



HAL
open science

Innovation Portfolio Management: How Can TRIZ Help?

Nikhil Shree Phadnis

► **To cite this version:**

Nikhil Shree Phadnis. Innovation Portfolio Management: How Can TRIZ Help?. 22th International TRIZ Future Conference (TFC), Sep 2022, Warsaw, Poland. pp.352-366, 10.1007/978-3-031-17288-5_30 . hal-04449790

HAL Id: hal-04449790

<https://inria.hal.science/hal-04449790v1>

Submitted on 15 Feb 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



This document is the original author manuscript of a paper submitted to an IFIP conference proceedings or other IFIP publication by Springer Nature. As such, there may be some differences in the official published version of the paper. Such differences, if any, are usually due to reformatting during preparation for publication or minor corrections made by the author(s) during final proofreading of the publication manuscript.

Innovation Portfolio Management: How can TRIZ help?

Nikhil Shree Phadnis ^[0000-0003-0003-561X]

Lappeenranta-Lahti University of Technology, 53850 Lappeenranta, Finland
nikhil.phadnis@lut.fi

Abstract. Prioritising the right innovation projects is necessary for effective strategic roadmaps and portfolios in a dynamic market with ever-increasing resource constraints. Innovation portfolio management is a process that informs decision-makers to help them focus and prioritise innovation projects to capitalise on their investments. On the other hand, the applicability of TRIZ in management is an ever-growing area proving its systematic and scientific capabilities. This paper builds on the foundation of expanding TRIZ and identifies several opportunities for TRIZ tools in the innovation portfolio management process. The study extracts data from the scientific literature to study innovation portfolio management as a process to find two distinct approaches to innovation portfolio creation: Emergent and deliberate innovation portfolio processes. The study investigates the pros, cons and gaps in these processes to potentially strengthen them with modern TRIZ tools. The research explores and explains which TRIZ tools can enhance the output of innovation portfolio management. This research finds TRIZ tools such as Main parameters of Value analysis, function analysis, S-curve analysis, Trends of evolution, contradiction analysis and quantum economic analysis critically benefit the portfolio process and can provide better innovation portfolio outputs through new unexplored insights.

Keywords: Innovation portfolio management, TRIZ, Innovation Management.

1 Introduction

“There are two ways for a business to succeed in new products: doing projects right and doing the right projects”, a statement by Cooper et al. paved the way for research in Portfolio management [1]. It is defined as a complex and dynamic process of distributing limited resources to a few prioritised projects to achieve maximal value, balance and a strategic fit with the firm. The innovation portfolio is concerned with creating a unified portfolio strategy and the maturation and selection of project candidates, known as concepts[2]. While the innovation portfolio process has been thoroughly examined in the past, no attempts have been made to combine diverse innovation methodologies to enhance its output. In this case, the theory of inventive problem solving (TRIZ). Even though various ideation techniques are available today, practitioners and academic researchers consider TRIZ a powerful but time-consuming method for systematically and scientifically improving engineering systems [3]. However, recent TRIZ research is expanding to new domains and the paper sets to explore its applicability in innovation management.

Recently, research into the applicability of TRIZ in Innovation management has been a rapidly developing area of interest[4-6]. Much research in this area concerns TRIZ tools, i.e. micro-level perspectives, for example, contradiction matrix applied to business and non-technical problems or adapting an existing cluster of TRIZ tools repurposed for creating strategic business roadmaps[5], [7-11]. This research adds to the "breadth" of knowledge by describing how TRIZ can enhance the output of an innovation portfolio, making it more robust and reducing failure rates of new product development. Consequently, this paper investigates the possible opportunities for enhancing the innovation portfolio process. As a result, the study question we are attempting to answer is "How can TRIZ tools potentially assist in approaches utilised in Innovation portfolio analysis?".

Firstly, the study identifies a research gap in the literature and provides an understanding of the fuzziness between innovation portfolio management and project portfolio management. Academic literature interchangeably "brands" these processes differently and creates an issue of clarity, portraying that both areas, innovation portfolio management and project portfolio management are the same. We address this issue by a systematic literature review and highlighting studies on innovation portfolio management and project portfolio management that establish a boundary to distinguish between them. Secondly, the literature review also explores a distinct portfolio process that outlines its stages in a well-defined manner. Our study finds that innovation portfolio management has two practical approaches with a small yet vital difference in the innovation strategy development of firms. This paper outlines both identified approaches to highlight their pros and cons. Lastly, an integrative literature review describes the potential of modern TRIZ tools to enhance the output of an innovation portfolio. This research adds novelty in two ways to existing research. Firstly creating a clear distinction between two innovation portfolio approaches and their different sequential phases. Secondly by proposing potential directions of improvement using Modern TRIZ and GEN-TRIZ(proprietary TRIZ tools used by TRIZ consulting companies) tools.

1.1 Innovation Portfolio Management

Most academic research confuses innovation portfolio management and project portfolio management, whilst some papers recently create a distinct separation between the two. Innovation portfolio analysis or management (IPM) is not to be mixed with project portfolio management (PPM). IPM is responsible for creating a unified portfolio strategy. In contrast, PPM is concerned with executing and delivering a group of projects known as a project portfolio. Matthews, 2010 outlines several differences between PPM and IPM, considering dimensions such as process type, objectives, planning horizons, technology readiness level, et cetera. IPM is a process that takes place before PPM, i.e. at an early stage initiation with a weakly defined strategic intent, in high uncertainty conditions [2].

Perhaps the most critical difference between them is in the deliverables of the two processes. IPM delivers a well-articulated strategy aligned with a few promising concepts that enable them to be released in a project portfolio. In comparison, PPM efficiently allocates a firm's resources aligned to its strategies. Strategies that were an output of the innovation portfolio process. PPM ensures the execution of the plans within the budget, scope, and required quality. The innovation portfolio analysis approach produces a cluster of concepts and tailored strategies for each group of concepts, which emerge over time and evolve during the analysis. IPM is more flexible and allows a concept to be substantially morphed by merging with another concept, partitioned into divergent concepts, or shelved altogether. Moreover, unlike the project portfolio's sequential stage-gate procedure, idea detail can be added to the innovation portfolio at any moment and in any sequence[2,12].

To summarise, innovation portfolio management should perhaps be referred to as “innovation portfolio analysis” as it is an analytical and strategic planning phase in the fuzzy front end as a preprocess to project portfolio management[13]. This phase allows decision-makers to shape their innovation strategy based on the ideation portfolio to provide strategic insights at a holistic level. Some researchers call it ideation portfolio management, referring to procedures that aid in producing and selecting valuable and relevant ideas and concepts for inclusion in the innovation project portfolio[14].

This paper concerns innovation portfolio analysis rather than project portfolio management since research has already established the proficiency of TRIZ in project management through the TRIZ assisted stage-gate process, its problem-solving capabilities with various TRIZ stools [15–17].

2 Methodology

We conduct a systematic critical literature review as an explorative study with a deductive approach to identify several phases in innovation portfolio analysis[18]. We used Web of science as a search engine to collect secondary data and analyse it. The initial search string “innovation portfolio management” without the exact search function focused on the Web of science core collection, i.e. peer-reviewed articles and publications. The initial hit yields 1418 papers from the Web of Science collection containing de-duplicated records. Next, we added a date range and filtered the results from 2010 to 2022 producing 1178 papers. The paper mainly focuses on the process perspective of the innovation portfolio analysis; therefore we decided to exclude mathematical or computer science studies that pertain primarily to algorithms and decision support systems. The search yields 1034 articles, including book chapters, journals, open access publications and proceedings. The papers were further filtered based on top-quality peer-reviewed publishers such as Elsevier, Emerald publications, Springer, Taylor and Francis, MDPI and IEEE to yield 698 articles. Lastly, papers were filtered by titles to produce 43 relevant publications, out of which 35 were available to the authors for analysis and synthesis. Figure 1 illustrates the systematic literature review process,

justifying the filter mechanisms, the number of hits(n), excluded and included studies to be analysed.

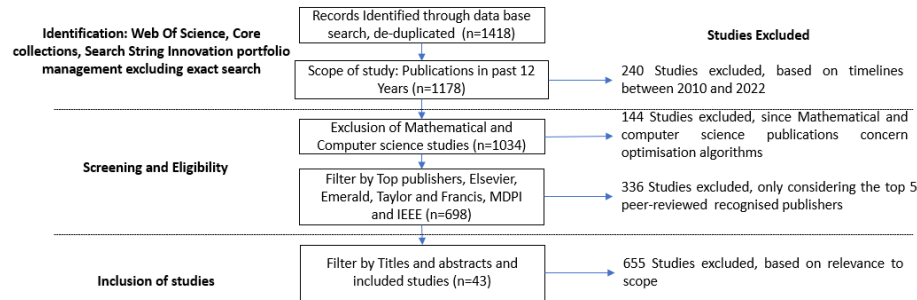


Fig. 1. Literature search and studies included

The final studies selected are analysed with two objectives. First, to investigate an explicit diagrammatic representation of the innovation portfolio process, outlining all of its stages or descriptions of the innovation portfolio management process activities. The systematic setting of the innovation portfolio management process may reveal research gaps and opportunities for TRIZ tools to fill these gaps. Secondly, identification of studies that attempt to integrate other innovation methods into the innovation portfolio process to enhance its output.

3 Results

The systematic literature review results in novel insights on innovation portfolio management as a topic and highlights the cloudiness between IPM and PPM. The results can be summarised in two complementing directions. First, general trends and statistics on innovation portfolio management, the state-of-the-art and the cloudiness of IPM and PPM. And secondly, two distinct innovation portfolio management processes, i.e., a deliberate innovation portfolio and an emergent innovation portfolio[19].

Our research reveals that 65% of the included studies explicitly mention innovation portfolio management as a process but do not study them from a process perspective. Instead, these studies focus on specific stages of the portfolio process. But only 22% of the studies have attempted to integrate, incorporate or hybridise an innovation method, tool and technique aimed toward enhancing the innovation portfolio output. Additionally, only 25% of the studies highlight innovation portfolio management as a separate process from project portfolio management.

To elaborate, most research considers the integration of an ideation phase before PPM to rebrand it as innovation portfolio management, strategic foresight, strategic innovation planning, ideation portfolio planning and many other names [13], [14], [20–27]. The addition of an ideation phase has also been linked with strategic innovation and

strategic foresight as a pre-step to project portfolio management and supports emerging strategies from the project portfolio. Additionally, research indicates scenario planning methods such as backcasting, forecasting, and technology road-mapping in the ideation phase allowing the innovation strategy to be formed at the end of the process. This process is known as an emergent innovation strategy. In traditional literature studies, emergent strategies are defined as processes that disclose emerging patterns in a project portfolio and inform the strategy formulation [19]. Some research studies claim that IPM is an emergent strategy formulation process; however other studies contradict this theory and argue that deliberate strategy implementation is as successful as emergent strategies[19].

Our research shows that the innovation portfolio management process can have two strategic control processes, with emergent or deliberate strategies. More importantly, the literature review IPM process revealed that 54% of the papers mention deliberate strategies to align the resulting portfolio to the organisation's goals, whereas 25% of the reports claim emergent strategies are more suited to the adaptability and growth of a firm. Four studies claim both approaches are equally crucial for strategic decision-making during the innovation portfolio process. We will outline both the emergent and deliberate processes in section 3.1, providing advantages, disadvantages and opportunities to strengthen them using TRIZ tools.

3.1 Innovation portfolio management approaches

Emergent innovation portfolios.

The term "emerging strategy recognition" refers to discovering unexpected and unplanned events. Such incidents are far more likely to occur in a dynamic business atmosphere. Emergent strategy recognition is a sensing capability that allows companies to recognise and adapt to environmental changes. Compared to incremental innovation projects, radically new product development or disruptive innovations benefit from a more emergent approach. Creativity and adaptability are necessary for effective solutions, especially in a volatile environment, because they are less planned, irreversible, and evolutionary[19], [28].

Figure 2 illustrates the process of an emergent innovation portfolio. Like any other strategic management approach, it initiates with a vision and mission statement of the firm. This is followed by an ideation stage, targeted towards the opportunity recognition and discovery to identify ongoing and new portfolio candidates. The ideation phase is exploratory and consists of several sub-phases. While the phase may be exploratory, organisations establish boundary conditions under which a sufficient amount of creative and valuable ideas can be generated. Therefore, there exists a "loosely defined" strategic intent for this stage, within certain specifications of innovation search. The search fields typically concentrate on customer needs in the future, new markets, megatrends, convergence of upcoming technologies or competing technologies that

could enable the organization to create new offerings. The deliverables of the ideation phase are conceptual directions that could transform into portfolio candidates for products or product lines that could potentially meet the future market needs[13], [14].

Subsequently, the research phase focuses on synthesis and analysis to substantiate and provide reasons to believe in conceptual directions generated in the ideation phase. Therefore, this phase is intensive and requires substantial support from subject matter experts to estimate its initial feasibility from the technical and business perspective. This step has also been called qualitative coarse screening with a rough order of magnitude estimate of value[2], [12]. The subsequent selection phase evaluates and compares potential candidates to eliminate projects strategically. Most research in this domain concerns evaluation methods, criteria, and risk assessment that inform decision-makers to establish a probability of market winning success. Portfolio balancing, interrelationship analysis, and synergistic selection of projects are critical in these phases. They provide insight into the prioritisation of projects and innovation strategies built around the result of the synergies between the business and the projects. Lastly, innovation strategies evolve or become a byproduct of project landscape and product strategies based on available data and insights. Therefore, this process is also known as the “bottom-up approach”. The emergent nature of this process allows firms to re-evaluate their competencies, strategy and vision-based practicality oriented towards the future in a relatively objective way.

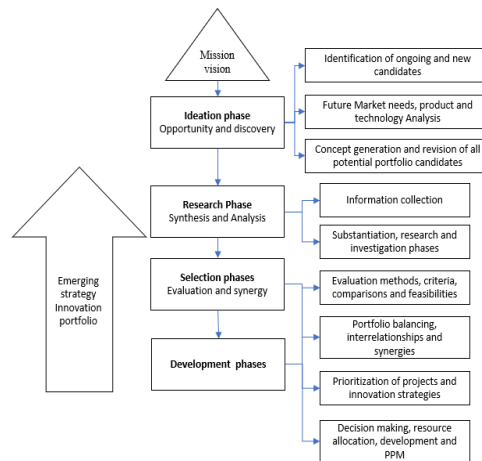


Fig. 2. Adapted Emergent innovation portfolio process[19], [26], [29]

Kopmann et al. 2017, highlights the need for an IPM approach for emerging strategies in dynamic and uncertain market conditions; in contrast, the study claims that deliberate strategies are best used when short term predictability is near perfect[19], [28]. However, this process comes with its own set of disadvantages. The research argues that the

ideation phase without focus generates too many irrelevant and non-implementable ideas instead of high-quality ideas. Moreover, studies claim that a systematic set of the ideation search field may increase the firm's innovation competencies, which could be debatable since more ideas do not necessarily mean better innovation competencies[19], [28]. Lastly, most tools used in this phase such as scenario planning, forecasting and backcasting, and technology road mapping occur at an abstract phase using brainstorming as one of the primary methods to create such futuristic scenarios[2], [13], [14], [21], [28]. To put it simply, there exists a lack of tools and methods used to strengthen the ideation phase of the emerging innovation portfolio process.

Deliberate innovation portfolios.

The process of consciously cascading the defined corporate strategy to the project level in a top-down manner is called deliberate strategy implementation[19], [28]. This is also known as the planned strategy approach, wherein the innovation, organisational, and business strategies are predefined and “pushed” down to projects and used to align the resulting innovation portfolio.

Our systematic literature review found that deliberate strategies were the more dominant ones in academic literature from 2010 to 2016. Kopmann et al. 2017, argue while stable long-term strategies facilitate a deliberate strategy implementation, they also require high accuracy of long-term market forecasts and technological advancements[19], [30]. Therefore, the market's level of turbulence plays an important role in the selection of a deliberate innovation portfolio strategy. The more instability in a company's market and applicable future technologies, the less accurate these long-term forecasts will be, and the more frequently the strategies will need to be altered.

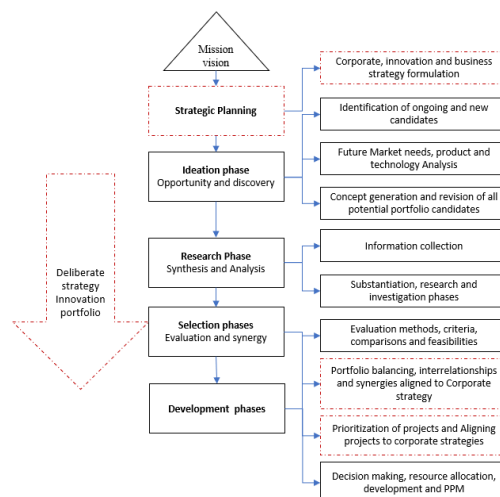


Fig. 3. Adapted deliberate innovation portfolio process[29], [31–33]

Figure 3 illustrates the alternative deliberate innovation portfolio strategy and its stages. It adds a stage of strategic planning before the ideation and discovery phase. In this phase, stakeholders and decision-makers formulate the business strategy and corporate and innovation strategy for their firm, which serves as an input into the ideation phase. These predefined strategies act as boundary conditions that, to a certain extent, restrict creativity and reject ideas misaligned with the fit of the organisation. Moreover, the top-down strategy cascades to the project landscape and eliminates projects that do not conform to the organisational strategy. Thereby leaving little room for long-term creative exploration of radical innovations in new business areas but an enormous scope for short to mid-term exploitation of existing portfolios and competencies. The level of strategic control over a deliberate innovation portfolio is significantly higher and goal-oriented. The deliberate innovation portfolio process plays a big role in the selection phases and prioritisation of projects aligned to predefined strategies wherein the top management controls strategic communication and oversight. The most obvious disadvantage of this process is a lack of flexibility and lost opportunities due to its un-explorative nature. For example, it's possible that a specific technological competency could potentially be used in a distant area of application far from the current market that this company serves, resulting in new markets and business lines.

To summarise, there seems to be a debate in the academic literature on emergent and deliberate innovation portfolio processes and a new area of “planned emergence”. Wherein, both approaches are hybridised to complement each other’s weaknesses[19]. However, TRIZ can effectively help in both the aforementioned approaches through its various tools and approaches.

4 Discussions

4.1 Enhancing the innovation portfolio analysis process with TRIZ

In section 3.1, we analyse approaches to innovation portfolio management to reveal their strengths and weaknesses. Section 4.1 consists of an integrative literature study that assesses TRIZ tools to fill the gaps identified in both methods presented. TRIZ in innovation management literature has seen some popularity however most practitioners limit its applicability to engineering systems. TRIZ provides the practical hands-on tools to link business problems with engineering systems such as this one in innovation portfolio processes. We systematically outline each stage of the innovation portfolio process and the applicable TRIZ tool or approach to highlight potential impacts reduce the risk of innovation failure and create strategic innovation agendas.

Ideation phase.

The objective of the ideation phase in the innovation portfolio process is to generate ideas and concepts that are future-oriented i.e discover future market needs. Scenario planning is a popular tool used by practitioners to forecast scenarios to help them identify events that are likely to happen in line with existing trends. In contrast, backcasting involves scenarios that start from a future vision to explore the resources necessary to create the envisioned future[22]. However, both approaches lack appropriate methods to forecast the future and create abstract scenarios based on obvious megatrends. Typical approaches for forecasting and backcasting techniques is heavily reliant on the voice of the customer (VOC). However, VOC can be insufficient or inaccurate to forecast the future market needs since they do not always reflect the customer's true wants and needs appropriately [34].

Additionally, technological forecasting or road mapping also involves identifying technologies and evaluating their ability to deliver potential product features. This step requires precise knowledge and trends rather than abstract assertive statements. The ideation phase in the Innovation portfolio process relies on brainstorming techniques to create scenario plans and technological forecasts. Therefore, TRIZ compensates for this weakness using the main parameters of value(MPV) analysis approach and trends of engineering systems evolution(TESE) to provide additional insights from the voice of the product and help us establish approximate developmental limits of the product lines [35], [36]. These processes help decision-makers reduce the risk of innovation failure significantly and act as an additional screening mechanism in the portfolio selection phases.

MPV Analysis and TESE.

Main parameters of value are defined as a key feature of an unsatisfied offering that influences the customer's purchase decision, making it a crucial tool for developing new products[34]. One may argue that MPV analysis is a repurposed process consisting of function analysis, S curve analysis and trends of engineering systems evolution. But, MPV analysis provides the voice of the product, which reflects a product's "needs and wants" to supplement the voice of the customer as additional insight. Put another way, it is as if we question the existing product or product line and allow it to show us its direction of evolution.

Typical tools used within MPV analysis initially begin with high-level function analysis with two different perspectives of the function model. Customer-oriented function model(macro or high-level model), wherein we consider different scenarios and use cases of the product highlighting its functional disadvantages super systems to reveal latent or hidden needs of the customer[34], [35]. And secondly, a product-oriented function model or regular function analysis to discover functional disadvantages within the product isolated from the super system. Based on the results of both function models, we perform either qualitative regular S-curve analysis (based on action principle)

or pragmatic S curve analysis for each potential MPV to determine their current performance level and their estimated developmental limits[36]. This process allows us to establish the feasibility and the effort of improvement needed to improve the product.

Parallely, TESE analysis is performed to analyse evolutionary directions for the identified MPVs. This step is different from other classical scenario planning methods that are based on creating futuristic scenarios for the entire product. Instead, we use each MPV of the product to forecast its evolution resulting in more precision. Since the technology forecasting is based on the MPV of the product, it automatically accounts for competing technologies that meet the minimally acceptable level of performance for the MPV. For example, if the MPV is long-range for electric vehicles, our analysis would include all competing technologies that meet the MPV of delivering long-range in a benchmarking study. In other words, state-of-the-art and upcoming new technologies are inbuilt into this approach. Lastly, S curve analysis coupled with TESE provides essential insights into innovation activity to improve the MPV. The organisation could get insights into types of innovation projects to be undertaken, such as adding new functionalities, cost reduction, switching to a new action principle, et cetera, to improve the engineering system effectively. Abramov, 2016 showcases the process of MPV discovery and outlines the process of discovering the latent needs of a product[35]. The MPV and TESE analysis result in new conceptual directions, ideas or evolutionary directions for product lines that become new potential candidates included in the innovation portfolio to be investigated in the subsequent phases.

Selection Phases.

The selection phase of the innovation portfolio process primarily has two goals. First, act as a screening mechanism and eliminate projects or concepts that do not create sufficient value for the organisation. Secondly, to help identify synergies between projects and concepts because at this stage, portfolio candidates can be merged, broken down into many divergent concepts or shelved altogether. Research suggests countless methods, evaluation criteria, and techniques to strategically select projects quantitatively and qualitatively to address the issue of effective screening[37–40]. However, none of the methods considers the S-curve positions of the potential new product, market and organisation simultaneously to estimate their level of fit. This may be achieved by a new Gentriz tool, Quantum Economic Analysis. Whereas addressing the synergy and assessing the interdependency of projects on each other can be resolved through contradiction analysis.

Quantum Economic Analysis Screening.

Quantum economic analysis (QEA-screening) is a new approach, which considers the combined stages of development of the company, its product and its target market to indicate a successful business set[41]. By considering S-curve positions of the product, market, and company simultaneously, this research provides 13 successful business combinations that claim a better chance of business success than others, irrespective of

the company's financial prowess. Consequently, research suggests that if a business combination does not fall within the allowed set, its chances of failure are significantly higher regardless of the company or the product [7], [8], [42]. Recently, QEA based screening has been used in the TRIZ assisted stage-gate process and in the new product development to provide a promising 80% success rate [8]. In some cases, QEA screening has also been used as a selection mechanism for open innovation strategies and innovation management [42].

While the approach is relatively new and is not a part of modern body of knowledge in TRIZ, it may still be utilised for research purposes to anticipate and quantify its impact on innovation portfolio success. The addition of QEA-based screening in innovation portfolio selection phases could allow decision-makers to converge on a set of projects and select suitable open innovation strategies at the early stage for better resource management and parallelisation of business development activities in the stage-gate process.

Contradiction Analysis.

"How many birds can you get with one stone?" is an analogy for synergy. It explains how solutions developed for one product may benefit another. Achieving portfolio balance and interrelationships between projects are necessary for project prioritisation phases and product strategies. While aligning potential projects to corporate strategy is necessary, it is equally essential to consider the synergies between several projects [17]. That is, to explore interdependencies and interrelationships across the portfolio. The technical synergy between projects explains how solutions developed for one product may benefit another, causing projects to be merged, divided, prioritised or eliminated entirely from the portfolio.

Identifying key contradictions at the macro level can be used to identify technical synergies and challenges across various product families and business units [43]. Similarly, identifying key problems or contradictions that could potentially impact the largest number of products in a portfolio could be prioritised. To elaborate, there could be four types of technical synergies possible.

Type 1	Type 2
When solutions of one technical challenge can be applicable to another	When existing solutions, technologies, and materials used in the production of one product may benefit the development of another
If some products interact, the technical challenge for one of them can be eliminated by changing another	When problems with one product may actually serve as solutions for another
Type 3	Type 4

Fig. 4. Framework for synergies in innovation portfolios

Verbitsky and Casey, 2008 outline a framework for four types of synergistic situations in an innovation portfolio, as seen in figure 4. Considering an innovation portfolio, a firm must assess and analyse all four types of synergies to exploit their existing competencies while exploring new potential opportunities that arise from these synergies. It is challenging for multinational companies with hundred plus product lines to identify key contradictions; however, it is possible to estimate a key contradiction at the macro level. Decision-makers and TRIZ practitioners can cluster a group of products based on similar bottlenecks, thereby having an additional set of screening criteria in the selection phases and maximising value. The key contradiction could enable a breakthrough technology or a solution that could be replicated across multiple product lines, business units or the entire portfolio. Therefore, potential portfolio candidates must be carefully studied and researched to look out for key contradictions that may have a potentially large impact across a range of products. Moreover, resolving major bottleneck contradictions may also create super effects that can impact other product lines. Lastly, resolving key contradictions allows for replicability of solutions and adaptation of existing solutions instead of inventing new ones, similar to the clone problems approach. Table 1 summarises the applicability of TRIZ tools in innovation portfolio processes and its potential impacts.

Table 1. Summary of TRIZ tools and their impact on innovation portfolio process.

TRIZ tools	Phase of portfolio process	Potential Impact on innovation portfolio
<i>MPV Analysis(combination of Function analysis, TESE and S-Curve analysis)</i>	<i>Ideation</i>	<ul style="list-style-type: none"> • <i>Identifies of Products voice and uncover latent needs</i> • <i>Better assessment of product and technology evolution</i> • <i>Identifies all competing technologies meeting a future MPV</i> • <i>Discovers better opportunities for disruptive innovation</i> • <i>Links future market requirements with the potential of the product to deliver on MPVs</i>
<i>QEA- Screening(combination of S-curve positions of product, company and market simultaneously)</i>	<i>Portfolio Selection</i>	<ul style="list-style-type: none"> • <i>Insights into fit conditions of Market, product and organization</i> • <i>Selection and resource allocation wrt open innovation strategy</i> • <i>Recommends changes to either product, market or company to meet synergize the strategic fit</i> • <i>Acceleration of early-stage business development activities and faster time to market</i>

<i>Contradiction analysis</i>	<table border="0"> <tr> <td data-bbox="608 398 826 450"><i>Portfolio Balancing and prioritization</i></td> <td data-bbox="842 398 1248 728"> <ul style="list-style-type: none"> • <i>Identifying key breakthrough contradictions impacting multiple products</i> • <i>Acts as an additional screening mechanism aiding in project prioritization</i> • <i>Resolving secondary problems that may produce super effects over other projects</i> • <i>Enables replicability of solutions through clone problems over many product lines</i> </td> </tr> </table>	<i>Portfolio Balancing and prioritization</i>	<ul style="list-style-type: none"> • <i>Identifying key breakthrough contradictions impacting multiple products</i> • <i>Acts as an additional screening mechanism aiding in project prioritization</i> • <i>Resolving secondary problems that may produce super effects over other projects</i> • <i>Enables replicability of solutions through clone problems over many product lines</i>
<i>Portfolio Balancing and prioritization</i>	<ul style="list-style-type: none"> • <i>Identifying key breakthrough contradictions impacting multiple products</i> • <i>Acts as an additional screening mechanism aiding in project prioritization</i> • <i>Resolving secondary problems that may produce super effects over other projects</i> • <i>Enables replicability of solutions through clone problems over many product lines</i> 		

5 Conclusions and future scope of work

This paper analyses innovation portfolio management, qualitatively to discover two distinct approaches, emergent and deliberate innovation portfolios and describes their pros and cons. The paper systematically outlines the process to highlight their weaknesses through existing literature and suggests improvements to enhance the portfolio output using TRIZ methods. While researchers suggest several perspectives on innovation portfolios, it was surprising to investigate a relatively small amount of papers indexed in Web of science. Similarly, few approaches integrate innovation methodologies such as Ecodesign, design thinking, creativity, technology road mapping and strategic foresight with innovation portfolio processes. However, very few approaches consist of systematic methods that follow scientific approaches such as TRIZ. This study contributes to the theoretical body of knowledge and encourages practitioners to use TRIZ in management domains.

On the one hand, TRIZ is expanding its applicability to innovation management, yet studies are still scarce and consider classical TRIZ tools to be applied to business problems[4], [44–46]. In this paper, we provide an overview of potential TRIZ tools and new approaches such as MPV analysis, TESE, S-curve analysis, quantum economic analysis and contradiction analysis to potentially enhance the output of the innovation portfolio. We highlight the stages in which specific TRIZ tools can help provide additional insights to aid in the selection of the right innovation targets. Currently, this research hypothesizes TRIZ tools to be used in IPM, however, it does not provide tangible concrete examples to demonstrate the claims in practice. Therefore, paving the way for further research to quantify the impact of utilising the proposed tools in IPM and empirically test the TRIZ tools.

Acknowledgement. We thank Dr Simon Litvin, Dr Oleg Abramov and Dr Alex Lyubomirsky (GENTRIZ) for providing valuable insights on GENTRIZ tools and knowledge that aided this research.

References

1. [1] R. G. Cooper, S. J. Edgett, and E. J. Kleinschmidt, "New problems, new solutions: making portfolio management more effective," *Research Technology Management*, vol. 43, no. 2, pp. 18–33, 2000, doi: 10.1080/08956308.2000.11671338.
2. [2] S. Mathews, "Innovation portfolio architecture," in *Research Technology Management*, 2010, vol. 53, no. 6, pp. 30–40. doi: 10.1080/08956308.2010.11657660.
3. [3] T. Shealy, M. Hu, and J. Gero, "Neuro-cognitive differences between brainstorming, morphological analysis, and TRIZ," *ASME International Design Engineering Technical Conferences*, 2018, [Online]. Available: <http://mason.gmu.edu/~jgero/publications/Progress/18ShealyHuGero-ASME.pdf>
4. [4] R. Teplov, "What is known about TRIZ in Innovation Management?," *ISPIM Conference* ..., no. June, 2014, [Online]. Available: <http://search.proquest.com/openview/7dcfb982d2ea05341092a69ae6fe2ae/1?pq-origsite=gscholar>
5. [5] P. Livotov and B. Ruchti, "TRIZ-based Innovation Principles and a Process for Problem Solving in Business and Management Educating the Edisons of the 21st Century View project Advanced Innovation Design Approach-AIDA View project," 2001. Accessed: Apr. 04, 2021. [Online]. Available: www.diwings.ch
6. [6] V. Kaliteevskii, M. Bryksin, and L. Chechurin, "TRIZ Application for Digital Product Design and Management," in *Creative Solutions for a Sustainable Development*, 2021, pp. 245–255.
7. [7] O. Y. Abramov, "Generating New Product Ideas with TRIZ-derived 'Voice of the Product' and Quantum -Economic Analysis (QEA)," *17th International TRIZ Future Conference*, pp. 80–87, 2017.
8. [8] O. Abramov, S. Markosov, and A. Medvedev, "Experimental Validation of Quantum-Economic Analysis (QEA) as a Screening Tool for New Product Development," in *Advances and Impacts of the Theory of Inventive Problem Solving*, 2018. doi: 10.1007/978-3-319-96532-1_2.
9. [9] O. Y. Abramov, A. v Medvedev, and N. Tomashevskaya, "TRIZ fest 2019 Entering adjacent markets is a widely accepted marketing strategy for developing business without," no. September, pp. 0–9, 2019.
10. [10] K. H. Chai, J. Zhang, and K. C. Tan, "A TRIZ-based method for new service design," *Journal of Service Research*, vol. 8, no. 1, pp. 48–66, 2005, doi: 10.1177/1094670505276683.
11. [11] E. Otavá and S. Brad, "TRIZ-Based Approach for Improving the Adoption of Open Innovation 2.0," in *IFIP Advances in Information and Communication Technology*, Oct. 2020, vol. 597 IFIP, pp. 452–464. doi: 10.1007/978-3-030-61295-5_34.
12. [12] S. Mathews, "INNOVATION PORTFOLIO ARCHITECTURE-PART 2: AFTRIROn SaECTION ANO «ALOATION A "sufficiently simple " valuation philosophy quickly identifies the most valuable concepts in an innovation portfolio while minimizing analytical time and cost," 2011.
13. [13] W. Heising, "The integration of ideation and project portfolio management - A key factor for sustainable success," *International Journal of Project Management*, vol. 30, no. 5, pp. 582–595, 2012, doi: 10.1016/j.ijproman.2012.01.014.

14. [14] A. Kock, W. Heising, and H. G. Gemünden, "How ideation portfolio management influences front-end success," *Journal of Product Innovation Management*, vol. 32, no. 4, pp. 539–555, Jul. 2015, doi: 10.1111/jpim.12217.
15. [15] O. Y. Abramov, "Innovation Funnel of Modern Triz: Experimental Study to Show the Efficacy of the TRIZ-Assisted Stage-Gate Process," 2018.
16. [16] O. Y. Abramov, "Innovation Funnel of Modern Triz: Experimental Study to Show the Efficacy of the TRIZ-Assisted Stage-Gate Process," *TRIZfest 2018*, no. September, pp. 105–110, 2018.
17. [17] O. Y. Abramov, "TRIZ-assisted Stage-Gate Process for Developing New Products," *Journal of Finance and Economics*, 2014, doi: 10.12691/jfe-2-5-8.
18. [18] M. Saunders, P. Lewis, and A. Thornhill, *Research Methods for Business Students*. 2016.
19. [19] J. Kopmann, A. Kock, C. P. Killen, and H. G. Gemünden, "The role of project portfolio management in fostering both deliberate and emergent strategy," 2017, doi: 10.1016/j.ijproman.2017.02.011.
20. [20] J. W. Brook and F. Pagnanelli, "Integrating sustainability into innovation project portfolio management-A strategic perspective," *J. Eng. Technol. Manage*, vol. 34, pp. 46–62, 2014, doi: 10.1016/j.jengtecman.2013.11.004.
21. [21] N. Hadjinicolaou, M. Kader, and I. Abdallah, "Strategic innovation, foresight and the deployment of project portfolio management under mid-range planning conditions in medium-sized firms," *Sustainability (Switzerland)*, vol. 14, no. 1. MDPI, Jan. 01, 2022. doi: 10.3390/su14010080.
22. [22] C. Villamil, J. Schulte, and S. Hallstedt, "Sustainability risk and portfolio management—A strategic scenario method for sustainable product development," *Business Strategy and the Environment*, vol. 31, no. 3, pp. 1042–1057, Mar. 2022, doi: 10.1002/bse.2934.
23. [23] K. Randhawa, N. Nikolova, S. Ahuja, and J. Schweitzer, "Design thinking implementation for innovation: An organization's journey to ambidexterity," *Journal of Product Innovation Management*, vol. 38, no. 6, pp. 668–700, Nov. 2021, doi: 10.1111/JPIM.12599.
24. [24] M. A. Paula Pinheiro, D. Jugend, L. C. Dematte Filho, and F. Armellini, "Framework proposal for ecodesign integration on product portfolio management," *JOURNAL OF CLEANER PRODUCTION*, vol. 185, pp. 176–186, Jun. 2018, doi: 10.1016/j.jclepro.2018.03.005.
25. [25] R. Ram Irez, L. Roodhart, and W. Manders, "How Shell's Domains Link Innovation and Strategy", doi: 10.1016/j.lrp.2011.04.003.
26. [26] M. G. Oliveira and H. Rozenfeld, "Integrating technology roadmapping and portfolio management at the front-end of new product development," 2010, doi: 10.1016/j.techfore.2010.07.015.
27. [27] R. Phaal, L. Simonse, and E. den Ouden, "Next generation roadmapping for innovation planning," *International Journal of Technology Intelligence and Planning*, vol. 4, no. 2, pp. 135–152, 2008, doi: 10.1504/IJTIP.2008.018313.
28. [28] S. Clegg, C. P. Killen, C. Biesenthal, and S. Sankaran, "Practices, projects and portfolios: Current research trends and new directions", doi: 10.1016/j.ijproman.2018.03.008.
29. [29] D. Pashley, T. Tryfonas, A. Crossley, C. Setchell, and S. Karatzas, "Innovation Portfolio Management for Small-medium Enterprises," *Journal of Systems Science and Systems Engineering 2020 29:5*, vol. 29, no. 5, pp. 507–524, Oct. 2020, doi: 10.1007/S11518-020-5467-Z.

30. [30] R. Cooper, E. Kleinschmidt, and S. Edgett, "J of Product Innov Manag - 2004 - Cooper - New Product Portfolio Management Practices and Performance," *Journal of Product Innovation Management*, 2004.
31. [31] Q. Xu, X. Zhao, W. Shaohua, and J. Chin, "Competence-based innovation portfolio," in *Proceedings of the 2000 IEEE International Conference on Management of Innovation and Technology*: , 2000, vol. 1, pp. 134–139. doi: 10.1109/ICMIT.2000.917303.
32. [32] R. Klingebiel and C. Rammer, "Resource allocation strategy for innovation portfolio management," *Strategic Management Journal*, vol. 35, no. 2, pp. 246–268, Feb. 2014, doi: 10.1002/smj.2107.
33. [33] A. Kock and H. Georg Gemünden, "Antecedents to Decision-Making Quality and Agility in Innovation Portfolio Management," *Journal of Product Innovation Management*, vol. 33, no. 6, pp. 670–686, Nov. 2016, doi: 10.1111/JPIM.12336.
34. [34] O. Y. Abramov, "TRIZ fest 2016 July 26- 28 , Beijing , People ' s Republic of China PRODUCT-ORIENTED MPV ANALYSIS TO IDENTIFY VOICE OF THE PRODUCT 1 . Introduction : Existing MPV Analysis is Insufficient to Identify the VOP," no. August, 2016.
35. [35] O. Abramov, A. Medvedev, and N. Tomashevskaya, "Main Parameters of Value (MPV) Analysis: Where MPV Candidates Come From," pp. 391–400, 2021, doi: 10.1007/978-3-030-86614-3_31.
36. [36] A. Lyubomirskiy, S. Itvin, S. Ikoenko, R. Aduka, and C. M. Thurnes, *Trends of Engineering Systems Evolution(TESE) TRIZ paths to innovation*. 2014. [Online]. Available: <http://library1.nida.ac.th/termpaper6/sd/2554/19755.pdf>
37. [37] X. A. Flechas Chaparro, L. A. de Vasconcelos Gomes, and P. Tromboni de Souza Nascimento, "The evolution of project portfolio selection methods: from incremental to radical innovation," *Revista de Gestao*, vol. 26, no. 3, pp. 212–236, Jul. 2019, doi: 10.1108/REGE-10-2018-0096/FULL/PDF.
38. [38] M. Montajabiha, A. A. Khamseh, and B. Afshar-Nadjafi, "A robust algorithm for project portfolio selection problem using real options valuation," *INTERNATIONAL JOURNAL OF MANAGING PROJECTS IN BUSINESS*, vol. 10, no. 2, pp. 386–403, 2017, doi: 10.1108/IJMPB-12-2015-0114.
39. [39] R. Klingebiel and C. Rammer, "RESOURCE ALLOCATION STRATEGY FOR INNOVATION PORTFOLIO MANAGEMENT," *Strategic Management Journal Strat. Mgmt. J*, vol. 35, pp. 246–268, 2014, doi: 10.1002/smj.2107.
40. [40] T. R. Browning and A. A. Yassine, "Managing a Portfolio of Product Development Projects under Resource Constraints," *Decision Sciences*, vol. 47, no. 2, pp. 333–372, Apr. 2016, doi: 10.1111/deci.12172.
41. [41] G. Topchishvili, Y. Katsman, and A. Schneider, "Science to win in investment, Management and marketing." 2003. [Online]. Available: http://1drv.ms/1D5ikaA%5Cnleader/nauka_pobezhdats_k_1.djvu
42. [42] N. Phadnis, "Integrating Open Innovation Strategies with Quantum economic analysis," 2021. [Online]. Available: [https://lutpub.lut.fi/bitstream/handle/10024/162408/Masters Thesis _ Final version1.pdf?sequence=1&isAllowed=y](https://lutpub.lut.fi/bitstream/handle/10024/162408/Masters%20Thesis%20Final%20version1.pdf?sequence=1&isAllowed=y)
43. [43] G. S. Altshuller, "The innovation algorithm: TRIZ, systematic innovation and technical creativity," *Technical Innovation Center, Inc.* p. 312, 1999. [Online]. Available: <http://www.amazon.com/dp/0964074044>
44. [44] O. Abramov and S. Sobolev, "Current stage of TRIZ evolution and its popularity," in *Advances in Systematic Creativity: Creating and Managing Innovations*, 2018. doi: 10.1007/978-3-319-78075-7_1.

45. [45] V. Souchkov, "BREAKTHROUGH THINKING WITH TRIZ FOR BUSINESS AND MANAGEMENT: AN OVERVIEW," 2007. Accessed: Apr. 04, 2021. [Online]. Available: www.xtriz.com
46. [46] L. Chechurin and Y. Borgianni, "Understanding TRIZ through the review of top cited publications," *Computers in Industry*, vol. 82, pp. 119–134, 2016, doi: 10.1016/j.compind.2016.06.002.