Developing hybrid SWOT methodologies for choosing joint bioeconomy co-operation priorities by three Finnish universities

Jyrki Kangas[1*], Jukka Tikkanen[1], Pekka Leskinen[2], Mikko Kurttila[3], Miika Kajanus[4]

1- University of Eastern Finland, Department of Forest Sciences, P.O. Box 111, 80101 Joensuu, Finland, jyrki.kangas@uef.fi

2 – Finnish Environment Institute, P.O. Box 111, 80101 Joensuu, Finland

3 – Natural Resources Institute Finland, P.O. Box 68, 80101 Joensuu, Finland

4 – Savonia University of Applied Sciences, P.O.Box 6, FIN-70201 Kuopio, Finland

Acknowledgements

This research was supported by the Strategic Research Project on *Sustainable, climate-neutral and resource-efficient forest-based bioeconomy* (FORBIO, proj. 14970), funded by the Academy of Finland under the Climate-Neutral and Resource-Scarce Finland - Strategic Research Programme in 2015-2020.

Aims of this study were two-fold: to provide decision aid for a practical bioeconomy RDI and education challenge, and to elaborate hybrid SWOT methodologies for providing tangible suggestions as to strategic choices to alleviate the challenge. Scientifically, the developed new methodology is the main result of the study, as it can be used to other strategy processes as well, while the case-wise strategic choices may not be generalized. A hybrid method was developed based on the combined use of SWOT that was enlarged by Goals and Actions, social choice theory and Robust Portfolio Modelling. The method was applied to deriving joint strategic choices on developing forest bioeconomy education and RDI together by three universities in eastern Finland. A joint brainstorming process was organized in order to choose together the means to develop the co-operation efficiently and in a manner acceptable for all the universities. Voting methods and the core value calculation of Robust Portfolio Modeling (RPM) were used for prioritizing elements in normal SWOT, Goals, and Actions. The most prioritized elements formed the basis for the co-operation development portfolio. The method development suggestions include, for example, a recommendation to prefer approval voting over cumulative voting in the workshop setting.

Keywords: A'WOT, bioeconomy, robust portfolio modelling, strategy process, voting

Introduction

Finland has a dual system in higher education. It consists of universities that emphasize scientific research and provide education from candidate to doctoral level, and of universities of applied sciences. Universities of applied sciences aim at a more practical approach both in fields of research, development and innovation (RDI), and education. All universities also aim at serving the society at large according to the "third mission" of universities, i.e. their role in having impact on their surrounding society and industry, like enhancing regional and cluster development.

There has been a lot of discussion about the development needs of the dual system, at one end also about integrating the two types of universities to form just one uniform education system. The whole higher education system has undergone a significant reform during recent years, including renewal of the corresponding legislation. In political discourse, pressures have been put for the further development needs. Criticism has been given on the efficiency of the dual system's functioning in practice; for instance, overlaps and deficiencies in mutual collaboration have been observed. More integrated and holistically effective performance of the dual model is called for. As a result, universities and universities of applied sciences in many fields have started to plan deeper co-operation both in education and RDI.

To response on these challenges, University of Eastern Finland (UEF) and Karelia and Savonia Universities of Applied Sciences have together decided to be in the national forefront of developing education and RDI collaboration between universities. Forest bioeconomy has been taken as the pilot field in that. Bioeconomy in Finland relies heavily upon wood biomass and multiple uses of forests.

Forestry and forest management, among other fields of study, is taught both at universities and at universities of applied sciences. Currently in Finland, forestry degree belongs to programs of two universities and six universities of applied sciences. In addition, it is included to some extent in studies related to other fields, such as agriculture, natural resource management and engineering. In the three Eastern Finnish universities of this study, higher forestry education is given by UEF and Karelia, both located in Joensuu. At Savonia, in Kuopio and Iisalmi, forestry studies are included in education of natural resources management and engineering. In addition, bioeconomy related RDI is among the most important functions in all three organizations. Iisalmi is locating about 200 km North-east from Joensuu, Kuopio situating in-between them.

Justifications for selecting the forest bioeconomy as the pilot field are based on recent Finnish Bioeconomy Strategy [1] which searches for economic growth from bioeconomy. As Finland's most abundant natural resource are forests, it is not a surprise that the Strategy relies much on forest sector, forest industry and forestry. More than half of the current Finnish bioeconomy (total output more than EUR 60 bill. and more than 300.000 persons employed) is based on the use of forests, and the future aims as well are to great extent based on forests.

The Finnish Bioeconomy Strategy was prepared by the previous government of Finland in 2011. The current government included the Strategy in its political program in 2015. Bioeconomy, concentrating on forest bioeconomy in particular, belongs to the so called key projects launched by the new government [2]. It is assumed that also the university sector adapts the aims of the key projects and that universities put them into practice in higher education and RDI. According to the Strategy, one key national goal is the strong bioeconomy competence base. In that, university level education and academic research are of central importance. Taken into account the pressures to

develop the dual model of higher education, it is natural to approach the challenges together via deepening the collaboration of universities within forest bioeconomy RDI and education.

UEF prepared quite recently its own bioeconomy research and education strategy. Different aspects of bioeconomy were identified in various faculties and departments. Bioeconomy was found as being of central strategic importance for UEF. It was concluded that a strong emphasis should be given to forest and wood related bioeconomy studies. Other research fields have a more supportive role in bioeconomy applications. In the strategy process of UEF, deepening and intensifying collaboration with universities of applied sciences, especially in higher education with Karelia and Savonia, was seen crucial. This also supports the choice of forest bioeconomy as the pilot in developing the efficiency of the dual model in Eastern Finland.

The aims of this study were two-fold. First, to provide practical support for developing the co-operation of the three universities in the field of bioeconomy RDI and education. Bioeconomy had been chosen as the pilot field by the rectors of the universities, and the experiences of the pilot are to be utilized in developing the dual university system in the region more generally as well. Second, to develop further the hybrid SWOT methodologies previously used in challenging brainstorming tasks within strategy processes. The brainstorming process should result in tangible suggestions as to strategic choices for enhancing efficient co-operation, and the elaborated methodology must provide readily interpretable and straightforwardly applicable decision aid for the universities' decision-makers. As a similar approach had already been planned to be applied in developing the universities' mutual co-operation in other fields of study, too, another important aim was to draw conclusions on the further development needs on both the methodology and the process on grounds of the experiences of the case brainstorming process.

In this study, an efficient brainstorming process, consisting of a preliminary assessment and a workshop in which a hybrid methodology tailored for the workshop was utilized to conduct strategic and joint developments related to bioeconomy education and research in Karelia, Savonia and UEF. The hybrid methodology was built by combining SWOT, social choice theory and Robust Portfolio Modelling. By doing so, benefits of them all were utilized. Traditional SWOT was enlarged by Goals and Actions as additional groups of factors. Voting methods and the core value calculation were applied for prioritizing elements in SWOT groups, Goals and Actions. The most prioritized Goals, Strengths, Weaknesses, Opportunities, Threats and Actions form the basis for the co-operation programme.

Methods used in the brainstorming process

Enlarged SWOT and A'WOT

SWOT analysis is a commonly used tool for analysing operational environments in order to attain both a systematic approach and support for strategic decision-making. In a SWOT analysis, the internal and external factors most important for the future success of a company (or any decision maker) are grouped into four categories: Strengths, Weaknesses, Opportunities and Threats. The purpose of applying SWOT is usually to develop and adopt a strategy resulting in a good fit between the internal and external operational environments as well as with the objectives of the decision maker.

SWOT could be used more efficiently and in a more versatile manner than has normally been the case when applying it. [3][4]. Too often, it has remained at the level of just pinpointing the factors. Furthermore, SWOT itself includes no means for analysing the importance of the factors or for evaluating the decision alternatives with respect to the factors. Thus, the further utilization of SWOT alone is mainly based on qualitative analyses made in the decision-making process, and on the capabilities and expertise of the persons participating. It is not a surprise, that research has aimed at enhancing the use of SWOT as a practical planning tool in many ways, e.g., by connecting other strategic planning tools to it. [5].

The idea in using Multiple Criteria Decision Support (MCDS) methods within a SWOT framework is to assess systematically the SWOT factors and to make them commensurable. [6] [7]. This enables more analytical SWOT procedures. The hybrid method A'WOT makes combined use of the Analytic Hierarchy Process (AHP) [8] and SWOT. It was first presented by Kurttila et al. [6], who applied it to natural resources management. Later, the hybrid SWOT-AHP method has been widely utilized in different application fields, including e-government [9], bioenergy [10], pulp and paper industry [11], and tourism management [12], among others. Nikolic et al. [13] applied fuzzy AHP and Yüksel et al. [14] the Analytic Network Process instead of the standard AHP in the A'WOT framework. Also other MCDS methods have been applied within the A'WOT framework, such as SMAA [15], ELECTRE [16], PROMETHEE [17] and SMART [18][19]. Kangas et al. [20] presented how voting methods can be made use of instead of MCDS methods within A'WOT.

After carrying out the assessments required by the MCDS method, quantitative information that is useful in the strategy process can be obtained about the decision problem. On the basis of comparisons of the SWOT factors and groups one can analyse, for example, whether there is a specific Strength or Weakness requiring most of the attention, or if the organisation is expected to

be faced with future Threats exceeding its combined Opportunities. In addition, use of A'WOT enables choice alternatives to be prioritized with respect to each SWOT factor and to each SWOT group. When the importance of different SWOT groups have also been determined, it is possible to evaluate decision alternatives with respect to the strategic choice situation as a whole.

In general, the hybrid methods that combine SWOT and MCDS proceed as follows:
(i) The SWOT analysis is carried out. The relevant factors of the external and internal environments, possible objectives and potential actions to be taken are identified and included in SWOT.
(ii) The relative importance of the factors are determined separately within each group of the Strengths, Weaknesses, Opportunities, Threats. Any Multiple Criteria Decision Support (MCDS) method, and its comparison principles, can be applied.
(iii) The relative importance of the groups are determined. There are several principles of doing this and also here any MCDS method can be applied, see e.g. [6][15][16][17][18][19].
(iv) The decision alternatives are evaluated with respect to each SWOT factor according to the comparison rules of the applied MCDS method.
(v) Global priorities may now be calculated for the decision alternatives in accordance with the MCDS aggregation techniques.

Often, performing just the steps (i), (ii) and (iii) provide a good basis for strategy formulation.

When applying basic SWOT it might be challenging to link the operational environment analysis with the goals as well as with the courses of actions to be taken. These both are important dimensions of any strategy process and in putting the developed strategy into practice. Without integrating internal and external operational environments with the goals it is hard to develop the

strategy. Moreover, defining goals can guide participants to create alternatives of greater value and to enhance getting the full range of each individual's thoughts articulated. [18][21]. When continuing from the formulation of the strategy in line with the goals, the crucial measures for implementing the strategy efficiently must be chosen for making the strategy alive and effective. That is why the solicitation of ideas for prospective actions during the strategy process may provide more focused, action-oriented, and comparable reflections on future developments. [22].

In this study, an approach for holistically managing the SWOT together with possible goals and potential actions to be included in the implementation of the strategy is presented. Adding the groups Goals and Actions leads to an enlarged version of SWOT, called GSWOTA (Goals + SWOT + Actions) in this study. The ultimate aim of GSWOTA is to find out the most important courses of actions and activities, by which the goals set can be reached within the operational environment as described using SWOT groups and factors. This further deepens the analysis and makes it more versatile. And what is important, it makes the whole process more practical and action-oriented.

Voting-SWOT hybrid method (VotSWOT)

A practical problem with many decision support methods is that collecting the preference input from stakeholders and/or decision makers may be difficult for many reasons. If the used method demands many complicated questions, it also typically demands a lot of time and guidance.

One possibility to alleviate the problems of too laborious preference inquiries for stakeholders is to apply the social choice theory based methods. [23]. Social choice problems are typically tackled by

using different modes of voting. That is why social choice theory is often called voting theory. Throughout the history of democracy, voting has proved to be an efficient tool for making choices among decision alternatives, e.g., in different kind of elections. Voting theory can be seen as a credible alternative in group decision making and participatory strategy processes, as in developing voting methods special attention has been paid to systems that are difficult to manipulate. [24].

In social choice, individual preferences are combined into a collective choice. [25]. The social choice situation can be described with four dimensions: (i) voters or players, (ii) choice alternatives, (iii) the information of voter's preferences over the alternatives, and (iv) an aggregation procedure. In fact, the approach greatly resembles MCDS. When individual utility functions are combined, the aggregation could be interpreted as a social welfare function. [25].

Of voting approaches, the simplest mode is plurality voting. It considers the preference ordering of voters, but only with respect to the best candidate. Each voter has one vote, and she/he votes for just one candidate. The candidates (or decision alternatives) are ranked according to the sum of votes and the candidate/alternative with the plurality of votes wins. No majority of votes is required.

When applying the approval voting, each voter votes for as many candidates as she/he wishes. Voters vote for all candidates they "approve". Each candidate approved by a voter receives one vote. The candidate receiving the greatest number of votes is the winner. If more than one candidate are to be chosen, then the candidates are ranked according to the number of approval votes they’ve got and candidates are chosen following their ranks.

Approval voting is harder to manipulate by voters than plurality voting, as it requires information about the distributions of approvals of the alternatives in order to be manipulated. [24]. It tends to

promote moderate candidates. The approval voting is argued to be the best voting system in cases where the real preferences of voters are dichotomous. [26].

The above-mentioned voting systems use information concerning the preference ordering of the alternatives only. There are also many other methods and modes of voting, with varying qualities and characteristics. Readers are referred to [23] for fundamentals of other voting methods than those applied in this study.

Utilitarian voting systems consider also information on the intensity of preferences. They resemble many MCDS methods. For example, in cumulative voting system, each voter is given a number of votes they can distribute to the candidates in any way: all votes can, for instance, be given to one candidate or many candidates can be given an equal number of votes. This is similar to the prioritisation principles of an MCDS method SMART.

When developing voting procedures closer to MCDS methods, they easily become more complicated, time-consuming and harder to understand. In this study, approval voting and cumulative voting were applied. They provide the necessary information for the process, at the same time being straightforward and simple enough.

Approval voting and cumulative voting were combined with the GSWOTA, i.e. the enlarged SWOT as outlined above, for analyzing the strategic situation and development task and for producing data for Robust Portfolio Modelling (RPM) calculations. By using the Voting-GSWOTA-RPM hybrid approach the most crucial factors in all the GSWOTA groups are searched for and the most important actions to be taken were chosen.

Robust Portfolio Modeling and the INTO innovation tool

INTO innovation tool includes a process and a calculation procedure to combine participative perception and systematic analysis in complex decision-making situations. Basically, INTO aims at fast and efficient decision making by involving multiple stakeholders and by making the whole process more transparent. INTO innovation process usually contains five steps: 1. Kick off, 2. Idea collection, 3. Evaluation of ideas, 4. Analysis with core index, and 5. Interpretation. The tool has been used in many different applications starting from regional waste-to-energy production and ending up to investment decision and business process management. [27][28]. Recently, one of the most popular applications has been business model design. Detailed information about business model planning can be found in [29].

INTO tool makes use of core value calculation as applied in Robust Portfolio Modeling (RPM). RPM is a decision aid methodology developed for analysing large-scale project portfolio problems. [30]. In natural resources sector, RPM has been applied e.g. by Könnölä et al. [31] for developing national priorities for the European level research, development and innovation projects in forestry and forest-industry sector.

A specific feature of RPM in comparison to other multiple criteria decision support methods is the ability to efficiently examine the multi-criteria dominances among all the possible portfolios covering all the possible combinations of criteria weights. [30]. In that, RPM uses the so called core index. A project getting core index value 1 is included in all non-dominated solutions, irrespective of criteria weights. Core index value 0, in turn, means that the project is not included in any non-

dominated solution, i.e., it is an exterior project. Typically, projects getting high core index values are regarded as potential ones in the final choice.

In INTO's RPM version, all the different kinds of elements for a business model are taken as projects. The whole bunch of business model elements is screened in the calculation. These elements may consist of the company's cost structure factors, key partners, resources, major activities, marketing channels etc. [29]. For INTO calculations, the "projects" within each category of elements are ranked or prioritized, normally using scale 1-7. By using core value calculation, INTO produces information on the core indices of the elements, and prepares a recommendation as to the business model including a portfolio of those elements.

It is recommendable to perform INTO analyses in an iterative and interactive manner. For example, the iterative process can proceed in the following way. First, it is examined whether there exist projects, or business model elements, getting core index value 1. If there are such elements, they are included in the portfolio recommendation. Next, the core index value requirement is marginally lowered and core value calculation is performed again. Technically, the core index value requirement is lowered via the Constraint Parameter (CP). [29]. If the CP value is 0%, only the item with the highest score in a respective criterion/weight combination scenario is selected. If the CP value is 10%, all items having a score higher than or equal to 90% of the highest score are included and so on. This is done successively until the project with the next highest core index value is found. By repeating this, the projects can be arranged according to their core index values. Projects with higher core index values have higher probability of belonging to the final portfolio.

In each CP value, a threshold value is used to relax the selection threshold when including elements into the optimum portfolio. The maximum portfolio count is multiplied with the threshold value to

get a core threshold. All ideas that have portfolio count greater than or equal to the core threshold are included. This does not change the order of elements. By default, INTO uses the threshold value 0,995.

In the Voting-GSWOTA-RPM hybrid approach of this study, the GSWOTA elements are regarded as projects in RPM calculation. This means that the portfolios considered using the core value calculation consist of Goals, Strengths, Weaknesses, Opportunities, Threats, and Actions. Following INTO terminology, the "business model" for deepening the co-operation of the three universities in the field of bioeconomy education and research is built utilizing those elements.

Case: developing forest bioeconomy co-operation between UEF, Karelia and Savonia

Overview of the process

Joint strategy process for three universities in eastern Finland served as a case for developing practical and action oriented hybrid methodology. A joint brainstorming process was organized in order to choose together the means to develop the co-operation efficiently and in a manner acceptable for all the universities. The process in general consisted of two main phases: preliminary assignment and innovation workshop. These two phases together formed the brainstorming exercise (Figure 1). Three of the authors of this article (Kangas, Kajanus, Tikkanen) acted as planners and facilitators of the whole process.

< Figure 1 >

First, the participants for the process from the three universities were invited. They were experts on bioeconomy, representing both RDI and education. Most of them were experts in forest bioeconomy, but there were also persons from other scientific fields like social sciences and applied physics as well as those from administrative positions.

In the preliminary assignment, the participants were asked to provide so-called long lists of Strengths, Weaknesses, Opportunities and Threats related to the development of collaboration of forest bioeconomy RDI, education and the third university mission, i.e. the societal impact. In addition, they were asked to list potential Goals and Actions. “Actions” here refer to measures to be taken, but also other kinds of activities, efforts, policies, etc. that are necessary for striving at successful co-operation. Actions could be called sub-strategies, as well. “Actions”, however, reflect better the aim of them being tangible efforts which can be put into practice as such.

The preliminary assignment was returned by 10 participants. Altogether 19 persons participated in the workshop – 4 from Karelia, 6 from Savonia, and 9 from UEF. Not all of them participated in the whole workshop, but at least 15 persons were present in each phase of it.

Using the long lists of factors in all the GSWOTA groups, the facilitators composed lists of candidates for voting to be applied in the workshop. All the potential factors proposed by the participants in the preliminary assignment were represented in the candidate lists and considered in the workshop. However, some proposals were combined, some were condensed a bit, and some were elaborated to some extent by facilitators in order to get the lists coherent and concise.

The long lists introduced in the workshop consisted of altogether 20 Goals, 20 Strengths, 19 Weaknesses, 19 Opportunities, 18 Threats, and 24 Actions. In the beginning of the workshop, these

lists were presented and discussed, and minor modification and fine-tuning was agreed, and a few new factors were added to the lists. Finally, the lists included 22 Goals, 20 Strengths, 19 Weaknesses, 19 Opportunities, 18 Threats, and 26 Actions.

By applying approval voting the elements of the long lists seen the most important by the participants were selected. Participants were given printed long lists, and each participant marked all the elements he or she "approved", i.e. found being of significance in developing co-operation, in his or her own list. Voting, and discussions in the workshop after that, resulted in a number of GSWOTA elements to be further considered in groups. During a break, lists of these elements were printed for the second voting.

Next, four groups were formed of the participants, all the groups having at least one representative from each university. The groups approached the overall aim of developing co-operation of the three universities from different perspectives. Each group performed cumulative voting among all the elements chosen in the previous phase. It could also be possible to organize cumulative voting separately within each GSWOTA group. Doing so would, however, require an additional process phase of assessing the mutual importance of the GSWOTA groups in order to estimate the overall priority of the elements. For the sake of fluentness of the process, that additional phase was avoided. When considering all the elements at a time, cumulative voting implicitly included the importance of groups and found out the most important elements irrespective of the group. On the other hand, it could be possible that no element from some group gain votes enough to be taken as important in developing the co-operation. Facilitators helped the participants and the groups technically, but did not affect the voting. Again, the results of cumulative voting, including the sum votes for elements in each GSWOTA group, were discussed together before proceeding the workshop process, first within groups and then together by all participants.

The results of cumulative voting were used as input for the RPM calculations, using the INTO system, i.e. votes of criteria were used as if they were scores. Special attention was given to the prioritization of Actions, and how they fit with other elements raised by the analyses. The INTO results were discussed and evaluated in the workshop, and also via a feedback questionnaire sent to the participants next day after the workshop.

Results of the voting procedures

In the first voting phase, i.e. the approval voting of the GSWOTA long lists, Weaknesses and Threats were given less approval votes in general than Goals, Strengths, Opportunities and Actions. This means that the participants emphasized positive dimensions directing the development of the bioeconomy co-operation of the three universities more than negative ones.

From the long lists, 6 Goals, 6 Strengths, 5 Weaknesses, 6 Opportunities, 4 Threats, and 9 Actions – altogether 36 GSWOTA elements – were chosen for further elaboration according to the approval votes they got (Table 1). Using voting results as the basis, the choice of the elements was discussed about and jointly agreed by the participants in the workshop. The discussion did not result in any certain number of votes to be required for elements chosen for further consideration. Instead, the votes varied to some extent in different GSWOTA groups. In the following, this list consisting of all these 36 elements is called the List of approved elements.

< Table 1 >

More elements were selected for the Actions group than for the other groups, as they were seen especially crucial in developing the practical co-operation of the three universities. Selecting more Strengths and Opportunities than Weaknesses and Threats after the discussion in the workshop reflected the general weights given to the corresponding SWOT groups as the sums of approval votes among the groups.

The greatest number of votes within each of the GSWOTA groups were given to the following ones: Goal ‘Speeding up the internalization’, Strength ‘Versatile and many-sided knowhow in bioeconomy matters’, Weakness ‘Lack of continuity and perseverance in the financing and management’, Opportunity ‘Bioeconomy is prioritized by national policies’, Threats (a tie, i.e. two Threats were given an equal highest number of votes within the group) ‘Mutual competition between the three universities’ and ‘Hard to get private companies to co-operate in research and education’, and Action ‘Preparing a joint internationalization strategy together’. Thus, these elements were taken as the most important in developing co-operation within each group.

Next, as presented above, the participants were divided into four groups, each consisting of representatives of all three universities and each considering the development of co-operation independently from different perspectives. The perspectives were: Group 1 research, development and innovation, Group 2 education, Group 3 benefits for the surrounding society, and Group 4 feasibility and implementation.

Each group allocated 1000 votes within the list of approved GSWOTA elements, according to the priorities of the elements from the viewpoint of the perspective represented by the group. Among

the elements in the List of approved elements, the element getting the most votes of all was Action 'Joint efforts in bioeconomy education (e.g. joint bachelor level examination)'. Deepening the education co-operation was highly prioritized, as the second most votes were allocated the Goal 'Increasing co-operation in bioeconomy education'. So, the most voted Action was well in line with the most voted Goal.

As can be seen from the results of cumulative voting, generally taken, Goals and Actions were prioritized over elements of SWOT groups. Actions got altogether 1600 votes, and Goals 1015 votes. This was a desirable result, as actions are a crucial part of any strategy, and the ultimate aim of this workshop was to find out the most important strategic measures to be taken for deepening the co-operation of the three universities in the field of bioeconomy. Strengths, Weaknesses, Opportunities, and Threats got altogether 315, 420, 445, and 205 cumulative votes, respectively. (Table 2).

< Table 2 >

INTO results

The results of cumulative voting, performed by the four Groups, were applied as input data for INTO analyses making use of RPM. The groups, representing four different perspectives in developing co-operation of the universities in the field of bioeconomy, were regarded as criteria in the core value calculation. For the core values, scenarios covering all the different weighting possibilities of different criteria (four perspectives) were calculated providing scores for each GSWOTA elements in each scenario (for the methodology see [29]). Organized in this way, the

method searched for balanced elements that were seen important among the four groups having different perspectives in their voting. As a result, it favored elements getting high votes for all or most of the criteria (i.e. perspectives).

In the first INTO calculation round the CP value was iteratively increased from 0% until five elements with the highest core values were found. These included two Goals and three Actions as the most prioritized GSWOTA elements over all the three groups' evaluations (Table 3). At this phase the CP value was 24%. When comparing Table 3 to Table 2, it can be seen that those elements included in the first round one got high number of cumulative votes from the majority of groups.

In this case, the differences between cumulative votes were extremely high: biggest vote being 400 and lowest 0. This being the case, those two elements which got 400 votes performed as a peak in the analysis. For that reason, in order to get balanced and robust results, the threshold value of including an element in an optimum portfolio had to be adjusted. In that, we used threshold value 0.5.

Next, the CP value was still increased, and iterative process was stopped when 7 GSWOTA elements were picked up: two Goals, one Weakness, and four Actions (Table 4) with CP value 56%. These elements included, naturally, the ones raised already by the first calculation round. The third calculation round with CP value 73% raised elements from all the other GSWOTA groups except Threats (Table 5). Finally, all six groups were represented in the results of the fourth INTO calculation round with CP value 90% (Table 6).

In the workshop, the iterative INTO process included also interphase calculations, kind of what-if analysis by changing the CP value to see how it affects the results. This was done in order to give deeper insight in the prioritization process and for improving the interpretability of the results. The calculation results were discussed actively, which further helped the participants understand the results and reasoning behind them.

< Table 3 >

< Table 4 >

< Table 5 >

< Table 6 >

Expost feedback

Participants were asked to respond to the feedback e-questionnaire sent right after the workshop. Although the response rate was low (28%) the feedback is valuable in considering further development directions for the methodology. Responses were mostly positive regarding to overall evaluation of the procedure (average evaluation 3.8 in scale 1-5). Especially respondents thought that they had good opportunities to address their own views along the process (average 4.4). They also considered that the process took all opinions into account equally (average 4.2).

From the different methodological phases of the procedure, respondents evaluated most positively individual approval voting that was the first task in the workshop (average 4.4) and GSWOTA-task that was conducted before the workshop (average 4.0). The cumulative voting task in groups got more critical evaluations (average 3.2).

In qualitative feedback participants appreciated the effectiveness of the procedure that was "*consistent, easy and prompt*" and "*raised good variety of viewpoints from individual pre-task into joint consideration.*" On the other hand, participants raised criticism that the results of such a voting based methodology is "*sensitive on the selection of participants"* to the procedure, and that the methodology should serve still more room for *"joint construction"* of "*innovative"* strategy formulations and "*solutions"*.

Discussion and conclusion

General Experiences

This study presented a new hybrid methodology in a real collaborative strategic planning situation, more closely in developing bioeconomy education and RDI co-operation between three universities in eastern Finland. The methodology consisted of SWOT enlarged by Goals and Actions, two voting methods and corresponding procedures, and INTO innovation tool with core value

calculations. For practical implementation of the results, the main aim of the whole process was a practical one: to find such recommendations for the development of co-operation of the three universities that are acceptable for all the universities and that simultaneously meet the general societal goals set for the universities. The workshop succeeded in that: right after the workshop University rectors founded three working groups for preparing more detailed plans for the choices of actions in order to deepen the co-operation. One working group deals with RDI, one with bachelor and masters level education, and one with education for experts already working in bioeconomy practice.

In addition to the practical development needs, it was important to gain experiences on the novel methodology. The brainstorming process aimed at fostering collaboration of the participants and learning in order to reach acceptability, commitment and operability, as recommended by Vacik et al. [32], who found A'WOT, among others, as a promising method in that. In this study, ideas of A'WOT were elaborated by making use of voting and RPM for providing a methodology that could further stimulate creativity and innovation in a strategy process.

Overall feedback from participants and experiences along the process was positive regarding the results of the workshop. The hybrid methodology presented and its application in a workshop setting are worth developing further. It has already been decided to be applied to another similar workshop also dealing with developing co-operation by UEF, Karelia and Savonia, namely that in the field of Information and Computer Technology. Experiences on the methods and the process will be utilized for planning the next workshop so that it is still more efficient and fluent.

Methodology and its development needs

According to Myllyviita et al. [33], mixing qualitative and quantitative methods yields more benefits than a combination of separate methods. However, it is important to integrate the methods fluently for exploiting the advantages of mixing methodologies. In practical cases, digitalized systems making use of computer programmes are needed. As the application in this study was the first test of the hybrid method, no such tools were available, and the process was mastered in a rather old-fashioned way, except the INTO software. In the future, more effort must be put on the digitalization of the process for getting the methodology ready for commercialization and general use.

In multiple criteria decision aid, there is a strong aim to identify and distinguish fundamental objectives and means objectives [21] and it is recommended to exclude means objectives from the evaluation phase to avoid double-counting and preferential dependency. Fundamental objectives are then used to evaluate action alternatives. According to our experiences, participants of the workshops have tendency to approach problem structuring tasks dominantly, not as a series of sequential decisions, but from the holistic action orientation where they prefer to phrase also fundamental objectives like means. Thus, ideally, objective hierarchy should be constructed jointly with workshop participants, as best applying visualization tools [34][35]. Such a problem structuring would require rather intensive and time consuming communication between facilitators and participants. In elaborating the hybrid methodology for the above-mentioned next application, this will be given more emphasis.

Keeney [36] emphasizes in his Value Focused thinking creating decision alternatives from values instead of problems. He proposes to use wish list as a tool for that, meaning asking decision maker to list her hopes, wishes, problems, alternatives etc. to creatively compose a versatile list of objectives and alternatives. Then, the list is used to elaborate a mean-end hierarchy by asking

questions like why is this objective important, is it a mean to reach more important objective or is it value as such. In this study, we used Goals, SWOT and Actions to compose a versatile and creative wish list. Then we prioritized the list items in order to fasten the process by identifying the most important items. As a result, we could provide to decision makers of the universities the list of those items which, according to workshop participants, should be used when elaborating objective hierarchy for final decision making.

In the case reported here, objectives, SWOT-dimensions and action proposals were valued simultaneously without explicitly constructing objective hierarchy, also in the voting phases. As such our application has inevitable limitations but the main aim of the paper is to demonstrate an application serving decision support for ad-hoc workshops, where available time is limited but where ranked action proposals are still called for. In order to avoid severe double accounting and preferential dependency, from the original factor lists those factors that were interpreted to have exactly same meaning were combined notwithstanding the message were given in objectives, SWOT-factors or action proposals.

Case study results

Actions selected by using the hybrid methodology turned out to be reasonable. The choice of the most important Actions was quite clear. Developing co-operation in bioeconomy education proved to be very important in the opinion of participants from all three universities. This was not a big surprise, since everybody knew beforehand that political pressures are striving to that direction in Finland anyway. On grounds of discussions within the workshop it seemed that the participants had adapted this political aim and searched means for enhancing the education collaboration.

All the phases, i.e. approval voting, cumulative voting and RPM, produced rather similar results on the priority of different GSWOTA elements within each group and in general. The Actions raised by INTO analyses were in line with the Goals and SWOT factors that were seen important in both voting procedures. The results were logical what comes to priorities of elements (i.e. projects in RPM terminology) in different GSWOTA groups. The most crucial Actions reflected the prioritized Goals, and they made use of the Strengths that were seen important, exploited the Opportunities, and avoided Threats and Weaknesses.

The brainstorming process

The results of different prioritization methods were so close to each other that it can even be concluded that, perhaps, all the phases performed in this case were not necessary. This suggests that one of the voting phases could be left out of future applications. Practically taken, approval voting and cumulative voting provided very similar information on the priorities of the GSWOTA elements that were further elaborated in the workshop. Additional test calculations showed that using results of approval voting would lead to nearly identical results as the INTO results reported above. On grounds of the experiences of this study it seems that applying just approval voting would be enough. Cumulative voting might not be needed at all, as, compared to approval voting, it is much more laborious and time-consuming, it did not produce any additional information, it was harder to understand and perform by participants, and different participants and groups implemented it somewhat differently. In addition, considering the elements of all the GSWOTA groups in cumulative voting without a separate step of weighting the groups according to their importance might be problematic for the participants, as when doing so the given votes implicitly include information on the importance of the groups. In cumulative voting, it would be more

meaningful to compare elements to other elements separately within each group and explicitly assess the mutual importance of the GSWOTA groups.

Both voting schemes functioned well in producing input data for INTO calculations. However, the use of groups that prioritized the GSWOTA elements from the viewpoint of different co-operation perspectives as criteria in RPM was not easy to adapt by all the participants. Perhaps, it would have been more comprehensible to evaluate the elements holistically by three groups each consisting of representatives of just one university. Then, the universities would have been regarded as three criteria in RPM instead of the four perspectives. This option could be studied in future applications of the hybrid methodology.

The discussion sessions in the workshop were very fruitful. The results were modified during the discussions after each phase, like using principles of the Delphi approach. Also in the end discussion of the workshop, two Actions were unanimously prioritized very highly, although they were not among the most important ones according to INTO calculations. These were ‘Preparing a joint internationalization strategy together’ and ‘Joint efforts for improving the reputation and attractiveness of the three universities’. These Actions were, however, implicitly included in the Goals that were highly prioritized in approval voting, but they were not voted for in the cumulative voting. Perhaps this was due to the choice of perspectives for the groups, as these Actions can be taken as more general ones and not specifically belonging to any of the perspectives represented by the groups.

The participants produced long list of elements individually before the joint workshop. The workshop was mainly used for prioritizing and selecting elements. One feedback was that more emphasis could have been given to joint co-creation of new elements. Most probably, on grounds of

experiences and conclusions on the methodology used in this study, cumulative voting phase will be excluded, and more time will be allocated for discussions within the next workshop. In our workshop we captured some mistakes in the first-time calculation of votes made by hand. Thus, an important practical need is to automate the calculation of voting results in order to save time within the workshop and to avoid the need to double check the voting results.

As a conclusion, the most important development needs and topics for further research regarding the methodology and the process were found to be:

- to study the effects of adding an objective hierarchy to the GSWOTA analysis and different ways of constructing the problem structure together with the participants with their methodological implications,
- more straightforward use of voting procedures within the process, e.g. by applying only approval voting in the process, and
- digitalization of the process in order to improve the efficacy and punctuality of the process.

References

1. The Finnish Bioeconomy Strategy. 2014. Ministry of the Employment and the Economy of Finland. http://www.tem.fi/files/40366/The_Finnish_Bioeconomy_Strategy.pdf.

2. Prime Minister’s Office Finland. 2016. Action plan for the implementation of the key project and reforms defined in the Strategic Government Programme. Government Publications 1/2016. http://valtioneuvosto.fi/en/implementation-of-the-government-programme.

3. Hill T, Westbrook R. SWOT analysis: it's time for a product recall. *Long Range Pl.* 30(1), 46–52 (1997).

4. Ip YK, Koo LC. BSQ strategic formulation framework: a hybrid of balanced scorecard, SWOT analysis and quality function deployment. *Managerial Audit. J.* 19, 533–543 (2004).

5. Helms MM, Nixon J. Exploring SWOT analysis—where are we now: A review of academic research from the last decade. *J. Strat. Manage.* 3(3), 215–251 (2010).

6. Kurttila M, Pesonen M, Kangas J, Kajanus M. Utilizing the analytical hierarchy process (AHP) in SWOT analysis - A hybrid method and its application to a forest-certification case. *For. Pol. Econ.* 1, 41-52 (2000).

7. Kajanus M, Leskinen P, Kurttila M, Kangas J. Making use of MCDS methods in SWOT analysis – Lessons learnt in strategic natural resources management. *For. Pol. Econ.* 20, 1-9 (2012).

8. Saaty TL. The Analytic Hierarchy Process. McGraw-Hill, New York, 1980.

9. Kahraman C, Demirel NC, Demirel T. Prioritization of e-Government strategies using a SWOT-AHP analysis: the case of Turkey. *Eur. J. Inform. Syst.* 16, 284–298 (2007).

10. Okello C, Pindozzi S, Faugni S, Boccia L. Appraising Bioenergy Alternatives in Uganda Using Strengths, Weaknesses, Opportunities and Threats (SWOT) - Analytical Hierarchy Process (AHP) and a Desirability Functions Approach. *Energies* 7, 1171-1192 (2014).

11. Posch A, Brudermann T, Braschel N, Gabriel M. Strategic energy management in energy-intensive enterprises: a quantitative analysis of relevant factors in the Austrian paper and pulp industry. *J. Cleaner Prod.* 90, 291-299 (2015).

12. Heidari M, Ashari HA, Farahbakht S & Parvaresh S. Using the Analytic Network Process (ANP) in a SWOT analysis for the development of tourism destination – case study: Kish Island. *Int. J. Manage* 5(6), 21-29 (2014).

13. Nikolić Đ, Spasić J, Živković Ž, Đorđević P, Mihajlović I, Kangas J. SWOT-AHP model for prioritization of strategies of the resort Stara Planina. *Serbian J. Manage.* 10, 141-150 (2015).

14. Yüksel İ, Dagdeviren M. Using the analytic network process (ANP) in a SWOT analysis - A case study for a textile firm. *Inf. Sc. Int. J.* 177(16), 3364-3382 (2007).

15. Kangas J, Kurttila M, Kajanus M, Kangas A. Evaluating the Management Strategies of a Forestland Estate - the S-O-S approach. *J. Envir. Manage.* 69, 349-358 (2003).

16. Borajee M, Yakchali SH. Using the AHP – ELECTRE III integrated method in a competitive profile matrix. International Conference on Financial Management and Economics 2011. Proceedings, 68-72 (2011).

17. Dagdeviren M. Decision making in equipment selection: an integrated approach with AHP and PROMETHEE. *J. Intelligent Manufacturing* 19, 397-406 (2008).

18. Kajanus M, Kangas J, Kurttila M. The use of value focused thinking and A'WOT

hybrid method in tourism management. *Tourism Manage.* 25, 499–506 (2003).

19. Kuo CH. An Applications of the Modified SMART-SWOT Method in Casino Institution – A Case of Penghu Archipelago, Taiwan. *J. Assur. Hospitality & Tourism* 9, 337-346 (2008).

20. Kangas J, Kajanus M, Leskinen P, Kurttila M. Incoprporating MCDS and voting into SWOT – Basic idea and experiences. Forthcoming in *Serbian J. Manage.* 11(1), 1-14 (2016).

21. Keeney R. Value-Focused Brainstorming. *Dec. Anal.* 9(4), 303–313 (2012)

22. Könnölä T, Brummer V, Salo A. Diversity in foresight: Insights from the fostering of innovation ideas. *Techn. Forec. Soc. Change* 74, 608–626 (2007).

23. Kangas A, Laukkanen S, Kangas J. Social choice theory and its applications in sustainable forest management - a review. *For. Pol. Econ*. 9, 77-92 (2006).

24. Nurmi H. On the difficulty of making social choices. *Theory and Dec.* 38, 99-119 (1995).

25.Martin WE, Schields DJ, Tolwinski B, Kent B. An application of social choice theory to U.S.D.A. Forest Service decision making. *J. Pol. Mod.* 18, 603-621 (1996).

26. Yilmaz MR. Can we improve upon approval voting? *Eur. J. Pol. Econ.* 15, 89-100 (1999).

27. Lõõnik J, Saarepera R, Käger M *et al*. Guideline on action plans and strategies to mobilize waste-to-waste energy production. Savonia-ammattikorkeakoulun julkaisusarja D 1795-0848, 1-83 (2012).

28. Vehviläinen M. 2014. Assessment of the Investment Memo of ABOWE Pilot A Finland. Thesis. Savonia University of Applied Sciences. Technology, Communication and Transport. 34 Pages.

29. Kajanus M, Iire A, Eskelinen T, Heinonen M, Hansen E. Business model design: new tools for business. *Scand. J. For. Res.* 29, 603-614 (2014).

30. Liesiö J, Mild P, Salo A. Preference programming for robust portfolio modeling and project selection. *Eur. J. Oper. Res.* 181, 1488-1505 (2007).

31. Könnölä T, Salo A, Brummer V. Foresight for European coordination: developing national priorities for the Forest-Based Sector Technology Platform. *Int. J. Techn. Manage.* 54, 438-446 (2011).

32. Vacik H, Kurttila M, Hujala T, Chiranjeewee K, Haara A, Pykäläinen J, Honkakoski P, Wolfslehner B, Tikkanen J. Evaluating collaborative planning methods supporting programme-based planning in natural resource management. *J. Envir. Manage.* 144, 304-315 (2014).

33. Myllyviita T, Hujala T, Kangas A, Eyvindsson K, Sironen S, Leskinen P, Kurttila M. Mixing methods – assessment of potential benefits for natural resources planning. *Scand. J. For. Res.* 29, 20-29 (2014).

34. Eden C. On the nature of cognitive maps. *J. Manag. Studies* 29(3), 261-265 (1992).

35. Eden C, Ackermann F. Making Strategy: The Journey of Strategic Management. Sage Publications, UK, 1998.

36. Keeney, R.L., 1992. Value-Focused thinking: A path to creative decision–making. Harvard University Press, Cambridge, MA.

Table 1. Results of approval voting among the GSWOTA long lists: the elements chosen for further elaboration in the workshop and their approval votes

Element	**Approval votes**
Goals	
Speeding up the internalization	12
More external RDI funding for the three universities	11
New innovations in developing bioeconomy research and education	11
Support for growth and internationalization of small and medium-sized companies	10
Increasing co-operation in bioeconomy education	9
Increasing the attractiveness and bioeconomy reputation of eastern Finland	9
Strengths	
Versatile and many-sided knowhow in bioeconomy matters	14
The three universities complement each other (fields of study, expertise, education)	12
Strong regional will to strengthen bioeconomy	9
Skills in innovation and financial management and in connecting them to bioeconomy	8
Good basis for multidisciplinary RDI	8
Internationally successful and recognized forest sciences	7
Weaknesses	
Lack of continuity and perseverance in the financing and management	12
Lack of real transdisciplinary collaboration	10
We do not know each other's skills, substances, qualities etc. well enough	8
Decreasing resources available for enhancing co-operation	7
Results of social interaction are not included enough in the financing models	7
Opportunities	
Bioeconomy is prioritized by national policies	14
Better chances for getting external funding jointly that individually	10
More versatile exploitation of funding instruments by cross-regional projects	10
Innovative and multidisciplinary groups of researchers	9
Strong will to develop co-operation and belief in getting good results by it	9
Unexpected breakthroughs as "side streams" of co-operation efforts	8
Threats	
Mutual competition between the three universities	12
Hard to get private companies to co-operate in research and education	12
Increasingly shortsighted project funding	10
Still decreasing resources for enhancing co-operation	9
Actions	
Preparing a joint internationalization strategy together	12
Joint efforts in bioeconomy education (e.g. joint bachelor level examination)	11
Committing both financiers and experts more persistently on bioeconomy matters	9
Giving more emphasis on developing businesses – new and current ones	9
Monitoring the needs of companies and considering the needs in education and RDI	9
Joint workshops for the three universities for getting to know better each other	8
Joint family of commercial products for exporting bioeconomy education	8
Joint efforts for improving the reputation and attractiveness of the three universities	8
Joint demo bioeconomy platforms in Joensuu and Kuopio	8

Table 2. Results of cumulative voting: sums of the cumulative votes given by the four Groups – Group 1 research, development and innovation, Group 2 education, Group 3 benefits for the surrounding society, Group 4 feasibility and implementation, and Sum of cumulative votes

Element	**Group 1**	**Group 2**	**Group 3**	**Group 4**	**Sum of votes**
Goals					
Speeding up the internalization	75				75
More external RDI funding for the three universities				50	50
New innovations in developing bioeconomy research and education	125		100	20	245
Support for growth and internationalization of small and medium-sized companies			50	10	60
Increasing co-operation in bioeconomy education		400		50	450
Increasing the attractiveness and bioeconomy reputation of eastern Finland		75	50	10	135
Strengths					
Versatile and many-sided knowhow in bioeconomy matters					0
The three universities complement each other (fields of study, expertise, education)		25			25
Strong regional will to strengthen bioeconomy					0
Skills in innovation and financial management and in connecting them to bioeconomy			100	30	130
Good basis for multidisciplinary RDI	100			50	150
Internationally successful and recognized forest sciences				10	10
Weaknesses					
Lack of continuity and perseverance in the financing and management	100		100		200
Lack of real transdisciplinary collaboration				50	50
We do not know each other's skills, substances, qualities etc. well enough		50		120	170
Decreasing resources available for enhancing co-operation					0
Results of social interaction are not included enough in the financing models					0
Opportunities					
Bioeconomy is prioritized by national policies					0
Better chances for getting external funding jointly that individually			100	30	130
More versatile exploitation of funding instruments by cross-regional projects				150	150
Innovative and multidisciplinary groups of researchers				20	20
Strong will to develop co-operation and belief in getting good results by it				20	20
Unexpected breakthroughs as "side streams" of co-operation efforts	125				125
Threats					
Mutual competition between the three universities					0
Hard to get private companies to co-operate in research and education			100	20	120
Increasingly shortsighted project funding					0
Still decreasing resources for enhancing co-operation	75			10	85
Actions					
Preparing a joint internationalization strategy together			100	30	130
Joint efforts in bioeconomy education (e.g. joint bachelor level examination)	50	400		30	480
Committing both financiers and experts more persistently on bioeconomy matters	125		100		225
Giving more emphasis on developing businesses – new and current ones			100		100
Monitoring the needs of companies and considering the needs in education and RDI	100		100	50	250
Joint workshops for the three universities for getting to know better each other				200	200
Joint family of commercial products for exporting bioeconomy education		50		30	80
Joint efforts for improving the reputation and attractiveness of the three universities				10	10
Joint demo bioeconomy platforms in Joensuu and Kuopio	125				125

Table 3. The GSWOTA elements by regarded as the most prioritized ones by INTO analysis, i.e. the elements raised by the first INTO calculation

Element
Goals
New innovations in developing bioeconomy research and education
Increasing co-operation in bioeconomy education
Actions
Committing both financiers and experts more persistently on bioeconomy matters
Joint efforts in bioeconomy education (e.g. joint bachelor level examination)
Monitoring the needs of companies and considering the needs in education and RDI

Table 4. The GSWOTA elements raised by the second INTO calculation round

Element
Goals
New innovations in developing bioeconomy research and education
Increasing co-operation in bioeconomy education
Weaknesses
Lack of continuity and perseverance in the financing and management
Actions
Committing both financiers and experts more persistently on bioeconomy matters
Joint workshops for the three universities for getting to know better each other
Joint efforts in bioeconomy education (e.g. joint bachelor level examination)
Monitoring the needs of companies and considering the needs in education and RDI

Table 5. The GSWOTA elements raised by the third INTO calculation round

Element
Goals
New innovations in developing bioeconomy research and education
Increasing co-operation in bioeconomy education
Strengths
Skills in innovation and financial management and in connecting them to bioeconomy
Good basis for multidisciplinary RDI
Weaknesses
We do not know each other's skills, substances, qualities etc. well enough
Lack of continuity and perseverance in the financing and management
Opportunities
Better chances for getting external funding jointly that individually
More versatile exploitation of funding instruments by cross-regional projects
Unexpected breakthroughs as "side streams" of co-operation efforts
Actions
Committing both financiers and experts more persistently on bioeconomy matters
Joint workshops for the three universities for getting to know better each other
Joint efforts in bioeconomy education (e.g. joint bachelor level examination)
Joint demo bioeconomy platforms in Joensuu and Kuopio
Preparing a joint internationalization strategy together
Monitoring the needs of companies and considering the needs in education and RDI

Table 6. The GSWOTA elements raised by the fourth INTO calculation round

Element
Goals
Support for growth and internationalization of small and medium-sized companies
New innovations in developing bioeconomy research and education
Increasing co-operation in bioeconomy education
Increasing the attractiveness and bioeconomy reputation of eastern Finland
Speeding up the internalization
Strengths
Skills in innovation and financial management and in connecting them to bioeconomy
Good basis for multidisciplinary RDI
Weaknesses
We do not know each other's skills, substances, qualities etc. well enough
Lack of continuity and perseverance in the financing and management
Opportunities
Better chances for getting external funding jointly that individually
More versatile exploitation of funding instruments by cross-regional projects
Unexpected breakthroughs as "side streams" of co-operation efforts
Threats
Still decreasing resources for enhancing co-operation
Hard to get private companies to co-operate in research and education
Actions
Committing both financiers and experts more persistently on bioeconomy matters
Joint workshops for the three universities for getting to know better each other
Joint efforts in bioeconomy education (e.g. joint bachelor level examination)
Joint family of commercial products for exporting bioeconomy education
Joint efforts for improving the reputation and attractiveness of the three universities
Joint demo bioeconomy platforms in Joensuu and Kuopio
Giving more emphasis on developing businesses – new and current ones
Preparing a joint internationalization strategy together
Monitoring the needs of companies and considering the needs in education and RDI

List of Figures