that the role of ethical assessment is to help policymakers see the values at stake and enable them to produce policies that are more evidence-based and less intuitive. Therefore, the integration of ethical assessment in technology assessment should clarify what is at stake instead of confirming a political approach (Graves & Cook-Deengan, 2019).

2-3-3. Technology forecasting

Technology forecasting refers to a systematic and targeted effort to understand, forecast, acquire, and exploit the characteristics and effects of technological changes, especially with regard to inventions and innovations. Technology forecasting involves predicting the future by analyzing past trends and, to some extent, employing creativity. This process helps to mitigate risk and uncertainty associated with future events. In addition, it is helpful to understand the characteristics of future technological innovations and the stance that should be taken towards them (Petropoulos et al., 2022). Revised 2: Technology forecasting is a structured and step-by-step process. The general steps involved are as follows: 1. Continuous identification and investigation of new and ongoing events, as well as scientific or technological fields that may lead to the development of new functions or attractive products in the future. 2. Confirmation step, where the gathered information is screened and evaluated based on a set of indicators.

This is done by consulting government, university, and industry experts. The aim is to determine the timing of possible events, the market potential of the products, their ability to solve problems, and their response to economic, social, or community needs. 3. Finally, the third step involves presenting special proposals to policymakers and decision-makers for the implementation of the calculated forecasts (Ghazinouri & Ghazinouri, 2016). Reason 2: The revised version improves the clarity and readability of the text by breaking down the steps of the technology forecasting process into separate sentences. It also provides additional information to enhance understanding.

2-3-4. Technology foresight

Technology foresight, looking into the long-term future, emphasizes the discovery of future opportunities and prioritization for investing in science and innovation activities that probably bring the most economic, social, and environmental benefits. Participating different actors in strategic discussions and networking and creating links among actors, sectors, or markets in the given issue is one of the important features of technology foresight (Martin & Johnston, 1999, Andersen & Andersen, 2014). The general process of foresight can be summarized in three steps: input, foresight, and output. In the input step, a strategic question is raised. Based on that, the scope of the foresight project is determined. Information is then extracted, collected, and stored from various sources such as publications and interviews with experts. The foresight step begins with the analysis of the collected data and then the data structure is interpreted in depth, which ultimately creates forward-looking insights. In the output step, possible futures are identified and evaluated, and policies and strategies are suggested for their realization (Durst et al., 2015).

It should be noted that due to the dynamics of the world, the traditional (top-down) policy-making approaches are ineffective and new approaches should be used. In the new policy-making approaches, it is assumed that there is a set of stakeholders who, while being influenced by the policy process, also have the ability to influence it. Foresight, as a participative process, is a valuable tool to aid policy-making in its modern context (Martin & Johnston, 1999). The knowledge obtained from foresight is pragmatic and takes into account the elements affecting the future, long-term trends, changes, and effective dynamics (Van der Steen & Van Twist, 2013).

2-3-5. Analysis of the social effects of Science, technology, and innovation and policy Reforms

In general, science, technology, and innovation policies in any country should take into account the impact of scientific and technological developments on the ethical and social structure of society. Today, in parallel with the growth and development of S&T, there have been questions raised about the impact of science, technology, and innovation on dominant social values such as justice, equality, autonomy, human dignity, and social harmony, all of which are closely related to individual and social life. Some technological innovations, such as the convergence between nanotechnology, information technology, biotechnology, and cognitive science, may have profound implications for privacy and citizenship. These implications raise fundamental ethical questions (Ladikas et al., 2015). Therefore, it is necessary to analyze the social consequences of S&T. The primary objective of assessing and analyzing the social impacts of science, technology, and innovation should be to drive policy reforms in this field (Finsterbusch, 1975). The development of indicators for measuring the social effects of S&T is a complex and challenging task. However, it is necessary and holds twofold importance, particularly in the case of emerging technologies. These indicators should be linked to research and responsible innovation (Chaturvedi et al., 2015). The Organization for Economic Co-operation and Development (OECD) is working on improving the current set of indicators by convening an expert group (Chaturvedi et al., 2015).

3. Research method

To identify how the evidence-based approach helps ethical policy-making in S&T, this research tries to identify the ethical components of evidence-based policy-making and then present these components in the form of a policy-making framework. In this regard, first, the ethical components of evidence-based policy-making are identified from related resources and documents using the qualitative method of documentary study. The documentary study method focuses on the analysis of those documents that contain information about the subject of study (Bailey, 1994; Mogalakwe, 2006). Based on this method, first, previous studies were retrieved from key bibliographic databases and engines, namely Google Scholar, Google Books, Web of Science, Scopus, EBSCO, and ERIC. Then,

through understanding the intentions and motivations of the sources, the ethical components related to the issue of evidence-based policy were extracted and cited. To classify the ethical components of evidence-based policy-making, identify the relationships between them, and formulate the framework of evidence-based ethical policy-making, a thematic analysis method inspired by the 7-step approach of Noblit and Hare (1988) has been used. Using this qualitative and interpretive method, ethical components are identified, coded, and analyzed, and a framework for understanding evidence-based ethical policy-making in S&T is provided inductively from these data (Charmaz, 2008). The stages of thematic analysis of the ethical components of evidence-based policy in S&T are described in Figure 1.

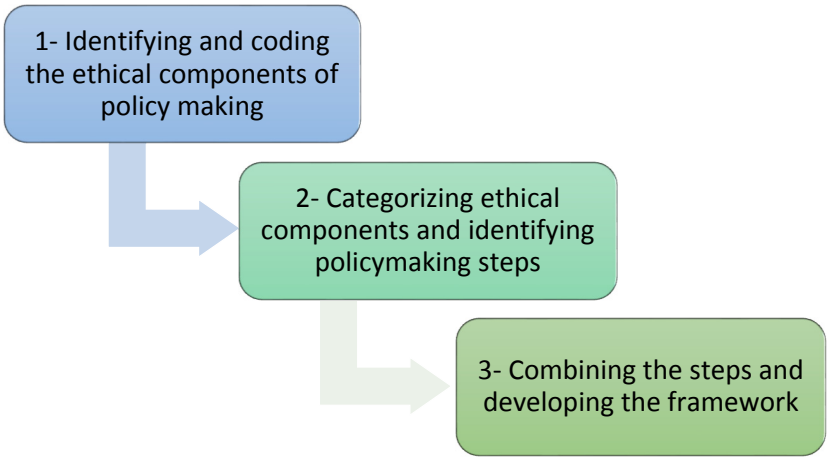

Fig 2. Development stages of the evidence-based ethical policy-making framework in S&T

To validate the evidence-based ethical policy-making framework in S&T, a nominal group meeting was held. The optimal group size for nominal groups varies between five and ten people in terms of productivity and satisfaction. When the number of participants in nominal groups increases to more than ten people, productivity and satisfaction will decrease (Burton et al., 1977). In this research, 5 experts from Iran's educational and research centers to which the authors had access participated in nominal group interviews. Considering the main concepts of this research, including policy-making, ethics, and policy intelligence, an effort was made to select experts with completely relevant specialized fields in a targeted

manner. Therefore, the specialty area of two experts in S&T ethics, two are S&T policy, and one is information technology management. Then, their opinions were asked about the components of the proposed framework. In general, based on the output of this meeting, all the components of this framework were approved.

4. Data analysis and findings

4-1. Identification of ethical components of evidence-based policy-making in S&T

Based on the study of research-related resources, 11 components for evidence-based ethical policy-making in S&T have been identified. In Table 1, each of these components is shown along with its specific code (Ci, i=1-11).

Table 1. Coding of the ethical components of evidence-based policy-making in S&T

Code	Component	Resources
C1	Participatory Technology Assessment	(Graves & Cook-Deehan 2019; Tubke et al., 2001; Hetman, 1974; Hennen, 1999; Kuosa, 2014; Owen et al., 2013; Hartley, Pearce, & Tylor, 2017; Trinder, 2008; COMEST, 2015; Kaplan et al., 2021)
C2	S&T foresight	(Ribeiro, Smith, & Miller, 2017; Martin & Johnston, 1999; Andersen & Andersen, 2014; Havas, Schartinger, & Weber, 2010)
C3	Using evidence from systematic research	(SPERU, 2018; Gough, Oliver, & Thomas, 2013; Phillips et al., 2009)
C4	Technology forecasting	(Petropoulos et al., 2022; Ghazinoory & Ghazinoori, 2012)
C5	Analysis of the social effects of science, technology, and innovation to carry out policy reforms	(Finsterbusch, 1975; Chaturvedi et al., 2015)
C6	Attention to local and indigenous knowledge about S&T and its effects	(COMEST, 2015)
C7	Public surveys about S&T (Perception Research)	(Decker & Ladikas, 2004; Chaturvedi et al., 2015)
C8	Converting the knowledge obtained from intelligence methods into policy options	(Evans, 2012; McKie & Heath, 2016; Kuosa, 2014; Calof, 2011; Cagnin et al., 2008)

Code	Component	Resources
C9	Identifying policy options taking into account ethical considerations	(Van de Poel & Royakkers, 2011; Namdarian, 2016)
C10	Ethical assessment of policy options	(Van de Poel & Royakkers, 2011; Namdarian, 2016)
C11	Decision-making, choosing the best policy option by considering ethical considerations and formulating policy	(Van de Poel & Royakkers, 2011; Namdarian, 2016)

4-2. Classification of components and identification of evidence-based ethical policy-making steps in S&T

In this step, the ethical policy-making components have been categorized into equivalent categories through interpretation. For example, components (C3) and (C6), both of which pertain to the knowledge required for ethical policy-making, are grouped together in the same category. Also, (C1), (C2), (C4), (C5), and (C7), each of which in some way demonstrate the tools and methods used in the ethical policy-making process in S&T, are grouped together in the same category. In this way, interpretations have been made about other components and classes related to them, as shown in Table 2.

Table 2. Classification of equivalent components in different classes

Class	Components	
1	C3	Using evidence from systematic research
	C6	Attention to local and indigenous knowledge about S&T and its effects
2	C1	Participatory Technology Assessment
	C2	S&T foresight
	C4	Technology forecasting
	C5	Analysis of the social effects of science, technology, and innovation to carry out policy reforms
	C7	Public surveys about S&T (Perception Research)

Class	Components	
3	C8	Converting the knowledge obtained from intelligence methods into policy options
	C9	Identifying policy options taking into account ethical considerations
4	C10	Ethical assessment of policy options
	C11	Decision-making, choosing the best policy option by considering ethical considerations and formulating policy

4-3. Combining evidence-based ethical policy-making steps and framework development

After categorizing the components, an attempt was made to select a name for each category that would encompass the underlying concepts of the components and elucidate a stage in the evidence-based ethical policy-making process for S&T. Accordingly, the steps that have been identified, along with their related components, are shown in Table 3.

Table 3. Identifying evidence-based ethical policy-making steps in S&T

Step		Components	
1	Information sources identification	C3	Using evidence from systematic research
		C6	Attention to local and indigenous knowledge about S&T and its effects
2	The use of strategic information-analytical tools in policy-making	C1	Participatory Technology Assessment
		C2	S&T foresight
		C4	Technology forecasting
		C5	Analysis of the social effects of science, technology, and innovation to carry out policy reforms
		C7	Public surveys about S&T (Perception Research)
3	Political intelligence	C8	Converting the knowledge obtained from intelligence methods into policy options
		C9	Identifying policy options taking into account ethical considerations

Step		Components	
4	Ethical policy formulation	C10	Ethical assessment of policy options
		C11	Decision-making, choosing the best policy option by considering ethical considerations and formulating policy

5. Discussion and conclusion

As stated, the first question of this research is, “How does evidence-based policy-making help to formulate ethical policies?”

In response to this question, it must be stated that evidence-based policy-making formulates ethical policies by utilizing strategic intelligence. Strategic intelligence in policy-making emphasizes the importance of using evidence to inform decision-making. It involves the search, processing, dissemination, and protection of information with the goal of transferring this information to the appropriate person at the appropriate time to facilitate informed decision-making. The quality and effectiveness of strategic intelligence lie in its ability to provide a forward-looking perspective. It helps policymakers understand the context in which they are making decisions, how their decisions will impact the future, and the potential consequences that may arise (Tübke et al., 2001). The power of using political intelligence tools comes from adhering to ethical principles such as participation, objectivity, learning, and methodicality (Hafner-Zimmermann, 2007).

- ◇ Participation: Strategic intelligence in policy-making involves incorporating the viewpoints of all citizens, rather than just selected interest groups, in decision-making regarding controversial innovative technologies (Carothers & Brechenmacher, 2014). An ethical approach to the governance of science and the science-society relationship requires serious attention to procedures that can ensure widespread and effective citizen involvement in the deliberation and decision-making processes regarding controversial innovative technologies.
- ◇ Objectivity: Objectivity refers to the absence of bias and prejudice in the creation, selection, and interpretation of evidence. (Leir & Parkhurst, 2016) Strategic intelligence in policy-making makes the policy-making process objective by integrating unbiased information and conducting detailed analysis.

◇ Learning: Learning is a purposeful effort to formulate or modify policy goals and solve problems in response to previous experiences and new information (Sanderson, 2009). The use of strategic intelligence in policymaking promotes understanding and mutual learning among stakeholders, facilitating the creation of consensus.

◇ Methodicality: refers to the systematic nature of any perception, understanding, or process of reaching the truth (Hafner-Zimmermann, 2007; Tübke et al., 2001). Strategic intelligence tools facilitate policy-making, decision-making, and the implementation of decisions that have been adopted.

To ensure that the functions of strategic intelligence in policymaking are appropriate for the ethical policy environment, it is important to consider these principles at every stage of the policy-making process (Hafner-Zimmermann, 2007).

In general, the framework of ethical evidence-based policy-making is presented in Figure 2, based on the findings of this research.

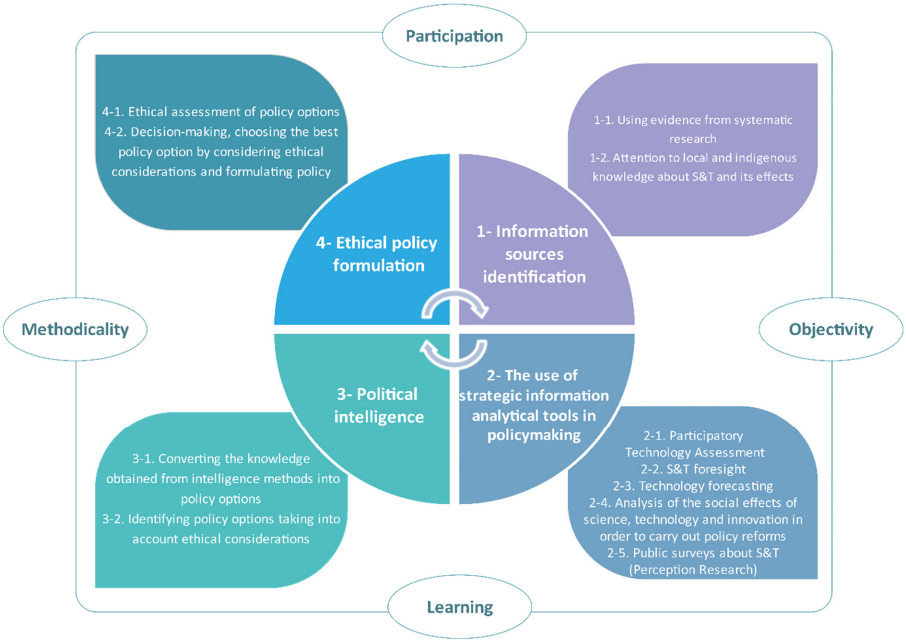

Fig 2. Ethical evidence-based policy framework in S&T

As stated, the second research question is “What are the most important

sources of evidence for S&T policymaking?" The answer to this question can be found in the findings of the research conducted in the first step of the ethical evidence-based policy framework. The first step of evidence-based ethical policy-making in S&T is the identification of information sources. This involves collecting accurate and reliable information from available sources to inform policy interventions. One of the most important sources of information is evidence from systematic research and local knowledge.

The third research question is "What are the most important policy tools that provide the evidence needed for S&T policy making?" The second step of evidence-based ethical policymaking emphasizes the utilization of various tools and methods for analyzing information sources. Participatory technology assessment, S&T foresight, technology forecasting, social impact analysis of science, technology, and innovation for policy reform, and public surveys about S&T are some of the most important methods. It can be said that all of these tools are prerequisites for the responsible innovation approach. This approach focuses on how to responsibly manage innovations and considers the ethical, social, and economic dimensions of innovation (Owen et al., 2013). Responsible innovation, achieved through the use of strategic intelligence tools in policy-making, enables the analysis of the social and ethical impacts of technology from its inception. This approach is proactive and active, as opposed to passive (Ribeiro, Smith, & Miller, 2017). By adopting this approach, instead of merely reacting to the effects and consequences of innovation, desirable social and ethical outcomes can be achieved (Hartley, Pearce, & Taylor, 2017).

In the third step of evidence-based ethical policy-making, the knowledge obtained from the previous step of analysis is transformed into various policy options and scenarios. Since, in real life, options are usually not pre-existing and have to be thought of and invented, the initiative of policymakers to develop solutions is very important.

In the fourth step of evidence-based ethical policy-making, after recognizing policy options, they are also ethically assessed. Various sources can be utilized for the ethical evaluation of these options. These sources include: ethical perspectives, inquiries, and dialogues from diverse social groups; ethical counseling frameworks; codes of ethics and codes of conduct; consideration of

ethical values and social acceptance criteria; and awareness of cultural norms and values. Using these sources, the potential outcomes and repercussions of each policy option should be predicted and assessed. After assessing the options, an effort is made to make a reasoned choice from among the various policy options. This choice can be analyzed using different ethical frameworks, such as consequentialist, duty-oriented, and virtue-oriented approaches.

The theoretical implications of the research results are as follows:

◇ The proposed framework of the current research, like a roadmap, shows policymakers how to integrate ethical components into the process of S&T policy-making.

This research demonstrated how policymakers can create practical and ethical policies by effectively utilizing strategic intelligence in policymaking. It is suggested that in future research, the proposed framework of the current research should be strengthened by incorporating general ethical theories in addition to the concept of strategic intelligence.

◇ This research presents a list of ethical components for S&T policymaking in Table 3. Researchers can utilize this list during both the policy formulation phase (ex-ante approach) and the evaluation phase of formulated policies (ex-post approach).

Researchers can utilize the proposed ethical components to assess policies formulated in a real case for future research. Based on the results of this research, the following practical suggestions are presented to S&T policymakers:

◇ One of the ethical actions in the process of drafting any policy document is to collect accurate and correct information from all available sources for policy interventions. The most important sources of information include the findings of systematic research as well as local and indigenous knowledge.

◇ It is necessary to utilize various tools and methods to analyze information sources and convert the knowledge acquired from them into tangible policy options for policymakers. Participatory technology assessment, S&T foresight, technology forecasting, social impact analysis of science, technology, and innovation for policy reform, and public surveys on S&T (perception research)

are some of the most important methods in this field.

◇ Evaluating and predicting the results and consequences of policy options with the assistance of ethical advisors, ethical codes, and charters is an essential step in the policy formulation process that should not be overlooked.
Formulated policies should be compatible with existing ethical frameworks so that ethical and unethical aspects of policies can be explained within the context of these frameworks.

◇ It is necessary to adopt a strategic approach to generate evidence in priority areas and to store that evidence in accurate and comprehensive knowledge bases.

◇ Effective dissemination of evidence and the development of efficient tools for widespread access are essential.

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