

TECHNOLOGY FORECASTING FOR DEVELOPING SMART INNOVATION AND ENTREPRENEURSHIP POLICY

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Abstract. *Competitive Innovation and Entrepreneurship Ecosystem (IEE) is recognized as the crucial force boosting development of a country. Governments are involved in developing smart policy with a balance of measures and instruments aimed at enhancing IEE competitive performance. Governments are oriented at developing evidence and data based management of IEE. Theoretical and practical focus on IEE metrics is vivid in the past decade. There is evidence of a steep rise in new approaches, models, methods and indices aimed at fulfilling the goal of creating influential government policies, and implementing, measuring and controlling their impact, adjusting them dynamically to be better attuned to the uncertainties and risks present in the IEE domains. Technology forecasting methods can be used and are argued to be appropriate in the process of planning and prioritizing the smart policy mix. We present a general framework for using a combination of the technology forecasting models and methods in the process of developing smart policy measures and instruments for reaching the development goals effectively.*

Keywords: *innovation and entrepreneurship ecosystem, smart policy mix, technology forecasting, framework*

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1. INTRODUCTION

Innovation and Entrepreneurship Ecosystem (IEE) development is achieved by introducing policy measures and instruments that will target the set of social and economic objectives and goals to be reached in the given time period. The specific nature of the Ecosystem Approach (EA) and its main strengths lie in its comprehensive, holistic perspective. Governments need support in creating a smart policy mix best suited to the development goals and the concrete ecosystem characteristics of a country. The Ecosystem is identified by recognizing the relevant actors, their activities, relations, strategy and their influences affecting future overall results and achievements. The IEE comprises innovation and entrepreneurship chains and activities in the economy and society [1, 2, 3]. Methodological support for Governments intervention by means of IEE Development Smart Policy Mix is based on the results of the previous research of the Competitive Innovation and Entrepreneurship Ecosystem Framework performed by the authors [3]. The third phase in the Framework is defined by smart policy mix considerations and this paper deals with these issues.

The basic steps for developing a Smart Policy mix of instruments and measures to upgrade the IEE are presented as:

1. Generating a set of policy levers, measures and instruments that address the different domains of the EII. The Framework [3] points to the Global Innovation and Entrepreneurship Indices, e.g. European Innovation Scoreboard (EIS), Global Innovation Index (GII), Global Competitiveness Index (GCI), Global Entrepreneurship Index (GEI), to be used in IEE metrics indicating the domains for government intervention with a set of policy measures and instruments.

2. Developing methodological support for Governments Smart Policy mix decision making. Based on the Framework results [3], in this paper the second step is in focus with the Integrated Technological Forecasting Model presented as the methodological support to smart innovation and entrepreneurship policy mix development.

The term Policy mix is used to refer to “the balance of and interactions among policies” [4, 5]. In this paper the policy mix refers to a set of policy measures and instruments to be used as means of government interventions aimed at the achievement IEE development policy goals.

It is noted that “For the policy mix concept to be useful in policy making and analysis, individual policy instruments and interactions among them need to be defined” [4, pp. 152]. In this paper Technological forecasting is deployed to assess individual policy measures and instruments contribution to the overall IEE development goals. The development of the Technological forecasting integrated methodological support and investigating its relevance in developing the smart policy mix is the main research question under consideration.

The relevance of the subject is found in the rising necessity to provide support for effective and smart government interventions, on the one hand, and the lack of methodological support, on the other. The situation is best described in the statement of the [4] emphasizing that “the field of interactions between policy instruments is still not investigated enough and one of the paths of future research of the Smart Policy mix would encompass the interactions between the policy instruments which has high impact on the effectiveness of a policy instrument”. It is also noted that “the greatest challenge of the successful Policy mix is to reflect the priorities of the concrete IEE” which represents an important aspect of the research presented in this paper and the main advantage of deploying technological forecasting integrated model as a means to set priorities for concrete IEE.

The paper is organized in the following manner. Section two presents the Integrated Technology Forecasting Model (ITFM) for IEE smart policy mix support, and explains the methods integrated in the model, i.e. the Modified Objectives Matrix, Delphi method, and Delphi-AHP method. Section

three gives the detailed description of the three phases of the ITFM. Section four concludes the paper.

2. DEVELOPING TECHNOLOGY FORECASTING MODEL BY INTEGRATING TECHNOLOGY FORECASTING METHODS AND TECHNIQUES

This paper focuses on defining the Integrated Technology Forecasting Model (ITFM) for prioritising the policy mix. It combines different TF methods. Figure 1 shows the process of transformation of the policy mix into the smart policy mix by using the defined ITFM which combines the following methods: Modified Objectives Matrix, Delphi method, and Delphi-AHP method.

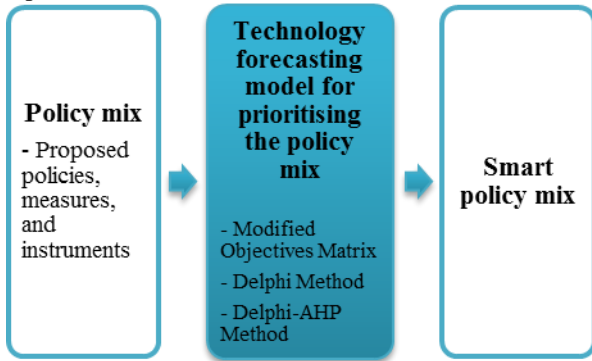


Fig. 1 Transformation of the policy mix into the smart policy mix

Table 1 Modified Objectives Matrix scheme

	Ind 1	Ind 2	Ind 3	Ind 4	...	Ind j	...	Ind n	Total score	Rank
Weight	W_1	W_2	W_3	W_4	...	W_j	...	W_n		
Policy measure	Policy measure scores									
Pol. meas. 1	S_{11}	S_{12}	S_{13}	S_{14}	...	S_{1j}	...	S_{1n}	TS_1	R_1
Pol. meas. 2	S_{21}	S_{22}	S_{23}	S_{24}	...	S_{2j}	...	S_{2n}	TS_2	R_2
Pol. meas. 3	S_{31}	S_{32}	S_{33}	S_{34}	...	S_{3j}	...	S_{3n}	TS_3	R_3
...
Pol. meas. i	S_{i1}	S_{i2}	S_{i3}	S_{i4}	...	S_{ij}	...	S_{in}	TS_i	R_i
...
Pol. meas. m	S_{m1}	S_{m2}	S_{m3}	S_{m4}	...	S_{mj}	...	S_{mn}	TS_m	R_m

$$\sum_{j=1}^n W_j = 100 \quad (2)$$

Column 1 presents the proposed policy measures of the policy mix, while the first row presents the defined indicators (criteria) for assessing the measures. Policy measure scores (s_{ij}) present the scores of each measure according to each criterion (indicator) defined. Total score for each policy measure is calculated in the following manner:

$$TS_i = \sum_{j=1}^n W_j * s_{ij} \quad (1)$$

using the following notation:

TS_i – total score of policy measure i ($i=1, \dots, m$),

s_{ij} – score of policy measure i according to indicator j ($i=1, \dots, m; j=1, \dots, n$)

W_j – weight of indicator j ($j=1, \dots, n$), where

2.1. Modified Objectives Matrix

Objectives Matrix (OM) is generally observed as a method for analyzing and evaluating productivity in terms of efficiency and effectiveness. It is a method of indexing productivity measures and calculating an overall, multi-factor productivity index. According to Felix and Riggs [6], an Objectives Matrix model enables management of an organization to combine all important productivity criteria into an easily communicated format. This method is comprehensive and very flexible. It can be used to derive a composite index for the entire organization based on the defined criteria. For the purpose of this paper, we define the Modified Objectives Matrix method. General scheme is presented in Table 1.

In this paper, values for s_{ij} are obtained by using the Delphi method, and for W_j by using the Delphi-AHP method. The overall score (TS_i) obtained by applying the Modified Objectives Matrix is used for ranking (R_i) policy measures. Policy measure with the highest score is ranked first and is recommended to be implemented first.

2.2. Delphi method

The Delphi method, developed by the RAND Corporation in 1950s, is a forecasting method which involves a group of experts who anonymously reply to the defined questionnaire. The idea is to obtain the most reliable consensus of a group of experts [7]. It is an iterative process. In each round experts are asked to fill in questionnaires individually and anonymously. After each round all responses are summarized by the

moderators and reported back to the panelists, who then have an opportunity to revise their answers in the next round. The process continues until a set level of stability in answers is reached [8, 9]. The goal of each round is to reduce the range of experts' responses and obtain the expert consensus.

The process of the Delphi can be summarized through the following steps [10]: (1) Choice of the moderators, (2) Choice of the experts for the panel, (3) Definition of the questionnaire, (4) Distribution of the questionnaire (by moderators), (5) Filling in the questionnaire (by experts), (6) Statistical analysis and feedback to the panel (by moderators). Each round consists of the steps 4, 5, and 6. Rounds of research are conducted until the consensus among experts is met.

Since its first introduction, researchers have developed variations of the method (see e.g. [11, 12, 13]). However, Linstone and Turoff [8] captured some common characteristics of the method, highlighting that the key advantages are that it avoids direct confrontation of the experts, increases the robustness of opinion gathering due to the structured and repeated process, and can engage geographically dispersed experts with low costs [9, 14]. The results of the Delphi method are highly dependent on the clarity and preciseness of the defined questionnaire and on the choice of experts for the panel. Okoli and Pawlowski provide detailed guidelines for the process of selecting appropriate experts for the Delphi study [15].

Researchers have applied the Delphi method to a wide variety of situations. In this paper, the Delphi is used for obtaining the policy measure scores which will be used for calculating total policy measure scores in the Modified Objectives Matrix.

2.3. Delphi-AHP method

Analytical Hierarchy Process (AHP) is a quantitative method used in various fields in multicriteria decision-making process [10]. Thomas L. Saaty [16, 17, 18, 19] developed this method as an analytical tool, which is based on a pairwise comparison of the hierarchy elements. Namely, since AHP is used for multicriteria decision making, at the first level of hierarchy it has the criteria (attributes) that are specific for the observed problem. At the lowest level of hierarchy, there are alternatives that are evaluated in the decision-making process. The process of AHP can be summarized through the following 7 steps [10]:

1. Establishing the hierarchy model by defining the main goal, criteria, and alternatives of the observed problem;
2. The examined group of experts does the pairwise comparison of criteria relevance and fills the matrix with numbers on the nine-point scale (Table 2);
3. The examined group of experts does the pairwise comparison of alternatives relevance from the perspective of each criterion and fills the matrix with numbers on nine-point scale (Table 2);
4. Aggregation of the results and calculation of the final scores for each alternative based on the determined weights of criteria and alternatives for each criterion;
5. Prioritization of the alternatives based on the aggregated scores;
6. Checking the consistency of the evaluation;
7. Selection of the appropriate alternative.

Table 2 Saaty's pair-wise comparison nine-point scale [20]

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favour one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favour one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation

There are several variations of this method, used combined with other qualitative and quantitative methods in analytics. Delphi-AHP method has been developed to use the advantages of both methods in the decision making process. This method has proven its applicability in some previous research [21, 22]. In this research, we combine the Delphi and the AHP method in order to obtain the weights for the defined criteria. Firstly, we use the AHP matrix to evaluate the significance of the defined criteria used for prioritising policies (strategies). The results of this step are weights of the proposed criteria. Since there is more than one expert, it is necessary to determine the consistency of the results by calculating the standard deviation of the average weights. If the deviation is higher than expected, the process repeats until

there is a consensus of the estimations, that is, until the deviation is lower than expected. At last, the final weights of the criteria are the elements (Weights) of the Modified Objectives Matrix.

3. INTEGRATED TECHNOLOGY FORECASTING MODEL FOR PRIORITISING THE POLICY MIX

The ITFM for prioritising policy measures and creating a smart policy mix is presented in Figure 2. It is a three-phase procedure. In the first phase, the Delphi method is used for forecasting the significance of each individual policy measure to the fulfillment of each individual goal (criterion). In the second phase, the Delphi-AHP method is used for

determining the weights of the observed criteria. The third phase refers to prioritising the policy mix and identifying the smart policy mix by using the Modified Objective Matrix which combines the results of the first two phases.

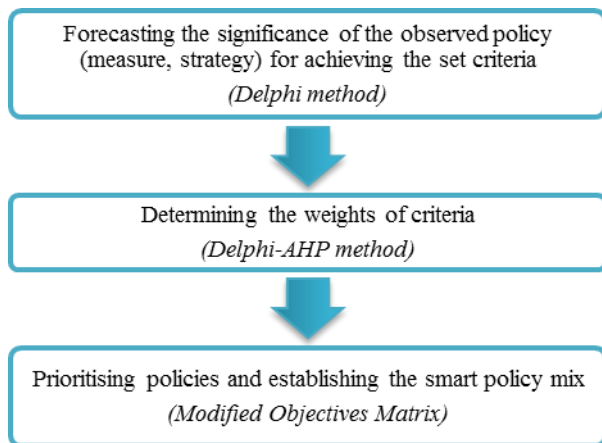


Fig. 2 Three-phase Integrated Technology Forecasting Model for prioritising the policy mix

PHASE 1

Following the steps of the Delphi method, the **first** step of this phase is to choose the moderators and coordinators of the research, while the **second** refers to the choice of the experts for the panel. The experts chosen for the panel possess the knowledge, experience and intuition in the relevant domains of government, industry and high education and research policies and measures, as postulated in the Triple Helix model [23, 24]. They are chosen based also on their expertise and insights related to both the macro and micro perspectives and influences that government policies and measures have on all the actors in the Innovation and Entrepreneurship Ecosystem. The panel is expected to be able to assess the different strategies comprising policies and measures according to specified criteria.

The **third** step is the definition of the Delphi questionnaire. In the model developed for the specific purposes of our research, it firstly refers to the specification of the criteria relevant for the observed problem.

The criteria relate to the appropriate performance objectives to be met, and the assessment of different policy measures is performed against these criteria during the Delphi procedure. Criteria were set based on the research and analysis of:

- the state of the entrepreneurial environment in the Republic of Serbia and the needs of its improvement as marked in different publications and documents (reports on county's performance obtained based on composite measures, such as EIS, GII, GCI, Doing Business etc., documents and strategies published by the Government, Statistical Office Yearbooks and similar documents);
- the relevant domains of Global innovation and Entrepreneurship indices, i.e Global Innovation Index – The European Innovation Scoreboard (EIS), The Global Innovation Index (GII), The World Bank's Doing Business, Global Competitiveness Index (GCI), Babson Entrepreneurship Ecosystem Project, and The OECD framework;

- the frameworks set in the Smart Specialization Strategy [25, 26];
- the strategic goals and priorities of the Government of the Republic of Serbia [27, 28, 29].

The results of the research are presented following the set of criteria relevant for the Serbian IEE development. They represent an open list and are subject to change. These criteria are used in the process of assessment and evaluation, performed by the panel, of the expected effects of different policies, strategies, and measures (in future text refers to as „policy measures“) that can be used for developing the IEE:

1. Fulfilling Sustainable Development Goals (SDG);
2. Contribution to employability (EMP);
3. Contribution to improvement of the entrepreneurial climate in the risk-accepting society (CLIM);
4. Contribution to networking, cooperation, and partnership (NETW);
5. Contribution to the development of higher education of creative and entrepreneurial human capital (EDUC);
6. Contribution to development and application of the ICT (ICT);
7. Contribution to strengthening links between science and practice (SP);
8. Contribution to rapid growth and achievement of short-term results (GROW);
9. Compliance with the relevant EU documents (EUSTR);
10. Compliance with the relevant Government Strategies and Plans of the Republic of Serbia (SRBSTR).

After identifying the relevant set of criteria, the scale for assessing the significance of the individual policy measures and instruments is defined. Policy instruments could be grouped in several ways [4, pp. 152]: target groups, refer to policy instruments specially targeting specific types of firms, sectors and technology, supply-side and demand-side policy instruments, desired outcomes, and mode of intervention. Mode of intervention is looking at the following categories of instruments:

- Financial Direct (e.g. grants, credits, loans, subsidies, innovation vouchers);
- Financial Indirect (e.g. fiscal instruments, tax incentives for R & D and Innovations, tax incentives applicable to different tax arrangements including corporate and personal income taxes to encourage private investments in R&D, exploitation of Intellectual Property assets, attract business angels and leverage early stage financing, etc.);
- Law and regulations comprise legal instruments in passing new laws and regulations in different domains (e.g. Intellectual Property rights, Business Bankruptcy procedures, Employment laws and regulations, etc);
- Non-financial instruments include different business innovation services, information campaigns to promote business innovation and entrepreneurship, organization of events, etc.

Individual policy measures are evaluated with a score of 1 - 5 (Likert scale). The defined scale for each criterion is presented in Table 3.

Table 3 Likert scale for assessing the significance of the defined criteria

Score→	1	2	3	4	5
SDG	Contribution to achieving one SDG: economic, social, or ecological	Moderate contribution to achieving one SDG: economic, social, or ecological	Significant contribution to achieving one SDG: economic, social, or ecological	Moderate contribution to achieving all three SDG: economic, social, or ecological	Significant contribution to achieving all three SDG: economic, social, or ecological
EMP	No influence	Dominant indirect long-term influence	Moderate direct influence, low indirect influence	Moderate direct influence, moderate indirect influence	Dominant significant direct short-term influence
CLIM	No influence	Low long-term influence	Moderate long-term influence	Significant long term-influence with certain short-term results	Significant long-term and short-term influence
NETW	No influence	Low influence	Moderate influence	Significant influence	Direct influence, short-term results
EDUC	No influence	Low influence	Moderate influence	Significant influence	Direct influence, short-term results
ICT	No influence	Low influence	Moderate influence	Significant influence	Direct influence, short-term results
SP	No influence	Low influence	Moderate influence	Significant influence	Direct influence, short-term results
GROW	No influence	Low influence	Moderate influence	Significant influence	Direct influence, short-term results
EUSTR	No compliance	Low compliance, long-term results	Moderate compliance, long-term results	Significant compliance, long-term and short-term results	Significant compliance, short-term results
SRBSTR	No compliance	Low compliance	Moderate compliance	Significant compliance	Complete compliance

The questionnaire being now complete, the first round of the Delphi is carried out. The experts chosen to be the panel individually receive the questionnaire with instructions to present their opinion by assessing each measure in relation to the given set of criteria. The question in the questionnaire for each proposed policy measure would be as follows: “Using the

scale presented in Table 3, please assess the extent to which the policy measure contributes to achieving the set criteria”. Number of questions would be equal to the number of policy measures. For example, if four policy measures are proposed, the questionnaire would have the form presented in Table 4. This questionnaire would be filled in by each expert of the panel.

Table 4 Example of the questionnaire used in the Delphi method

Using the Likert scale presented in Table 3, please assess the extent to which the policy measure contributes to achieving the set criteria.

		SDG	EMP	CLIM	NETW	EDUC	ICT	SP	GROW	EUSTR	SRBSTR
Q1	Financial Direct										
Q2	Financial Indirect										
Q3	Law and Regulations										
Q4	Non-Financial										

After each round, moderators summarize all answers and provide a report to the panelists. If a set level of stability is not reached, experts then have an opportunity to revise their answers in the next round. The process continues until experts’ consensus in answers for each question is met.

Following this procedure, policy measure scores are obtained for all policy measures, on the scale 1-5 (Table 5). These scores are later used in the Modified Objectives Matrix for calculating the total policy measure scores.

Table 5 Policy measure scores obtained using the Delphi method

Criteria	SDG	EMP	CLIM	NETW	EDUC	ICT	SP	GROW	EUSTR	SRBSTR
Policy Measure	Policy measure scores									

Financial Direct	S1-SDG	S1-EMP	S1- CLIM	S1-NETW	S1-EDUC	S1-ICT	S1-SP	S1-GROW	S1-EUSTR	S1-SRBSTR
Financial Indirect	S2-SDG	S2-EMP	S2- CLIM	S2- NETW	S2- EDUC	S2- ICT	S2- SP	S2- GROW	S2- EUSTR	S2- SRBSTR
Law and Regulations	S3-SDG	S3-EMP	S3- CLIM	S3- NETW	S3- EDUC	S3- ICT	S3- SP	S3- GROW	S3- EUSTR	S3- SRBSTR
Non-Financial	S4-SDG	S4-EMP	S4- CLIM	S4- NETW	S4- EDUC	S4- ICT	S4- SP	S4- GROW	S4- EUSTR	S4- SRBSTR

PHASE 2

In this phase, the Delphi-AHP method is used for assess the significance of the criteria by filling in the pairwise determining weights for all defined criteria. Experts comparison matrix presented in Table 6.

Table 6 Pairwise comparison matrix for the defined criteria

	SDG	EMP	CLIM	NETW	EDUC	ICT	SP	GROW	EUSTR	SRBSTR
SDG	1									
EMP		1								
CLIMATE			1							
NETW				1						
EDUC					1					
ICT						1				
SP							1			
GROW								1		
EUSTR									1	
SRBSTR										1

Each expert anonymously and individually fills in the comparison matrix by providing scores using the Saaty's pairwise comparison nine-point scale (Table 2). If e.g. criteria SDG has one of the above non-zero numbers assigned to it when compared with criteria EMP, then EMP has the reciprocal value when compared with SDG. Then, the moderators calculate the mean comparison matrix by finding the arithmetic mean of all experts' answers. Additionally, for

each cell in the matrix, standard deviation is calculated. For those cells for which the set level of stability is not met, experts revise their answers in the second round. After reaching consensus, weights of criteria are obtained by applying the AHP method procedure. In the end, sum of the obtained weights (Table 7) would be equal to 100. These weights are used in the Modified Objectives Matrix.

Table 7 Weights of indicators obtained by using Delphi-AHP method

Criteria	SDG	EMP	CLIM	NETW	EDUC	ICT	SP	GROW	EUSTR	SRBSTR	Σ
Weight	W_{SDG}	W_{EMP}	W_{CLIM}	W_{NETW}	W_{EDUC}	W_{ICT}	W_{SP}	W_{GROW}	W_{EUSTR}	W_{SRBSTR}	100

PHASE 3

This phase implies the prioritization of the policy mix by applying the Modified Objectives Matrix. An example of the matrix for 10 defined criteria and 4 policy measures is presented in Table 8. Elements of

the matrix are obtained in the phases 1 and 2. Total policy measures scores are calculated by applying formula 1 (Section 2), and the policy measures are ranked accordingly.

Table 8 Modified Objectives Matrix example for 4 policy measures and 10 criteria

Criteria	SDG	EMP	CLIM	NETW	EDUC	ICT	SP	GROW	EUSTR	SRBSTR	Total score	Rank
Weight	W_{SDG}	W_{EMP}	W_{CLIM}	W_{NETW}	W_{EDUC}	W_{ICT}	W_{SP}	W_{GROW}	W_{EUSTR}	W_{SRBSTR}		
Policy Measure	Policy measure scores											
Financial Direct	S1-SDG	S1-EMP	S1- CLIM	S1-NETW	S1-EDUC	S1-ICT	S1-SP	S1-GROW	S1-EUSTR	S1-SRBSTR	TS₁	R₁
Financial Indirect	S2-SDG	S2-EMP	S2- CLIM	S2- NETW	S2- EDUC	S2- ICT	S2-SP	S2- GROW	S2- EUSTR	S2- SRBSTR	TS₂	R₂
Law and Regulations	S3-SDG	S3-EMP	S3- CLIM	S3- NETW	S3- EDUC	S3- ICT	S3-SP	S3- GROW	S3- EUSTR	S3- SRBSTR	TS₃	R₃
Non-Financial	S4-SDG	S4-EMP	S4- CLIM	S4- NETW	S4- EDUC	S4- ICT	S4-SP	S4- GROW	S4- EUSTR	S4- SRBSTR	TS₄	R₄

The ranked policy measures present the smart policy mix which identifies the sequence of implementation of the

measures according to their contribution to the fulfilment of the defined criteria.

4. CONCLUSION AND FUTURE WORK

Competitive Innovation and Entrepreneurship Ecosystem (IEE) is recognized as the crucial force enhancing development of a country. Governments are involved in boosting IEE competitive performance by developing smart policy with a balance of measures and instruments.

In this paper we generated an Integrated Technology Forecasting Model (ITFM) combining technology forecasting methods for the purpose of prioritising and developing a Smart Policy Mix as support to decision makers. The main strength of the ITFM is viewed in its capacity to reflect the specific character of a particular IEE by defining the set of criteria (goals) for each particular IEE, and also by determining criteria weights and policy measure scores according to each criterion defined for the observed IEE.

The first phase of the model refers to determining the significance of the observed policy for achieving the set criteria using the Delphi method. In the second phase the panel of experts determines the weights of criteria using the Delphi-AHP method. In the third phase, Modified Objectives Matrix is used for prioritising policies and establishing the smart policy mix. Final outcome of the suggested model, when used in practice, is the set of policy measures ranked in such an order that reflects the sequence of their implementation based on their contribution and significance to the achievement of the set goals (criteria).

The field of interactions between policy measures and instruments is still not investigated enough and one of the paths of future research of the Smart Policy mix would involve the deeper analysis of interactions between the policy measures and instruments which have high impact on the effectiveness of the policy instrument and the policy mix. The specific country/regional IEE circumstances will affect the Smart Policy mix and in this way countries' smart policies will differ.

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