Impact of Theory of Inventive Problem Solving (TRIZ) on Innovation Portfolio Development

Phadnis Nikhil, Torkkeli Marko

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Impact of Theory of Inventive Problem Solving (TRIZ) on Innovation Portfolio Development

Nikhil Phadnis[0000-0003-0003-561X] and Marko Torkkeli[0000-0003-1357-871X]

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

Abstract. Innovation portfolio management (IPM) is a critical planning phase for organisations to visualise all possible growth opportunities and strategically allocate resources. However, to maximise the probability of business growth, it is necessary to follow a robust structured portfolio process. This paper analyses research and highlights several success dimensions of innovation product portfolios by a systematic literature review and outlines nine success criteria. Additionally, it examines all the portfolio methods that significantly influence the portfolio's "innovation" aspect. Secondly, we evaluate and discuss the impact of TRIZ tools and approaches on innovation portfolios and explore their relationships with business growth. Thirdly, the research presents modern TRIZ approaches, and the types of TRIZ-based innovation projects organisations can execute to build robust, innovative product portfolios. Finally, the article summarises critical information on the different types of innovation projects and TRIZ tools utilised for these projects.

Keywords: Product Portfolio, Innovation Portfolio, Business Growth Strategy, TRIZ.

1 Introduction

Today, an emerging technology in an area far from a firm's business may threaten its market despite not being a direct competitor. Moreover, rapid technological breakthroughs pressurise the innovation portfolio planning phases, making it a critical inflexion point that could seal a company's fate. The uncertainty of future business drivers poses a complex challenge for individuals and organisations, where innovation managers place their bets on potential market winners in the short, mid and long terms with maximal reliability and accurate forecasts. Furthermore, they have a herculean responsibility to distribute and allocate scarce resources to their innovation portfolios [1]–[4]. The analytical phase before the actual distribution of resources, with weak strategic intent and high uncertainty conditions, is known as Innovation portfolio planning or Innovation portfolio analysis [1], [5], [6]. On the other hand, firms that correctly utilise the synergies of their product portfolios represent their investment strategies and provide the organisation with increased benefits above and beyond those gained from projects run independently [7]. However, despite extensive research, there has not been a clear consensus on the success criteria of innovation portfolios. Therefore, this paper

focused on the success criteria insights from literature for defining successful innovation portfolios in organisations. Additionally, scarce research compares the various portfolio creation and selection techniques that influence portfolio success criteria.

On the other hand, Theory of Inventive Problem Solving (TRIZ) continues to be strong in its applicability to technical systems. Moreover, it expands its capabilities to business and management, i.e. non-technical areas [8]–[19]. However, a survey conducted in 2013 reveals that TRIZ was rarely applied to technology strategy, forecasting or business and management areas [20], [21]. We theorise that the findings in this study may have changed as of 2023, mainly because most modern TRIZ approaches for business needs developed from 2016 onwards and, therefore, can be applied to strategic business management. In addition, several TRIZ tools, while being the same, were formalised in the form of step-by-step approaches for innovation-related applications [8], [22]–[30]. However, despite the methodical developments mentioned above, relatively low TRIZ studies outline and describe the relevance of TRIZ in Innovation management, and even fewer studies are explicitly directed towards innovation portfolio analysis [21], [27], [31], [32]. Phadnis [32] provides some evidence and outlines the applicability of TRIZ tools to create better Innovation portfolios; however, the research needs to go deeper into the potential impact of Modern TRIZ on innovation portfolios [6]Therefore, this paper explains the influence of modern TRIZ on product portfolios.

This paper adds novelty by attempting to identify the success dimensions of product portfolios, the impact of various methods on these success dimensions, and how TRIZ can impact a portfolio's success dimensions. Consequently, we answer the following research questions:

1. What are the success dimensions of robust innovative portfolios?
2. Which methods in the literature appear to be the most influential on the success dimensions of portfolios
3. What impact do Modern TRIZ approaches have on the success dimensions of portfolios?

2 Methodology

This research is divided into two sections: section 1 analyses IPM success dimensions and sub-dimensions. Section 2 of the report illustrates different methodologies utilised for innovation portfolios and their impacts on the success dimensions mentioned in Section 1.

For section 1, we conduct a systematic critical literature review as an explorative study with a deductive approach to identify the characteristics and traits that define innovation portfolios. We utilise the Web of Science and Scopus as databases to collect and analyse secondary data. The initial search string includes “innovation portfolio characteristics, innovation portfolio traits and innovation portfolio success” without the exact search function focusing on peer-reviewed articles and publications yielded 563 papers. The Web of Science collection papers ensures that they contain de-duplicated records. We decided to focus on research papers in the past ten years and therefore added a date range between 2013-2023, producing 377 articles. The paper investigates

research and extracts success dimensions of innovation portfolios, and therefore we decided to exclude mathematical and computer science-related studies that were irrelevant to the objective. Next, the papers were filtered based on top-quality peer-reviewed publishers, including Elsevier, Wiley, IEEE, springer nature and Emerald publications, to yield 309 relevant studies. Lastly, the papers were filtered based on title and abstracts, making 48 relevant publications available to the authors for analysis and synthesis. Figure 1 illustrates the systematic review literature review process and showcases the filtering mechanisms, number of hits(n), and studies excluded and included for the analysis.

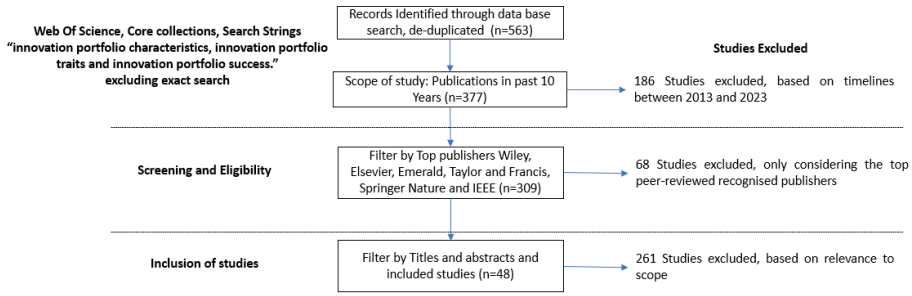

Fig. 1. Literature search process.

For section 2, we use an integrative literature review to study all known methods utilised for IPM and evaluate them based on the success dimensions found in section 1. This step allows us to assess the level of impact that known techniques make on the portfolio. Secondly, we use an integrative literature review to study known TRIZ impacts on IPM and the success criteria of portfolios. For this task, the study includes most modern TRIZ tools that are a part of the official body of knowledge. Lastly, we map several types of innovation projects with business growth strategies to enable the creation of IPM.

3 Literature Review Results

This paper focuses on IPM and considers it a pre-phase to PPM. However, some of the characteristics outlined for project portfolio management apply to innovation portfolio management and, therefore, will be a part of the analysis. The operational definition of a project portfolio considered for this paper is "maximising the contribution of projects to the overall welfare and success of the enterprise" [7], [33]–[35].

The resulting forty-eight papers are examined in-depth for portfolio success dimensions. In several cases, the articles needed to define portfolio success clearly. Instead, there were indirect success dimensions for portfolios referenced in other studies. The researchers, therefore, decided to trace the original references from the 48 papers to empirical studies that mention the success dimensions of innovation portfolios. Surprisingly, only three studies provide precise portfolio success dimensions, the measures of success, metrics of management, sub-dimensions and time dynamics [4], [33], [35],

[36]. The following section briefly describes the ten success dimensions of innovation product portfolios.

3.1 Dimensions of Innovation Portfolio Success

Project efficiency. Project efficiency is a function of project execution of governance of an organisation. This dimension is perceived as the least important to short-term success and relates to project management. Strong product portfolios meet their resource constraints within the given time. Project efficiency also correlates with a lean organisation with less hierarchical structures and governance mechanisms that lead to faster product development cycles. However, research implies that a successful implementation of a project does not necessarily produce commercial success and therefore has relatively low importance for an overall innovation portfolio success [36].

Impact on the customer. This dimension relates to the market and the ability of the product to meet customer needs. It consists of sub-measures like meeting functional performance, fulfilling customer needs, overall impact during the product use and value created by the offering. It is a market-driven dimension and explains how well the product gets the "job" done, identifying and fulfilling current as well as future customer needs, the ability of the product to retain the customer for future generations, and the overall value created including the ecosystem of offerings with the product [37]. Therefore, customer impact is among the most critical innovation-related success dimensions [36].

Business success. This dimension relates to financial returns and performance, often considered unimportant for long-term projects since we cannot measure it for at least one to two years post-product launch. All financial measurement metrics apply to this criteria, including return on investment, internal rate of return, net present values, et cetera. However, research suggests that this criterion is used in low levels of market uncertainty and is typically suited for incremental, iterative innovations [35], [38], [39].

Future preparedness. This criterion is relevant to the organisational and technological infrastructure built for the future and is often considered critical for long-term portfolio planning. It explores opportunities for new markets, ideas, innovations, unexpected developments from technologies, and disruption of business models. Some of its sub-dimensions are exploring adjacent markets, opportunity exploration, development of core competencies and countering future threats from competitors or other threatening supersystem technologies [40]–[42]. It is a critical aspect and contributes to the "innovation" part of portfolio planning.

Strategic alignment. This criterion primarily relates to the governance and execution of projects and the ability of projects to meet the business vision and missions of their

respective corporate strategies. Phadnis [50] outlines two processes to align projects to their corporate strategy, namely emergent or deliberate innovation portfolios, and research recommends using both approaches in appropriate balance for sustainable portfolio success [43].

Portfolio balance. Portfolio balance deals with interrelationships, dependencies of one product on the others and technical synergies of the portfolio. Portfolio balancing is also a function of the resource-based view wherein resources in the organisation are appropriately allocated and reorganised for the development of technologies based on the prioritisation of projects. It optimises the entire portfolio for maximal benefit. Some of its sub-dimensions revealed longitudinal interdependencies, technical synergies, and vertical interdependencies of projects. Longitudinal interdependencies are when one product family improvement benefits some other product category. Whereas vertical interdependencies typically refer to manufacturing processes, wherein the impact of the process innovation can be realised at a broader scale across multiple product families, thereby impacting the organisation's operational efficiency [43], [44].

Value maximization. This criterion has no measurable metric since it can only be realised strategically. We cannot measure the absolute value of a potential project before its execution and cannot account for intangibles, resources, and competencies it creates for the organisation. Therefore, from a mathematical perspective, it is less important as a success criterion for innovation portfolio management. However, its success is a direct function of all other criteria mentioned above, i.e. project efficiency, impact on the customer, business success, future preparedness, strategic alignment and portfolio balance [2], [36].

Systematic decision-making. This criterion refers to the overall decision-making structures of the organisation. Research suggests that a formalised IPM structure, with clear stage gates, go-no-go interventions, and methodological knowledge of the innovation process, leads to higher probabilities of success of product portfolios. Therefore, while the criterion is a function of organisation management systems, it is crucial for appropriately implementing IPM.

Resource management and information availability. These two dimensions are positioned at a higher hierarchy than other criteria since all other success measures depend on accurate information and resources. Therefore, they are not considered in further analysis, and we assume that resource management and information availability are constants throughout the innovation portfolio development process.

3.2 Success Dimensions Synthesis

All forty-eight studies examined in this research demonstrated the abovementioned dimensions of portfolios either directly or indirectly. Our research results suggest that the

abovementioned dimensions are good general indicators for organisations to focus on. Furthermore, these dimensions can help achieve a higher probability of success for growth. Therefore, to summarise the findings, a company must excel in each dimension to increase its chances of commercial success. Figure 2 illustrates the success dimensions and subdimensions and traces their sources to the original authors.

		Project Portfolio Success dimensions					
		Success Dimensions	**Measures**	**Metrics**	**Sub-dimensions**	**Importance of dimensions based on time dynamics**	**Original References**
Resource management	**Information availability**	**Project Efficiency**	Meeting schedule goal	All project management metrics are applicable	1. Efficiency of mangement of a project wrt constraints and resources 2. Estimated Time to market to until commercial success	Important for Short term during project execution	(Martinsuo and Lehtonen, 2007),(Shenhar et al., 2001), Cooper,and Edgett. and Kleinschmidt, 2002.
			Meeting budget goal				
		Impact on the customer	Meeting Functional performance	Expected level of performance vs actual delivered performance	1. How well does the product get the "job" done 2. Fullfilling current customer needs 3. Fullfilling future customer needs 4. Customer perception of the brand, and willingness to pay for a future development of the product 5. Overall satistifaction including the ecosystem of services before, during and after the products lifecycle	Important for Short term after-project execution and sales, since assessment can be done few months after product launch	(Shenhar *et al.* , 2001), Cooper,and Edgett. and Kleinschmidt, 2002.
			Fulfilling customer needs	Voice of the customer and satisfaction metrics applicable			
			overall impact during product use	ability of the product to retain the customer and gaining loyalty			
			Customer value creation	all customer related Satisfaction and value creation metrics			
		Business success	Commercial success	All traditional financial metrics apply	1. Estimated Time to market to until commercial success 2. Estimated return on investments	Direct success measurement possible only 1-2 years post product launch ,Mid to long term	(Shenhar et al., 2001), Cooper,and Edgett. and Kleinschmidt, 2002.
			Creating a large market share				
		Preparing for the future	Creating a new market	Market analysis, customer profiles and substantiation for the selected target market	1. Creating a new market for the same product or its components. 2. Exploration of new ideas, innovations, and technologies. 3. Developing core competencies and skills. 4. Countering future threats from competitors or other technologies	Long term , can only be assessed after 2, 3 or 5 years	(Shenhar et al., 2001) Cooper,and Edgett. and Kleinschmidt, 2002.
			Creating a new product line				
			Developing a new technology				
			Developing a new business model				
		Strategic alignment	Alignment of the projects and its ability to meet business visions and missions		Prioritization of projects and aligning projects to corporate strategies		Cooper,and Edgett. and Kleinschmidt, 2002.
		Portfolio balance	Interrelationships, dependencies and technical synergies of the portfolio		1. Longitudinal interdependencies and technical synergies of projects 2. Vertical interdependencies and technical synergies of projects		Cooper,and Edgett. and Kleinschmidt, 2002.
		Value maximization	Maximising overall value of the portfolio complimentary to each other	No direct measurement			Cooper,and Edgett. and Kleinschmidt, 2002.
		Systematic Decision making	Risk analysis, project prioritization and governance of the portfolio process				(Martinsuo and Lehtonen, 2007), Cooper,and Edgett. and Kleinschmidt, 2002.

Fig. 2. Innovation Portfolio success dimensions.

3.3 The "Innovation" in Innovation Portfolio Management

Unsurprisingly, academia and practitioners consider innovation the most critical driver that defines the long-term sustainability of an organisation. Additionally, research also suggests that the maximum probability of commercial innovation failure is associated with the fuzzy front end of product development, thereby recommending that organisations focus their efforts on more robust methodologies and approaches that do not rely on "guesswork" for decision-making [45]–[47] But, unfortunately, the word "innovation" in innovation portfolio management is subject to the same uncertainty as commercial success.

Research suggests that the four types of uncertainty faced in the fuzzy front end are market, technological, environmental, and resource allocation uncertainty [48]. These uncertainties are also faced during innovation portfolio development. However, if we map all the above uncertainty types to the extracted success dimensions, only three relate and are a function of innovation. Those are (2) impact on the customer, (4) future preparedness and (6) portfolio balance. All three innovation-related success dimensions exist in the most critical phases of IPM process: the ideation phase, often associated with opportunity recognition, and the selection phase, which is associated with evaluation and synergy. First, the ideation phase aims to generate concepts that match the future market needs, explore technological developments and create product concepts that could be injected into the portfolio for further analysis and substantiation. Secondly, a selection phase which acts as a screening mechanism to achieve portfolio balance either eliminates, merges, recombines, or diverges projects strategically to yield maximal value [2], [3], [6], [49]–[51].

Since categories 2, 4 and 6 were the most critical innovation-related dimensions, we decided to investigate if all known methods used to develop innovation portfolios impact these dimensions equally. This step examines which existing techniques influence innovation-related dimensions of the portfolio and whether a best-suited approach exists amongst them. The most common methods related to the ideation phase were technological road mapping, scenario planning, forecasting and backcasting techniques, and market /technology trend analysis[40]. On a broader perspective, these methods are categorised into a cluster of strategic or scenario-based plans, wherein an end visual scenario is simulated. Then, firms work backwards to determine which technologies, product features, and improvements could make to realise the vision. On the other hand, project selection methods comprise several mathematical models, financial techniques, and behavioural and probabilistic models to find synergies and maximise the portfolio's value.

Flechas et al., 2019 provide an in-depth review of more than 140 methods potentially utilised in IPM since 1974 to study their evolution and cluster them into 12 taxonomies. These 12 taxonomies of IPM methods are mapped to the success dimensions found in section 1 to identify methods that potentially impact the innovation aspect of IPM. Table 1 illustrates the clusters/taxonomies of various methods that influence the dimensions of a successful innovation portfolio. The columns indicate the success dimensions in a numerical form, as seen in section 3.1. The "x" indicates a significant impact, and a bold "x" indicates an impact on the "innovation" aspect of IPM [52].

Table 1. Impact of Portfolio Methods on Portfolio Success Dimensions.

	Portfolio success dimensions							
Portfolio method clusters	1	2	3	4	5	6	7	8
Financial methods			x		x		x	x
Probabilistic models			x		x		x	x
Option pricing theory	x		x		x		x	x
Strategic methods	x		x		x		x	x
Scoring models	x		x		x		x	x
Combinatorial optimisaion	x		x		x		x	x
Behavioural models	x		x		x		x	x
Mapping approaches			**x**		**x**	**x**		**x**
Real options	x		x		x		x	x
Integrated methods	**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
Information gap theory		**x**	**x**			**x**	**x**	**x**
Scenario-based approach		**x**	**x**	**x**		**x**		**x**

Table 1 illustrates that only four clustered portfolio taxonomies, integrated methods, information gap theory, mapping and scenario-based approaches impact the IPM's most critical innovation-related dimensions. The following section provides a deeper examination of these methods to explain their impact on innovation portfolios.

Scenario-based planning. Scenario-based planning methods have multiple techniques for visualising end conditions or future use cases and creating a roadmap to achieve the perceived vision. Several approaches, such as technological road mapping, forecasting, backcasting and similar techniques, are utilized [41]. Scenario-based planning is best used in the ideation phases of the innovation portfolio since it gives direct input on potential product features that can meet future customer needs and technological developments associated with meeting future requirements and guiding decision-makers to decide which products and possible features they should invest in. However, all scenario-based planning approaches are highly dependent on the creative potential of an individual or team. Therefore, while the industry utilises structured or guided brainstorming techniques such as design thinking, concept boards, scenario envisioning techniques, et cetera, consistently delivering relevant and innovative ideas takes time and effort. However, these methods fail to provide a detailed perspective, especially while ideating disruptive innovations, due to the irrelevance and uncertainty of historical market data [48], [53], [54]. Therefore it is challenging for organisations to account for and visualise all possible market-winning landscapes.

Mapping approaches. Research suggests that plotted visual data against various parameters in a matrix, bubble plots or diagrammatic illustrations allow organisations to visualise their strategic position and help decision-making. Additionally, these methods are prevalent among multinational organisations and widely used in the industry. Several specific techniques are used under mapping approaches. However, the most

common ones include the BCG matrix, McKinsey matrix, bubble plots, project sequence charts or risk versus reward plots [36], [55]. While these methods demonstrate strong capabilities in project selection and prioritisation phases, they mainly depend on financial data, customer data, technical data, scoring criteria and project-related variables. As a result, these approaches fall apart and must be adapted for their application in the ideation phases [52].

Integrated methods and information gap theory. The information gap theory model is an intriguing method of balancing immunity to uncertainty and goals. This method relies on identifying information gaps, uncertainties, and risks to assess the tolerance for bad outcomes. It works with a mathematical process model, performance requirement and uncertainty model. The information gap approach enables the evaluation of robustness (identifying potential negative consequences) and opportunity (windfall opportunities) by allowing analysts to determine what they consider valid and essential regarding the analysed system. While this approach helps determine probabilities of success, it cannot be used during the ideation phases of the innovation product portfolio. Due to its mathematical nature, it utilises existing measurable and tangible metric data, but its accuracy is subject to error regarding radical innovations.

Furthermore, the lack of market data regarding radical breakthroughs can limit its application severely. Lastly, Integrated approaches use two or more separate taxonomies to direct the project selection process. It is the best compromise between mathematical project selection approaches and strategic mapping approaches that provide a more or less balanced portfolio with a better chance of success.

Upon closer inspection of all methods, the integrated approaches that use multiple techniques to narrow down and increase the probability of portfolio success are the most effective and significantly influence all success dimensions. Integrated methods operate throughout the innovation portfolio development process and utilise a combination of ideation and portfolio selection techniques. But where does the TRIZ approach position itself among these techniques impacting the portfolios?

4 Discussion

The discussions section describes where and how TRIZ fits into the picture and how it can impact the innovation portfolio outcomes. First, we provide reasons why TRIZ is considered an integrative method among the abovementioned types. Second, to justify the impact of TRIZ, we demonstrate the relationship between TRIZ tools and business growth. Finally, we propose different innovation projects that help obtain more robust and innovative product portfolios.

4.1 TRIZ as Integrated Method

When we consider the ideation phase of innovation portfolios, unsurprisingly, TRIZ is known to tackle psychological inertia and reduces the dependence on the creative genius of a person to generate better ideas. Extensive research has already proven the

effectiveness of the approach on ideation. Firstly, TRIZ approaches such as main parameters of value analysis (MPV), S-curve analysis, and trends of engineering systems evolution (TESE) can be utilised for each product family. MPV analysis is typically a pre-step to S-curve analysis comprising function analysis (FA) and cause and effect chain analysis (CECA) for MPV candidates. In practice, it guides decision-makers in selecting the features to improve and setting realistic product development goals. Several papers outline the method and provide enough evidence of its success [22], [23], [25], [28], [30], [56], [57] In principle, TRIZ-based tools support the existing scenario-based planning methods through a functional and customer-oriented lens. Pragmatic S-curve analysis, TESE and MPV analysis enable engineers to set realistic parameters for improvement and facilitate appropriate resource allocation to achieve the required specifications in innovation portfolio outcomes [6].

Secondly, it is necessary to screen projects strategically for maximal portfolio value in the selection and project prioritisation phases. It identifies synergies between projects and guides decision-makers to allocate appropriate resources to a small project group that maximally impacts the portfolio. Research suggests that quantum economic analysis (QEA) screening and contradiction analysis help to identify technical synergies between potential products and technologies, dependent on the framework for synergies as provided by Verbitsky and Casey 2008 [6], [24], [49], [56], [57].

Therefore, TRIZ can be considered an integrated method since it utilises more than two taxonomies in its project execution phases. Furthermore, while the TRIZ method is primarily qualitative, its combination with other mathematical techniques listed in Table 1 further improves the chances of portfolio success, especially considering the recent interest in artificial intelligence-integrated mathematical methods for predicting innovation success.

4.2 Impact of TRIZ on Innovation Portfolios

The main driver of why innovation portfolios exist in the first place is to achieve sustained business growth. According to Treacy and Sims [58], there are only five distinct sources of business growth. They are as follows: base retention, gross share gain, market positioning, adjacent markets and new lines of business. Table 2 below provides a summarised explanation of the different sources of growth. Three of these sources stem from a company's core business: continuing sales to established customers (base retention), sales won from the competition (share gain), and new sales in an expanding market (market positioning). The other two lie outside the core: move into adjacent markets where core capabilities can be leveraged and entirely new lines of business unrelated to the core are exploited, i.e. adjacent markets and acquisitions [58]. The resulting portfolio must provide input to all sources of growth.

Consider a hypothetical scenario and view the innovation product portfolio as a single project. In that case, its end product is an "innovation agenda/landscape" of existing, new and future-oriented projects assigned to each source of growth, as mentioned above. To do that, organisations must execute several exploratory innovation projects to build an innovation portfolio landscape. Consequently, think of them as a series of mini-projects that do not directly impact business growth but involve exploring ideas,

detailed analytics, and the type of project to be performed for each product family, aligned to the sources of growth. This innovation agenda can allow decision-makers to gather information on what to improve and whether the improvements are practically feasible. Naturally, treating the IPM as a product, all product-related success criteria also apply [51], [59]. To summarise, decision-makers require a clear innovation agenda of all types of innovation projects from the portfolio that can be strategically aligned with the sources of growth. Table 2 summarises the sources of growth, their descriptions and critical understandings.

Table 2. Adapted summary of the five sources of growth [58].

Sources of business growth	Description
Base Retention	Keep existing customers from switching to competitors
Share Gain	Induce customers to switch from competitors.
Market Positioning	Predict and show up where growth is expected to take place.
Exploiting Adjacencies	Apply existing capabilities and technology to other related market opportunities.
New lines of business and acquisitions	Create a new, unrelated business line by strategically buying out other entities.

4.3 Typical Innovation Projects that Relate to Business Growth

Following the five growth sources mentioned in Table 2, we study the various innovation projects organisations can execute using TRIZ-based approaches that directly impact IPM. Finally, the typical innovation project types targeted towards their suitable growth strategies are studied and summarised below [11]–[19].

New product development (NPD) projects. This type of project is typically executed in all organisations to stay competitive. It involves a new product, process, service or business model developed from scratch that addresses futuristic market needs. Several academic research articles outline that it is one of the riskiest projects for innovation with a shallow success rate[19]. However, they also imply that successful NPD creates significant growth for organisations and can be a primary source of revenue [25], [60]–[62]. NPD projects can impact base retention, and adjacent markets, used to gain market share or position the product carefully for growth. For base retention, NPD projects could have an ecosystem designed to lock in the customer and increase his switching costs.

On the other hand, NPD projects are also used to explore adjacent markets, i.e. ancillary markets where similar functionality is required. It also impacts product positioning, wherein developing products placed in a niche segment and appropriately priced can attract new customers and create a temporary monopoly. NPD projects apply to all sources of growth for firms.

Product/Process/service Improvement Projects. These projects are typically about improving the existing offering without introducing radically new functions. Such projects aim to improve at least one MPV to outperform the competitor's product. Therefore, improvement-related projects are typically incremental that optimise products, thereby leading to several product iterations [52], [63], [64]. In addition, product improvement types of projects impact base retention and share again since they typically do not require radical changes or bring new novel functionalities.

Cost reduction projects. Cost reduction projects are the bread and butter of engineering teams worldwide as technology becomes cheaper and more accessible over time. Therefore, organisations must invest in continual improvement and cost reduction of their offerings. This type of project is well exhibited for creating impacts to capture market share, retain customers or position the product appropriately. Cost reduction projects can also be exploratory, leading to new products altogether. For example, if a technology reaches stage III on the S curve, one possible way to add value to the product is to switch the action principle of the product, which in turn may lead to NPD [65]. The other technique to add value would be cost reduction on the product or its manufacturing process. Ideally, innovation portfolio landscapes should provide information on product families that have reached close to their developmental limits and require cost-reduction strategies to be applied for businesses to stay competitive in the market [65].

Intellectual property (IP) strategy projects. Literature provides a variety of strategic methods, including typical strategies for marketing, R&D, sourcing, and innovation. An IP strategy is a part of this pool of underlying strategies, each of which serves as a building block for creating and executing the firm's overall business plan. IP may be included in the strategic planning process on several levels. "Organisations recognise that a well-crafted patent portfolio may be used for a variety of objectives, such as bolstering market position, protecting research and development efforts, generating revenue, and encouraging favourable cross-licensing or settlement agreements" [66]. TRIZ applications to IP strategy are well-researched, documented and applied in the industry. IP strategy-related projects impact base retention, adjacent markets, gaining market share, positioning, adjacent markets and new lines of business.

Main parameters of value discovery projects. This process aims to uncover the customer's latent needs and provides direct input to the portfolio of new products. It also helps uncover the voice of the product, meaning it allows us to assess the achievable level of performance of a product concerning the future market need [22], [23], [30], [56]. MPVs impact base retention, adjacent markets, market share again, positioning and acquisitions since they provide market -needs that drive all sources of revenue. Extensive research indicates the usage of MPV analysis and provides evidence of its success [23]–[25], [28], [30], [56], [57], [67].

Technology mining and technology due diligence projects. These projects typically relate to technology roadmaps to forecast critical developments in technical systems to gain competitive intelligence. It provides navigational assistance in an unknown territory that informs decision-makers to inform on product strategies. Technology roadmaps link commercial and technological perspectives in the firm and are used aggressively to align the company's innovation strategy. It involves scouting key emerging technologies, benchmarking existing technologies, valuation, and acquisition for strategy purposes. Research papers already provide the effectiveness of TRIZ on technology road mapping through case studies and provide an algorithm for the same [65], [68]–[70]. These types of projects impact adjacent markets and new lines of business.

Failure anticipation projects. There can be two distinct types of projects within failure anticipation, failure analysis and failure prediction. Failure analysis is a systematic procedure for identifying the root causes of failure or other undesired phenomena occurring in a system, allowing decision-makers to correct it promptly. On the other hand, failure prediction is a process for identifying and preventing all dangerous or harmful events associated with the engineering system - both types of projects can be used for innovation portfolios [71]In addition, failure anticipation projects impact base retention, share gain and new lines of business.

Adjacent market identification (AMI). AMI is a type of project category that is executed to either (1) find new markets for a product /applications for a technology or equipment for a product other than the one currently produced, (2) to find applications for a product that acts as a component for another product. Typically these projects are widely applied for products in the 3rd stage of the S-curve and are nearing their developmental limitations. Therefore, organisations can run AMI projects and identify adjacent markets that leverage existing competencies [28]. Table 3 summarises the types of projects, their alignment with the source of growth and the most common TRIZ tools used in the projects.

Table 3. Types of innovation projects and their relationship with growth strategies.

Types of Innovation Projects	**Sources of growth**					**Key TRIZ tools utilised**
	Base retention	*Share-gain*	*Positioning*	*Adjacent markets*	*New lines of business*	
New Product Development	x	x	x	x	x	FA, MPV analysis, FOS, Trimming, Contradiction resolution, TESE, S-curve analysis, QEA [22], [25], [30], [57], [65], [72]
Product Improvement	x	x				CECA analysis FA, Flow

						analysis, Trimming, FOS [25], [26]
Cost reduction	x	x	x			Trimming, FOS and contradiction resolution [73]
IP strategy	x	x	x	x	x	Trimming, FOS, TESE
MPV discovery	x	x	x	x	x	MPV analysis, FA, CECA, benchmarking, IP strategy, TESE [22], [65]
Technology mining and due diligence				x	x	Benchmarking, FOS, S-curve analysis, PEL
Failure analysis and prediction	x	x			x	CECA, resource analysis
Adjacent market identification				x		RFOS, FA, MPV analysis, QEA [49], [56], [57], [73]

5 Conclusions and Future Scope of Work

A successful innovation portfolio is critical for sustained business growth. However, the potential means of measurement of a successful innovation portfolio still need to exist clearly. We successfully answer the first research question by analysing the IPM process to find nine criteria defining portfolio success in the studied literature. If organisations focus on these factors, the chances of commercial success could improve. Moreover, we also qualitatively measured the impact of various existing IPM methods against the identified criteria. For the second research question, we found that integrative approaches used in IPM can create maximum impact on the success of innovation portfolios. We discussed why TRIZ falls into the criteria of integrated methods. Additionally, we provide a link between IPM, business growth and TRIZ projects.

Our literature review of the IPM process indicates the absence of a structured algorithm to execute IPM as a project.

Answering the third research question, the impact of modern TRIZ on IPM is showcased by providing a relationship between sources of growth, outcomes of innovation portfolios, types of projects that can be executed and their association with TRIZ approaches used within those projects. While independent TRIZ algorithms exist for all the abovementioned project types, we still lack roadmaps to execute IPM as a project.

The literature review provides insights about the success dimensions for product portfolio, while during this research the focus was more on physical products but given the type of criteria that emerged from the research, it might be applicable and generalisable to all industries alike. Non-physical product offerings may have additional criteria that physical products lack. However, this must be investigated and verified for other industries for additional reliability and validity of the research.

While modern TRIZ and its applicability are expanding to the innovation management domains, there needs to be more evidence of successful case studies to substantiate the claims. However, due to the nature and sensitivity of product portfolios, it is challenging for researchers to collect data from organisations. Currently, literature primarily studies the generalised portfolio approach, technology road mapping and IPM methods; however, some variations of brainstorming(such as scenario planning) still appear to be a popular method used to shape portfolios in the fuzzy front end of innovation that addresses opportunity recognition. This research provides ample evidence of potential modern TRIZ tools, types of innovation projects that can be executed with them and how they can help the business growth. This research currently explains the use of TRIZ for better product portfolios but lacks the algorithm to construct and execute IPM-type projects. It also paves the way for future studies for building, testing, refining and proposing a method for IPM-type projects using TRIZ.

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