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# Artificial Intelligence Implementation for Project Portfolio Management

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# Introduction

Project portfolio management, also known as PPM, is a process that companies employ to manage multiple initiatives simultaneously with success. PPM assists organizations in determining which initiatives to undertake and how to allocate resources to them. It also ensures that a company's project portfolio correlates with its strategic goals. Businesses must implement PPM in order to achieve their goals and maintain a competitive advantage in today's fast-paced marketplace.

In recent years, Artificial Intelligence (AI) has emerged as a new technology with the potential to fundamentally alter how organizations manage their projects and portfolios. The application of artificial intelligence has the potential to revolutionize project portfolio management by delivering effective tools that can help organizations make better-informed decisions, improve resource distribution, and optimize project performance.

The work of thesis has been carried out during a 6 month curricular internship with the support of BTO S.p.A research team and explore the potential for AI to revolutionize project portfolio management (PPM) and improve project performance overall. To begin, it is provided an overview of project management and project portfolio management, with an emphasis on the significance of efficient portfolio management in achieving organizational objectives; exploring the main areas that project portfolio management (PPM) involves like selecting and ranking projects, achieving a balance between resource constraints, and managing project hazards.

This will be followed by a discussion of artificial intelligence (AI) and its implications in modern business, with an emphasis on the potential benefits of using AI in PPM. It is described how artificial intelligence can assist organizations with the rapid and accurate analysis of large quantities of data, the identification of patterns and trends, and the formation of decisions based on this information. AI can also improve resource allocation and organization, reduce the risk of project failure, and optimize resource allocation for businesses.

Project Prioritization, Risk Management, Scheduling, and Resource Allocation are the four main development areas examined in the core of the thesis as they relate to the implementation of artificial intelligence in project portfolio management. A deep investigation of the literature has been crucial in defining how artificial intelligence can be utilized to enhance performance in each of these areas, which are all essential for an efficient portfolio management. Then, for each of these field of application, have been examined some of the most effective AI technologies and algorithms that can be found in the research literature.

In the final section of this discussion, the focus was on the most promising potential applications of AI for PPM, discussing the advantages and disadvantages of incorporating AI into PPM, offering future possible developments and concentrating on the potential benefits of AI in PPM, such as improved project outcomes, reduced risk, and increased efficacy. However, nowadays, there are still some barriers to implementing AI in PPM, such as the need for significant

technology investments and the prospect of job displacements as a result of technological advancements.

So, overall, this thesis presents a comprehensive analysis of the potential of artificial intelligence in project portfolio management and demonstrate how AI can be utilized to enhance project performance and achieve organizational goals, providing an exhaustive examination of the potential of artificial intelligence in PPM. By analyzing the most effective algorithms and AI technologies identified in the literature, the main objective is to shed light on how organizations can successfully implement AI in PPM to gain a competitive edge in today's fast-paced business environment, providing companies an insight into how they can implement AI in PPM successfully.

## 1.0 Company History

BTO Research S.p.a is an Italian research firm with its headquarters in Milan. The company's name is an acronym that stands for Business, Technology, and Organization, and it is specialized in providing consulting and research services for industries, such as technology, business, telecommunications, consumer goods, market analysis, and more. BTO Research S.p.a is known for offering high-quality and efficient solutions that assist organizations in making a better use of their technology.

The organization places a significant emphasis on assisting organizations in Italy to recognize and make the most of new opportunities presented by technological advancements. However, they also provide services to international clients throughout Europe, particularly in Austria, Germany, and Luxemburg. They have on staff a group of specialists that have a wealth of expertise in the research and consulting fields related to the optimization of business technology.


*Figure 1: Company logo*

They provide their clients knowledge and insights in order to aid them in making intelligent decisions and improving their overall performance in the markets in which they operate. The company was born several years ago, when a group of experienced researchers and analysts got together with the intention of establishing a company that would aid in the expansion of existing businesses. This was the main input for the formation of the organization.

The group was aware of the market need for high-quality research and analysis services that could provide clients with reliable and helpful information that would assist them in the decision-making process for their businesses.

BTO Research has evolved and expanded throughout the course of the years, earning the reputation as a reliable and trustworthy research and analytical partner; also the company has established a track record of supplying clients in a wide range of sectors with high-quality services that assist in the process of decision-making, goal setting, and project management.

## 1.1 Methods and Research Department

The technique that is utilized by BTO Research is methodical, and it includes the following stages: identifying the problem or opportunity, collecting and analyzing data, making solutions, and finally putting those suggestions into action and evaluating the results of those processes.

BTO Research's methods and strategies includes the implementation of different types of frameworks and technologies, such as ITIL, COBIT, and Lean Six Sigma. Collecting and evaluating data on technical trends, market changes, and competitor activity is a necessary step in the process of identifying new opportunities in the field of technology. Additionally, the corporation is active in technological research, which comprises assessing the capabilities as well as the potential commercial implications of different technologies; this information is used by BTO Research to assist customers in understanding the potential implications that new technologies may have on their businesses and in developing plans to take advantage of the opportunities that this technology presents. So the customer is provided with the necessary knowledge to keep one step ahead of the competition and to make better informed decisions.

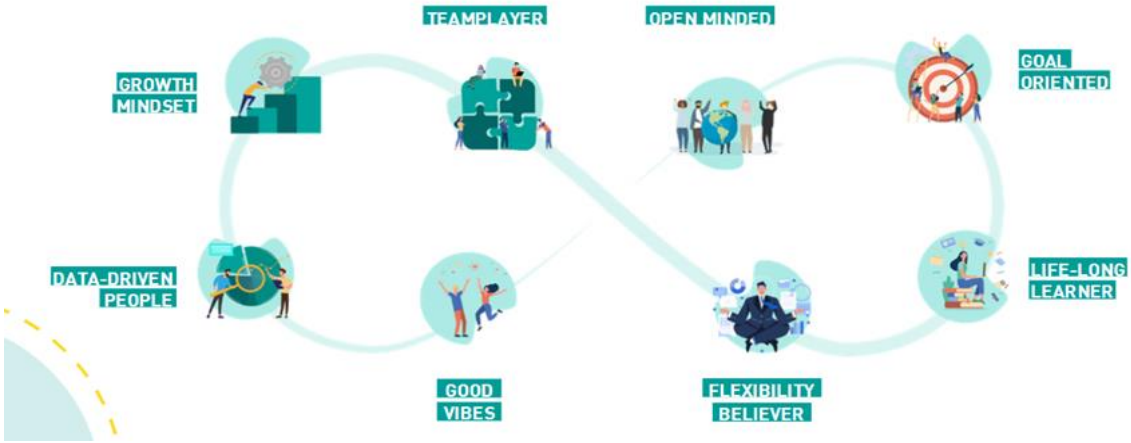


*Figure 2: BTO Manifesto*

When it comes instead to providing consulting services for IT management and governance, the evaluation process begins by assessing the client's existing practices and procedures. This evaluation may involve data analysis, process mapping, and interviews with key stakeholders in order to discover areas where there is room for improvement. The results of the evaluation are used as the basis for the development of an improvement plan for IT management and governance. This technique could entail modifying the organizational structure, improving the processes, or adopting IT management frameworks such as ITIL or COBIT.

In particular, the ITIL framework is widely utilized in IT service management. This framework provides a variety of best practices, some of which include incident management, issue

management, change management, and service level management. The organization is able to assist clients in increasing the quality and efficiency of their IT services by discovering areas in which ITIL best practices may be employed and establishing plans to put those best practices into effect.

BTO Research often starts the process of delivering consulting services for digital transformation by defining the client's business goals and objectives before looking at the ways in which digital technology might potentially be used to assist in the accomplishment of those goals. After the aforementioned areas have been identified, BTO Research will collaborate with clients to develop a digital transformation strategy that will incorporate a timetable for the implementation of new technology and processes. Defining the scope of the project, establishing the resources that will be needed, and developing a plan for change management are all examples of things that might fall under this category. In addition, BTO Research is able to assist customers in identifying and mitigating any risks that are associated with the shift to digital.

In terms of strategy, BTO Research utilizes a methodology that places a significant emphasis on the collection of data, the interpretation of that data, and research. They apply a variety of research methodologies, including as surveys, interviews, case studies, and literature reviews, in order to collect information and insights. In addition to this, they utilize a variety of analytical approaches, including as process mapping, data visualization, and statistical analysis, in order to conduct data analysis and come up with suggestions. Because of this strategy, the firm is now in a position to provide its customers with well-researched, actionable solutions that are backed by both data and the standard practices of their sector

## 1.2 Professional Services

The company offers a wide selection of services, such as assistance with product creation, analysis of the competition in the market, market research, and information about the industry. Customers will be better equipped to make judgments and will have improved performance in the specific sectors in which they operate with the assistance of these services. They cater to a wide range of markets, including the business sector, the telecommunications industry, the consumer products sector, and the technology sector. The experienced consultants and researchers at BTO Research interact with clients to gain an understanding of their one-of-a-kind requirements and provide recommendations for solutions that are tailor-made to assist clients in accomplishing their objectives; Among these several services, the following are figured out:

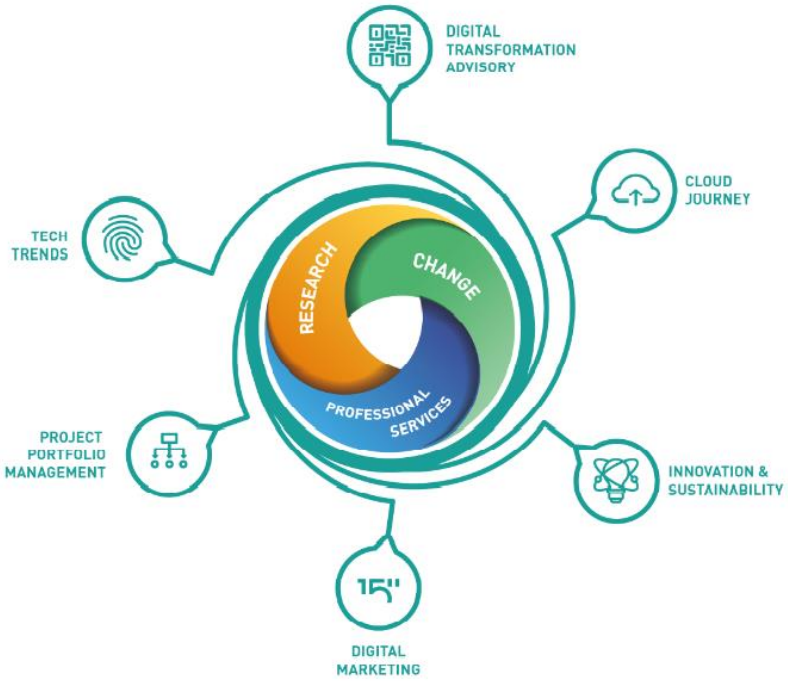


*Figure 3: Company Services*

1. Market Intelligence: the company offers services in the field of market intelligence to customers in order to assist such customers in better understanding their target market, including market trends, consumer habits, and the competitive environment. This information is utilized to guide corporate planning to provide the company an advantage over its competitors.

2. Competitor Research: BTO Research provides its clients with the service of competitor analysis to assist those clients in better understanding their competitors, including their strengths and weaknesses, market share, and business strategies. Utilizing this information allows for more informed decisions to be made, as well as more informed business planning.

3. Customer Insights: with the customer insights services offered by BTO Research, clients are able to obtain a comprehensive understanding of the requirements, habits, and preferences of their customers. Utilizing this data allows for the development of new products, an improvement in overall customer happiness, and a rise in sales.

4. Data Analysis: the organization offers services in the form of data analysis in order to aid clients in making sense of complicated data and employing it to influence the decisions they make regarding their businesses. This includes graphical representation of the data, interpretation of the data, and statistical analysis.

5. Strategic Planning: BTO Research works closely with its clients to develop and execute strategic plans that are in line with the research goals that they have set for themselves, and it provides assistance to its clients in this endeavor. A component of this is the formulation of plans for the development of products, entry into markets, and expansion.

6. Training and Consultation: the organization provides training and consultation services in order to assist clients in interpreting and using the findings of the study to influence their business decisions. This involves attending seminars and lectures, as well as having private sessions with seasoned advisors.

Research and the development of strategies are two of the primary services that BTO Research provides. This service assists firms in identifying new possibilities afforded by technical advancements and developing strategies for capitalizing on such advancements. The company conducts research in a broad variety of technological fields, such as artificial intelligence, blockchain technology, and the internet of things, with the goal of assisting businesses in better comprehending the potential implications that new technologies may have on their operations. In addition to this, they provide assistance to companies in the development of technology roadmaps and plans that lead the companies' purchase and utilization of new technologies.

Instead, firms that make use of consulting services for IT management and governance are able to improve the effectiveness of the methods they use for IT administration. Experts from the organization work with businesses to evaluate their present information technology management practices, locate areas in need of improvement, and devise and carry out strategies to improve IT management and governance. This approach might prove to be quite beneficial for businesses who have difficulty effectively managing and monitoring their IT operations.

Consulting for digital transformation is yet another important service offered by the company. Using this service, firms are assisted in developing digital transformation plans and putting those strategies into effect. Before supporting businesses in developing and putting into effect adoption plans, the experts employed by the organization collaborate with those businesses to identify areas in which digital technologies may increase productivity and competitiveness.

This service will be of particular use to organizations who are looking to capitalize on the plethora of opportunities that are made possible by the advancement of digital technology.

In comparison to other research and analysis firms, BTO Research S.p.a stands out due to the comprehensive scope of services that it provides. The company has a proven track record of supplying customers in a wide range of sectors with high-quality research and analytical services, therefore supporting those clients in reaching their goals, managing research projects, and making choices.

The group of specialists employed by the organization have an exceptional level of expertise and knowledge, as well as an in-depth comprehension of a variety of fields and sectors. They utilize the most recent techniques and methods available to provide clients with information that is accurate, trustworthy, and helpful.

Because of the firm's unwavering commitment to delivering services of the highest caliber, they have earned a solid standing in the industry as a reliable and trustworthy collaborator in research and analysis. Their attention to detail, capacity to provide outcomes on time, and dedication to meeting their requirements are all highly regarded by their customers.

In addition to providing services in project management, these offers assist clients in the processes of decision-making, managing research projects, and achieving their goals. BTO Research is dedicated to providing its clients with the information and help they need to achieve success in their respective industries.

## 1.3 Project Management Consulting

By providing services in project management, BTO Research aids customers in managing the delivery of a diverse variety of projects, particularly those related to the information technology industry, with dependability and quality. Their project management services are designed to ensure that clients receive high-quality research findings that live up to the standards they have set for themselves and their businesses. The full project management services offer clients aid in managing the delivery from the beginning to the conclusion, ensuring that it is completed on schedule, within the allotted budget, and to the best level possible.

The following is a list of the many project management services:

1. Project Planning: the company meticulously collaborates with customers to understand their research goals and construct a detailed project plan that outlines the project's boundaries, timelines, and deliverables. This plan is then presented to the client for review and approval. The implementation of this approach helps to ensure that the research project is appropriately structured and planned, and that all parties engaged are aware of their respective roles and responsibilities.

2. Resource allocation: BTO Research offers its clients assistance in the process of selecting the suitable personnel, materials, and financial resources for their research projects. Because of this, the likelihood that the research project will be completed on time and to the highest standards is significantly increased.

3. Risk management: the company works closely with its customers to identify and mitigate any potential threats that may have an impact on the study project. In order to accomplish this, you will need to devise strategies to reduce the likelihood of undesirable outcomes and establish protocols for dealing with unexpected complications.

4. Communication and collaborative efforts: the success of a research endeavor is dependent on the ability to effectively communicate and collaborate with others. BTO Research collaborates closely with the research team to ensure that everyone is informed and on the same page. Additionally, BTO Research provides customers and stakeholders with frequent updates as well as progress reports.

5. Project monitoring and reporting: BTO Research keeps a close watch on the growth of the research project and provides customers with frequent updates and reports on the status of the project. Because of this, it is much simpler for customers to remain informed about the development of the project and to make any adjustments that are required to ensure the project's success.

The following are some examples of projects that were successfully completed by the company:
• Developing a digital strategy for a manufacturing company to increase the company's efficiency and competitiveness in the market.

• Evaluating and improving the effectiveness of the IT governance framework for a big financial institution

• Improving the overall quality and dependability of service provided by a government agency by putting into place the best practices for IT service management.

In a nutshell, BTO Research S.p.a. is a research and consulting organization that provides its clients with a wide range of services to assist them in achieving success in their respective industries. Because of their commitment to delivering services of a high quality and the team of professionals the firm has distinguished itself as a reliable and trustworthy business associate

## *2.0 Project Management*

Project management is the process of planning, executing, and concluding a team's work to meet specified goals and success criteria. The most challenging aspect of project management is finding a way to achieve all of the project's goals while taking into account all the constraints that have been set, like costs, scope, timeline, and quality. The main phases of project management can be described as follows:

**The Project initiation –** the first phase of the project management life cycle is known as the project initiation phase, and its objective is to initiate a new project. During the "initiation" phase, a business problem or opportunity is identified, a solution is defined, a project is established, and a project team is chosen to design, develop, and deliver the solution to the end user.

**The Planning Phase –** involves determining project goals and objectives, but also its tasks and the required resources to complete them. In addition, it is necessary to develop a strategy and budget for the undertaking. The project plan, that is developed in this stage, is utilized as a road map for the project team, providing specific instructions on what must be done, when, and how. In addition, it can help determining the essential path while identifying and managing the project's associated risks.

**The Execution Phase –** includes all the activities of supervision and coodiation of the project team in order to guarantee that all duties are carried out in a quick and effective manner. The tasks are distributed to different people, the progress is monitored, while any required adjustment is made. The manager of the project is responsible for ensuring that the project team has all the resources they need to successfully complete the tasks that have been delegated to them and that the project is completed on schedule.

**The Monitoring Phase –** it involves keeping track of the progress of the project throughout specific controls while the project is progressing and making any necessary modifications to ensure that it stays on track. During this phase the project manager is responsible for monitoring the status of the project, identifying any difficulties that arise, and implementing any required adjustments in order to ensure that the work is completed on time and without exceeding the allocated budget.

**The Closing Phase –** entails finishing all remaining project-related tasks prior to formally ending the endeavor. In order to do this, a project review has to be carried out, the outcomes need to be documented, and the ownership of the project deliverables needs to be transferred. It is the responsibility of the project manager to ensure that all project tasks are completed, that all deliverables are produced, ensuring that the undertaking is concluded efficiently and effectively.

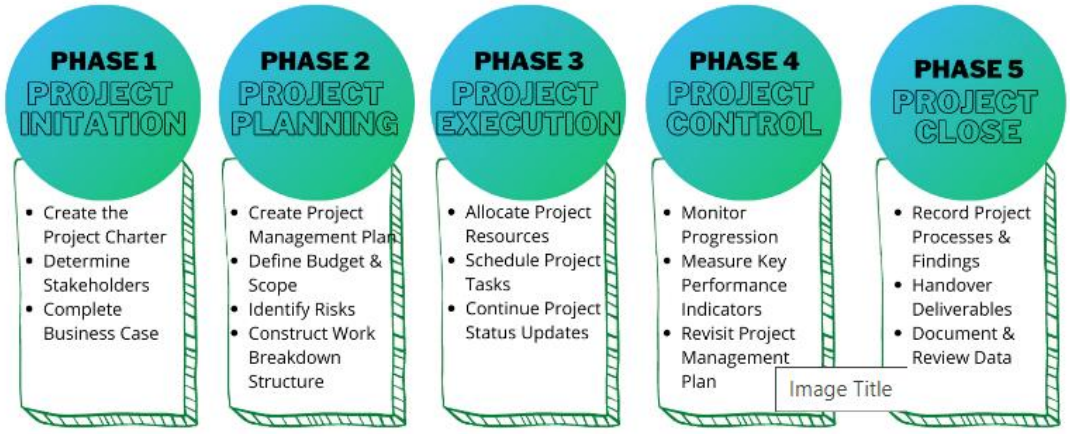


*Figure 4: Project Management Main Phases*

Communication with the project's many stakeholders is essential to the achievement of a successful outcome for any given project. It is the responsibility of the project manager to keep the stakeholders informed on the status of the project, any difficulties that have arisen, and any changes that have been made. To accomplish this, it is necessary to provide an overview of the project's goals, objectives, and current status while also addressing any concerns or issues that may arise.

The process of determining, analyzing, and prioritizing risks, as well as taking steps to limit the impact those risks have on the project are all components of risk management. The project manager is responsible for identifying and analyzing potential risks to the project, in addition to developing risk management methods and putting them into action.

Management of the process of acquiring products and services from external sources is referred, instead, as procurement management. The project manager is responsible for establishing the project's procurement needs, developing procurement strategies, and supervising the procurement process to guarantee that the project's demands are fulfilled on time and within budget.

It is possible to use many different methodologies for project management, such as Waterfall, Agile, Scrum, Kanban, Lean, and Six Sigma. These methodologies are all viable options but strongly depends on the nature of the project. Although each technique employs a specific strategy and collection of tools, the end goal of using any of them is to produce a successful project.

• **Agile** is an iterative and incremental strategy in which requirements and solutions are developed through cooperation amongst self-organizing and cross-functional teams.

• A linear sequential strategy is referred to as "**Waterfall**" and is one in which the development of the project is planned as descending through the stages of conception, initiation, analysis, design, construction, testing, deployment, and maintenance.

• **Scrum** is a particular framework for the Agile approach that places an emphasis on the production of a potentially marketable incremental product.

• The **Kanban** method to managing work moves through a process places a priority on just-in-time delivery as well as a decrease in the amount of work that is currently in progress.

• **Lean** is an approach that focuses on reducing waste, increasing value, and improving workflow

• **Six Sigma** is a methodology that focuses on decreasing process variability and discovering and removing failure origins.


*Figure 5: Project Management Methodologies*

## 2.1 Project Portfolio Management

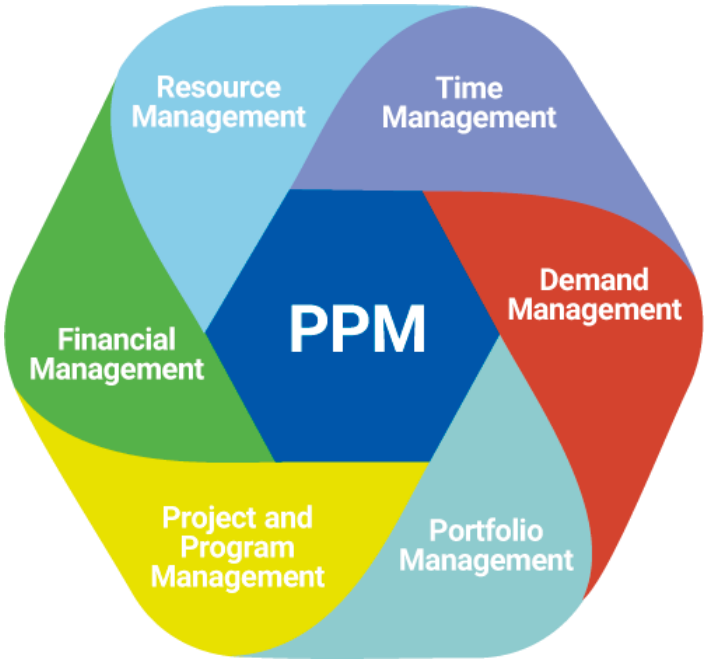


*Figure 6: PPM Framework*

A relatively new discipline of business management known as project portfolio management (PPM) examines how projects are selected, prioritized, integrated, managed, and controlled within a multi-project environment that is now the norm for the majority of businesses. In addition to PPM frameworks and approaches, academics have investigated a variety of PPM-related topics, such as portfolio management success and performance (Patanakul, 2015) and how it is connection to the overall business performance.

The project portfolio management (PPM) methodology may be thought of as a collection of processes, although the PPM's essential procedures are still up for discussion.

The process of project portfolio management incorporates a wide range of sub-categories, some of which include project selection, prioritizing, and assessment. In a similar manner, Padovani and Carvalho (2016) developed a framework for the fundamental PPM processes. This framework takes into consideration the objectives of the organization in addition to other internal context factors, such as installed capacity, technological and human resources, and other limitations.

**• Individual project evaluation**

There is a connection between individual project factors and portfolio management, such as the availability of information and the clarity of project objectives, methodical decision-making, ownership by or support from senior management, type project management framework,

metrics, and measurement. This connection has the potential to increase the efficiency of portfolio management (Martinsuo and Lehtonen, 2007). According to Ghasemzadeh (1999) and other researchers, instead, it is recommended to identify some common parameters be evaluated for each project before the stage of selection, when each individual project analysis stage was being completed.

**• Distribution of available resources**

PPM has a direct connection to resource allocation, which may be defined as the process of assigning specific resources to certain activities during the lifetime of a project (Chilton, 2014). The consequences of ineffective management of resources allocation are readily apparent, for example when organizations waste money on activities that do not provide desirable results, they are unable to finance activities that do produce desirable results (Cooper et al., 1997). In addition to this, a few studies that were conducted during the past years have demonstrated that the distribution of resources may have an effect on performance (Klingebiel and Rammer, 2014).

**• Risk management**

Both PPM and financial portfolio management focus on maximizing value while also mitigating risk, which is one of the main similarities between the two (Chiang and Nunez, 2013). The Project Management Institute (2008) defines portfolio risk as an uncertainty that, if it materializes, will have one or more repercussions on at least one of the portfolio's strategic goals, independently of the nature of those repercussions.

Responses to risks need to be planned, identified, analyzed, monitored, and controlled as part of a project's risk management process before it can be considered complete.

The objectives of risk management are to increase the possibility and impact of positive occurrences while simultaneously reducing the likelihood and impact of adverse events. After the risks associated with the project have been cataloged and evaluated, the overall potential effect of the endeavor is computed.

**• Establishing priorities for a project**

Prioritization is the process of designating a greater level of importance to certain initiatives based on the results of evaluations and other managerial considerations. The ranking of projects by priority provides input for the methodologies used to make decisions regarding constraints such as the distribution of resources and the continuation or termination of projects.

There are a variety of qualitative and quantitative methods and techniques that have been proposed in the literature for project prioritization. These methods and techniques include those that are used for project selection, such as multi-criteria methods like AHP (Analytic Hierarchy Process) and MCDA (Multiple Criteria Decision Analysis). These methods can be combined with artificial intelligence techniques to create hybrid methods like fuzzy AHP. When it comes to prioritizing initiatives, it is necessary to take into account different project aspects like finances, risks and strategic alignment.

Like said before, Project Portfolio Management is a process that involves managing many projects, programs, and portfolios to ensure that they are aligned with the strategic goals and priorities of the business. It entails picking out projects and programs, ranking them in importance, and managing them such that the benefits are maximized while at the same time resources are used as effectively as possible. PPM assists businesses in striking a balance between their resources, managing their risks, and prioritizing their investments so that they can produce the most value and accomplish their goals. To guarantee that the portfolio of projects continues to be aligned with the organization's strategy, it requires an ongoing cycle of evaluation, prioritizing, and decision-making. The following are important aspects of PPM:

1. the **selection and prioritization process** is needed to identify potential projects and programs, evaluate them considering factors such as strategic alignment, risk, value, and resource limitations, and then decide which projects should be approved and which should be given priority for funding and resources.

2. One of the primary responsibilities of **resource management** is ensuring that the right resources can be accessed and coordinated to support the portfolio of projects and activities. This includes both financial and human resources, in addition to other resources like as equipment, infrastructure, and technology. Moreover, this also includes various types of resources.

3. The **supervision** and management of ongoing initiatives and programs which necessitates the ongoing management and supervision of projects and programs to ensure that they are completed in accordance with the stipulated deadlines, without exceeding the allotted spending limit, and to the desired standard of quality. Consistent reporting on the current situation, effective risk management, and thorough evaluation of performance are all components of this.

4. **Monitoring and communicating** the performance of the portfolio to all relevant stakeholders, such as senior management, the board of directors, and clients, is an essential aspect of reporting and analyzing the performance of a portfolio; in this way it is much easier to confirm that the portfolio is delivering the promised benefits and to ensure that any issue is promptly identified and resolved.

5. The term **portfolio risk management** refers to the process of identifying, analyzing, and then managing the risks that are associated to a portfolio of projects and initiatives. This not only mitigates the negative effects of risk occurrences but also ensures that the portfolio continues to align with the organization's core values and long-term objectives.

In order for PPM to be effective, it requires strong leadership as well as collaboration within the company and among all of the stakeholders. It is a continuing process that needs constant progress as well as adaptation to shifting conditions. Through the implementation of PPM, businesses can enhance the results of their projects and programs, maximize their return on investment, and guarantee that their portfolio of projects and programs contributes to the accomplishment of their strategic objectives.

PPM can be defined as a fluid process that evolves along with the of company, modifying during its lifetime in the objectives, initiatives, and resources available. It is important for companies to perform periodic portfolio reviews to guarantee that their resources are being utilized effectively and that their projects and programs are in accordance with their overall goals.

The main benefits that come from having effective project portfolio management may have a considerable impact on a company's overall level of success, which are respectively:

• the **improved alignment with company goals**: PPM helps to ensure that resources are utilized in the most efficient manner possible by aiding organizations in aligning their projects and programs with their strategic objectives.

• **Enhanced Productivity**: PPM helps firms prioritize their projects and initiatives, which ensures that resources are used in the most effective and efficient manner possible. This contributes to an increase in overall productivity. It is possible that this will lead to less waste, decreased costs, and improved outcomes for the project.

• **Improved decision-making:** PPM provides organizations with the knowledge and expertise they require to make decisions regarding their portfolio of projects and programs. This can be accomplished through activities like maintaining consistent performance reporting and risk management analysis; as a consequence, a correct and informed decision-making process may also lead companies in discover and solve issues more quickly.

• **Increased levels of satisfaction** among stakeholders: Effective project portfolio management enables businesses to communicate with stakeholders and work with them to achieve their requirements for projects and programs, leading to stronger connections with stakeholders as well as improved levels of consumer satisfaction; without close cooperation and participation with a diverse group of stakeholders, including project teams, department heads, senior management, and customers it is impossible to have successful project portfolio management.

• **Improved risk management**: PPM is designed to help businesses in recognizing and managing the risks that are associated with the portfolio of projects and programs they are working on. Because of this, they are able to mitigate the consequences of risk occurrences and maintain alignment between their objectives and goals.

• **efficient use of resources**: PPM can assist organizations in ensuring that the appropriate resources are available and in line with the portfolio of projects and programs, lowering possible waste both in a temporary and monetary perspective.

• **Better project results**: Project portfolio management helps organizations in finishing projects and programs on time, within budget, and to the required quality, which improves project outcomes and creates value for stakeholders.

To ensure PPM strategy being effective, companies need to take into account, in addition to the fundamental aspects that have previously been described, a number of additional crucial PPM-related variables governance systems and process improvement. The first one is fundamental

since a solid governance structure is essential to guarantee that projects and programs are aligned with company goals and to ensure that the best decisions are made regarding the allocation of resources and the management of risks; for this reason, a solid governance system should always include establishing coherent norms and guidelines, clear roles and responsibilities, regular reporting, and decision-making procedures. For what concern process improvement, instead, it is necessary to specify that PPM is an ongoing process that needs to be constantly developed and updated to accommodate for possible evolution of the around environment and existing processes and workflows will need to be modified. Consequently, an organization's PPM procedures to be successful, efficient, and provide the outcomes that are desired, need be examined and improved on a regular basis.

A possible checklist of the most important steps involving a solid PPM implementation process can determined by the following 7 steps:

1. Specify the **organization's goals** and aims in as much detail as possible: during the process of implementing PPM, organizations should explain their aims and objectives while also considering the projects, initiatives, and more general strategic goals that they are currently working toward.

2. Evaluate **present procedures**: an in-depth analysis of an organization's existing project and program management processes should be carried out in order to identify areas in need of enhancement and to ensure that PPM is in accordance with established practices.

3. Establish a **governance structure:** companies have to establish a governance structure for PPM that specifies roles, responsibilities, policies, and decision-making procedures.

4. Involve all **relevant stakeholders**: in order to ensure that project portfolio management satisfies the requirements and expectations of all relevant stakeholders, including customers, project teams, departmental leaders, and senior management, and a strong collaboration among all these groups.

5. Establish PPM **processes and tools**: In order to support the prioritizing, resource allocation, and risk management processes, organizations should implement PPM processes and tools, such as project management software and portfolio management tools. These tools can help support the PM and the PMO in the processes of prioritizing, allocating resources, and managing risks.

6. Continuous **monitoring and evaluation**: Monitoring and evaluating processes and tools on a regular basis is something that businesses should do in order to ensure that they are effective, efficient, and producing the desired results.

7. Strive for **continuous improvement**: Project Portfolio Management (PPM) is an ongoing process that has to be continuously enhanced and updated to account for shifting environmental conditions. The portfolio of projects and initiatives that an organization is working on should be reviewed on a regular basis to ensure that the projects and programs being worked on are in

accordance with the company's goals and that resources are being utilized in the most effective manner.

In conclusion, in order to guarantee the achievement of the desired results during the implementation of Project Portfolio Management (PPM), careful planning and performance are required. The goals and objectives of the organization should be defined, their current processes should be evaluated, a governance structure should be developed, stakeholders should be involved, PPM processes and tools should be implemented, monitored, and evaluated, and the organization's activities should be improved continuously. Only then the company can be sure that its PPM processes are producing the expected results.

The extent to which an organization's culture influences the success of its PPM implementation is another factor that businesses need to take into account. It is possible that a culture that respects the values of PPM, such as openness, cooperation, and ongoing progress, is most likely to provide and develop an efficient PPM framework and provides profitable outcomes.

In order for enterprises to successfully promote the adoption of PPM and ensure its success, they must also have the proper leadership and support in place. This may be accomplished by appointing a "PPM champion", establishing a "PPM steering committee," and making certain that senior executives are excited about and devoted to the success of the PPM initiative.

Nevertheless, enterprises need to take into account the relevance of education and training to guarantee a successful implementation. This might include educating project managers, portfolio managers, and other essential stakeholders on PPM methodology, tools, and best practices, as well as supporting continuous professional advancement in the project portfolio management (PPM) sector.

From all the previous passages it is possible to deduct that Project Portfolio Management is an iterative process that needs regular evaluation and development; tools and methods adopted should be evaluated often by businesses to ensure that they are achieving the intended outcomes and this can be accomplished conducting periodic performance reviews, benchmarking against the best practices in the sector, and involving stakeholders to ensure that PPM is in line with their requirements and expectations.

## 2.2 Artificial Intelligence

The term "artificial intelligence" (AI) refers to the process of imitating human intelligence in computer programs. These programs are designed to carry out activities that have historically required human intelligence, such as speech recognition, language translation, visual perception, and decision-making.

The concept that a machine can be taught to perform tasks that would normally require human intelligence by learning from vast quantities of data was the underlying main idea for the development of artificial intelligence; in particular Machine Learning is a type of learning process that is used to construct most of the contemporary artificial intelligence systems. The main classification of Artificial intelligence systems is the following:

• **Narrow or weak AI**: This type of artificial intelligence is designed to carry out certain tasks, such as speech or image recognition.

• **General or powerful artificial intelligence**: This sort of AI is capable of learning and adapting to new conditions, and it can carry out actions that would ordinarily need the intelligence of a human being.

• **Supervised learning** is a form of machine learning that involves training an algorithm on a labeled dataset in order to accurately predict the correct label for new, unmodified data.

• **Unsupervised learning** is a type of machine learning that includes training the algorithm on an unlabeled dataset in order to discover patterns or correlations in the data. This type of machine learning may be thought of as "learning without supervision."

• **Reinforcement learning** is a type of machine learning in which an algorithm learns by behaving in a particular environment and then being rewarded or punished for that behavior. This allows the system to acquire information in a manner that is more natural to humans.

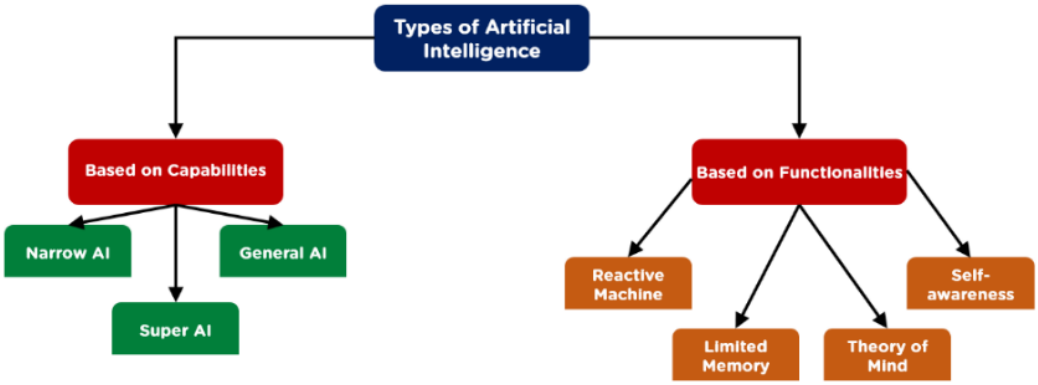


*Figure 7: Types of AI*

Nowadays AI is being utilized in a wide variety of industries, including healthcare, finance, retail, and transportation, amongst others, to boost efficiency, automate procedures, and make decisions based on data. However some concerns have been raised over the impact that AI will have on employment including the long-term impact that AI will have on employment and the workforce, as well as how society will adapt to the rising prevalence of AI in both the working world and in everyday life.

Another challenge is ensuring that AI is utilized in a manner that is both ethical and responsible; fo this reason, in order to alleviate the concerns that have been raised as a result of the potential for AI to perpetuate preexisting biases, businesses need to be transparent about the process by which they develop and train their AI systems.

One of the possible solution to this kind of problem, like suggested by different studies, is to establish clear rules and best practices for AI development and deployment in collaboration with relevant stakeholders that should include experts in ethics and human rights; all this in order to ensure that artificial intelligence is developed and utilized in a responsible and ethical manner.

So Artificial Intelligence has the potential to significantly impact a wide variety of industries and increase efficiency but also has the potential to present a number of challenges and obstacles. Nevertheless, it is important to remember that artificial intelligence is still in its infancy and that there is still a great deal of space for research and development. For example, the current limitations in artificial intelligence systems' ability to comprehend context and emotions which may result in misunderstandings or errors.

As part of a deep dive, it is possible to investigate the underlying systems and techniques that make artificial intelligence possible: the core concept of artificial intelligence (AI) is known as machine learning, which refers to the process of enabling computers to learn from data and improve their performance over time; the classification system for machine learning techniques can be divided into four fundamental subcategories: reinforcement learning, unsupervised learning, semi-supervised learning, and supervised learning. (Goodfellow et al., 2016).

A **machine learning** model is trained on a labeled dataset in the presence of human oversight, with the end goal of the training already established. The model then generates predictions on new data based on what it has learnt from the training data. These predictions are based on the unknown data. Analysis of emotions, speech recognition, and the categorization of images are examples of common applications of this technique.

**Unsupervised learning** refers to the process of training a machine learning model using an unlabeled dataset, which is a situation in which the desired output is unknown. Finding patterns or connections in the data that may be utilized for activities such as clustering or detecting anomalies will be the focus of this endeavor.

**Learning** that is **semi-supervised** makes use of both labeled and unlabeled data. This type of learning is a hybrid of supervised and unsupervised learning, and it is helpful in situations in which the classification of data requires a lot of time or money.

A machine learning model may be trained using **reinforcement learning** in a simulated environment by being rewarded for doing the right thing and penalized for doing the wrong thing throughout the training process. This type of learning is involved in a wide variety of activities, including playing video games, constructing robots, and generating recommendation systems.

One of the most important aspects of artificial intelligence is **deep learning**, which is a subfield of machine learning that makes use of deep neural networks. The ability to recognize patterns in data is the primary function of deep neural networks, which are built from several stacked layers of interconnected nodes. This particular type of machine learning is utilized for activities such as the categorization of pictures, the recognition of sounds, and the processing of natural language.

## 2.3 Industry 4.0

In the context of Industry 4.0, which refers to the fourth industrial revolution and is characterized by the integration of cutting-edge technologies such as the Internet of Things (IoT), big data analytics and cloud computing, artificial intelligence has the potential to completely transform the manufacturing and production processes. This is because AI is able to learn from its mistakes and adapt to new situations. A closer look at how artificial intelligence is affecting the industrial and manufacturing industry is provided as follows:

1. **Predictive Maintenance**: this is one of the core uses of artificial intelligence in the fourth industrial revolution (Industry 4.0). AI algorithms may be used to examine data from sensors and machines to estimate when equipment will need to be maintained. This helps to cut down on equipment downtime and increases overall equipment efficiency. By using predictive maintenance, businesses may reduce their overall maintenance costs and prevent unscheduled downtime.

2. **Quality Control**: artificial intelligence is also employed for quality control in the industry 4.0 paradigm. AI algorithms may be utilized to carry out inspections and categorizations of various objects to guarantee that only the highest-quality goods are distributed to customers. Implementing AI algorithms may help businesses reduce the number of faulty products they ship to customers, improve customer satisfaction, and increase revenue.

3. **Optimization of Supply Chains**: supply chain optimization is another crucial use of AI in the fourth industrial revolution. AI algorithms may be used to improve the efficiency of supply chain operations, reduce waste, and maximize the effectiveness of logistics by analyzing data on demand, production, and transportation. By adopting AI algorithms, businesses stand to benefit from reduced costs, shortened delivery times, and increased customer satisfaction.

4. **Personalized Manufacturing**: the concept of personalized production is becoming increasingly prevalent in the industry 4.0 sector. It is possible to utilize AI algorithms to personalize production processes and make commodities that are tailored to the requirements of individual customers. By using AI algorithms, businesses have the potential to raise their levels of production and customer satisfaction while simultaneously lowering their costs.

5. **Decision Support**: AI algorithms may be utilized to provide support for decision-making in a range of scenarios, including the allocation of resources, the management of inventories, and the planning of production. Algorithms based on AI can provide assistance to organizations in the areas of decision-making, the reduction of costs, and greater productivity.

6. **Self-Driving Robots**: the usage of self-driving robots is becoming more prevalent in the industry 4.0 sector. AI algorithms allow for the creation of autonomous robots that can carry out a number of activities, including the handling of materials, assembling, and packing of goods. Businesses that use autonomous robots are able to reduce their spending on labor, therefore increasing their productivity and improving their relationship with their customers.

7. **Energy Management**: another essential use of AI in the Industry 4.0 space is in the realm of energy management. AI algorithms may be used to increase energy efficiency and optimize energy use. This is accomplished by analyzing data on energy use and identifying areas in which improvements are possible. Through the implementation of AI algorithms, businesses have the potential to cut their energy costs, reduce their carbon footprint, and improve their overall sustainability.

8. **Health and safety**: in the field of production and manufacturing, health and safety are of the utmost importance. AI algorithms have the potential to significantly improve worker safety in industrial settings. They can do this by monitoring equipment, identifying potential hazards, and immediately alerting employees. Through the use of AI algorithms, businesses may reduce the risk of accidents, improve workplace safety, and save expenses associated with injuries sustained on the job.

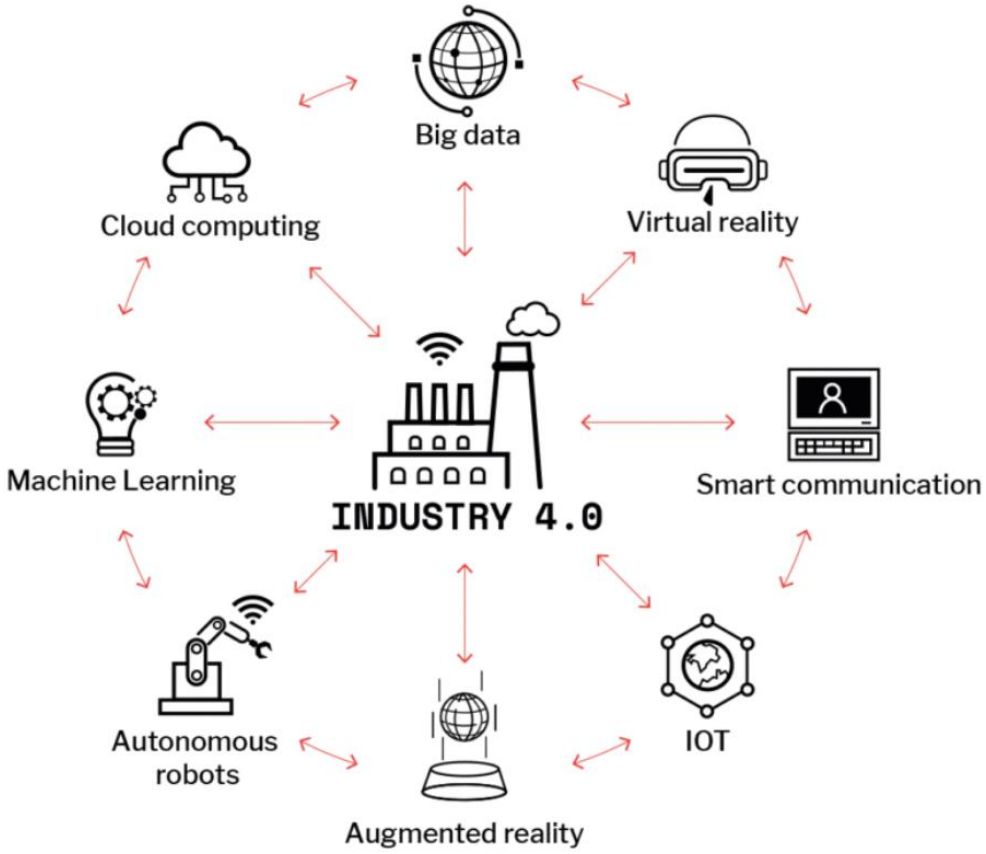


*Figure 8: Industry 4.0 Framework*

Some of the ways in which artificial intelligence (AI) has been connected to Industry 4.0 is causing changes in the manufacturing and production industry are listed below. As the technology evolves and gets more advanced, there will surely be novel and imaginative uses of AI in the fourth industrial revolution. However, in addition to manufacturing and production, a vast array of other categories of businesses stand to gain significantly from the use of artificial intelligence. Here are a few examples of how artificial intelligence is being employed in a variety of fields:

The application of artificial intelligence (AI) in the **medical field** has the potential to improve patient outcomes, reduce expenses, and boost efficiency. For example, AI algorithms might be used to analyze patient data, such as medical records, imaging scans, and laboratory findings, in order to enhance diagnostics and treatment protocols. This would allow for more accurate patient care. It is also possible to utilize algorithms that are based on artificial intelligence to monitor patients in real time. These algorithms can detect early symptoms of illness and provide an alarm to medical staff about potential issues.

Artificial intelligence (AI) is being used in the **financial services** industry to boost productivity, save expenses, and improve customer experiences. AI algorithms make it possible to automate a wide variety of formerly labor-intensive tasks, including as fraud detection, customer service,

and compliance monitoring, amongst others, but they may also be used to evaluate financial data, such as stock prices and market movements, to enhance investment decisions.

AI is being used in the **retail industry** to enhance the shopping experiences of customers and boost revenue. AI algorithms may be used to improve, among other things, supply chain management, customize suggestions, and optimize pricing and promotions. they may also be used to evaluate client data, such as purchase history and browsing activity, to improve marketing and sales efforts. All these implementations can be done in order to increase marketing and sales efforts.

In the **transportation and logistics** field artificial intelligence is being used to boost productivity while simultaneously lowering operating expenses. For example, algorithms powered by artificial intelligence may be utilized to improve delivery times, optimize routes, and reduce the amount of gasoline needed. Algorithms powered by AI may also be used to analyze data on traffic patterns, weather conditions, and road conditions in order to make driving more secure and lessen the risk of accidents happening.

Artificial intelligence can be used in the **energy sector** to achieve the goals of increasing efficiency, lowering prices, and improving the industry's capacity to remain sustainable. For example, AI algorithms may be used to maximize energy output, reduce waste, and improve efficiency while simultaneously optimizing energy consumption. In addition, AI algorithms may be utilized to do data analysis on energy usage, weather patterns, and customer behavior in order to improve energy management and save costs.

The use of AI in **education** has been shown to increase student outcomes while also reducing costs and increasing efficiencies. For example, AI algorithms may be used to personalize students' educational experiences, improve grading and assessment processes, and give them with feedback in real time. Algorithms based on artificial intelligence may also be used to analyze student data such as grades and test results in order to make learning and teaching more effective.

Artificial intelligence is being used by the **government** to boost efficiency, cut costs, and improve public services. AI algorithms, for example, make it possible to automate a wide variety of labor-intensive tasks, including the preparation of tax returns, the filing of benefit claims, and the monitoring of compliance. Additionally, AI algorithms may be used to analyze data on crime trends, traffic patterns, and population demographics in order to improve public safety and to limit the amount of money spent.

| Industry gaps | |
|---|---|
| **Projects have no baseline** | Over 1 in 3 projects have no baseline. |
| **Millions wasted on projects** | For $1 Billion invested in the USA, $122 M was wasted from poor project outputs. |
| **A large number of projects fail** | 75% of executives anticipate software projects will fail. |
| **Half of PMOs will close in 3 years** | 50% of all Project Management Offices) close within just 3 years. |
| **A lack of knowledge if projects align with strategy** | 80% of PM executives don't know how their projects align with business strategy. |

*Figure 9: Industry 4.0 Gaps*

## 3.0 AI Implementation for PPM

Every sector of the economy is now being challenged by new digital technologies, and these days, artificial intelligence and machine learning are progressively finding applications in a broad variety of economic fields. This competition is forcing businesses to adapt, or risk being left behind. Project Portfolio Management is one of the most interesting topics because of the significance of successfully managing corporate investments and the volatility that is inherent to projects. AI will be mostly implemented during the planning process and the formulation of the portfolio itself when it comes to ensuring that suitable projects are picked and managed in the appropriate manner. A great deal of discussion is taking on in this moment about the influence that artificial intelligence (AI) will have on program managers and portfolio managers in the future. For example, the results of a study of project managers all across the country that was conducted by the Harvard Business Review, and carried out in the United States, found that administrative duties accounted for 54% of the managers' time. This proportion is greater than the total amount of time spent on doing all other PPM-related duties combined. These responsibilities include determining a project's scope, cost, and duration, as well as the schedule for individual activities.

The following are some of the possible ways that artificial intelligence and machine learning will modify the processes and procedures that are now engaged in projects:

**Lower expenditures**: It is possible that teams and project managers will be able to focus their attention on activities that deliver a greater overall return on investment instead of focusing on manual operations that can be automated with the aid of AI. In particular, Project Managers can able to focus on human-centric responsibilities such as strategic thinking, creativity, problem-solving, communication, and team building, amongst other things, while also contributing to the automation of the more laborious components of project management, allowing for a more streamlined and efficient workflow.

**Improved Analytics**: The ability of artificial intelligence to create prediction models, which can then be utilized in analytics, is another key advantage given by AI. Artificial Intelligence programs are able to gather data on previous projects and make highly accurate predictions about when projects will be finished or which projects will advance thanks to the use of historical data and real-time cost estimation, used to inform the team when a project is deviating from the track that it was expected to follow; also the delivery of reports with updates in real-time and the automation of approval processes can be helpful application to remove bottlenecks.

**Increased accuracy:** The incorporation of AI into project and portfolio management will result in improved outcomes due to increased accuracy and efficiency when assessing data points in real-time during the execution of a task. This is especially true when it comes to lowering the quantity of human data entry in order to reduce mistake rates and making use of that information in order to control possible hazards.

**Data driven decision-making**: The most significant obstacle that many companies must overcome is not a deficit in data collection but rather an inability to effectively utilize the data that they have collected. Future project managers will benefit greatly from artificial intelligence's capacity to analyze massive quantities of data, apply multiple analytical frameworks, and present pertinent information in a manner that can be easily understood.

**Risk management**: hazards are one of the key variables that contribute to the failure of a project; failing to manage risks could have a negative influence on the result of the project. Because of artificial intelligence, project managers will be able to perform in-depth studies, discover repeated patterns and trends that could be overlooked and use these information to make decisions that are founded on real data. However, it is important to note that his aspect does not lessen the importance of the so-called "human factor," characterized by intuition, environmental awareness, and personal experience; rather, it merely adds another degree of accuracy and depth to the study.

## 3.1 Financial Portfolio Similarities

The processes and goals of project portfolio management (PPM) and financial portfolio management (FPM) are somewhat comparable; in fact, both types involve collecting and analyzing data, determining goals and objectives, selecting investments or projects, continuously evaluating performance and making necessary adjustments, in order to reach certain goals and objectives

The acquisition and analysis of data in order to arrive at well-informed conclusions, appears both in PPM and FPM relying heavily on the gathering and analysis of relevant data. Data may contain project ideas, schedules, budgets, resource requirements, and metrics about project performance or they may include economic indicators, stock prices, financial statements, and several other types of financial measurements while working with FPM. Both traditional portfolio management and project portfolio management require the capacity to gather and analyze enormous volumes of data in order to recognize patterns, opportunities, and trends.

A clear set of goals and objectives is also a need of both the PPM and the FPM, and each require their own unique formulation. Increasing profitability, enhancing customer happiness, and cutting expenses are all possible objectives that may be pursued through PPM. In the context of FPM, goals might include things like optimizing returns, reducing risk, or reaching a desired degree of diversity. Both forms of portfolio management involve the capacity to establish goals and objectives that are clear, quantifiable, and in line with the overarching strategic direction that the firm is moving in as a whole.

Consequently, it is also necessary a coherent selection of investments, in fact Project Portfolio Management and Financial Portfolio Management both include the selection of investments or projects. While the first one selects projects based on how well they connect with organizational goals and objectives, the second one selects investments based on how well they align with the aims and objectives of the portfolio. This needs the capacity to analyze many possibilities, determine risks and possible returns, and make choices based on accurate information that are in line with the portfolio's overall aims and objectives.

Another aspect of relevant importance is the performance monitoring; in fact PPM and FPM require the continuous monitoring of performance in some capacity. PPM allows for performance to be monitored through the tracking of project progress, the identification of possible hazards, and the implementation of necessary modifications. The performance of an FPM, instead, is managed by following the value of the portfolio, determining any possible hazards, and adjusting as necessary. So, both the portfolio management environments involve the capacity to monitor and evaluate performance on an ongoing basis in order to discover areas that might use better and to make necessary modifications.

Obviously variations, alterations, and modifications must be considered on a case-by-case basis in both PPM and FPM. Adjustments in PPM could involve redistributing resources, shifting the priorities of a project, or even dropping a project entirely. Adjustments in FPM could involve

purchasing or selling investments, rebalancing the portfolio's asset allocation, or cutting the portfolio's overall risk. In conclusion, both traditional portfolio management and alternative portfolio management involve the capacity to respond effectively to shifting conditions, formulate appropriate strategies, and implement appropriate improvements in order to achieve desired results.

## 3.2 Flexible Integration of Machine Learning

Due to the unpredictability and complexity of the project management industry as a whole, organizations and specialists face a number of obstacles when it comes to managing projects; one example of this category of problem is the management of possible conflicts and dependencies during the process of resource allocation and, his sort of issue, can appear in many forms like constraint due to financial dependencies or time dependencies. Other examples include the adjustments of multiple projects to prevent disorganized planning and the utilization of an informed shared decision making to manage potential opportunities or threats during the project's execution; both of them can help assure the successful completion of a project.

The majority of the methodologies and technologies that are currently used to support and improve the quality of PPM are founded on the application of complex analytical techniques that were created and developed in the field of operations research; and this valid for the majority of the methodologies and technologies that are currently used. These methods make use of statistical analysis and quantitative optimization in order to assess Whether the potential solutions to a particular problem are the most effective or the least efficient that can be accomplished.

AI-powered project management systems have been developed to integrate processing knowledge with procedural methods in order to provide specific kinds of decision support for establishing objectives and administering projects. For instance, the use of AI in project management circumstances that are both heavily focused on data or cognitively challenging can support the PM and the PMO in many different kind of activities.

Using artificial intelligence, and in particular through the use of machine learning, project managers can rapidly distribute thousands of tasks while maintaining an overview of their resources and projects. This helps to reach the sufficient degree of accuracy and precision while simultaneously reducing bottlenecks and other potential impediments that may slow down the actions of the company.

These strategies may also be used from managers and other specialists in evaluating enormous amounts of data and gaining crucial insights on how to improve their overall PM practice, like providing forecast of possible adverse situations, provide prompt warnings, and suggest preventative measures in reference to problematic resource loads or deviations from business priority lists based on past data in a very short amount of time.

Operations research and artificial intelligence undoubtedly provided a substantial contribution to the evolution of the PM practice by addressing pertinent challenges from a variety of research and philosophical perspectives and there is no doubt that this has led to significant advancements in the practice of project management.

In terms of labeling, correlating, modeling, and measuring PM data and knowledge, there is still a substantial amount of work to be done; the majority of this work must be performed by people and it is important to keep in mind, especially in the context of project management, that

essential data and knowledge are continuously generated throughout the course of a company. During the decision-making process, these pieces of information and insights relate to both the organization as a whole, such as the duration of a project, the overall budget, and key performance indicators, and its individual employees, such as their competencies and performance.

Nowadays there is a wide choice of different project management software packages that are available on the market: Wrike (www.wrike.com), Asana (www.asana.com), Trello (www.trello.com), and Jira (www.atlassian.com/software/jira) are among the project management applications that are utilized the most frequently. These sorts of solutions provide a setting that is easy to use and fundamentally supports several project management tasks while also making it simpler to keep track of problems. In addition, they make the processes of planning, coordinating, reporting, and time management clearer by offering interactive graphics, issue boards, and deadlines. It is widely believed that the commercial PM solutions that are currently available on the market can increase the overall efficacy of a business and prevent teams from deviating too far from their original objectives. On the other hand, due to complex and variable data accessible in hosted projects, many of them inaccurately hide vital PM-related information.

Some examples of digital project management solutions that were constructed in the past utilizing an AI-based approach are Stratejos.ai, PMOtto.ai, and x.ai amongst others. This kind of software can be distinguished by an intuitive and simple user interface that offer aid to project managers while they carry out routine responsibilities such project oversight. In order to give a "zero-level" environment introduction, they rely on the expressiveness, immediacy, interactivity, and descriptiveness that natural language delivers. They are utilized to automate routine tasks such as generating project tasks from textual conversations, to remind and schedule important occasions such as meetings, to extract superficial insights such as "top contributors of the week", and to provide answers to fundamental questions such as "what is my team working on today?".

It is important to bear in mind that artificial neural networks are at the core of the majority of AI-based approaches to PM. Many publications, for example, demonstrates how neural networks may be used to help solve a few issues, including resource allocation, prediction, clustering (Zhang et al., 1998), classification, and forecasting (Burke and Ignizio, 1992), In addition, neural network methods have been used, as stated by Wang et al. (2012), to predict the success of building schedules and expenditures. Other noteworthy research includes the development of a neural network for the purpose of predicting project performance (Cheung et al., 2006), as well as the categorization of the riskiness of a project based on knowledge about previous projects that were either successful or unsuccessful (Costantino et al., 2015).

## 3.3 Machine learning for risk assessment

AI has the potential to be used to improve risk management within a project portfolio by delivering capabilities for more advanced analytics and decision-making. The following is a list of some of the several uses of AI that might be used for risk management in project portfolios:

**Predictive modeling**: predictive modeling is a technique that uses statistical and machine learning algorithms to analyze historical data and identify patterns that can be used to make predictions about future events. When it comes to the management of project portfolios, predictive modeling may be applied to offer an assessment of the likelihood that specific risks will become actualized. For instance, a predictive model may be used to investigate data on previously finished projects to identify patterns that are associated with cost overruns or delays. Once all these information has been gathered, decision-making processes may be guided by it, and areas of risk within the project portfolio may be found and examined using the information.

**Real-time monitoring**: real-time monitoring systems that are powered by AI may be used to follow the state of projects in real-time, delivering insights on prospective risks and difficulties in the process. Real-time monitoring systems may be used to follow the status of projects in real-time. For instance, a monitoring system that is powered by AI might be used to keep track on the progression of a project, as well as its usage of resources and the constraints placed on its financial resources. It is possible to make use of this information to identify potential risks early on, such as a project that is at risk of falling behind schedule or a resource that is at risk of being over-allocated.

**Natural Language Processing (NLP):** is a technique that may be used with AI to extract valuable information from unstructured data sources such as project papers, emails, and social media. NLP can also be used to translate natural language into machine language. For instance, a system that is powered by natural language processing (NLP) may be used to analyze project documents and locate key terms or phrases that are associated with potential dangers. It's possible that phrases like "delays" or "budget limits" will be among these. Once all this information has been gathered, decision-making processes may be guided by it, and areas of risk within the project portfolio may be found and examined using this information.

**Machine learning**: the algorithms employed in machine learning may be applied to the examination of huge amounts of data in order to discover patterns and trends that are not immediately obvious at first look. This information may be utilized to identify potential areas of risk, speculate on the outcomes of the project, and make the most efficient use of the resources that are at one's disposal.

**Expert systems**: a body of past knowledge and a specified set of criteria may be utilized by expert systems that are powered by artificial intelligence in order to provide recommendations on risk management. These systems are able to analyze difficult circumstances, determine the existence of potential dangers, and provide recommendations for mitigating or avoiding such threats. They may also be used to give an analysis and identification of possible dangers, which

is another service they can provide. For instance, a data analysis expert system might be used to study information on finished projects in order to find patterns that are associated to prospective risks. This would allow for earlier detection and mitigation of such issues. The findings of this analysis might then be presented to the management of the project as ideas for minimizing the risks that were discovered.

Of course, applications of the technology and methods described include, but are not limited to, the following: data analysis; the localization and identification of potentially hazardous circumstances; the acquisition of insights that may be utilized to influence decision-making. In addition to these, they may be used to automate the procedures that are involved in risk management, which enables project managers to spend their attention on other tasks that are more vital. The implementation of AI in risk management may provide organizations with the capacity to identify potential dangers at an earlier stage, to take corrective action, and to improve the overall efficiency and effectiveness of their project portfolio management.

It is possible to use learning algorithms on vast amounts of data in order to discover patterns and trends that are not immediately obvious. Because of this, the application of on of the four main machine learning subset previously described can now be utilized to analyze the data. In the context of project portfolio management, machine learning might be used to review data on prior projects and uncover patterns that are related with risks in order to mitigate them. Finding patterns that are associated with dangers is one way to go about accomplishing this goal. For example, an algorithm for machine learning may be applied to the task of evaluating data on finished projects in order to identify patterns that are associated to cost overruns or delivery delays.

Utilizing each of these distinct methods, tactical approaches, and technological advancements together there is the possibility to develop a comprehensive risk management plan. With the assistance of AI-powered systems, data can be evaluated, potential risks can be recognized, and insights can be supplied and used to inform decision-making procedures.

In particular, the area of artificial intelligence known as machine learning can be defined as a subset of AI that use algorithms to learn from data and then either make predictions or judgements. The process of evaluating historical data and discovering patterns that are associated with several different types of dangers might benefit from the application of machine learning. Within the parameters of risk assessment, this is something that can be accomplished. The following represent an illustration of one potential use of machine learning to risk assessment while overviewing the main steps for a successful implementation and deployment of a ML integration within the risk management framework:

1. The gathering of data and the preliminary processing of it: when using machine learning for risk assessment, the first step is to collect and preprocess the data that will be used in the training of the model. This data will be used to simulate real-world scenarios. A "training set" will be constructed with the use of this data. This may include information about prior efforts, statistics from the relevant industry, or any other relevant data. Alternatively, this may contain any other

relevant data. The data will need to be cleaned, converted, and formatted in a way that is appropriate for use with the machine learning approach before it can be utilized.

2. The Process of Training the Model: after the data has been cleaned and structured, it can then be used to train the machine learning model. This happens after the data has gone through the data preparation process. This is often performed by utilizing a training dataset in order to "teach" the algorithm how to detect patterns that are associated with a range of threats. This allows the algorithm to more accurately assess the risk posed by the data. There are several algorithms that may be utilized, such as decision trees, random forests, and neural networks, which are all viable possibilities for achieving this objective.

3. A critical analysis of the model: after the training phase of the model has been completed, the following step is to conduct an evaluation of it to confirm that it is reliable and accurate. This may be performed by utilizing a unique dataset, also known as a validation set, which was not included in the process of the training the model. This collection of data was not included in the original dataset that was used. During the phase where the evaluation is taking place, a number of other metrics, such as accuracy, precision, recall, and score, will be taken into consideration.

4. Use of the Model in Real-World Situations: if the evaluation stage of the process shows that the model is effective, then it will be possible to implement it in a production environment. It is possible that the model will need to be included into a risk management system or some other type of software instrument in order to achieve this objective.

5. Continuous inspection and upkeep of the system: after the model has been successfully implemented, it will need to be monitored and maintained in order to ensure that it continues to perform properly after the deployment process has been completed. It is possible that the model will need to be retrained on a frequent basis in order to achieve this objective. This is necessary in order to take into account any changes that may occur in either the data or the environment. It's possible that part of the procedure will involve monitoring the performance of the model in the production environment and making modifications when they become necessary.

When doing risk analysis, a company that makes use of machine learning may be able to analyze massive amounts of data and identify patterns that are associated with a wide variety of dangers. It's possible that the organization will benefit from this. It is likely that this might be of assistance to organizations in the early identification of risks, which in turn could lead to more efficient risk management. In addition, many of the tasks associated with risk assessment may be automated by using machine learning in the appropriate context. Because of this, organizational resources are unburdened, allowing those resources to be redirected toward other crucial obligations.

When it comes to the most frequent specific risks, like in software projects, Boehm, who is considered, by many, to be one of the most important authors in this research area, listed risks such as personnel shortfalls, unrealistic schedules and budgets, and the development of the wrong functions and/or user interface as some of the most frequent risks that have a direct effect

on the success of software projects. Boehm also listed risks such as developing the wrong functions and/or user interface as one of the most frequent risks that have an indirect

In this field of study, the categorization of risk elements by team, organizational environment, requirements, planning and control, user and complexity that was developed by Wallace is still commonly utilized. Not only does it present common risk items in software projects, but by grouping them according to a specific dimension within the areas that project managers have

to consider in the development of a software project, it makes it possible to identify what areas are more likely to be problematic throughout the course of the development of the project itself and prepare their risk management strategies accordingly. In addition, it presents common risk items in software projects and groups these common risk items according to a particular dimension within the areas that project managers have to consider in the development.

The usage of a portfolio chart, such as the one that was introduced by Dr. Ernest Wallmuller and which can be seen in the table below, is an effective method for categorizing the discovered risks in accordance with the priority that they pose to the organization.

*Table 1: Risk Priorities According To Their Probability and Impact*

| **Impact** | | | | |
|---|---|---|---|---|
| High | B | A | A | |
| Medium | C | B | A | |
| Low | C | C | B | |
| | Low | Medium | High | **Probability** |

In recent years, machine learning has been increasingly popular in the field of risk management, and a wide variety of methodologies have been utilized to implement this trend. Finding practical applications of machine learning that can forecast prospective project hazards or an overall risk level for a project was the primary emphasis of the examination of the current state of the art that was carried out in this piece of research for the objectives of this article. From that point on, it became able to determine not only some of the algorithms and assessment metrics that were utilized the most frequently, but also the kind of information that was utilized as inputs in the process of training the models.

An Artificial Neural Network model was developed in [18] to forecast the occurrence of deviations in newly developed software projects. The risk factors that were found in the projects served as the model's inputs, and the model's outputs included the differences that were discovered in terms of time, budget, and personnel, as well as the number of work packages that were successfully completed and the level of success achieved by the project that was being

investigated. This experiment demonstrated the applicability of Neural Networks when the intended information spans more than one category (in this case, the deviations in five attributes related to the project), as well as the fact that the model can have a great performance and accuracy, as seen in its results. In addition, the experiment demonstrated that the model can have great performance and accuracy.

Both a Neural Network model and a Support Vector Machine model were developed in [19] with the purpose of contrasting the two methodologies with regard to the amount of accuracy they provided when assessing the degree of danger posed by software development projects. The input that was used was a vector of risk factors from 120 different software projects. These risk factors were collected after several interviews with industry professionals and were then categorized according to six distinct risk categories (Environment Complexity, Project Requirement Complexity, Cooperation, Team, Project Management, and Engineering). The output was the anticipated result of the endeavor, which may be one of three different phrases: "successful," "failed," or "challenging." Due to the tendency of the Neural Network method to find a local optimum [19], the Support Vector Machine model had a higher accuracy than the Neural Network method (80% vs. 70%, respectively). However, after changes were made to the NN method by optimizing it with a Genetic Algorithm (GA), this caused it to become so that the NN-GA method surpassed SVM in accuracy (85% vs. 80%, respectively) by reducing the search for a local optimum.

The author of proposes a Neural Network architecture with a back propagation algorithm to learn the patterns of a data set of completed projects in the past, which also includes 22 project risk factors of areas such as estimations, requirements (for example, frequent changes to requirements), and team organization. This can be found in [20]. (e.g., lack of skills or experience). The results of the model were presented in the form of a categorization of the degree of danger posed by the project: "risky" or "not risky." When compared to a Logistic Regression model that was generated from and used on the same data set, it was discovered that the model that had been developed had a greater level of accuracy and sensitivity.

An approach to predicting runaway projects in an organization was developed by the authors of [11]. This approach involves using a questionnaire to identify the characteristics of projects and then classifying them as "runaway" or "success" projects using a Naive Bayes classifier. Runaway projects are projects that significantly exceed their budget and deadlines and fail to produce an acceptable deliverable. These characteristics are broken down into five distinct categories, which are as follows: requirements (for example, ambiguity of requirements), estimations (for example, absence of stakeholders present for estimation process), planning (for example, unspecified milestones), team organization (for example, lack of skills or experience), and project management (e.g., inadequate project monitoring). Their approach was put through a 10-fold cross validation in order to see how successful it was, and the results showed that it had a predicted accuracy of 82.5%, with 33 out of 40 projects being properly identified.

Moreover, Bayesian classifiers were utilized in both [21] and [22]. In the first approach, a Bayesian Belief Network (BBN) was utilized in order to construct a software risk estimate model. This model was then applied to the primary software risk indicators in order to perform

risk assessment in software projects. In the latter, a model for identifying and analyzing risks in software development projects was constructed by combining data from 302 different software projects with a Bayesian network that had causality constraints. This model was used to evaluate the data. The authors found that it had an accuracy that was 1% to 7% higher than the other models that were tested (Logistic Regression, Decision Tree, and Naive Bayes), which they attributed to the incorporation of expert domain knowledge and causality discovery into the BBN. Specifically, they found that the BBN was more accurate than the other models in the range of 1% to 7%.

Support Vector Machines were utilized by the authors of [23] in order to simulate risk categorization in software development initiatives. The model assigned each project either a high risk or a low risk category. Another use of SVM was found in [24], where it was used to forecast if the risk level of certain projects was "low," "medium," or "high." The authors employed a Neural Network as a comparative tool and discovered that the Support Vector Machine (SVM) had a higher accuracy (85% accuracy of the SVM compared to 75% accuracy of the NN).

In [25], Multiple Logistic Regression was utilized in order to categorize various aspects of software projects as either a "risk" or a "non-risk." This was done in order to determine the likelihood of adverse outcomes. The input data was obtained by sending questionnaires to professionals in the fields of software project development and management. The questionnaires asked these individuals to categorize risk factors from eight different categories (User, Requirements, Estimations, Cost, Schedule, Planning and Control, Team, and Software) according to their risk level on a scale ranging from 1 to 5.

Last but not least, the writers of [26] classified initiatives according on whether they were "risky" or "not risky" using Logistic Regression. The input data for the model that was built was the responses to a questionnaire that focused on five perspectives of important risk variables (Requirements, Estimations, Planning, Organization, and Management). The model that was developed properly identified 35 out of 40 projects.

When it comes to machine learning models that may be used to anticipate risks in software projects, there are a wide variety of options available, as is evident from the preceding discussion. Yet, there are certain aspects of this subject that might benefit from more investigation in order to enhance the applicability of machine learning models for risk assessment.

Several of the studies that are provided in table 2 compare various machine learning algorithms (for example, [19] and [24]). The objective of these comparisons is to evaluate the accuracy of the algorithms' predictions in relation to a particular issue. But, they are also comparable in terms of interpretability and the performance trade-offs that are involved in more interpretable algorithms. This comparison should receive a greater amount of attention.

The term "interpretability" refers to "the degree to which a person can grasp the source of a choice" [27], and it is used in the context of machine learning. Machine learning models that are interpretable make it much simpler to comprehend not just the forecast that the model has generated, but also, and perhaps more crucially, the reasoning behind that prediction. In the event that a forecast does not correspond to what was previously anticipated, developers can make use of this information to determine whether or not there are problems with the data set, the model, or potentially both. Yet, there is a tradeoff associated with interpretable machine learning algorithms, and that tradeoff is the fact that predictive performance tends to be worse with these algorithms. In other words, interpretable machine learning algorithms tend to be less accurate.

In addition, taking into consideration the widespread use of software for project management such as JIRA and Asana, the development of machine learning models that are compatible with these applications may be one of the next areas of concentration for researchers working in this subject. This integration with tools used for daily project management tasks has the potential to make risk management just another step in the project management cycle, rather than a process that requires a significant reorganization of an organization's workflow in order to integrate it into their processes.

*Table 2; Studies On The Use Of ML Techniques For Risk Management*

| Reference | Inputs | Outputs | Algorithm(s) | Evaluation metric(s) |
|---|---|---|---|---|
| A Novel Model for Risk Estimation in Software Projects using Artificial Neural Network [18] | 45 risk factors of 20 software projects (70% of data used for training, 30% for testing) | Deviations in project duration, cost, number of personnel, completed work packages, project success | Neural Network | Training $R^1$= 0.9978<br>Testing R = 0.9935<br>Validation R = 0.996<br>$MSE^2$ = 0.001 |
| Software Project Risk Management Modelling with Neural Network and Support Vector Machine Approaches [19] | Data of 120 software projects collected through questionnaires distributed in cities in China (83.3% of data used for training, 16.7% for testing) | Classification of projects as either "successful", "challenged", or "failed" | Neural Network | Accuracy = 70% |
| | | | Genetic Algorithm NN | Accuracy = 85% |
| | | | Support Vector Machine | Accuracy = 80% |
| Discriminating Risky Software Project Using Neural Networks [20] | 22 attributes of 40 projects in the OMRON database (80% of data used for training, 20% for testing) | Risk level of the project - "risky" or "not risky" | Neural Network | Accuracy = 82.2%<br>Precision = 81.82%<br>$TPR^3$ = 81.82%<br>$TNR^4$ = 82.61% |
| | | | Logistic Regression | Accuracy = 87.5%<br>Precision = 100%<br>TPR = 66.7%<br>TNR = 100% |
| An Empirical Evaluation of Predicting Runaway Software Projects Using Bayesian Classification [11] | Responses on a 4 point Likert scale to a questionnaire focusing on 5 viewpoints of key risk factors in 40 SSBC projects (10-fold cross-validation used for testing) | Project classification as either "runaway" or "success" | Bayesian classifiers | Accuracy = 82.5% |
| A Probabilistic Software Risk Assessment and Estimation Model for Software Projects [21] | Assessment of 27 risk factors (low, medium or high) in 12 software projects | Probability of the project being of low, medium, or high risk | Bayesian classifiers | $MMRE^5$ = 0.03842<br>$BMMRE^6$ = 0.03911 |
| Software Project Risk Analysis using Bayesian Networks with Causality Constraints [22] | Software project data from 302 projects collected through questionnaires (10-fold cross-validation used for testing) | Classification of project's performance based on risks identified as "low" or "high" | Bayesian network with causality constraints | Accuracy = 75.15% |
| | | | Decision Trees | Accuracy = 70.86% |
| | | | Naive Bayes | Accuracy = 72.85% |
| | | | Bayesian classifiers | Accuracy = 74.17% |
| **Classification of Risk in Software Development Projects using Support Vector Machine [23]** | **530 samples of a data set created from information of software development projects (70% of data used for training and 30% for testing)** | **Project risk classification as either "low risk" or "high risk"** | **Support Vector Machine** | **Accuracy = 99.51%<br>$AUC^7$ = 98%** |
| An Intelligent Model for Software Project Risk Prediction [24] | 64 risk factors of data from 120 projects (83.3% of data used for training, 16.7% used for testing) | Classification of projects as either "successful", "challenged", or "failure" | Neural Network | Accuracy = 75% |
| | | | Support Vector Machine | Accuracy = 85% |
| **Prediction of Risk Factors of Software Development Project by Using Multiple Logistic Regression [25]** | **Data obtained from questionnaires regarding the risk level of 70 software projects** | **Classification of characteristics of a software project as "risk" or "non risk"** | **Multiple Logistic Regression** | **Accuracy = 90%** |
| **An Empirical Approach to Characterizing Risky Software Projects Based on Logistic Regression Analysis [26]** | **Responses on a 4 point Likert scale to a questionnaire focusing on 5 viewpoints of key risk factors in 40 SSBC projects** | **Classification of projects as either "risky" or "not risky"** | **Logistic Regression** | **Accuracy = 87.5%** |

In conclusion it is important to at least identify possible risks that can occur before development begins, as software projects can face a variety of challenges before they are released to the market. This makes it possible to begin planning risk management and mitigation strategies if the risks materialize, which is preferable to dealing with the challenges as they arise. Risk management in software projects is a research area that is consistently growing in popularity, particularly when combined with machine learning approaches to create models that can identify or predict risks before project development starts. The objective of this research is to identify risks in a software project, and ultimately develop and implement strategies to prevent or limit the impact of the identified risks if they materialize during the development of the project.

Explainable AI is another study subject that is gaining traction and should be explored to explain the prediction of black-box models like Neural Networks and Support Vector Machines. This research should be studied because the field is expanding. The use of interpretable models or black-box models that, in the case of the latter, have their predictions explained by explainable artificial intelligence should be one of the next steps in this line of research as one of the next steps in this research area should be to focus on understanding the predictions that are made by the models.

## 3.4 Advanced Resource Allocation

Within the context of project portfolio management, there are several ways in which artificial intelligence may be applied to make improvements to project scheduling. The main artificial intelligence applications for project scheduling in PPM are:

1. The optimization of resources: Algorithms based on artificial intelligence might be used to increase the efficacy with which project schedules allocate available resources. In order to ensure that the project will be completed on time and without going over the budget that was set aside, this may require figuring out how to make the most use of the resources available, including the people, the equipment, and the resources at your disposal. One instance of this notion is the employment of either the genetic algorithm or the simulated annealing method in order to tackle the problem of resource-constrained project scheduling. Algorithms are optimization methods that may be used to find the best possible answer to the problem of allocating resources to tasks in a project schedule. Genetic algorithms depend on the principles of natural selection and genetic mutation in order to build a population of potential solutions to a given problem. On the other hand, simulated annealing makes use of the process of cooling in order to find the solution that is optimal in every way.

2. the order in which activities are carried out in a project schedule: one use of artificial intelligence is to help enhance the order in which tasks are carried out in a project schedule. The critical path method (CPM), for instance, is an algorithm that may be used to identify which activities need to be performed on time in order to keep a project on schedule. This may be accomplished by reviewing the project schedule to identify the most important path and then determining which tasks are to be carried out along that path. An additional illustration of this would be the use of heuristic methods, such as the greedy algorithm or the branch and bound approach, in order to find an estimated solution that is optimal. This would be an example of how this would work. By considering a variety of criteria, such as project deadlines, interdependence between tasks, and resource limitations, these algorithms can assist businesses in determining the optimal sequence in which to execute activities.

3. Condensation of the timetables for the project: It is possible to employ artificial intelligence to compress project timetables, which enables businesses to complete projects more rapidly without losing quality or incurring in additional costs. The utilization of the critical chain method (CCM), which seeks to reduce the amount of time necessary to finish a project by including a buffer in the project's critical route while eliminating buffers from tasks that are not on the critical path, is one example. CCM seeks to accomplish this goal by including a buffer in the critical route of the project. The CCM algorithm can be of aid to businesses in finding the critical path of a project and concentrating their efforts on finishing tasks that are placed on the critical path in order to decrease the amount of time that will be required to complete the project in its entirety.

4. Monitoring and control of the timetable: It is feasible to utilize artificial intelligence to keep track of project timelines in real time and spot potential issues far before they become severe.

Performing this step may entail recognizing activities that are going behind schedule, discovering probable conflicts involving resources, and finding other factors that might have an affect on the project's timeframe. After the potential issues have been identified and analyzed, artificial intelligence may also be used to suggest answers that will bring the project back on track. For example, algorithms for machine learning might be applied to the analysis of historical data in order to draw conclusions and make projections on the upcoming timeframes of various projects. These predictions may be used to assess the existence of potential threats and give recommendations for corrective steps that can be done to decrease the severity of such dangers. In addition, these forecasts can be used to determine whether or not these potential dangers will occur.

5. Predictive analytics: This method uses artificial intelligence to analyze previously gathered data in order to formulate forecasts on the timing of future project milestones. This may entail making an estimate of the length of time it will take to complete the project, detecting any possible dangers, and calculating how alterations to the schedule will affect the timeline. For instance, firms can generate forecasts regarding the future timetable of a project by employing techniques such as time series analysis or forecasting algorithms. These techniques help them analyze historical data. These forecasts can contain information such as the amount of time tasks will take, the date the project will be finished, and the resources that will be necessary to carry out the work. These projections can be used from businesses to spot potential threats and determining what precautionary measures to take in order to mitigate the impact of such threats.

So, Artificial intelligence, in general, possesses the ability to play an essential role in the process of project scheduling for project portfolio management. This is due to the fact that it provides organizations with the potential to optimize the allocation of resources, sequence activities, compress schedules, monitor and regulate the project schedule, and make predictions about future project schedules. This can eventually lead to better management of project portfolios, as well as more efficient and effective scheduling of projects.

Additionally, technologies such as big data analytics, cloud computing, and the internet of things can be used to collect, store, and analyze large amounts of data, making it possible to use these AI techniques in real-time. This is made possible by the fact that these technologies can be used to collect, store, and analyze large amounts of data. Nevertheless, in general, the choice of an AI approach will rely on the specific problem that needs to be solved as well as the data that is now accessible.

## 3.5 Project Prioritization

Project prioritization is the process of determining which projects or project components are the most important and should have the priority in terms of resources, time, and funding. This decision is made by weighing the relative importance of various projects or project components. It is possible to make use of AI in a number different ways to assist with the prioritization of tasks, including:

**1. Algorithms for Multi-Criteria Decision Making**, more commonly referred to as MCDM, are mathematical methodologies that are used to evaluate and rank projects in accordance with a number of different criteria. The following are the two basic categories that may be applied to these algorithmic processes:

• The Weighted Sum Approach: In this technique, each criterion is assigned a weight, and then the evaluation of the project on each criterion is added to the product of the weight and the evaluation of the project. This results in a total score for the project. It is widely accepted that the project that was awarded the highest score was the one that was deemed to be the most successful.

• Outranking Approaches: These techniques determine which project is the most successful all around by contrasting and analyzing the performance of a number of various efforts. The Analytic Hierarchy Process (AHP), also known as the Technique for Order Preference by Similarity to Ideal Solution, is now tied for first place with the Technique for Order Preference by Similarity to Ideal Solution as the two outranking procedures that have the most widespread use (TOPSIS). The Analytic Hierarchy Process (AHP) is an organized process that gives the decision-maker the capacity to break down a challenging choice problem into several smaller sub-problems that are easier to handle. The TOPSIS method is based on the assumption that the endeavor that is conceptually closest to the "ideal solution" and conceptually farthest away from the "worst solution" will be the one that is the most successful. This is the underlying criteria upon which the TOPSIS methodology was developed.

**2. Predictive Analytics**: Techniques from predictive analytics, such as time series analysis and forecasting, are used in order to examine previously gathered data in order to generate forecasts on the future performance of the project. Time series analysis is a statistical method that may be applied to the study of historical data in order to identify patterns, trends, and seasonality. Techniques of forecasting such as linear regression, exponential smoothing, and ARIMA models are some examples of those that may be used to generate predictions regarding the future performance of a project. These projections can be used to rank the priority of projects based on the likelihood that they will be finished.

**3. Machine Learning**: The algorithms that are used in machine learning may be used to the examination of historical data in order to provide projections on the success of future initiatives. Using a variety of different methods, like as decision trees, random forests, and neural networks, it is possible to find patterns and correlations in the data. This may be a very useful skill to

have. This may be used to rate projects in terms of the chance that their completion will result in a successful outcome.

**4. Natural Language Processing (NLP)** is a set of techniques that may be used to extract and comprehend information from unstructured data like as emails, meeting notes, and project documentation. These techniques can be used to extract and understand information from unstructured data. Techniques from the field of natural language processing (NLP) such as topic modeling, named entity identification, and sentiment analysis are some examples of the methods that may be used to isolate the most important concerns linked to a project, identifying potential dangers and deciding how the project should be prioritized. Other techniques that may be used includes topic modeling, named entity identification, and sentiment analysis.

**5. decision-making Algorithms**: These AI-based solutions are utilized to prioritize projects according to a set of established guidelines, best practices, and the accumulated expertise of experts. Decision-making in rule-based systems is obtained from the system's adherence to a specified set of principles, which is referred to as an algorithm. Expert systems are computer programs that base their decision-making on the collective knowledge of a group of people who are experts in a certain topic. It is possible to use decision-making algorithms, such as decision trees and Q-learning, to make judgements based on historical data and predetermined criteria.

**6. Simulation-based Techniques**: Approaches based on simulation, such as discrete event simulation and system dynamics simulation, can be utilized to model and evaluate the performance of a project. This can be done through the use of simulation-based modeling and evaluation tools. These techniques may be utilized to assess the potential dangers posed by a project, keeping track of task pogress, and reach judgments on the proper sequence in which project priorities should be completed.

The nature of the problem that needs to be solved, the amount of data that is readily available, and the level of automation and accuracy that is required will all play an important role in the decision regarding which of these approaches to use, sinse each of them comes with its own of benefits and drawbacks. In addition, it is feasible to combine different strategies in order to boost the efficacy as well as the precision of the process of assigning priorities to projects.

One of the main approaches that has been developed in literature is the multistage project prioritization based on a portfolio value maximization, that is accomplished through the formulation of a multiobjective optimization problem. Throughout the planning phases, the optimality process chooses and schedules the projects, constructing portfolios whose purpose is to optimize the global values of both technical and financial characteristics.

Problems of multiobjective optimization simultaneously consider two or more of the problem's objective functions. A single objective function can be derived from an aggregate of numerous functions by using certain criteria and weighting them appropriately, as is done in various methods. As a result, the optimal solution to the issue has been determined by using the knowledge that was supplied a priori (Stummer and Heidenberger 2003; Leite da Silva et al. 2011). Two methods that are frequently employed in the process of resolving issues of this nature are known as mathematical programming and heuristic algorithms. These techniques, on

the other hand, rely on subjective judgments and are not well adapted to deal with both financial and nonfinancial characteristics at the same time. In some methods, the optimization process for each objective function occurs one after the other, whereas in others, the objective functions are handled as issue constraints (Tamaki et al. 1996).

The concept of optimality must be rethought in many multiobjective issues since the answer may not be a global optimum but rather a group of solutions that include trade-offs among all of the problem's objectives (Coello 2006; Ngatchou et al. 2005). According to Rivas-Dávalos et al. (2007), in these kinds of challenges, the solution that is best suited to a particular scenario might be selected based on certain criteria that are determined after the fact. The optimality concept, which was developed by Francis Ysidro Edgeworth in 1881 and then expanded by Vilfredo Pareto in 1896, can be utilized to derive the trade-off solutions. This strategy is predicated on the idea that the most advantageous option should be chosen.

The optimization model may be conceived of as a combinatorial problem with several objectives and different variables, and it requires a significant amount of search space. The Nondominated Searching Genetic Algorithm-II (NSGA-II) has been utilized to successfully solve the given optimization model because of its ability to effectively provide a collection of Pareto Optimal solutions in a single iteration of the algorithm. The solutions that were found constitute a collection of feasible efficient project portfolios since they are the best trade-offs among all of the technical and financial characteristics that were taken into consideration, in accordance with the limitations of the issue.

The evolution of organisms is the inspiration for genetic algorithms, which are effective search processes (Holland 1975). In order to carry out a simultaneous search in the solution space, they make use of a collection of coded parameters and probabilistic transition rules (also known as crossover and mutation operators). The information that is now available as well as information from the past, including the fitness function, selection technique, and elitism mechanism, are used to direct and define the next search state in order to investigate the most fruitful parts of the solution space. Combinatorial issues are a natural fit for this approach to the problem; even though it is not guaranteed that the genetic algorithms will find the global optimal solution to the problem, the answers they provide are of high quality (Coello 2006; Goldberg 1989).

The Nondominated Sorting Genetic Algorithm-II (NSGA-II), which was presented by Deb et al. (2002), was chosen to solve the proposed model out of the several multiobjective genetic algorithms that are currently available. This was done because the NSGA-II has good performance and overcomes some difficulties presented by other algorithms. These difficulties include computational complexity for large populations, a lack of elitist mechanisms, diversity maintenance, and the ability to handle problem constraints.

The NSGA-II features a fast nondominated sorting technique, in which each solution is connected with a set of dominated solutions as well as a counter of solutions that dominate them. This allows for the sorting of solutions in a more efficient manner. In this method, the solutions are placed in order of importance according to the nondominated front in which they are located.

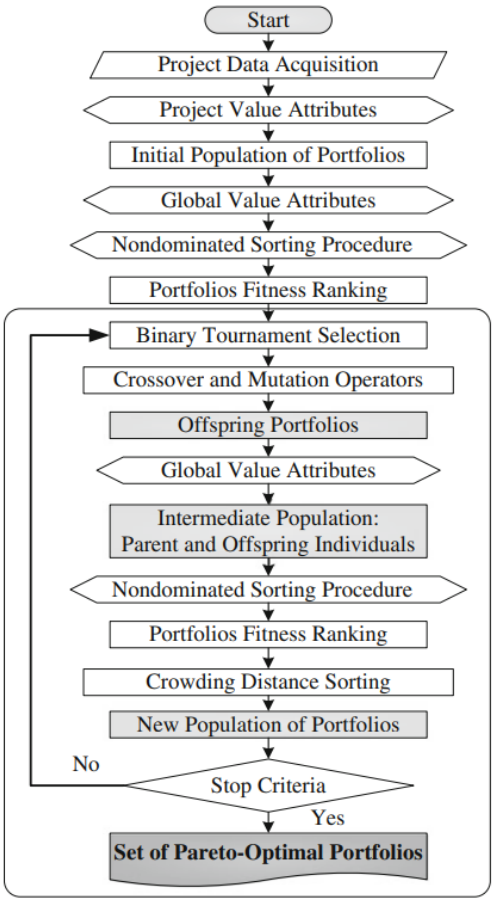


*Figure 10: Multiobjective Genetic Algorithm Flowchart*

The challenge of assigning priorities to projects within a planning timeline with many stages was investigated in the study. For the purpose of selecting and scheduling projects throughout the planning horizon, the decision model that was built is predicated on value qualities. The use of a multiobjective strategy makes it possible to concurrently address several technical and budgetary criteria. The NSGA-II is employed in the process of decision model optimization. The solution is a Pareto-optimal frontier that is made up of a group of trade-off portfolios, and it is adapted to the requirements and parameters of the underlying issue.

## 3.6 Improved Scheduling

Project portfolio scheduling is an essential component of project portfolio management. Using AI may allow for the automation and improvement of the scheduling process, which may subsequently be used to optimize the scheduling of project portfolios.

One use of artificial intelligence that might be used to create changes to the scheduling of project portfolios is the employment of optimization algorithms. Optimization algorithms can be used to determine an optimal schedule for a portfolio of projects based on a number of parameters, such as the total duration of the projects, the availability of resources, and the interdependencies between the projects. This ideal schedule can then be used to prioritize the projects in the portfolio. For instance, genetic algorithms may be used to simulate the process of natural selection in order to find the approach to a project that will be most successful.

Artificial intelligence may be applied in different ways to accomplish the goal of improving the scheduling of project portfolios. One of these ways is the employment of methodologies that are based on simulation. These techniques may be applied to model and simulate the scheduling process, as well as to identify and resolve any potential problems and conflicts in advance of their manifestation. For example, a simulation model might be used to identify whether or not there are potential bottlenecks in the scheduling method and whether or not there are probable resource conflicts between different projects.

AI may also be used to improve project portfolio scheduling by providing project managers with real-time information and insights on the scheduling process. This can be accomplished by giving AI access to project portfolio data that can be so updated in real time. For instance, a system that is based on AI might be used to monitor the scheduling process and provide project managers with real-time information on the availability of resources, the progression of the project, and any potential issues that may arise.

However, it is crucial to keep in mind that the inclusion of AI into project portfolio scheduling can be a very demanding task that requires a large investment of both time and money in order to be accomplished properly. In addition, an AI system that is used for the scheduling of project portfolios needs continuous updates and developments carried out on it in order to ensure accuracy and consistency over time.

In general the use of artificial intelligence to the scheduling of project portfolios necessitates the completion of different steps of factors, including:

1. Being aware of the specific scheduling problems that the artificial intelligence system is intended to resolve for these problems. For instance, an artificial intelligence system for project portfolio scheduling might be used to improve the accuracy of project schedules, identify probable conflicts and bottlenecks, or optimize resource allocation.

2. Figuring out the requirements for the artificial intelligence system, which includes determining the data that will be used to train the model, the performance metrics that will be used to evaluate the system, and the particular use cases that the system will be used to address.

3. Acquiring the data that will be used toward the development of the model and getting it ready for usage. In most cases, this requires cleaning up and organizing the data, in addition to perhaps combining it with other sources of data, such as resource allocation, project status, budget, and other data associated with the project.

4. Teach the AI model to do certain tasks by utilizing the many different machine learning approaches. In order to achieve this objective, it is frequently required to train the model using a dataset that contains data from previously completed projects and to search for patterns and trends within the data. It is possible to train the model using a wide number of approaches, such as neural networks, genetic algorithms, and decision trees.

5. Incorporating the AI system into the process of project portfolio management: the majority of the time, this necessitates integrating the AI system with the PPM tools and processes that are already in place, in addition to testing the system to ensure that it is functioning in accordance with the plans.

6. Monitoring how the AI system is operating and making any required adjustment to it as necessary. In most cases, this means studying how the system is performing with the help of the predetermined performance indicators and making adjustments as required in order to boost how well the system is operating.

7. Ensuring that the data are accurate and up to date by doing consistent reviews of the data pertaining to the project in addition to any additional data that is linked in order to enhance the functionality of the model.

There are numerous different applications for AI that may be used to optimize the scheduling of project portfolios. One of these applications is scheduling software. The following is a list of some of the most typical approaches:

1. Algorithms for optimization: These algorithms may be used to optimize the scheduling of projects within a portfolio by determining the best viable schedule given a set of limitations. This allows for the portfolio's overall efficiency to be increased and making it possible to raise the portfolio's overall efficiency. For instance, evolutionary algorithms, simulated annealing, and other optimization approaches can be used to build a most effective schedule by taking into consideration the total duration of the different projects included in the considered portfolio, the accessibility of the resources and any additional pertinent constraints.

2. Predictive modeling: Predictive models, which are developed by analyzing data from completed projects in the past, may be used to produce estimates about the length of time it will take to complete a project. For instance, in order to provide an accurate estimate of the amount of time a project will take to complete and the resources that would be necessary, a neural network model may be trained with data taken from previously finished projects.

3. Simulation: A variety of different scheduling scenarios can be investigated and assessed with the help of AI-based simulation models. For example, a simulation model may be deployed in order to investigate the impact that a variety of strategies for the assignment of resources have on the schedules of different kinds of projects.

4. Support decision: decision support systems that are based on artificial intelligence have the ability to deliver real-time information and insights to project managers on the scheduling of projects; in fact an AI system may do real-time data analysis on a project and provide project managers with early notification of any possible conflicts in the project timetable or restrictions in the resources that are now available.

5. Natural Language Processing (NLP): Information may be extracted from unstructured data such as emails, meeting notes, and other project-related materials by using natural language processing. For example it may be possible to utilize these kind of information to make projects' deadlines more precise and complete and speed up the completion of the work.

However, like said before it is necessary to remember that the inclusion of AI into project portfolio scheduling is a demanding undertaking that requires a large investment of both time and money, and for this reason it is essential to stress the difficulty of this endeavor. In addition, the AI system needs to go through regular upgrades and enhancements in order to guarantee that it will continue to be accurate and relevant in the future. On the market, right, it is possible to find a variety of tools for managing projects using AI in multiple roles. Primavera P6, Deltek, and Microsoft Project are some examples of these kinds of systems; each of them has integrated AI into their own software in their own unique way. These technologies offer optimization and scheduling based on artificial intelligence, resource leveling, and other functions that can increase the scheduling capabilities of project portfolios.

## 3.7 AI assistant for PMs

There are artificial intelligence assistants available for project managers that may assist them into different kind of duties connected to projects. These artificially intelligent assistants make use of natural language processing (NLP) and machine learning methods to comprehend the project manager's demands and provide responses to them.

The Microsoft Project xAI is a good illustration of an AI assistant that can be used by project managers. It makes use of AI to deliver real-time insights and recommendations to project managers, such as spotting possible schedule issues or resource restrictions. The AI assistant may also be used to optimize project timelines by offering various solutions for the distribution of available resources.

Another illustration of this would be the Wrike AI, which is a component of the widely used Wrike project management software. It automates repetitive operations using artificial intelligence, such as organizing meetings and assigning resources, for example. In addition to that, it is able to conduct an analysis of the project data in order to identify any possible hazards and make suggestions about how these risks might be mitigated.

| Challenges with PM software | |
|---|---|
| No AI-based dashboard | AI-based Dashboard is missing for Project Sponsors and PMs. |
| No real-time change management | Change Management is not real-time nor integrated. |
| Lack of integrated issue management | Integrated issue management and escalation are missing. |
| No project baseline, versioning | Project Baseline, Versioning, and Forecasting are missing. |
| Real-time project status reporting | Some PM software tools lack the capability of real-time project status. |
| Lack of risk scoring | Risk Scoring is missing & unavailability of automated risk notification. |

*Figure 11: Challenges of PM software*

There are also artificial intelligence-based virtual assistants for project management that may assist with a variety of activities, including the scheduling, budgeting, and allocation of resources, amongst others. These AI-powered systems may be included into already existing project management platforms like Trello and Asana that can be used to automate repetitive tasks as well as provide real-time insights and recommendations to project managers; furthermore, these assistants can be used to automate tasks that require a high degree of human judgment. Also it is important to remember that the particular features and capacities of AI assistants might differ based on the tool or platform that is used. Obviously some artificial intelligence assistants are more sophisticated than others and may provide assistance with a larger variety of activities, while others may have more restricted capabilities.

In general, the more relevant field of application for these software are:

1. Scheduling: Artificial intelligence-based scheduling can employ optimization techniques and algorithms such as genetic algorithms, simulated annealing, and other optimization approaches to develop and optimize project schedules. They are able to produce the most effective schedule possible by taking into consideration a variety of restrictions, such as the availability of resources, the relationships between tasks, and the deadlines for the project. In addition to this, they are able to offer real-time updates on the status of the program and indicate any possible conflicts or delays in the timetable.

2. Budgeting: AI-based budgeting assistants can employ techniques such as predictive analytics and machine learning to examine previous project data and give insights on cost patterns and anticipated cost overruns. This is accomplished through the usage of AI. They are also able to offer advice on how to make the most of the allocated funds for the project.

3. Resource Allocation: AI-based resource allocation aides can employ optimization techniques such as linear programming, mixed-integer programming, and other optimization approaches in order to distribute resources across projects. They can design the most effective strategy for allocating resources by taking into consideration a variety of restrictions, such as the availability of resources, the skill levels of the workers, and the deadlines for the projects. Furthermore, they are able to deliver real-time information on the status of resource allocation and detect possible resource bottlenecks.

4. Risk Management: AI-based risk management assistants have the ability to apply techniques such as text mining, sentiment analysis, and natural language processing in order to assess project data and detect possible dangers. They are also able to employ predictive analytics to forecast potential future dangers and offer advice on how to protect themselves from such risks.

5. Communication: AI-based virtual project management assistants can use natural language processing and machine learning to understand and respond to project manager's requests, such as scheduling meetings, sending reminders, and providing real-time updates on project progress. In addition, they are able to make use of sentiment analysis in order to comprehend the tenor of the message and deliver a response that is more suitable.

6. Document management: AI-based assistants may utilize methods such as optical character recognition (OCR) and natural language processing to automatically categorize and tag project papers, which makes it simpler for project managers to locate the appropriate document at the appropriate moment.

7. Predictive analytics: AI-based project management assistants can employ techniques such as machine learning, time series analysis, and other predictive modeling approaches to make predictions about the future results of projects and recommend strategies to improve their performance.

8. Progress tracking: AI-based project management assistants can use techniques such as computer vision and natural language processing to track the progress of the project by monitoring the project's documentation, communications, and other relevant data. This provides the project manager with insight that can assist them in making decisions regarding the project.

| Challenges with PM software | | |
|---|---|---|
| Project builder | Dependency management | Personal Kanban board |
| Project baselining | Schedule management | Resource management |
| Integrated risk management | Resource calendar | Task management |
| **Dashboard reports** | | |
| Project burndown chart | Resource rate report | Project issue report |
| Milestone report | Task allocation report | Project status report |
| Project forecasting report | Project wise productivity report | |

*Figure 12: Challenges of PM software and Dashboard reports*

However, is essential to emphasize that these types of software are not intended to act as a substitute human project managers, because the real purpose of these tools is, on the contrary, to enhance the capabilities of human project managers and to assist those managers in making choices that are better informed.

## 4.0 Conclusion: benefits and challenges

Today, Artificial Intelligence and Machine Learning are becoming a reality in a wide variety of industries, which means that digital transformation poses a challenge for every sector currently available on the market. Project Portfolio Management is one of the most interesting topics because of the importance of effectively managing corporate investments and because of the volatility that is inherent to projects. When it comes to ensuring that multiple projects are selected and managed in the appropriate manner, AI can be considered a valid support, especially during the planning process and the definition of the portfolio itself. This is because AI is able to predict which projects will be most successful. The impact that artificial intelligence (AI) will have on Program Managers and Portfolio Managers is a topic that is receiving a lot of attention right now. According to the findings of a survey of project managers that was carried out by Harvard Business Review, administrative tasks took up 54% of the managers' time, which is a bigger percentage than all of the other PPM-related duties combined. The majority of these responsibilities consist of making decisions on the project's scope and budget, as well as establishing work schedules.

The following is a list of the most significant areas in which AI and ML might potentially alter the processes and workflows involved in projects:

Reduced Expenditures: By assisting in the automation of laborious manual processes, artificial intelligence (AI) may free up teams and project managers so that they are better equipped to focus on tasks that have a greater overall value. In particular, project managers concentrate on human-centric responsibilities such as strategic thinking, creativity, problem-solving, communication, and team building, among other things, while also contributing to the automation of the more arduous components of project management.

Analytics: Another significant advantage brought about by artificial intelligence is the ability to create predictive models. For example, the engine can deliver reports and updates in real-time using historical data, estimate costs in real-time, and eliminate bottlenecks thanks to process automation. Additionally, the engine can make highly accurate predictions about when projects will be finished, or which projects will advance. It may also boost visibility for managers and team members by alerting them when a project is diverting from the track that was originally planned for it.

Efficiency: Whenever it is feasible, incorporating AI into a strategy for Project and Portfolio Management will improve outcomes as a result of improved accuracy and efficiency in real-time analysis of data points as the work progresses. This is especially true in regard to the reduction of human errors in data entry, which allows for potential dangers to be managed in advance. By improving the decision quality (DQ) with the use of AI, managers may be able to improve their performance on projects throughout the portfolio, which may then lead to the PPM function being more strategic and "intellectual."

Decision-making that is driven by data: Rather than a deficiency in the collecting of data being the primary issue, many companies struggle with effectively employing the data at their disposal. The ability of future AI to filter through massive volumes of data, apply analytical frameworks, and provide pertinent facts in ways that are easy to understand will be of significant use to future project managers.

Hazards are one of the primary factors that contribute to the failure of a project; risks that are ignored may result in an unfavorable outcome for the project. Risk management is essential. Project managers will be able to deep dive into data, identify repeating patterns and trends that would be missed by cursory looks, and then utilize this knowledge to make choices that are data-driven. This capability will be made possible by artificial intelligence (AI). However, this does not diminish the usefulness of the "human factor," which is defined by intuition, environmental knowledge, and personal experience when evaluating the risks associated with a project; rather, it provides an additional degree of precision and depth to the study.

| PMO challenges | |
|---|---|
| Ongoing improvement | A value add adds looks for opportunities to add value to portfolio management, project management processes, project management tools, and project management knowledge. |
| Projects not aligned with strategy | A PMO needs to understand the business strategies and if the current projects are aligned with the business strategy & what value is going to be delivered by them |
| A surviving PMO is an adaptable one | Projects are becoming more complex & using new ways to deliver projects such as SCRUM, Lean, and Six Sigma., For these new ways, a PMO needs adaptable processes, governance, reporting & metrics. |
| Getting the project basics right | With all the challenges that a PMO faces, the one challenge that should not exist but often does, is getting projects basics done right – business case supported projects, status reporting, resource management. |
| A PMO tool can be a key to success | This is not a simple task and the success of a PMO can rest on the success of the tool it chooses if the tool is too complex for the PMs to use or does show value reports, it will fail. |
| Use of PMO tools to show value | A big challenge for a PMO to survive is to understand what is valuable to senior management & provide this value in terms of metrics via automated reports. |

*Figure 13: PMO challenges*

## 4.1 Takeaways

As a direct consequence of the increasing prevalence of AI across all industries, PPM software has evolved to the point where it can gradually automate the activities of project managers. This accelerates the delivery and execution of projects by project teams; however, the use of AI in project management is not predicting the end of project managers and PMOs in their present forms. In this age of change and automation, the position of project manager will likely continue to exist, however, in the same way that other professions, its tactical and operative roles will progressively diminish during this digital transitions.

In fact, despite the fact that AI is capable of carrying out more mechanical and tactical project tasks, such as resource assignment or status reporting, the Project Manager's primary focus will be on ensuring that the outcomes of the project produce the expected level of business value and that these outcomes are in line with the strategic goals of the company. At the same time, PMOs have the ability to free themselves of tasks that are "less intellectual" and become more active in assisting PMs in the process of strategy formulation.

For this reason, organizations have already begun to plan for the use of artificial intelligence in the field of project management in order to prevent project managers from being fully overtaken by the new technology; for instance, some have even incorporated it into their courses for training and certification in order to teach project managers how to use AI to automate, enhance, and maximize the return on investment from projects. This is done in order to prevent project managers from being completely overwhelmed by the new technology.

| Use of AI in PM software | |
|---|---|
| **Eliminates the need for human input** | An AI project management system can effectively handle scheduling, reminders, and follow-ups to eliminate the need for human input. |
| **Ensures nothing is overlooked** | AI helps PMs save time on their various tasks by helping to make sure that nothing is overlooked. |
| **Predictive analytics for projects** | AI can use its ability to observe how a project is moving & make educated predictions. |
| **Project teams' productivity** | AI can monitor project teams & make predictions based on the patterns of habits. |
| **Integration with comms tools** | Some AI PM tools integrate with comms tools like Slack & PM tools like JIRA to solve issues. |

*Figure 14: Use of AI in Pm software*

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