

POLITECNICO DI TORINO

Master of Science in Engineering and Management

Critical analysis of the COVID-19 pandemic and war situations: the Project Management perspective



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Contents

Abstract	5
Introduction	6
Project Management	6
What is a project	6
Project Life Cycle	6
Project Constraints	7
Stakeholders	8
Waterfall approach	9
Agile Approach	11
Scrum	13
Kanban	15
Extreme Programming (XP)	17
Lean Programming	19
Feature-Driven Development	20
Crystal Clear	22
Dynamic System Development Method	24
Literature Review	27
Disruptions of 2020-2022	27
Impact on Project Management due to the outbreak of COVID-19	27
Changes introduced after the outbreak of COVID-19	32
Impact and changes on Project Management due to the outbreak of the war in Ukraine	39
Consequences towards project success and performance	43
Construction Industry	43
India	43

Malaysia	45
United Arab Emirates	46
United States of America	47
United Kingdom	50
South Africa	51
Ukraine	52
Software Development	52
Sweden and Finland	53
China	54
Brazil	55
Ukraine	56
COVID-19 Responses Projects: Healthcare	56
Operation Warp Speed: COVID-19 Vaccines	56
Emergency field hospitals	59
Project Management methodologies and tools	61
Why Agile works better	61
Risk identification	61
Collaboration tools	62
Benefits of Agile	65
Ukraine	68
Conclusion	70
References	74

List of Figures

1	Triple constraint	7
2	Project constraints	8
3	Power-Interest Grid	9
4	Waterfall structure	10
5	Agile structure	12
6	Scrum structure	14
7	Example of a Kanban board	16
8	Extreme Programming practices	18
9	Feature-Driven Development process	21
10	Crystal Family	23
11	Crystal Clear process	24
12	DSDM process	25
13	Level of negative impact COVID-19 on different categories	28
14	Actions relevant to the four horizons	33
15	Organisation's project demand vs delivery capacity before and after COVID-19	36
16	Sample project prioritization	37
17	Employment data for the construction industry in the United States between January and July 2020 as reported by the Bureau of Labor Statistics (BLS)	48
18	AstraZeneca vaccine timeline (in orange) vs Industry standard (in blue)	58
19	Example of remote workday for an agile team	63
20	Variation in the stock price for Zoom Video Communications Inc.	64
21	Variation in the stock price for Atlassian Corp	65
22	Example of a Kanban board created with Miro	66
23	Example of a Sprint Retrospective board created with Miro	66
24	Four critical dimensions to measure the impact of disruptions	70
25	Flow chart	71

26 Example of risk framework 72

ABSTRACT

The recent years, especially the period from the beginning of 2020 to now (end of 2022), have been characterized by several disruptions that introduced additional uncertainty, complexity, and volatility into the world. This thesis focuses on how the outbreak of COVID-19 and the ongoing war in Ukraine are influencing and changing project management practices worldwide. Various impacts are analyzed, including decreased productivity, challenging communication among the stakeholders due to remote work policies, and supply chain disruptions. In addition, the changes introduced to mitigate the effects of these impacts are also evaluated, namely implementing an effective communications and stakeholder management, using online collaboration tools, and reshaping supply chains to make them resilient. To assess the consequences of such disruptions towards project success and performance, projects from three different sectors, and different countries, are examined: the construction industry, software development, and healthcare projects as a response to COVID-19. The reason behind the choice of these three different sectors stems from the different challenges faced and approaches used by the project teams, as will be discussed. The conclusion is that a strategic implementation of Agile methodologies or of a Hybrid approach (a combination of Agile and Waterfall), contrary to predictive project management, allows companies to pivot and adapt quickly to the new market in a productive and cost-effective way.

INTRODUCTION

Project Management

What is a project

According to the PMBOK® guide by the Project Management Institute (2017), project management is "the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements". However, to understand this discipline, it is critical to define what is a project. The PMBOK® guide by the Project Management Institute (2017) gives the following definition: "A project is a temporary endeavor undertaken to create a unique product, service, or result". To be considered so, a project must have a start and an end date, as the definition above explains. A project is considered to be finished when its objectives have been met and achieved. As the Project Management Institute (2017) states, an objective can be a product to be produced, a service to be performed, a purpose to be achieved, or a strategic position to be attained. When the objectives are no longer viable, or the project is no longer considered necessary, it is terminated. While projects are temporary, their deliverables may extend beyond the project's duration. Indeed, they can and should continue to deliver value and benefits even after the project life cycle. The other attribute of a project is unique. This means that the product produced or the service performed must be new. These two attributes, temporary and unique, differentiate projects from operations, which are ongoing and repetitive (Barron and Barron 2020).

Project Life Cycle

A project life cycle includes the phases that take the project from its beginning to its end date. As the PMBOK® guide by the Project Management Institute (2017) explains, these phases can be sequential, iterative, or overlapping. While each project has different stages that are specific to its deliverables, a generic life cycle can be defined. The five major phases are:

1. initiation. The project objectives are identified, and solutions are proposed. Then, a feasibility study is conducted to understand the proposed solutions address the project's objectives (Barron and Barron 2020). To move to the next phases, it is necessary to obtain the authorization

to start the project (Project Management Institute 2017);

2. **planning.** The project's solutions are developed in detail by identifying tasks and resource requirements (labor, equipment, material) (Barron and Barron 2020). During this phase, the schedule and budget are created, and risk management is performed. Furthermore, a stakeholder analysis is conducted, and a communication plan is developed (Barron and Barron 2020);
3. **implementation (or execution).** During this phase, the work is performed with project team members completing their tasks;
4. **monitoring and controlling.** The project's progress and performance are monitored and reviewed. Actions are taken whenever it is required (Project Management Institute 2017);
5. **closing.** The project is handed to the customer, the resources are released, and the contracts with the various suppliers are terminated (Project Management Institute 2017). Finally, the project team assesses the lessons learned by analyzing what went well and what went wrong.

Project Constraints

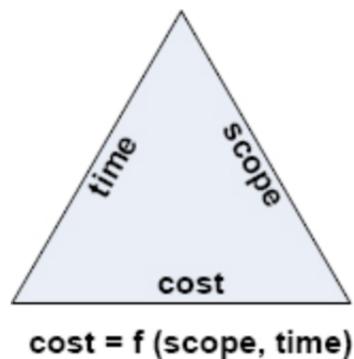


Fig. 1. Triple constraint

Every project has different constraints based on the type of tasks required. However, three main constraints in project management are usually represented in the so-called "triple constraint", as shown in Figure 1. It consists of scope, time, and cost (Rahimi 2013). According to (Project

Management Institute 2017), cost is a function of scope and time. Consequently, if one of the constraints changes, the other two will also change.

However, the PMBOK® guide by the Project Management Institute (2017) recognizes six constraints: time, scope, cost, quality, resources, and risk, as shown by Figure 2 by Rahimi (2013).

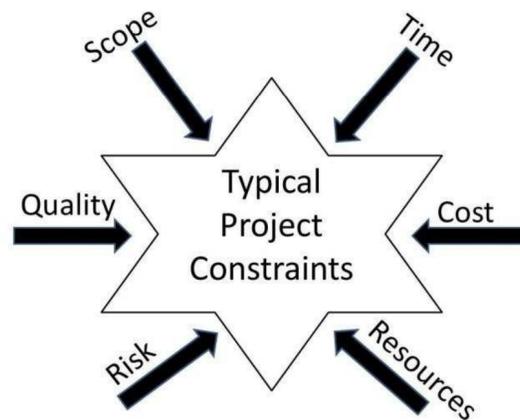


Fig. 2. Project constraints

Stakeholders

The stakeholders of a project are "the people, groups, or organizations that could impact or be impacted by the project" (Project Management Institute 2017). For this reason, it is critical to conduct a stakeholder analysis to analyze their needs, interests, expectations, and how they could affect the project. Furthermore, it is fundamental to establish a continuous communication process with them to address any issue that could arise.

While some stakeholders might only have a limited effect on the project, others could be very influential. Therefore, one of the main tasks of the project manager is to carry out a thorough stakeholder analysis including all of them. As the Project Management Institute (2017) explains, this process is iterative, as stakeholders can change during the various phases of the project.

A useful tool is the power-interest grid originally introduced by Colin Eden and Fran Ackermann in their book *Making Strategy* (see Figure 3). The horizontal axis represents the power, while the vertical one represents the interest. Based on where a stakeholder is located on the graph, different

actions will be taken (Baker 2012):

- high power and high interest: manage closely;
- high power and low interest: keep satisfied;
- low power and high interest: keep informed;
- low power and low interest: monitor.

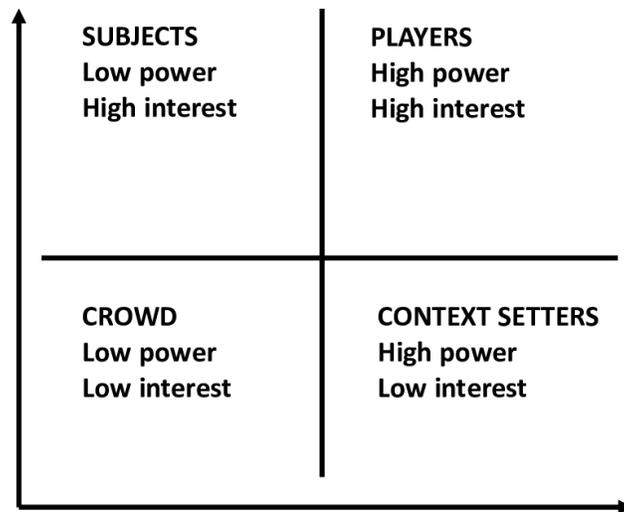


Fig. 3. Power-Interest Grid

Waterfall approach

Project management has different approaches that can be divided into two main categories: predictive and adaptive. This section focuses on the first approach, which is also referred to as Waterfall.

Waterfall is the classical project management approach, with projects being planned from the beginning to the end (Thesing et al. 2021). Work packages, responsibilities, and deadlines are set at the start of the project, and the goal is to implement the original plan as precisely as possible (Thesing et al. 2021). As McCormick (2012) explains, the Waterfall philosophy was developed during the 1970s for the manufacturing and construction industries. This is one of the reasons why it entails a very structured approach.

As it can be seen from Figure 4, originally defined by Winston W. Royce in 1970, Waterfall is

a sequential process. Indeed, its name gives the idea of water falling from an altitude to the lower point(Mccormick 2012), similar to what happens for a project cycle that moves from one phase to another. The project team can move to the following phase only after completing the previous one.

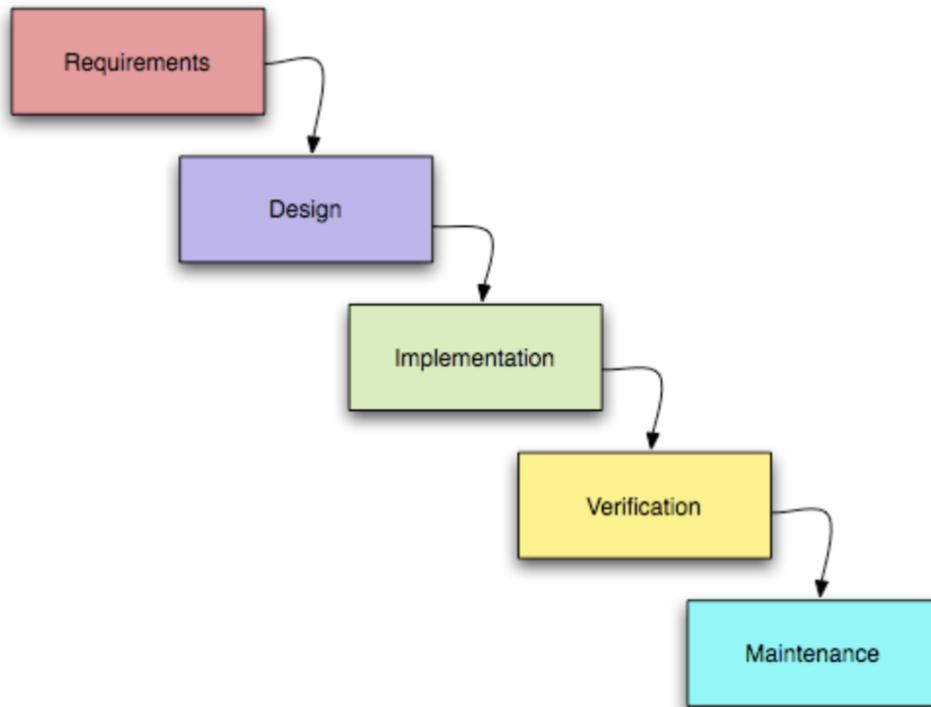


Fig. 4. Waterfall structure

In general, the Waterfall approach is more suited for projects that are already stable and for which the customer provides a clear list of requirements that are not likely to change (Mccormick 2012). Indeed, customer involvement is usually very low and only limited to certain milestones. However, communication with the client is fundamental at the beginning of the project, as highlighted by Figure 4. It is critical that the project manager gets a detailed understanding of the user's requirements to proceed with the project.

As Casteren and Casteren (2017) explains, Waterfall requires significant documentation to be approved in each step as part of the deliverables. This makes it easier for new project team members who join the team at a later stage to get up to speed. Indeed, everything they need to know is included in the documents and explained in detail.

Waterfall is also characterized by difficulties in making changes to the project, which are discouraged and costly. Consequently, customers could complain that their needs are not met at the end of the project and that some implemented features will never be used (Casteren and Casteren 2017).

Agile Approach

Because of the disadvantages of the Waterfall approach, project managers started to look for alternatives. One of the downsides of the traditional approach, namely the lack of communication with the customers, led to the development of a new framework that accepts changes during the project life cycle. Indeed, in the fast-paced world we live in right now, it is hard to imagine developing a project with fixed requirements from the beginning.

In 2001, a group of software developers published the "Agile Manifesto" (McCormick 2012), which contains the values and principles of the Agile approach. The four Agile manifesto values are:

1. Individuals and interactions over processes and tools;
2. Working software over comprehensive documentation;
3. Customer collaboration over contract negotiation;
4. Responding to change over following a plan.

It follows that the Agile approach is very different from the Waterfall one. Indeed, it does not focus on linear and comprehensive planning (Thesing et al. 2021) as Figure 5 by Revutska and Antlová (2022) shows. Instead, the project team develops a solution in an iterative way. Each iteration can be considered as a smaller project that follows the various phases, including analysis, design, implementation, and test (Casteren and Casteren 2017).

However, the authors continue, each iteration release is internal. Typically, Agile iterations last between one and four weeks (Thesing et al. 2021). Customers are often given a demonstration after each iteration to provide feedback on the output, which will be incorporated in the following iterations (McCormick 2012). Therefore, the Agile approach allows customers to define their

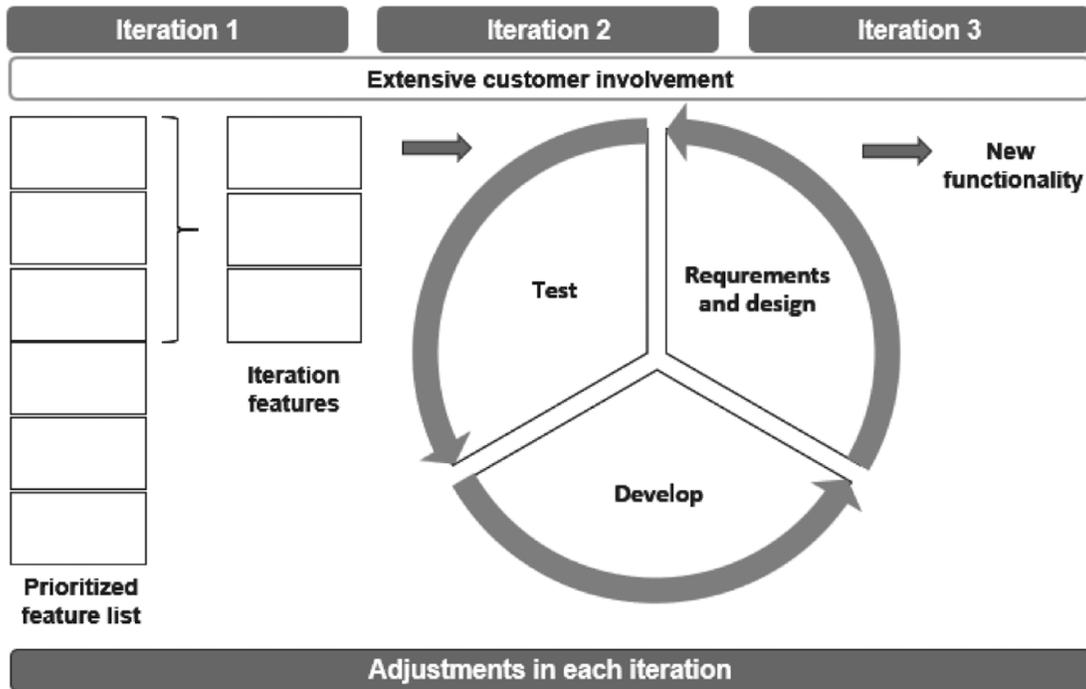


Fig. 5. Agile structure

requirements throughout the project life cycle and not necessarily at the beginning. This shows how the role of the customer shifts significantly compared to the Waterfall framework, as the third value in the Agile Manifesto states: the customers are viewed as integral members of the team (Nazir et al. 2022).

Furthermore, the Agile approach is characterized by flexibility and adaptability to changes, which are not considered negative as in the Waterfall methodology (Thesing et al. 2021). Indeed, Agile involves multiple iterations that aim to improve the output after each one (McCormick 2012).

In addition, as the second value in the Agile Manifesto reports, comprehensive documentation does not play an important role and is given less importance (McCormick 2012). Indeed, as Casteren and Casteren (2017) explain, more emphasis is put on simplicity, speed of delivery, and maximizing the amount of work done.

Implementing an Agile framework is more suitable in some cases, as McCormick (2012) states:

- customer's requirements are not clear from the beginning of the project and will evolve

during the life cycle;

- the time frame to deliver the output of the project is short;
- software development projects. Indeed, developing applications following an Agile philosophy makes it easier for the developers to include new features and correct bugs that might emerge.

Another characteristic of the Agile framework is that the traditional hierarchy of the predictive approach is replaced by self-organizing teams with a high degree of decision-making authority (Revutska and Antlová 2022). Indeed, Agile should lead to a structure where every team member is equal and where the roles are more about having an Agile mindset than authority.

However, introducing the Agile approach in a company is more complicated than it might seem. Indeed, several barriers can hinder its implementation. Among them, as Revutska and Antlová (2022) say, are the following:

- organizational resistance to change;
- inadequate management support that prefers to preserve top-down management;
- inconsistent processes and practices;
- risk aversion;
- lack of understanding of the Agile mindset, which is user-oriented.

Agile consists of several different frameworks, and among them, we find Scrum, Kanban, XP, Lean Programming, Feature-Driven Development, Crystal Clear, and Dynamic System Development Method, which are described in the following sections.

Scrum

The Scrum framework was introduced by Schwaber and Sutherland in 1995 (Casteren and Casteren 2017), who later wrote the Agile Manifesto with other authors.

The structure of a project that follows Scrum is shown in Figure 6 (Casteren and Casteren 2017).

The Scrum approach is based on three common roles:

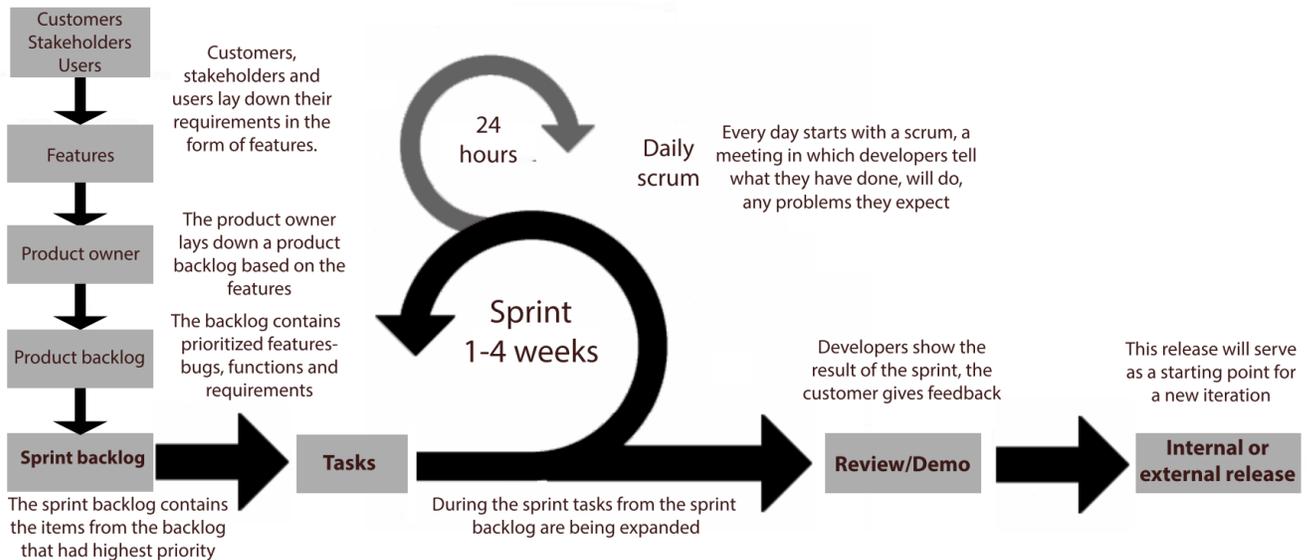


Fig. 6. Scrum structure

- Scrum Master: their role is to facilitate all the meetings, ensure transparency, and remove impediments (Sutherland 2014);
- Product Owner: they are responsible for keeping track of the backlog and ensure that the team has user stories to work on during the sprints (Sutherland 2014). User stories are short set of requirements that should be included in the final product;
- the Team: made up of people that perform the tasks. Usually a Scrum team has less than 10 people (Casteren and Casteren 2017).

The goal of a project that adopts the Scrum approach is to work together with stakeholders. The product owner creates a product backlog, which contains the prioritized requirements and functions (Casteren and Casteren 2017). After the product backlog is defined, sprint planning takes place. During this process, the team estimates how much time each user story requires by assigning story points (Zahraoui and Idrissi 2015). As the authors explain, they are a measure of complexity, the effort involved, and the inherent risk. Subsequently, the team creates sprints. A sprint is an iteration during which the tasks from the backlog are expanded (Casteren and Casteren 2017). Each sprint lasts 1-4 weeks, and the number of sprints needed depends on the project.

Typically, every day starts with a daily scrum (or daily stand-up), which lasts approximately 15 minutes. During this time, the team members explain what they have accomplished, what they will do, and any impediments experienced. At the end of each sprint, a demo occurs, as seen in Figure 6, in which a so-called potentially shippable product is presented (Sutherland 2014). This product is shown to the product owner, who will provide feedback. Right after the demo, the sprint retrospective takes place: the team reflects on what went right, what could have gone better, and what can be improved in the next sprint (Sutherland 2014).

Kanban

Agile Kanban is a simple approach that helps delivering high-quality value to customers on time and within budget (Brechner 2015). This approach is especially popular in software development projects in software development organizations (SDOs) (Saeed et al. 2018).

Kanban can aid in improving visibility, understanding, controlling of the workflow, and identifying possible bottlenecks (Alaidaros et al. 2021). Therefore, it is very useful in exposing the problems of a system, which is done by using a pull system: a team has only one task to work on at a specific time (Alaidaros et al. 2021).

David J. Anderson, the pioneer of Kanban in software development (SD), has defined five principles, as Saeed et al. (2018) explain, which are:

1. limit work in progress (WIP). The project manager usually identifies the maximum number of tasks that can be on the Kanban board (Alaidaros et al. 2021);
2. visualize workflow. As Alaidaros et al. (2021) state, it means highlighting the queues, interactions, mechanisms, and delays in the process;
3. measure and manage flow, which means keeping the task moving throughout the process;
4. make process policies explicit;
5. use models to recognize improvement opportunities.

Among the tools used when implementing the Kanban approach is the Kanban board. This board helps visualise the workflow, as the second principle reports, and in controlling the WIP, as the first principle says. The Kanban board is vertically divided in different columns, which are usually To Do, Doing, and Done (Alaidaros et al. 2021), as Figure 22 shows. As the authors explain, each task is represented by a card attached to the board in the column representing its current stage.

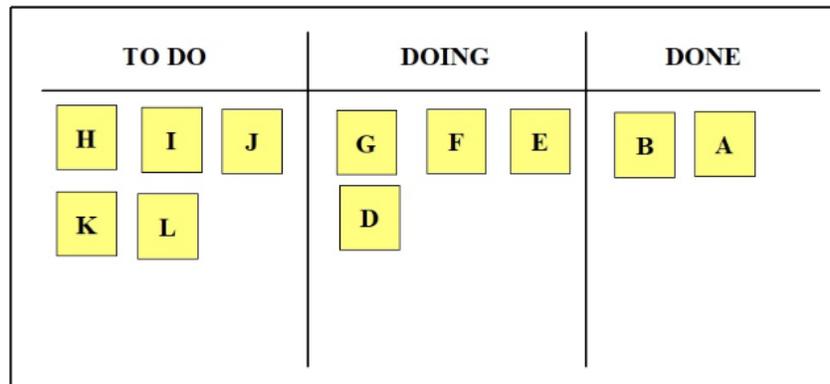


Fig. 7. Example of a Kanban board

The Agile Kanban, other than the principles, also has four practices (Alaidaros et al. 2021):

1. starts with what you have. This makes this approach completely different from the others, which require the creation of new structures and roles;
2. agree to pursue incremental and evolutionary change;
3. respect the existing roles, processes, and responsibilities;
4. encourages leadership acts during the whole development process.

The use of the Kanban approach has several benefits. Among them, there is better visibility and understanding of the overall process and workflow thanks to the use of the Kanban board (Alaidaros et al. 2021). Furthermore, as the authors continue, Kanban can improve transparency, communication, customer satisfaction, and team coordination. Kanban boards are, indeed, very

helpful in promoting a visual communication instead of just verbal communication, like Agile does. However, among the challenges faced by this framework is that, because of its simplicity, some people believe that it must be complemented with other methods (Alaidaros et al. 2021). Therefore, frameworks that combine Kanban with other approaches were developed, such as Scrumban. Finally, while the Kanban board can be a very helpful tool in visualizing the process, it does not give any quantitative information regarding the project's progress (Alaidaros et al. 2021). Such information is critical for project managers to make decisions about project development.

Extreme Programming (XP)

Extreme Programming (XP) is an agile software development framework that was developed by Kent Beck in 1996 (Sharma et al. 1969). As English (2002) explains, XP is deliberately lightweight and not thought to be a full life cycle framework. Instead, it consists of a collection of practices to support project management practices.

XP is better suited for small and medium projects when the team size is less than ten people (English 2002). Furthermore, it works very well with projects whose requirements are expected to change multiple times throughout the project's duration.

Because it is part of the Agile umbrella, XP consists of many iterations that last a short period. These releases help in improving the software quality gradually (Sharma et al. 1969). In addition, like other Agile frameworks, XP fosters communication, and faster delivery over comprehensive documentation (Sharma et al. 1969).

Extreme Programming consists of thirteen practices, as shown in Figure 8.

In the following paragraphs, some of the practices will be explained.

For projects that use an XP approach, customer satisfaction is critical. Therefore, it is suggested to have an on-site customer, which means having a representative of the customer work closely with the team to address any emerging issues (Sharma et al. 1969).

Moving on to another practice, we find the planning game, which describes that planning is performed by defining the requirements through user stories (English 2002). The team then prioritizes them and schedules the stories for the next release. Each release is quick to ensure rapid

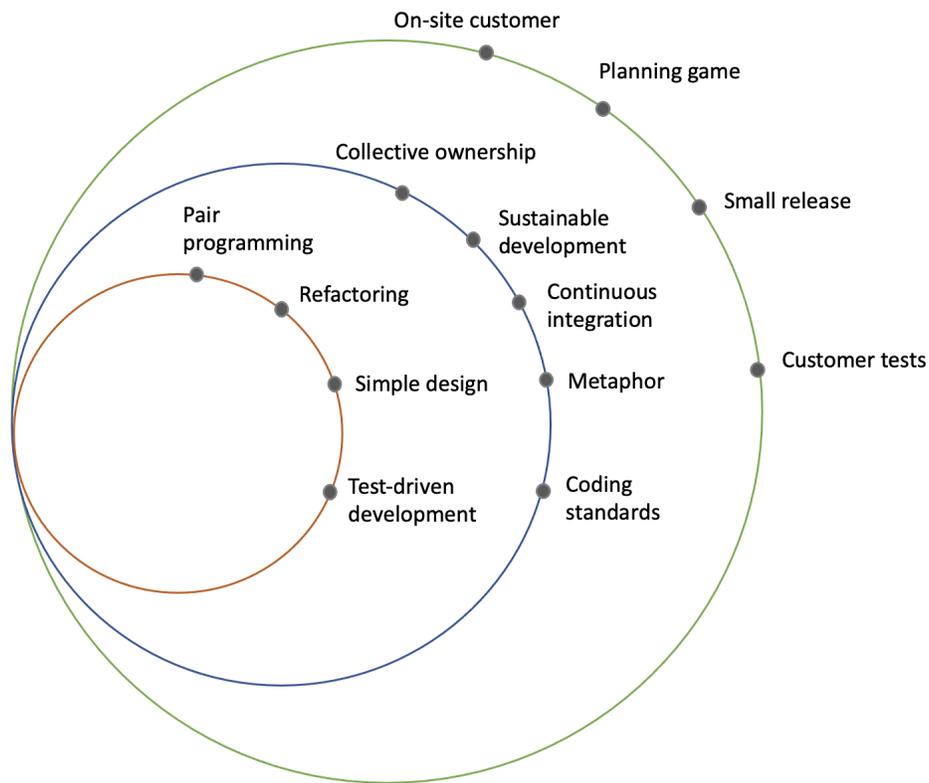


Fig. 8. Extreme Programming practices

customer feedback, which will be implemented in the following iterations.

Among the several practices is pair programming, which means that two programmers work together on a single computer. One writes the code, and the other one reviews it (English 2002). During the day, the developers switch both roles and teams. This allows to get a new perspective every time and helps in spreading knowledge and expertise (Goebel 2003). The goal of pair programming is to promote collective ownership. This means that the code is owned by everyone on the team. Therefore, anyone can and should make changes to the code whenever they find some issues (Goebel 2003). This can improve the quality of the code as everyone on the team checks if there are bugs. Strictly linked to this is continuous integration. Indeed, developers must run their code multiple times a day to fix bugs daily instead of letting them accumulate throughout the project's life cycle (Goebel 2003).

Like every framework, Extreme Programming has some disadvantages. Two of them are very

critical. Firstly, there is the risk that code overcomes design, as Sharma et al. (1969) explains. Indeed, as it can be understood from the thirteen practices, code is the center of XP. However, design is also critical in software development, and it is important to ensure that it is at par with the requirements (Sharma et al. 1969). Finally, the second drawback regards location. XP works well when co-located team members work together with a customer representative. However, due to the disruptions of the past years, which will be analyzed in detail in the following chapters, having all the developers working from the same location can be hard, if not impossible. Indeed, it makes it complicated for programmers to interact with each other effectively.

Lean Programming

Lean Agile combines the agile approach with lean manufacturing, developed by the Japanese automakers Toyota and Honda in the 1980s (Poppendieck and Poppendieck 2003). While lean principles were first developed for manufacturing, they can also be applied to software development projects. Eliminating waste and reducing defects can improve the lead time and the quality of the code and lower the budget (Poppendieck and Poppendieck 2003). Poppendieck and Poppendieck (2003) analyze the seven lean principles and apply them to software development projects:

1. Eliminate waste. Waste is anything that does not add value, such as incomplete or unnecessary code. In addition, detailed documentation is also considered a waste, which perfectly aligns with the second value from the Agile manifesto.
2. Amplify learning. Learning is enhanced after every iteration because of the frequent testing and customer interaction.
3. Decide as late as possible. Since projects that follow an adaptive framework entail a high level of uncertainty regarding the requirements, delaying decisions means that better decisions can be taken in the future when the requirements are more defined and less likely to change.
4. Deliver as fast as possible. This goes hand in hand with the Agile framework, which is centered on several short iterations to incorporate customer feedback into future ones and

improve the product. As Poppendieck and Poppendieck (2003) say, the shorter the iterations, the more can be learned.

5. Empower the team. The development teams must be empowered to make decisions independently, without needing a central authority (Poppendieck and Poppendieck 2003). This is consistent with the Agile framework, which, as mentioned above, promotes self-organizing teams with a high degree of decision-making authority.
6. Build integrity in. Integrity means that the customer is satisfied with the product and that the project works smoothly and cohesively. The latter aspect is of utmost importance as software development projects must continue to work and evolve overtime (Poppendieck and Poppendieck 2003).
7. See the whole. Project team members must work toward what is best for the whole organization and not for their personal interests.

Feature-Driven Development

Feature-Driven Development is part of feature-centric processes, aiming to regain some control on the planning and management of projects that adopt the agile approach (Hunt 2006). Indeed, as the author explains, such projects typically require significant effort in planning because of the iterations. Therefore, FDD is a good alternative for companies that want to implement an agile approach but are not ready to abandon detailed planning.

Feature-centric means that the units of requirements, such as user stories, must be aligned with the planning units, namely tasks and work packages (Hunt 2006). Consequently, as the author highlights, features do not come from users but rather from a planning process and are associated with a cost, priority, and necessary resources. Furthermore, another aspect of this approach is timeboxing, meaning that the duration of each iteration is known (Hunt 2006).

The FDD process is shown in Figure 9 (Palmer and Felsing 2002). According to Palmer and Felsing (2002), "FDD starts with creating a domain object model in collaboration with Domain Experts". The output of this first step are class diagrams that describe and break down the problem

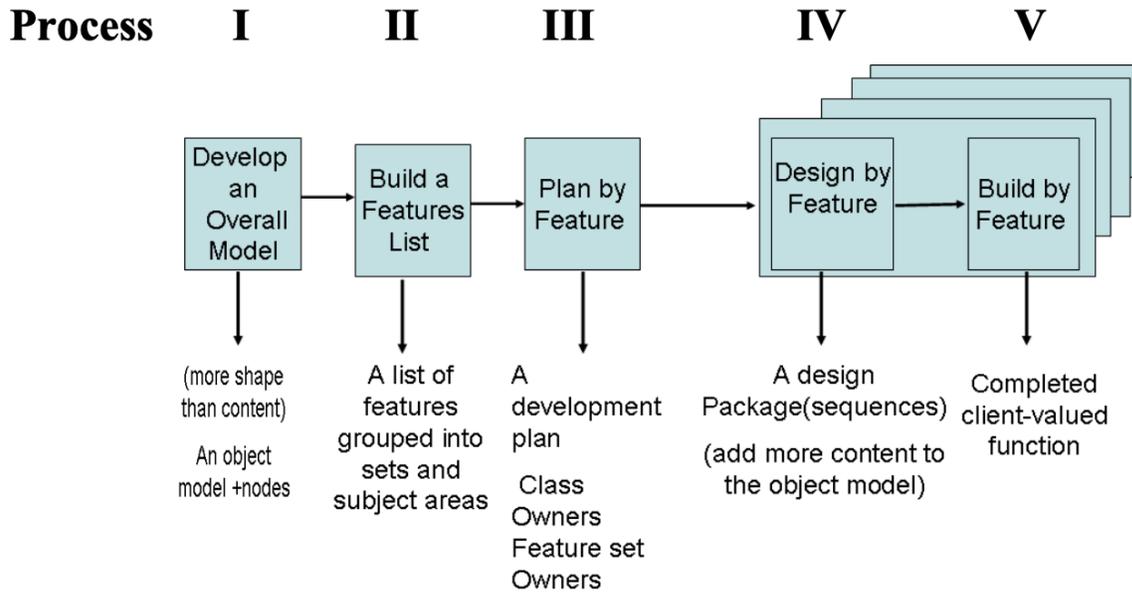


Fig. 9. Feature-Driven Development process

by identifying its objectives and their relationships (Satzinger et al. 2016). Each class is assigned to a specific class owner, a member of the team (Palmer and Felsing 2002).

By combining this information from the class diagrams with any other possible requirements, the developers create a feature list, and tasks are assigned. A feature, according to (Palmer and Felsing 2002), is a small, client-valued function expressed in the following form:

$$\langle \text{action} \rangle \langle \text{result} \rangle \langle \text{object} \rangle \tag{1}$$

As for classes, also each feature needs to be assigned to team members. However, as Palmer and Felsing (2002) highlights, a feature may involve more than one class. Therefore, the feature owner must collaborate with several developers.

At this point, the iterations can start, each lasting less than two weeks (Palmer and Felsing 2002). If some features take more than two weeks, they need to be broken down into smaller ones (Palmer and Felsing 2002).

Contrary to several agile frameworks, including Extreme Programming, FDD promotes individual ownership of the code (Palmer and Felsing 2002). This means that each individual is

responsible for the portion of code they wrote. To ensure a high quality of the code, inspections are carried out (Palmer and Felsing 2002). This, as the authors say, promotes both knowledge transfer and standards conformance. Indeed, as for the first one, by inspecting pieces of code from more experienced developers, the less experienced ones can learn fast. The latter refers to the idea that developers are more likely to conform since they know that if they do not do their code will not pass inspection.

Crystal Clear

Among the various Agile frameworks is Crystal Clear, which was developed by Allistair Cockburn in the early 1990s (Faiza et al. 2017). It is part of the Crystal Family, which focuses on close communication, frequent delivery, and reflective improvement (Cockburn 2004). As the author explains, he chose "Crystal" because he describes projects along two dimensions, size and criticality, that are the equivalent of color and hardness for minerals. Crystal methodologies differ by their color (see Figure 10 (Cockburn 2004):

- clear for teams of a maximum of eight members;
- yellow for 10-20 members;
- orange for 20-50 members;
- red for 50-100 members;
- maroon, blue, violet for larger teams.

While the number identifies the team size, the letter (C,D,E, or L) identifies the criticality: C stands for loss of comfort, D for loss of discretionary moneys, E for loss of essential moneys, and L for loss of life (Cockburn 2004).

In his book "Crystal Clear: A Human-Powered Methodology for Small Teams" (Cockburn 2004), Cockburn describes Crystal Clear as a "human-powered methodology". Indeed, the author developed Crystal Clear by working with different teams to find the best practices (Faiza et al. 2017). As the authors explain, he noticed that the teams that developed the most successful projects were those that did not follow a formal methodology and, instead, fostered frequent communica-

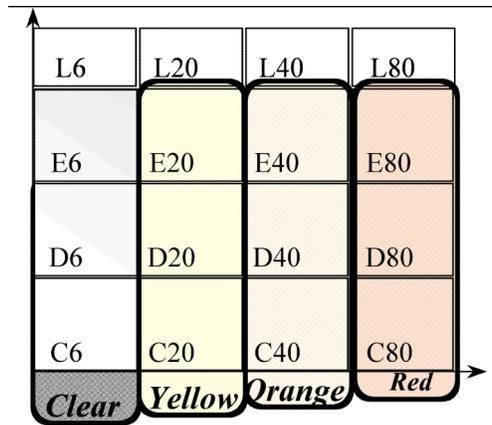


Fig. 10. Crystal Family

tion. As a conclusion, Cockburn developed the Crystal Clear approach, which focuses more on people and collaboration rather than on the process (Faiza et al. 2017). Another characteristic of this methodology is "ultralight" (Head 2010). Indeed, the idea is to reduce paperwork and documentation.

As (Cockburn 2004) states, Crystal Clear, like for all the Crystal methodologies, focuses on three properties:

1. frequent delivery, which occur every few months so that feedback can be incorporated in the following deliveries;
2. reflective improvement, so that team members can discuss about the progress of the project and think about how it could be improved;
3. osmotic communication. Team members learn relevant information by hearing the other members talking in the background. This can take place because the team is co-located.

The Crystal Clear process is shown in Figure 11 (Cockburn 2004).

The project development process consists of multiple deliveries. Each delivery consists of different iterations, which can differ in length, and can go from one week to two months (Cockburn 2004). After each iteration, the team does a reflection workshop to evaluate their work so far and assess possible improvements. Each iteration starts with planning to set the priorities and divide the

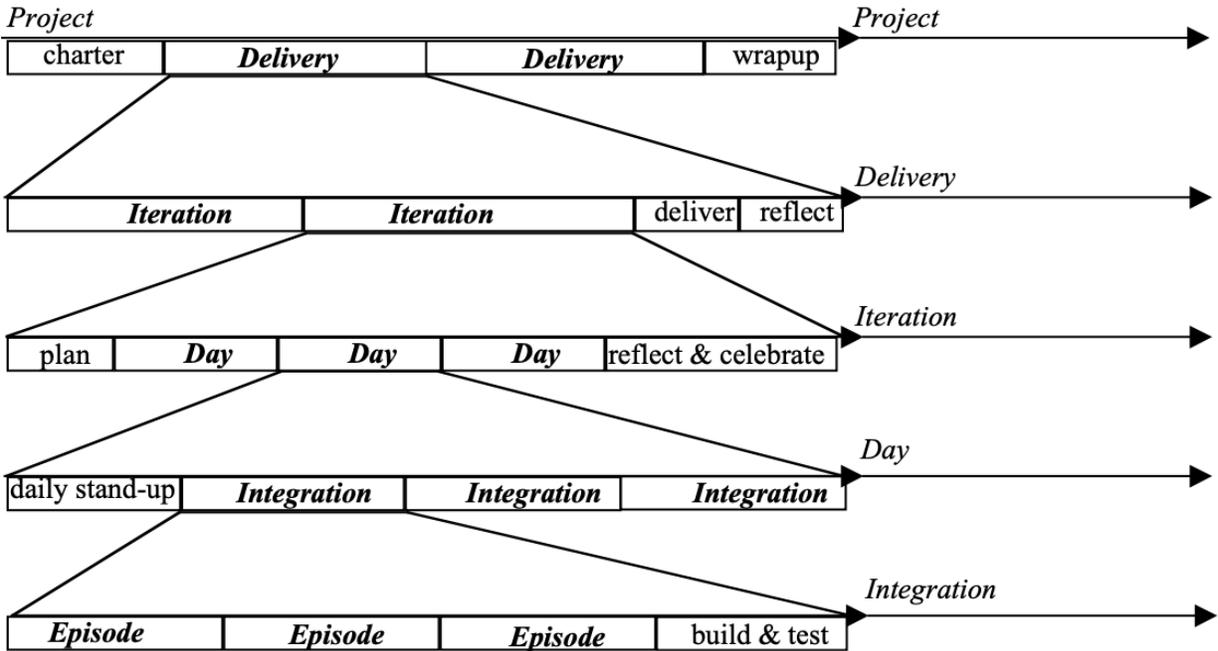


Fig. 11. Crystal Clear process

work. Each day begins with a daily stand-up to foster information flow within the team (Cockburn 2004), and then integrations follow. At the end of each iteration, the team reflects to catch mistakes and bugs while they are still on time (Cockburn 2004). The last cycle are episodes, which consist in developing and checking the code (Cockburn 2004).

While Crystal Clear has several advantages, including effective communication, it also has some drawbacks. Indeed, it lacks code verification and design activities, making it not appropriate for life-critical systems (Faiza et al. 2017).

Dynamic System Development Method

Dynamic System Development, also known as DSDM, is part of the broad Agile umbrella. It was developed in the UK in 1994 by practitioners of a consortium (Faiza et al. 2017). DSDM is an incremental approach with an emphasis on rapid application development and quality (Faiza et al. 2017). It consists of seven phases, as Figure 12 (Zafar et al. 2017) shows:

1. pre-project. The scope and the objective of the project are identified, and the financial requirements are estimated (Faiza et al. 2017). In addition, the team roles are identified;

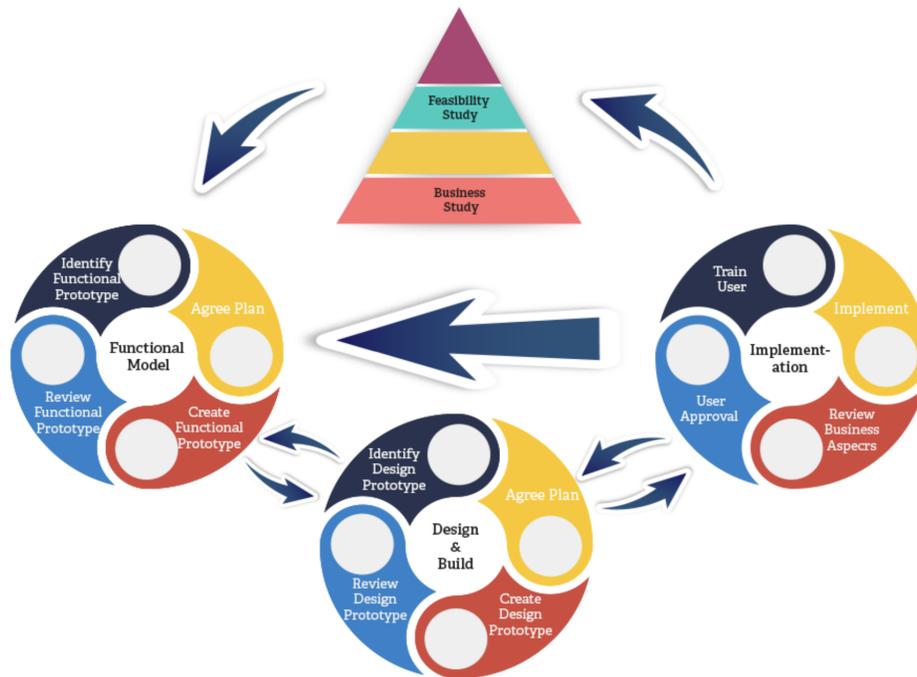


Fig. 12. DSDM process

2. feasibility study;
3. business study. Priorities are set and a broad plan of the prototype is developed (Faiza et al. 2017);
4. functional model iteration. Coding and prototyping tasks are performed by the team (Faiza et al. 2017);
5. design and build iteration. The requirements identified are implemented and user's feedback is incorporated after each iteration (Faiza et al. 2017);
6. implementation. The final project is given to the customer;
7. project post-phase. A review is performed to evaluate how the project went (Faiza et al. 2017).

DSDM focuses on the following eight principles, as Faiza et al. (2017) highlight. Among them, we find on-time delivery, which is critical to developing a relationship based on trust with customers.

For this reason, timeboxing techniques are used, like for the FDD approach. However, trust is fundamental also between team members. For this reason, communication and collaboration are other principles that DSDM promotes. Furthermore, like for all the Agile frameworks, building a solution incrementally and iteratively is a key aspect, so that customer feedback can be implemented. Finally, as Faiza et al. (2017) states, the last principle is to establish control through plans, by monitoring the project using Key Performance Indicators (KPI).

LITERATURE REVIEW

Disruptions of 2020-2022

The period that goes from the beginning of 2020 and now 2022 has been a hard one due to the many challenges and disruptions brought about by catastrophic events worldwide that have introduced new uncertainty into the world.

In December 2019, an outbreak of pneumonia was reported in Wuhan, China (Ciotti et al. 2020), and its causes were initially unknown. However, it was rapidly shown that the reason was a novel coronavirus (Fauci et al. 2020) which was given the name SARS-CoV-2 or COVID-19 (Yang et al. 2020). On March 12, 2020, it was declared a pandemic by the World Health Organization (WHO) (Ciotti et al. 2020) as it spread globally and, as of September 30, 2022, it has infected around 617 million people and caused 6.54 million deaths, according to the COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU). However, the pandemic is just one of the catastrophic events in recent years. Indeed, following the escalating crisis between Ukraine and Russia (Wang et al. 2022), Russia attacked Ukraine on February 24, 2022 (Boungou and Yatié 2022). The war has caused many deaths and destruction around Ukraine and disrupted supply chains even more, which had already been negatively affected by the pandemic. Indeed, both Ukraine and Russia are two major producers and exporters of commodities such as crude oil, natural gas, wheat, and aluminium (Wang et al. 2022), and this has caused a surge in the prices of such commodities. This chapter discusses the impact that the outbreak of COVID-19 and the war in Ukraine has had and still have on Project Management and what changes were introduced as a consequence.

Impact on Project Management due to the outbreak of COVID-19

The pandemic outbreak caused significant consequences for all sectors of the economy worldwide, leading to many global changes in organizations and societies (Shamim 2022), subsequently affecting project performance and success rate (Hussain et al. 2021). According to a survey that was jointly conducted by the Project Management Institute (PMI) and the Project Business Foundation on the impact that the COVID-19 crisis had on project business, 80% of the respondents said it

had an extreme to moderate negative impact on business in general (Project Management Institute and Project Business Foundation 2020). Instead, the remaining 20% of respondents said that they had not been negatively affected by COVID-19 since they are typically in the IT/IS industry or are working on IT/IS projects (Project Management Institute and Project Business Foundation 2020). The authors inferred that the projects they were working on were about building infrastructure for remote working and running their clients' companies remotely. According to the survey mentioned above, the different project areas were not affected in the same way by the outbreak of COVID-19 as Figure 13, taken from the Project Management Institute and Project Business Foundation (2020), shows. Not considering the general business impact, COVID-19 negatively affected the ability of projects to realize more than 75% of their intended benefits and the project financials, such as costs, profitability, and cash flows.

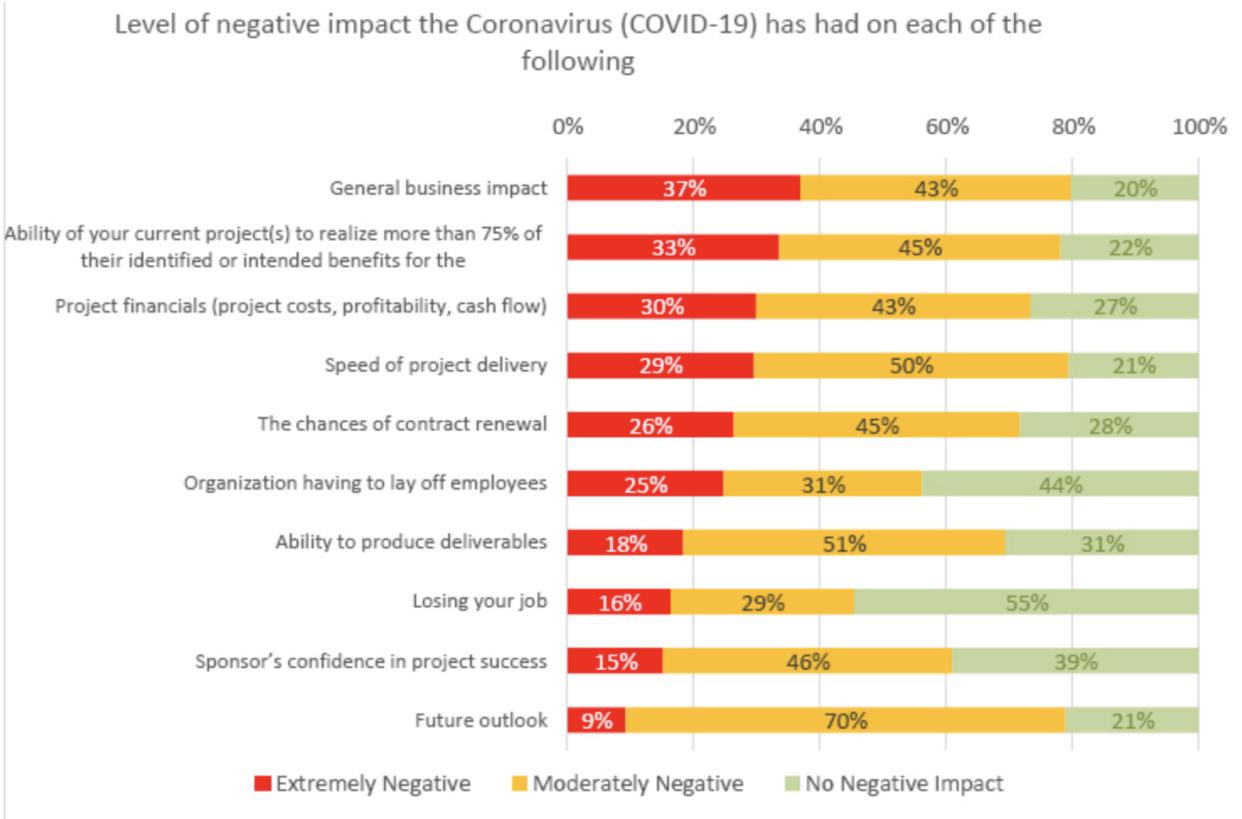


Fig. 13. Level of negative impact COVID-19 on different categories

The disruptions of the 2020-2022 period have had both a short-term and long-term impact,

leading to changes in the field of project management.

Firstly, let us analyze the direct consequences COVID-19 had and, afterward, the solutions implemented.

One of the main changes was that of a shift in communications management. As Zulch (2014) highlights in his article communication is considered the lifeblood of a project: "Project team members need to collaborate, share, collate and integrate information and knowledge to realize project objectives." Communication in a project refers to internal, in the form of conversations, meetings, discussions, and external communication with stakeholders such as customers and vendors. The outbreak of COVID-19 led to numerous lockdowns imposed by governments worldwide, as well as the introduction of social distancing policies. As a consequence, many companies faced the challenges that come with remote working. Indeed, employees started experiencing working from home, which was a new and challenging reality: as Shamim (2022) says, remote communication affected the communication plan created during the project planning stage as well as the "loss of some bits of the informal communication structure." With employees not going to work every day, the ordinary conversations in the offices that helped get context and insight on projects did not take place any more. At the same time, these missed informal opportunities may have made it more difficult for colleagues to collaborate as remote communication "may lack the emotional richness of regular face-to-face interactions" (Koch and Schermuly 2021). In addition, reaching a consensus on some aspects of the projects while working remotely took more time than discussing them in face-to-face meetings (Shamim 2022).

Strictly linked to communications management, we find stakeholder management. According to the PMBOK® guide by the Project Management Institute (2017), it includes identifying whoever could impact or be impacted by the project, analyzing stakeholders' expectations, and developing appropriate strategies for engaging with them in project decisions and execution.

Companies must communicate clearly and openly with stakeholders. Instead, the spread of COVID-19 led to inaccurate and mixed messaging (Deloitte 2020), and, especially at the beginning, stakeholders were not informed about what was going on transparently: "imprecise, inconsistent

and delayed communications and engagement creates additional uncertainty and kills trust quickly." (Deloitte 2020). Furthermore, potential customers were also negatively affected, but differently. Indeed, because no one knew what the future after the outbreak of COVID-19 would look like, most organizations, as Shamim (2022) highlights, did not want to make binding agreements with them. In addition, the author continues moving to the execution phase from the planning one was hard. Indeed, as aforementioned, making decisions on several aspects of the project at this stage took longer than usual because of activities such as getting approval to access planned investments. Furthermore, almost all stakeholder engagement activities had to be moved online. However, as Süsser et al. (2021) say, it is still unclear how suitable this new method of digital communication is for successfully engaging with stakeholders. While virtual interactions have proven helpful for many reasons, including access to a larger audience, there is a risk of reduced commitment to online-only engagement processes (Süsser et al. 2021). Furthermore, as Beaunoyer et al. (2020) observe, not every stakeholder is used to online technologies. Therefore, this might have led and still could lead to the exclusion of particular stakeholder groups because of technology-related inequalities and, consequently, to incomplete or superficial results.

Among the stakeholders, it is essential to mention the project team members. Indeed, they were heavily affected by the pandemic as the companies placed a strain upon them. Organizations, especially at the beginning, were trying to achieve consistent results, despite the numerous changes caused by the outbreak of COVID-19, which brought a lot of disorganization and anxiety to the executors or workers of the projects (Shamim 2022). Consequently, this extra pressure on team members, who were isolated, working from home for longer hours in front of a computer without human interaction, affected their mental health, as Shamim (2022) explains. Other causes include unfinished tasks, which caused feelings of emotional exhaustion (Koch and Schermuly 2021). The authors go on to describe other reasons, such as the lack of the emotional richness of face-to-face interactions, as well as missing possible promotion opportunities. By working remotely, team members feared being "out of sight, out of mind" regarding recognition and awards (Kurland and Bailey 1999). Therefore, this employee exhaustion sometimes led to poor results in project

deliverables and project delays.

Among the various impacts that the COVID-19 pandemic brought about is a lack of project funding. Indeed, many customers around the world faced liquidity issues which, combined with uncertainty about the future, discouraged them from investing in new projects as well as existing ones. At the same time, companies that were carrying out projects decided to use its funds to address the impacts of COVID-19 on their business. For example, in many cases, organizations faced COVID-19-related expenses, such as face masks and test kits to ensure the safety of their employees. As a consequence of both a decrease in project activities and an increase in expenses, many companies laid off some of their employees to eliminate unnecessary operational costs.

One of the biggest problems that surfaced due to the outbreak of COVID-19 was the supply chain disruption globally. This meant, and still means, an increase in the costs of such materials and a longer time to access them. Consequently, as Shamim (2022) points out, this affected the planning stage of projects. Indeed, project managers had to change the entire sourcing and procurement process, considering such disruptions and the minimum required time to get the materials to decide the various deliverables and milestones. Of course, some sectors were more affected than others, with the top ones being the manufacturing, construction, and trade sectors in the United States (Helper and Soltas 2021).

Let us consider an example of how the supply chain disruption negatively impacted the project performance in the United Arab Emirates (UAE) construction industry. According to Rehman et al. (2022) most construction projects were delayed across the UAE, and new completion dates had to be planned. The authors explain how this depended on the current project stage: the ones in the execution phase were assigned a revised schedule baseline whose aim was to postpone the impact of COVID-19 at the final stages, whereas the ones that were almost completed applied for an extension of time to deal with the delays caused by the pandemic. Furthermore, some design modifications were made to reduce such delays, and some requirements were relaxed.

However, delays in some projects could not be avoided because they required face-to-face interactions and physical teamwork that could not occur because of the government's several mea-

asures, such as social distancing policies, quarantine, and lockdowns. This happened to operational projects that required physical involvement, such as those in the construction industry.

Finally, the need for schedule compression has been frequently observed because of the many problems that arose due to the pandemic (Winch et al. 2021). According to the PMBOK® guide by the Project Management Institute (2017), schedule compression shortens the schedule duration without reducing the project scope. Two main compression techniques are crashing and fast-tracking. The first one identifies whether some tasks could be done in parallel rather than sequentially. The second one is about finding tasks that can be shortened by adding extra resources, such as overtime. According to Lu et al. (2022), substantial studies show that the maximum degree of schedule compression is usually below 25%, generally remaining between 10 and 20%. However, in some projects that arose because of the outbreak of COVID-19, such as the need for new hospitals, project managers resorted to sharp schedule compression, reaching a degree above 90%, such as in the case of the Huoshenshan and Leishenshan Hospital projects in Wuhan (Lu et al. 2022). While it was achieved successfully in that case, it is usually extremely tough to implement at various levels. It entails high risks and high costs due to the numerous resources needed.

Changes introduced after the outbreak of COVID-19

Due to the impact that COVID-19 had on project management and its different areas, several changes were introduced, as will be explained in detail in this paragraph.

Considering COVID-19, refer to Figure 14 (Tash and Eelco 2020) for the relevant actions.

First, let us consider Horizon 0, which is Reaction, meaning what project managers did immediately when COVID-19 surfaced. Communications management played an important role: because employees were forced to work remotely, the immediate solution was to create virtual teams that met regularly for team members to feel connected and motivated (Shamim 2022). The author also highlights how companies preferred using chats for minor issues to reduce phone calls to give team members more flexibility in their working schedules. Furthermore, constant communication was essential to quickly identify possible issues and, therefore, find solutions in a short period. At the same time, the use of emails by project managers was fundamental to have written documentation

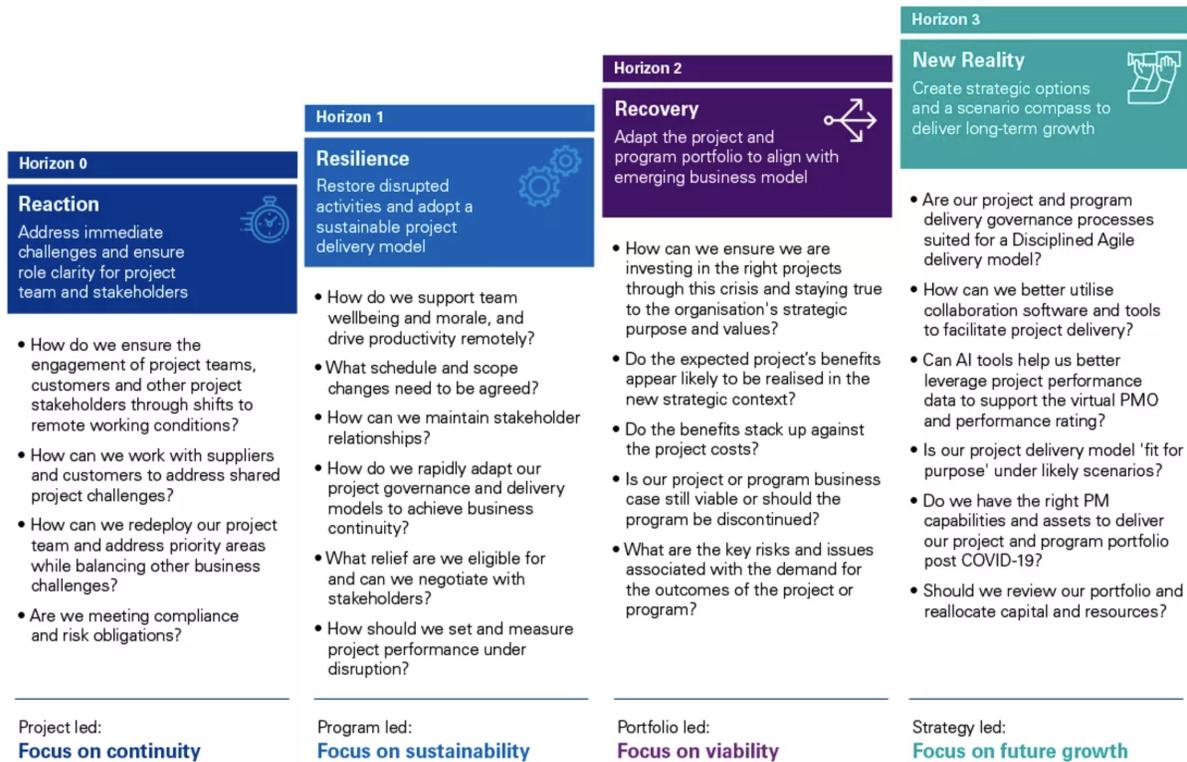


Fig. 14. Actions relevant to the four horizons

as it served both as proof and as a way of ensuring the clarity of messages between different stakeholders (Salamin et al. 2021).

In addition, using video conferencing tools was critical in giving a feeling of a "real" meeting and in avoiding that employees felt too distant from the project and, consequently, less motivated to work on it. Therefore, an important decision was which tools the company would use in the remote environment. For example, for the projects that used an agile approach, one of the main challenges was to find the right tools for collaboration and sprint retrospectives (Jabbour et al. 2020). Indeed, the authors go on, it was fundamental to find one that was online and that allowed all the team members to access the boards, such as the Kanban boards, at the same time. However, what was and is most important is to have a clear communication strategy. Because working from home will probably continue to be partially implemented in the future as part of a hybrid approach, clearly defining the objectives, the deadlines, and who is responsible for each deliverable is fundamental.

Because of remote working, the centralization of data (Shamim 2022) is also essential. Before the outbreak of COVID-19, different project teams could decide how to store documents and which forms of data to use. However, since employees could not go to the office in person, it was necessary for project managers to have all the required information readily available online to track the projects' status and to assign tasks to project team members. The centralization of data is very useful and should continue to be used in the future since it avoids wasting time trying to find and access all the various documents (Shamim 2022).

Moving on to Horizon 1, Resilience, which concerns restoring activities during the pandemic and building a sustainable project delivery model, we need effective monitoring of the project status and the team members' work under disruption. Indeed, it is vital for project managers to closely monitor the project's progress (Shamim 2022) to avoid being behind schedule and over budget. Thanks to the centralization of data, this is easier to do and also to get a report of the status of the projects. In this way, the team members can easily understand whether something is going wrong and, if necessary, take the relevant actions. Instead, when the projects' documentation and information cannot be easily retrieved, the risk of using incomplete or wrong data is extremely high, as well as missing potential and emerging issues that can hinder the project's success.

Then, there is stakeholder management, which is strictly connected to communications management. Indeed, to maintain stakeholder confidence, it was necessary to assemble a cross-function crisis-response and communication team (Deloitte 2020). The people on these teams outlined communication, i.e., the different ways of communicating with the various stakeholders, the content to respond to possible questions and doubts, and the objectives. As Tash and Eelco (2020) say, using project management and collaboration software, combined with documented delivery plans, change management processes, and risk and issues tools has been critical in keeping stakeholders engaged. Among the stakeholders, a critical role is that of the suppliers. Engaging with them was fundamental to understanding the current state and how to prepare for the worst-case scenarios.

Then, as part of the internal stakeholders, we find the project team members. Appropriately engaging with them was essential to ensure their well-being and the project's success. Managing

their productivity was one of the key issues. PwC (2020) suggests the following four tips that can be implemented now and in the future:

- team engagement: celebrate positive behaviours, communicate wins and share learnings, as well as emphasizing individual recognition and a high level of trust in delivering projects' outcomes (Tash and Eelco 2020);
- regular check-ins and regular one-on-one catch-ups with team members (Tash and Eelco 2020);
- performance reporting to track the achievements;
- training and development.

Furthermore, due to the disruptions, the importance of leadership for the project managers became increasingly important, with flexibility and adaptability among the most critical aspects. Disruptions taught them that they need to focus more on the progress than on the actual end deliverable, going beyond the percentage complete to track the project's progress (Tash and Eelco 2020).

Then there is Horizon 2, Recovery, which is about adapting the project and program portfolio to the new reality. This means that the companies need to review their portfolio to make sure they are investing in the right projects and programs and to review them to ensure that the project benefits outweigh the costs, as well as to understand whether they are still viable, given the disruptions.

As Figure 15 (Massie 2021) shows, after the outbreak of COVID-19, new projects emerged, especially those strictly linked to the new reality, such as security updates to address vulnerabilities. At the same time, the delivery capacity decreased for many reasons, including lower productivity (Massie 2021). Therefore, organizations must select the right projects and programs based on the changed business priorities, which vary from industry to industry. Figure 16 (Massie 2021) is a sample project prioritization diagram that shows which projects should be started or continued and which should be stopped or deferred.

To decide which projects and programs to implement, FarWell Project Advisors (2022) suggests three key steps:

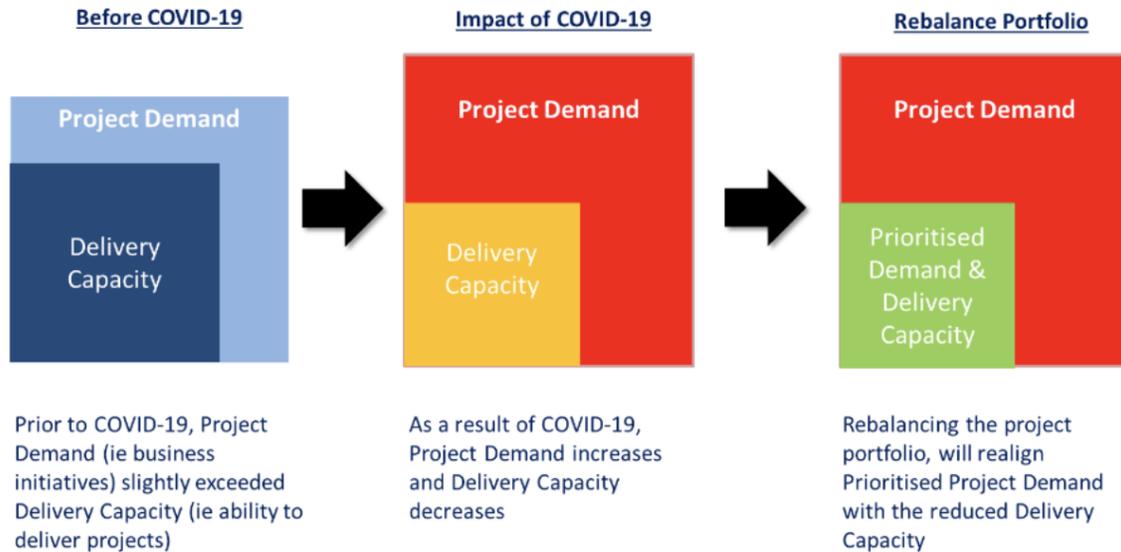


Fig. 15. Organisation’s project demand vs delivery capacity before and after COVID-19

- analyze. It consists of understanding the company’s new strategy and goals, as well as the project constraints (time, people, money, and scope) and identifying the risks.
- decide. It consists in assigning each existing project a new status and, as for the new project requests, deciding whether to approve or decline them. Then, carry out an impact analysis for each project.
- communicate. To all the stakeholders, including the project teams that want to know if their work will stay the same or experience some changes.

Finally, there is Horizon 3, which is about long-term growth post-COVID-19. To ensure that the model will work under likely scenarios, it is of utmost importance to take steps toward reshaping supply chains and making them resilient. Supply chain resilience means recovering from an undesired performance level and taking steps in the direction of recovery or adaptation (Ozdemir et al. 2022). Unfortunately, disruptions are increasing, including those linked to climate change and geopolitical events. Therefore, the old model based on a reduced number of suppliers to create leverage in negotiating payment terms and prices (van Hoek 2020) does not work anymore. Instead, flexible networks of suppliers and partners (Schatteman et al. 2020) need to be built.

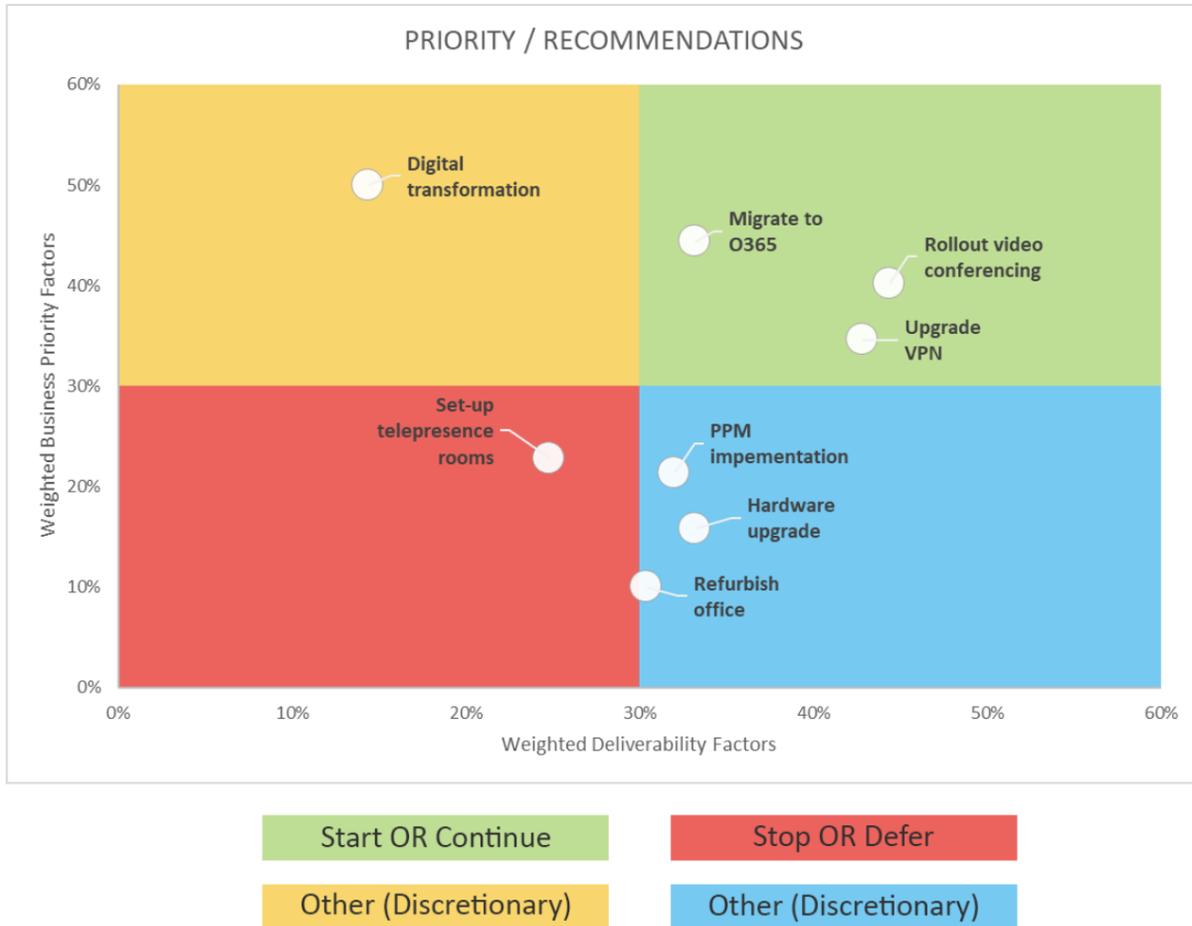


Fig. 16. Sample project prioritization

As Banaszak et al. (2020) say, project managers should map out the supply chain and identify alternatives, consider whether and where to stockpile, and review contingency budgets to source and expedite critical materials. Finding options is one of the most vital aspects: finding suitable additional suppliers to avoid relying on a single or a few ones are fundamental for preventing disruptions resulting from plant closures (van Hoek 2020). The author also adds that it is equally important to include near and local sourcing in the supply chain. Finally, Paul et al. (2021) express that the supply chain should be data-driven and focus on the latest technologies. Indeed, they can help predict disruptions and improve demand visibility and inventory transparency (van Hoek 2020).

To conclude, a general guideline suggested by many authors is to implement an Agile approach,

where possible, or at least a hybrid one. Indeed, agile means pivoting quickly (Tash and Eelco 2020), which is one of the key aspects during and after disruptions. Certainly, more than ever, flexibility is needed in adjusting schedules, accommodating changes, and adapting to dynamic customers' needs (Sharma et al. 2022). Furthermore, the Agile practice of the daily scrum meeting, which would be moved online, works perfectly with remote working. Indeed, it helps in keeping the project team members aligned and focused. (Tash and Eelco 2020). Having virtual agile meetings differs from the traditional agile approach: having teams work in immediate proximity to foster more effective communication and collaboration (Schmidtner et al. 2021). However, as the authors point out, it has been recognized that new technologies and collaboration tools can bridge the gap between virtual offices.

The role of the agile project manager is also changing. Indeed, their role is to remove obstacles, foster motivation among team members, and focus on adaptive leadership (Sharma et al. 2022). It follows that project teams become more autonomous and are better at self-organizing, two fundamental characteristics in the light of new possible disruptions.

However, of course, there are some challenges to agile project implementation. Sharma et al. (2022) highlight some of those challenges, and among them, we find:

- less motivation and enthusiasm due to the impact of COVID-19;
- resistance to change;
- skepticism towards agile project implementation, including the misconception about the fact that it does not work for complex projects;
- lack of understanding of the agile principles and how to implement them.

To conclude, what Tash and Eelco (2020) believe is that there is a need for what they call Disciplined Agility. The rationale is that while flexibility is of utmost importance, having clear documentation and governance structures is also important. This is very close to what is called Hybrid Project Management.

Impact and changes on Project Management due to the outbreak of the war in Ukraine

To assess the effect of the war in Ukraine on Project Management, I interviewed the President of the PMI (Project Management Institute) Ukraine Chapter, Dr. Roman Reznikov.

Before discussing the impact, it is crucial to consider that not all areas of the country are affected similarly. Indeed, as Dr. Reznikov stated, there are areas, especially those near the Polish border, where businesses are regularly working, and this is where he is located. Working for an IT company, he said almost nothing had changed since the war started. At the same time, unfortunately, the areas that are near the war zone and those that are occupied by the Russians are where businesses were utterly disrupted. No one knows what is going to happen next, and uncertainty dominates. Therefore, something fundamental is trying to be as precise as possible in forecasting what will happen in the future, monitoring the situation, and assessing the situation correctly.

Moving on to project-related aspects, the first question to Dr. Reznikov was about communications and stakeholder management and how it was affected. He described it as stressful, both within the country and outside. To overcome this challenge, he says that building trustworthy communication with all the stakeholders was fundamental. This started before the outbreak of the war as it was included in the risk management of all projects and assigned a high probability of occurring. Therefore, regular communication became very important with internal and external stakeholders. As for employees, he mentioned that in the company he works for, the CEO updated them daily to describe what was likely to happen and what actions were necessary to mitigate it. As for external stakeholders, mainly customers, a business continuity plan for all the projects was developed. A business continuity plan (BCP) means guidance to create plans to prevent, prepare, respond, manage, and recover from any disruption (Fani and Subriadi 2019). This helped to reassure the stakeholders that the companies had a plan on how to ensure that the companies would continue working even if the war started.

The three critical aspects of communication necessary to deal with disruptions, according to Dr Reznikov, are frequency, clarity, and transparency.

Among the stakeholders involved in the projects are, of course, project team members. Even

before the war started, they were scared about it and about how it would affect the company they worked for and the related projects. Therefore, communicating with them was essential for their well-being as knowing that the company knew what to do and was as prepared as possible to face the consequences of the war made them feel safer. Emergency response teams were created to, among all the various tasks, communicate very frequently with stakeholders (typically daily) as the situation was changing and still is changing very fast. This is similar to what happened after the outbreak of COVID-19, as mentioned in the paragraph above.

However, communicating the correct information during the war is more challenging than it may seem. Indeed, Dr. Reznikov pointed out how there is strong Russian propaganda in the news channels which is not truthful. Instead, it was, and still is, very important to communicate the right and accurate information to the stakeholders, especially the ones located outside the country. In this way, they can be informed about what is going on in Ukraine, and what is happening within the businesses and with the projects. For example, Dr. Reznikov says that a few times, there were some missile attacks near the headquarters of the company he works for and explains the importance of immediately telling the stakeholders that they were safe before they heard it on the news.

As regards stakeholder management, Dr. Reznikov said how many external stakeholders from other countries, especially the U.S.A., showed empathy toward the situation and expected projects to be delayed by a couple of weeks. Surprisingly, it took just a few days to resume regular working activities. He explains that this is also strictly linked to the team members' mental health: they preferred continuing to work as they saw it as a distraction from reality. As it happened for COVID-19, preserving the well-being of employees is fundamental and should be considered a priority by all companies.

To monitor how the stakeholders, especially customers, were reacting to the war news, they did a "risk analysis" to see whether some were more likely to stop doing business with the company. This was done at the project, department, and company levels. Three colors were used, green, yellow, and red, to assess which ones were at higher risk (red) and which actions could be taken.

Moving on to risk management, Dr. Reznikov said the risk register included the outbreak of

the war and that they were prepared for it. Indeed, before the Russian invasion, they had done a scenario-based risk assessment that analyzed the different areas where Russia could attack Ukraine and which employees would need to be relocated. However, he admitted, the actual scenario was much worse than the worst they had prepared for.

At the project level, they also considered the risks that would arise if one or more people stopped working on the project team for various reasons and figured out mitigation strategies.

Among the various risks, there are also those related to cyber security. The whole risk management process was and is reviewed quite frequently to identify which are the top five risks and how to mitigate them.

New projects were created to avoid disrupting operational activities, such as securing the internet connection and electricity. Of course, relocating the employees to safer areas was a big project. As Dr. Reznikov explains, it included many activities and entailed high costs. For this reason, and to have a risk buffer, costs were cut from other areas.

As for project delivery, whether delays were experienced or not strictly depends on the type of business the companies do. For example, the company Dr. Reznikov works for is a software engineering company, and they did not experience any significant delays as they are pretty flexible, and working from different locations is not an issue as everything is on the cloud. However, the same does not apply to companies whose projects mainly required physical interactions in the war zones (e.g., construction projects).

As for supply chain disruptions linked to the war, the mitigation strategy is differentiation, especially from a geographical perspective. That means including other countries other than Ukraine and excluding or limiting others, such as Russia, Belarus, and other countries that support Russia.

Talking about the future, that is when the war ends, Ukraine will need numerous new projects, especially in infrastructure (construction, energy, transportation) and social recovery (education, counseling). Dr. Reznikov highlighted that many skilled project managers in Ukraine would be able to lead these projects. However, hiring expert project managers from abroad for specific projects

will probably be necessary. Some areas where they will be needed will most likely be construction and energy.

As for COVID-19, the horizon model shown in Figure 14 can be applied to the the war in Ukraine. Indeed, for Horizon 0, which is about addressing the immediate challenge, communications management played a fundamental role, like for the pandemic. As Dr. Reznikov said, and as explained above, communication was critical right after the outbreak of the war as all the stakeholders involved, including the project team members and the customers, had to be actively involved in the current events. Among the reaction measures that were taken, was the creation of emergency response teams. This is strictly linked to communications management as one of their roles was, indeed, ensuring that the correct information was conveyed.

As for Horizon 1, that is Resilience, ensuring the well-being of the team members is essential, as well as managing their productivity. For this reason, several initiatives were taken to improve their safety by relocating those that lived and worked in the areas that were affected the most. Furthermore, to restore the disrupted activities, it is critical to understand which stakeholders are going to stop doing businesses with the companies, and, therefore, stop funding projects. One of the way this is done, as suggested by Dr. Reznikov, is explained above.

As for Horizon 2, namely the Recovery phase, like for COVID-19, new projects have been created, such as the relocation ones, and those necessary to improve internet connection and to protect from cyberattacks. Therefore, companies need to adapt and align their projects and programs, including the new ones, to the emerging business model and prioritize the most critical and important ones.

Unfortunately, Horizon 3, that is the new reality, has not been reached yet as the war is still ongoing and the future is uncertain.

CONSEQUENCES TOWARDS PROJECT SUCCESS AND PERFORMANCE

The disruptions taken into account in this thesis, namely COVID-19 and the war in Ukraine, have significantly affected project success rates and performances worldwide. The following paragraphs describe the impacts that the pandemic has had on three main sectors: that are the construction industry, software development, and healthcare, and analyze such impacts based on different geographical areas. As for the impact that the war in Ukraine has had and keeps having on specific projects, there have yet to be published case studies to analyze. Therefore, it will only briefly describe how it impacts the construction industry.

Construction Industry

The disruptions have taken into account negatively affected the construction industry. Therefore, projects' performance and success rates were also negatively affected. Usually, a project in construction development is considered successful when it efficiently achieves the iron triangle of time, cost, and scope or quality (salwati Ibrahim et al. 2020). However, the authors also highlight the importance of other success factors, such as stakeholder satisfaction, customer acceptance, and future project opportunities. This sector was significantly affected because, as Lam et al. (2022) explains, it involves a significant level of "hands-on" operations and, at the same time, is characterized by a slow adoption rate regarding technologies. For these reasons, adopting a remote working policy in this sector cannot be easily applied as it happened for other industries, such as software development, which will be analyzed later.

Some case studies from different countries were analysed to understand better the effect of COVID-19 on project management in the construction industry. Unfortunately, due to the study's novelty, the number of papers analyzed is limited. However, case studies from four continents (Asia, North America, Europe, and Africa) have been considered.

India

As Rani et al. (2022) point out, the construction industry in India is the third-largest market globally, with a predicted average yearly growth of 7% until 2025. However, the pandemic caused a significant crisis in construction projects, leading to several impacts. Firstly, financial

institutions became more cautious, and subsequently, the number of project financing rejections rose significantly, from 20-25% to 30-35% (Rani et al. 2022). Indeed, the authors point out that there is no guarantee that a project will be valuable in the future and get its revenues back. Secondly, another problem that occurred was labor scarcity. This was particularly challenging since the construction industry is labor-intensive. The issue in India was that most of the workforce consisted of migrant workers who stayed in temporary housing at construction sites (Rani et al. 2022). However, due to the lockdown, the authors explain that many returned to their hometowns, and more than 30% did not come back after the lockdown. This was a significant issue, given that, according to the Confederation of Real Estate Developers' Associations of India (CREDAI), there are an average of 20,000 ongoing construction projects and 18,000 sites across India. As a consequence, construction projects experienced a decrease in productivity. Furthermore, the pandemic caused a decrease in the number of both public and private projects. As for the first category, the reasons behind it can be found in the fact that the Indian government, like governments all over the world, used its funds to address COVID-19 impacts on different areas, such as public health measures and emergency economic measures (Rani et al. 2022). As for the latter, similar reasoning applies. Indeed, the pandemic negatively affected the financials of companies that decided not to invest in construction projects because of the uncertainty toward the future. As for existing projects, some of them were terminated because of liquidity issues (Rani et al. 2022). Indeed, the authors explain, companies downsized to eliminate unnecessary operational costs by resorting to layoffs and pay cuts. Finally, construction projects in India were also negatively affected by supply chain disruptions that caused a shortage of raw materials, input, and labor, as aforementioned. The materials shortage in India was caused by the fact that it mainly relied on China as a source (Rani et al. 2022). While in the beginning, the main problem was getting access to raw materials, then it became about the prices getting higher, especially for timely deliveries. According to the study that Rani et al. (2022) did, some countermeasures can be taken. Firstly, adopting building information modeling (BIM) technology can be beneficial as it allows one to obtain a digital visual representation, allowing employees to conduct analyses from home rather than visiting construction sites in person. Lastly,

creating a supply chain emergency plan is very thoughtful as it allows the identification of different suppliers in the event of disruptions (Rani et al. 2022), which can occur in the future for reasons other than COVID-19.

Malaysia

The Malaysian construction industry was significantly affected by COVID-19 as the government stopped all construction activities in the period that went from March 18th to April 14th, 2020 (Lam et al. 2022). The paper focuses on construction projects in Sibuluan Town, Sarawak. The impacts that it experienced because of the pandemic regarding the availability of resources, contractual issues, and permits. As for the first challenge, the Malaysian town of Sibuluan faced several issues in getting the necessary labor force, materials, and machinery on-site (Lam et al. 2022). Indeed, there was a shortage of labor caused by two main factors: workers could not reach the workplace because the transportation system shut down, and some other workers did not want to go to work to avoid getting infected. This led to a decrease in productivity, also enhanced by the layoffs of various workers because of the poor financials of construction companies (salwati Ibrahim et al. 2020).

At the same time, construction projects were also severely affected by material shortage as Malaysia mainly relied on Chinese manufacturing plants which were temporarily closed, just like it happened for India. Furthermore, most suppliers that delivered by trucks stopped their businesses as they did not want to risk crossing the borders: they feared both contracting the virus and being subject to a quarantine period (Lam et al. 2022). Consequently, projects experienced significant delays, which led to higher costs, changes in the work breakdown structures, and rescheduling the project timelines (salwati Ibrahim et al. 2020). In addition, because of remote work, securing permits became difficult as the government agencies did not adapt quickly to working from home and experienced difficulties in accessing the necessary information and documents (Lam et al. 2022). What Lam et al. (2022) suggests to overcome the challenges posed by the pandemic is to use artificial intelligence (AI) and machine learning (ML) by introducing software like BIM, AutoCAD, Revit, and Etabs to plan and design the construction projects from home and allow everyone on the team to collaborate remotely without the need for physical interaction. At the same time, to

avoid the risk of experiencing other future supply chain issues, they advise promptly identifying all the potential alternatives for suppliers and fostering continuous and effective communication with them. As it can be noted, the solutions proposed by Lam et al. (2022) almost overlap with those promoted by Rani et al. (2022) for India.

United Arab Emirates

As Rehman et al. (2022) highlight, the construction industry plays a significant role in the United Arab Emirates (UAE) and is one of the most established in the world. It dates back to the 1960s, when oil was discovered in the country, leading to the development of this sector, which, in turn, transformed the UAE into a country with cutting-edge design. For example, Dubai has the tallest building in the world, the Burj Khalifa. Because of the construction industry, the UAE became such a digitally advanced country that it is today (Rehman et al. 2022).

Before the pandemic hit, several projects were underway, such as Expo 2020, airport extensions, and new metro lines (Rehman et al. 2022). However, the outbreak of the pandemic posed several challenges for this sector. Among them, we find the supply chain disruption, which led to difficulties in obtaining the necessary materials and equipment which were supposed to be imported from abroad, especially from China and Europe (Rehman et al. 2022). To address this issue, the authors explain that the solution was to allow some design changes to replace unavailable materials with alternate ones which could be easily accessed. For example, one person interviewed in the paper mentions that they usually use granite imported from Italy. However, they agreed to use other readily available solutions like ceramic and marble to reduce the delays.

Furthermore, among the various challenges faced, there was a lack of productivity caused by the forced dismissal of some project team members because of reduced activities and financial problems (Ghandour 2020). This affected both the duration of the projects, which increased, and the quality due to a lack of supervision of the workforce (Ghandour 2020). According to research that included 150 project managers in the construction industry in the UAE conducted by Ghandour (2020), a paired samples t-test showed that the projected number of days to complete a project significantly increased due to the outbreak of the pandemic. Indeed, they went from a mean (M)

of 515.3646 days and a standard deviation (SD) of 63.83305 pre-COVID-19 to M=659.5195 days and SD=79.86338 during COVID-19. Furthermore, the analysis of the findings revealed a p-value of 0, which means that the relationship between the projects' completion rates and COVID-19 is 100% (Ghandour 2020).

After the first wave of COVID-19, project managers in the UAE working for the construction industry started thinking about engaging in new projects. However, to avoid the same consequences caused by the pandemic outbreak, they decided to take additional measures during the planning phase and for risk identification. For example, as Rehman et al. (2022) explains, for the project duration, they increased it to make it more realistic. Furthermore, the authors add, project managers also decided to include human resources reserves, alternate equipment and materials options, and some financial margins in case something similar occurred. Among the various changes that should be included, Rehman et al. (2022) suggest a digital transformation process based on BIM, 3D printing, Internet of Things (IoT), and artificial intelligence (AI). Indeed, the latter can reduce the number of workers needed for a construction project, leading to a lower amount of money spent on salaries. Again, these are the same changes suggested for projects in India and Malaysia. To conclude, while the pandemic caused significant problems for the UAE construction industry, the positive attitude of the stakeholders, the mutual agreements to some changes in contracts, as well as the efficient economic support schemes promoted by the authorities helped the sector to recover quickly from such a difficult period (Rehman et al. 2022).

United States of America

COVID-19 has had a significant impact on the United States economy. Indeed, the National Bureau of Economic Research (NBER) announced a recession phase in February 2020, the COVID-19 recession, causing an increase in unemployment rates (Alsharif et al. 2021). This affected the construction industry as well, which experienced a high number of job losses because of the suspension of many projects that were deemed non-necessary, as Alsharif et al. (2021) say (see Figure 17). The authors highlight that two of the most affected sectors within the construction industry were the ones in the oil and gas sectors. The reason behind it is that, due to travel

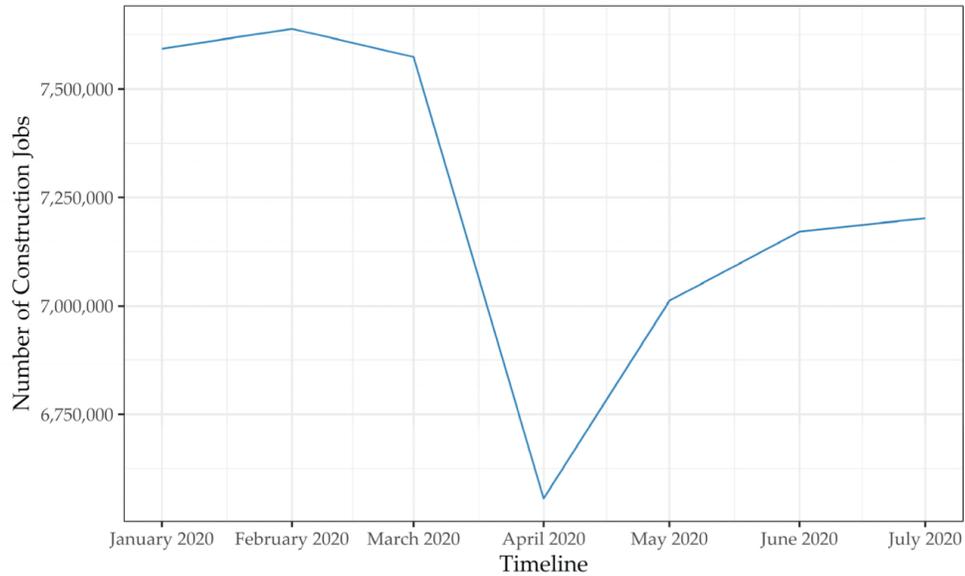


Fig. 17. Employment data for the construction industry in the United States between January and July 2020 as reported by the Bureau of Labor Statistics (BLS)

restrictions, the demand for oil and gas decreased. Among the early impacts that the pandemic caused on the construction sector, we find the disparities across the 50 states on whether such industry was considered essential or not (Alsharif et al. 2021). Indeed, as the authors point out, whereas some states had restrictions, others did not, causing uncertainty and early confusion. Consequently, delays were experienced, and existing projects were suspended.

Furthermore, the pandemic also caused shortages and delays in delivering the necessary materials because of international manufacturing and shipping issues. This led to higher costs for construction operations (Alsharif et al. 2021). For example, one of the project managers interviewed by Alsharif et al. (2021) explained how some building elements that had to be shipped from Europe were not delivered as the manufacturing plants there were not operating because of the pandemic. The same also happened for materials that needed to be imported from other countries such as China, Mexico, and Canada. However, also within the U.S., delays were experienced. Indeed, as mentioned before, different states had different regulations on the construction industry operations. In some of them, Alsharif et al. (2021) say that some manufacturing units and trucking companies within the supply chain were considered non-essential. Consequently, construction

companies began to find alternative material sources locally (Alsharef et al. 2021). However, as the authors explain, local suppliers and manufacturers experienced a significant surge in demand, also caused by an increase in minor renovations and home improvement projects that individuals carried out. This prevented them from being able to supply the necessary materials to the construction companies.

Among the various consequences of COVID-19 on the American construction industry, there are delays in inspections and in securing permits (Alsharef et al. 2021), just like what happened for Malaysia. Indeed, the offices in charge of such roles did not experience a smooth transition to remote working and suffered from a lack of the necessary technological equipment to deal with their work online: they had issues accessing the required documentation and information remotely. However, the reduction in the number of projects was not only caused by the challenges mentioned above. Indeed, some projects were stopped or slowed because the owners, especially private ones, were negatively affected by the pandemic from a financial perspective (Alsharef et al. 2021). Some other projects, instead, were deemed to be not urgent and, therefore, were postponed. For example, Alsharef et al. (2021) report the case of a project about building new student apartments: the owners asked to slow its completion since classes were taught online and they did not know when in-person ones would be resumed.

All of these impacts ultimately caused the construction industry in the United States, just like in other countries, to suffer from a reduction in productivity (Alsharef et al. 2021). This resulted from delays in the delivery of materials and in the permits and inspections. However, as Alsharef et al. (2021) points out, there are also other reasons, such as the social distancing policies, which meant fewer workers could be physically present on-site, leading to additional coordination efforts required. In addition, some workers could not go to work for several pandemic-related causes, such as quarantining requirements (Alsharef et al. 2021). However, as a result of the pandemic, also new opportunities started to make their way in the American construction industry. Indeed, Alsharef et al. (2021) highlights securing loans at lower interest rates is now possible, offering the opportunity for strong industry growth. For this reason, as the people interviewed by Alsharef et al.

(2021) say, there will probably be a spike in demand for new residential construction projects. They also believe that there will be an increase in projects regarding the construction of warehouses and storage units because of the importance that online shopping has acquired in recent years.

United Kingdom

Moving to Europe, the United Kingdom's construction industry was also severely affected. For the UK, the focus is mainly on the infrastructure sector, especially on roads and rails. As for the first one, in 2015, "Highways England (HE)" was established to invest in a portfolio of projects and programs to improve road efficiency (Jallow et al. 2021). The aim was to have completed at least 100 major road projects to add over 1300 lane mileage construction and rework 60 major problematic junctions (Jallow et al. 2021). As for the rail network, the authors continue the object for the year 2020 was to complete three main projects and programs: High-Speed Rail 2 (HS2) to link 8 out of the top 10 major cities in the UK, Crossrail, to increase London's rail capacity, and the Intercity Express program. The COVID-19 pandemic brought about several delays in project delivery since it was necessary to perform the tasks on-site, but this was only sometimes possible.

Furthermore, it was not allowed to do site investigations and complete the required health and safety inspections, leading to postponed deadlines. In addition to that, because of the lockdown rules in place, the project managers could not go on-site and consequently, it was difficult for them to have a comprehensive vision of what was happening (Jallow et al. 2021). For this reason, one of the proposed solutions was the implementation of the BIM, as we already saw for India, Malaysia, and UAE. Indeed, its use eased the digitization process and allowed project teams to continue working on their projects without being physically on site (Jallow et al. 2021). The UK infrastructure sector also experienced short-term cash flow issues for several reasons. Among them, we find that staff members were still being paid their full salary but could not perform the required work (Jallow et al. 2021).

Another issue that is shared with other countries as well is a shortage of skilled people. This hit the UK construction sector particularly hard as it was at its peak before the pandemic outbreak, as Jallow et al. (2021) point out. Recruiting new people became even more complicated since

interviews could not be held in person. Finally, like most countries around the globe, the UK also faced challenges as a consequence of global supply chain disruptions. Indeed, as Jallow et al. (2021) highlights, at the beginning of COVID-19, many suppliers did not want to travel to the various sites to deliver the necessary materials as they were afraid of getting COVID-19, as well as being subject to quarantine policies. However, in the following months, new guidelines were introduced to make the delivery process more accessible, allowing employees to continue working on the projects while ensuring safety. Since the infrastructure sector is critical for "re-booting economic growth" (Jallow et al. 2021), reshaping the existing strategy in light of the pandemic is fundamental, as well as undergoing a cultural change that emphasizes change and dynamic relationships (Jallow et al. 2021).

South Africa

South Africa was particularly affected by the pandemic: as noted by Aigbavboa et al. (2022), as of April 2020, only 26% of businesses involved in the construction sector were still operating. That can be explained by many reasons, including the fact that it took a lot of work to implement the correct response strategy. Indeed, Aigbavboa et al. (2022) explains that South Africa is a developing country facing many challenges, such as lack of compliance, adequate personal protective equipment, and ignorance. South Africa faced some of the same issues previously analyzed, leading to poor project performance and success rates. Among them, we find layoffs, especially in the early phases of the pandemic. Indeed, as Aigbavboa et al. (2022) explains, most South African organizations did not manage to get approvals for new projects and could not recover from the loss of existing projects, which in some cases led to project abandonment. Therefore, because of the consequent loss of revenues, they were forced to reduce the number of people working on projects.

As a consequence, projects also experienced a reduction in productivity. Furthermore, the South African construction industry was also affected by supply chain disruptions, which caused a shortage of the necessary materials, as for all the other countries analyzed above. Finally, a long-term issue that was foreseen is the difficulty in getting the necessary work permits due to a

reduction of the capacity of municipalities (Aigbavboa et al. 2022). This also happened in Malaysia and the United States, as aforementioned.

Ukraine

As already mentioned, there have yet to be any specific case studies on this subject. What can be observed, though, is that the war in Ukraine is causing several disruptions, which have been having a ripple effect even outside of the country's borders (Reaper 2022). Among the impacts, the most important is the energy and commodities price increase (Reaper 2022). This, of course, has a direct effect on the construction industry as such a spike in the costs can and will lead to the postponement and cancellation of several projects (Reaper 2022). Indeed, as the authors continue, several materials are fundamental in the sector that requires energy-intensive production processes, such as bricks, cement, plastic, ceramic, and steel (after China, Russia and Ukraine are the world's largest exporters). For these reasons, many companies are entering a new era of deglobalization, and regionalization (Reaper 2022), with a trend for reshoring manufacturing.

Furthermore, it is necessary to review the validity of the prices and the work programs for the projects in their initial phase (Duncan and McEvoy 2022). At the same time, regarding future projects, Duncan and McEvoy (2022) suggest including cost fluctuation provisions in case prices increase even more. Finally, we will probably see a tendency to shift the supply chain strategies from lean or just-in-time delivery to stockpiling so that construction companies can protect themselves against changes in prices (Duncan and McEvoy 2022).

Software Development

The next sector that is going to be analyzed is Software Development. It was chosen because it is entirely different from the construction industry and, therefore, faced other challenges as a consequence of the disruptions. Contrary to construction projects, which require significant hands-on and physical work, developers can perform their tasks, such as coding and debugging, from anywhere (Bao et al. 2022). Furthermore, many companies had already adopted remote work long before the pandemic, making it easier for employees to transition to the new reality. Nonetheless, several challenges were introduced due to the pandemic outbreak, as will be explained in detail

below. The following paragraphs describe how software development companies in three different continents were affected by the outbreak of COVID-19.

Sweden and Finland

Gregory and Kruchten (2021) investigate the pandemic's effect on software development companies in Northern Europe (Finland and Sweden) and how well agility has helped them respond to the crisis. The first result analyzed concerns a decline in overall productivity and the well-being of the project team members. As the authors specify, the impact depends on the project type, size, and age of employees. However, because the companies analyzed adopted an agile approach even before the pandemic, meaning that they were more capable of dealing with change, the expected result is that they were able to cope with the pandemic better than other industries (Gregory and Kruchten 2021). Despite that, the agile approach is thought to be implemented in a context where people can interact frequently and face-to-face. Therefore, the pandemic posed challenges to agile practices, which had to be reviewed and applied differently (Gregory and Kruchten 2021). Working remotely caused significant issues in communication among project team members, making it more difficult for them to cooperate. This negatively affected the employees' well-being, which was also worsened by the fact that work schedules changed and had become longer by up to one hour a day (Gregory and Kruchten 2021).

Among other impacts the pandemic has brought about, there is a decline in the number of customer projects, and sales (Gregory and Kruchten 2021), as well as impeded development, meaning that improvement activities were put on hold. In their paper, Gregory and Kruchten (2021) also analysed the correlation between how the pandemic has impacted companies and their agility. The results show that agile practices have been helpful for organizations in dealing with the challenges posed by COVID-19. In particular, the more successful were the ones that had more mature agile business units (Gregory and Kruchten 2021). Indeed, they could pivot to new targets and continue their business quickly.

China

To analyze the impacts of COVID-19 on Chinese software development projects, let us examine the Baidu, Inc. case study. Baidu is the world's largest Chinese language Internet search provider, and a world-leading artificial intelligence (AI) company (Bao et al. 2022). Since Baidu asked all of its employees to work remotely after the pandemic outbreak, the case study analyzes the effects it has led to. The overall results of the paper written by Bao et al. (2022) are that working from home has had different impacts on developers' productivity and that it depends on the project's characteristics. Firstly, Bao et al. (2022) noted how the developer's productivity varied based on the different types of programming languages. Indeed, for example, C++ projects in Baidu are typically more complex, and they are required to be programmed and debugged using a power machine, which might be challenging to access when working remotely. Instead, most other projects are built using Java and can be easily developed using regular computers from the comfort of the developers' homes.

Furthermore, Bao et al. (2022) explain how the different project ages affect productivity. Indeed, older projects require more maintenance tasks, such as reading the documents and the source code more often. Working remotely might mean it is more difficult to access those resources from home rather than from the office (Bao et al. 2022). Finally, also the project size has an important role. The higher the number of people working on a project, the more difficult it is to communicate with everyone remotely (Bao et al. 2022) effectively.

Therefore, as Bao et al. (2022) suggest, different arrangements should be made for different developers. For example, those who believe they experienced decreased productivity should be asked to work from the office. On the other hand, those who noticed an increase in productivity should be allowed to continue working remotely. While it may seem complicated to measure productivity, for software development companies, it is relatively straightforward. Indeed, several metrics can be used, such as the number of submitted lines of code, the time to implement a requirement, and the completed tasks (Bao et al. 2022).

Brazil

In this paragraph, a Brazilian agile software startup named Di2Win will be analyzed. The company was founded in Recife in 2018, but it has partners worldwide (Camara et al. 2020). To better understand the impact that COVID-19 had on the business, the focus is on a specific project: "an insurance onboarding platform for automobiles that communicates with a legacy ERP (Enterprise Resource Planning) through two Web-applications that works as an interface" (Camara et al. 2020). The team was made up of a scrum master, a product owner, a technical leader, and six developers, and it followed an agile approach and models such as Scrum and Kanban (Camara et al. 2020). The outbreak of the pandemic posed significant challenges to Di2Win, with the most important ones being the following, as (Camara et al. 2020) explains:

- productivity;
- which tools to use to deal with remote work;
- align expectations with customers;
- continue to deliver value;
- employees' well-being.

To continue to have high levels of productivity, some internal collaboration guidelines were established, including an official chat tool (Microsoft Teams) and a daily meeting at a specific time and the project team members were given the necessary hardware needed to work from home (Camara et al. 2020). As for the tools to manage work from home, the authors say that an official document storage tool was chosen (One Drive) and one for the sprint retrospectives (FunRetro). Moving on to customers' expectations, it was fundamental to establish continuous communication with them and make them aware of the possible impacts of the pandemic on the project (Camara et al. 2020). For this to be possible, a communication schedule was defined so that the project manager knew who would join each meeting, which was the channel and the frequency (Camara et al. 2020). In the end, the project team members agreed that the actions taken had been constructive in reducing the uncertainties, improving the quality of the work produced, and bridging the gap

between the various team members caused by the work-from-home policies (Camara et al. 2020).

Ukraine

Before the war, Ukraine was one of the largest hubs in the world for IT professionals working remotely for global companies (Sniesar 2022). However, as the author explains, around 80 % of Ukrainian programmers relocated to western areas of Ukraine or to other European countries to be safer. Many companies showed their support by donating to the Ukrainian military and continued to pay salaries to employees that had to join the military, as Sniesar (2022) say. However, many companies decided to stop projects and shorten employment agreements with Ukrainians. For example, Sniesar (2022) reports a case of a software development company named TemaBit, which stopped assigning tasks to about 30% of its IT specialists. However, they were not fired, and the idea is to continue giving them assignments whenever there are more of them. Similarly, Parimatch Tech had to fire around 15% of its employees because their responsibilities were not aligned with the current needs that surfaced because of the conflict.

COVID-19 Responses Projects: Healthcare

As a response to COVID-19, numerous projects were developed. All these projects presented unique characteristics as they included multiple stakeholders trying to work together for a common goal under extreme schedule and resource pressures (Winch et al. 2021). For these reasons, the traditional project management approaches could not be applied, leading to many challenges. The following paragraphs focus on healthcare projects, namely the global vaccine development projects and the construction of emergency field hospitals.

Operation Warp Speed: COVID-19 Vaccines

As COVID-19 spread around the globe, the need for a vaccine that would protect against the virus was fundamental. Several pharmaceutical companies worked on developing one in the shortest amount of time. This was very complicated as, typically, the time required to develop a vaccine is measured in years (Winch et al. 2021). The vaccine development projects that started around the world faced many challenges, as Winch et al. (2021) explains:

- safety concerns;
- need for billions of doses;
- the virus might stop spreading before the vaccines become available, which is what happened in 2002-4 with the SARS epidemic.

Operation Warp Speed (OWS) is the name given to the partnership between the American Departments of Health and Human Services and Defense, whose ultimate goal was to speed up the process of producing 300 million doses of a COVID-19 vaccine by January 2021 (Winch et al. 2021). The OWS started working with different pharmaceutical companies that were in the process of developing the vaccines using various mechanisms (Winch et al. 2021): the mRNA one promoted by Moderna and Pizer/BioNTech, the replication-defective live-vector one by Janssen and AstraZeneca, and the one based on a recombinant adjuvanted protein by Sanofi and Novavax. Even if by doing this, the OWS was trying to get a viable and effective vaccine in the shortest time possible, there were more challenges to overcome. Indeed, two of the main problems were a shortage of the available workforce, which was experienced by many different projects worldwide, as aforementioned, limited manufacturing capability, and supply chain uncertainty (Winch et al. 2021). Especially to overcome the last one, the authors explain that a list of critical supplies was developed and that the delivery of the necessary equipment was expedited. Among the various project management techniques that were adopted to shorten the duration of the project, the vaccine companies adopted schedule compression in the regulatory approval (Winch et al. 2021). However, as the authors explain, it was of utmost importance to follow a waterfall approach. Indeed, agility promotes flexing the scope, which cannot be done for vaccine development projects: everything must follow the required standards. Now, let us focus in detail on the development of the AstraZeneca vaccine project, whose timeline is illustrated in Figure 18.

As the Project Management Institute (2021) says, the AstraZeneca vaccine project faced uncertainties and reputation risks, among others. Furthermore, one of the most complex challenges was to dedicate numerous resources to the project and assign top-talent employees without compromising the other projects in the company's portfolio (Project Management Institute 2021). Of course,

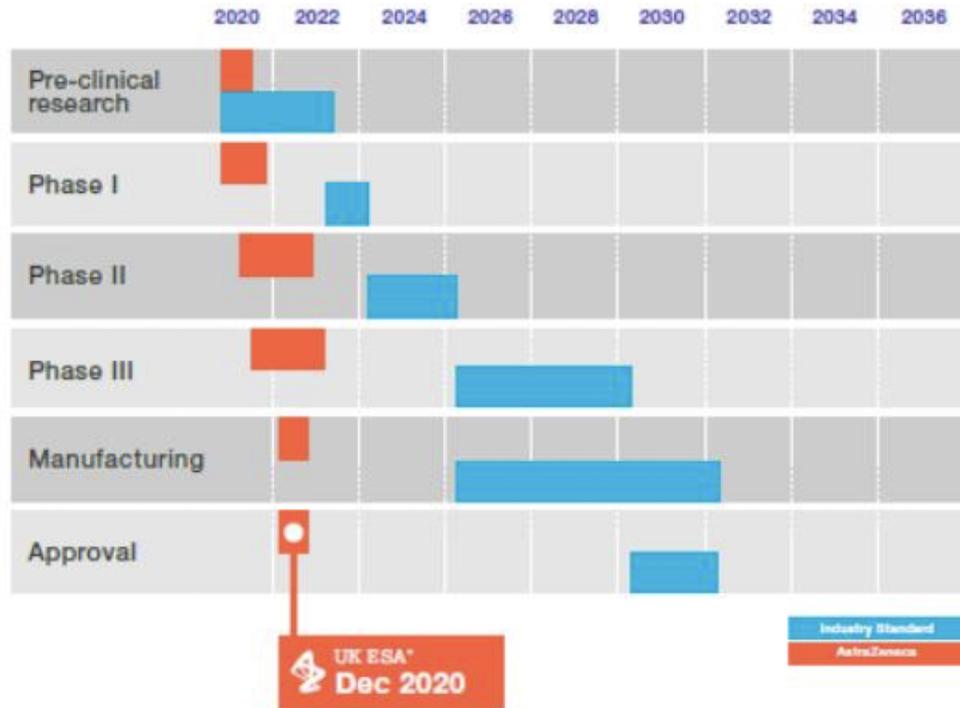


Fig. 18. AstraZeneca vaccine timeline (in orange) vs Industry standard (in blue)

complexity also played an important role. It was mainly due to the accelerated timeline, as well as to the need of the different customers (mostly governments), as each of them brought additional regulatory requirements and, therefore, complexity (Project Management Institute 2021). From a project management perspective, three were the main identified gaps as the Project Management Institute (2021) reports:

As the Project Management Institute (2021) explains, the first step AstraZeneca took was to create a Project Management Office (PMO). Four leading roles were assigned to it:

- integrating the schedule and budget of the project;
- contract management with numerous governments;
- guidance and training for the project team members;
- risk management.

Then, as aforementioned, there was the issue of hiring a project manager that had both experience in vaccine development and in contracting with the government (Project Management Institute

2021). As the author continues, AstraZeneca had to hire from outside, which was complicated since the pandemic had brought about challenges with recruiting. Furthermore, it was fundamental to secure the agreements with manufacturing companies before the other pharmaceutical companies did, otherwise it would have become very complicated to have access to the necessary production capacity.

The lessons that AstraZeneca learned from the vaccine development project are invaluable. Indeed, they understood the value of adaptability, which the words of Tina Guina, the lead R&D global project manager for the vaccine project, can summarize: "There's also a fine line between how much adaptability there should be, how much adaptability is feasible, and deciding when it's ok to let go. It's the goal for the project manager to know when to push and when to pull."

Emergency field hospitals

Emergency field hospitals were built all over the world as a response to the outbreak of COVID-19. This paragraph will focus on the UK's Nightingale Hospital program of constructing seven field hospitals due to an increase in the number of people in regular hospitals (Winch et al. 2021). The total cost of the program was \$302m, and it took less than three weeks to build them (Winch et al. 2021). One of the characteristics of these projects worldwide was rapid mobilization, as Winch et al. (2021) explains. Indeed, people were taken off other projects that were not deemed urgent anymore to work on the new and more urgent ones.

Furthermore, a Project Management Office (PMO) was established to coordinate the work (Winch et al. 2021), just like it happened for AstraZeneca. If we take one of the seven emergency field hospitals as an example, the one in Manchester, Winch et al. (2021) says that the workforce on site peaked at 1,000. For this reason, the project's duration was just thirteen days. However, even though the speed of building the field hospitals was remarkable, Winch et al. (2021) focuses on the fact that the Nightingale Hospital program delivered the outputs, not the outcomes. Indeed, while the output of actually constructing them was achieved, the outcome of providing COVID-related healthcare services was not (Winch et al. 2021). Out of the seven field hospitals, only the London and Manchester ones served this purpose, whereas some of the others were used to treat

non-COVID-19 patients, and others became mass vaccination centers (Winch et al. 2021).

PROJECT MANAGEMENT METHODOLOGIES AND TOOLS

Why Agile works better

The COVID-19 outbreak and the war in Ukraine have emphasized the importance of business agility (Revutska and Antlová 2022). Indeed, an agile approach can be very helpful in dealing with the dynamic, complex, and volatile environment of the last few years. As the authors highlight, such environment requires project leaders to quickly pivot and adapt to the new market in a productive and cost-effective way. For this reason, an increasing number of companies is incorporating agile: as the 15th State of Agile Report (State of Agile 2021) states, agile adoption for non-IT organizations doubled since the previous year (2020). As for software development companies, instead, it increased from 37% in 2020 to 86% in 2021. According to the report, the most popular technique is Scrum, followed by Scrumban, XP Hybrid, and Kanban. The reason behind this significant increase in the use of agile methodologies is that the original waterfall approach is no longer relevant in a volatile and uncertain market that undergoes constant changes (Švecová and Mastný 2021). Indeed, for most projects during the pandemic and the war in Ukraine, it is not possible to define all the requirements upfront. Instead, its use allows to start a project with only minimal requirements definition and analysis, and to add and develop the remaining ones throughout the duration of the project. This iterative approach allows to incorporate feedback at every iteration leading to continuous improvement (Kline 2021). Therefore, as scope, requirements, and priorities change during the project, agile helps in quickly adapting and moving forward. For this reason, agility can be considered as a source of competitive advantage for companies (Revutska and Antlová 2022).

Risk identification

Because of all the reasons mentioned above, agile plays a fundamental role in helping minimize risks and uncertainties. Indeed, delivering value in iterations can reduce exposure to risks. Contrary to projects that follow a waterfall approach and deliver value after the project's completion, those who implement agile can identify and mitigate risks easily and early in the project: since the value is delivered after each iteration, risk visibility increases. Indeed, agile means starting with just a

component: if it meets customers' needs, then the company will do more, otherwise, it can pivot to something else. Furthermore, the agile framework allows risks to be identified not only in the planning phase of the project but throughout its duration. This is particularly crucial in case of disruptions, such as COVID-19 and the war in Ukraine, as the future is unknown, the market is constantly changing, and new risks could emerge at any time.

Collaboration tools

Both the pandemic outbreak and the war in Ukraine have caused significant problems in communication and collaboration as teams were not co-located and working from home.

Synchronous communication was one of the hardest challenges for all the projects that use Scrum (Valgeirsdóttir et al. 2022). Indeed, Scrum requires to have a Sprint Planning, Daily Scrums, a Sprint Review, and a Sprint Retrospective within each sprint (or iteration) (Valgeirsdóttir et al. 2022). Before the pandemic and the war, it was easier to plan these meetings since everyone was working in the same office and during the same work hours. Instead, transferring to a remote work setting led to issues in finding a time frame that works for everyone. However, this is only one of the several challenges encountered. Among the others there are lack of involvement and going off-topic (Valgeirsdóttir et al. 2022). For these reasons, Valgeirsdóttir et al. (2022) suggest implementing the following countermeasures:

- break Sprint Planning down into smaller pieces;
- perform Daily Scrums through an instant messaging application so that every project team member can perform it at their own pace. If held during a video call, instead, the suggestion is to extend the duration to 30 minutes, so that the last 15 can be used for problem-solving ;
- have pre-recorded demos for Sprint Review.

Another suggestion that was proposed by Mahapatra and Naik (2020) is to experiment with holding daily scrums of scrums with both agile teams within a portfolio and senior IT and business leaders. This is particularly helpful for the team members to avoid feelings of isolation, as well as for the leaders, who can see what each team is working on. This can lead to an overall stronger

sense of collaboration and trust, which is more difficult to foster in a remote working environment.

Figure 19 shows an example of a typical remote workday for an agile team according to McKinsey & Company (2020). The Figure shows the perspective of both the product owner and a

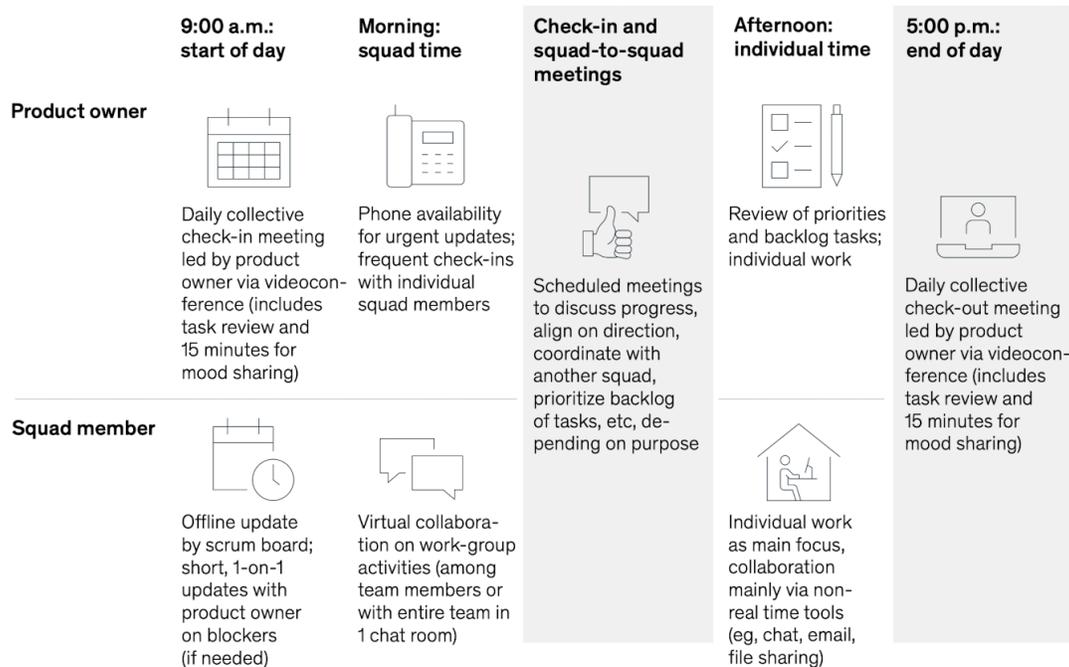


Fig. 19. Example of remote workday for an agile team

member of the agile team. The main role of the product owner is to have frequent check-ins with individual team members and with the whole team to discuss several topics, including the team's progress and priority of the items in the backlog. As for each individual team member, instead, the focus is on virtual collaboration for the various activities, check-ins with the product owner (if needed), and individual work on the tasks.

As mentioned above, virtual collaboration is among one of the most important aspects of agile teams working remotely. However, to increase such collaboration in a remote working environment, organizations need to provide the necessary technology tools to the project team members (Mahapatra and Naik 2020). Among them are the tools for video conferencing and virtual collaborative online whiteboards. Solutions such as Zoom and Atlassian products, such as Jira and Trello, are popular solutions, as the increase in their stock prices highlights.

As Figure 20 shows, Zoom stock skyrocketed during the first months of the pandemic: it went from around \$76 per share in January 2020 to a peak of \$559 per share in October 2020. Indeed, it was during these months that lockdowns around the world caused schools and businesses to close, forcing them to use video conferencing tools. However, as it can be noted from Figure 20, Zoom’s growth has slowed since in-person meetings are resuming and schools and universities reopened. Furthermore, Zoom is experiencing competition from other platforms, such as Microsoft Teams, which comes together with Microsoft Office subscriptions. Therefore, some businesses decided to use that instead of paying additional sums for a Zoom subscription (Grothaus 2022).



Fig. 20. Variation in the stock price for Zoom Video Communications Inc.

As for Atlassian, an Australian software development company used by agile teams, the variation in its stock price is shown in Figure 21. Similarly to Zoom, its stock price increased significantly because of the pandemic. Indeed, it went from around \$130 per share in January 2020 to a peak of \$458 per share at the end of October, 2021. The reason behind Atlassian’s significant growth lies in the digital revolution caused by the outbreak of the pandemic. Its products, like Jira and Trello, became, and still are, very popular among project teams as they are considered to be useful tools that increase productivity. These tools can be particularly beneficial since, as explained in detail in the previous chapter, almost all the projects in various industries worldwide experienced lowered productivity due to the social distancing policies.

Such collaboration tools aid companies in collaborating virtually and help in managing employ-



Fig. 21. Variation in the stock price for Atlassian Corp

ees working remotely. For example, Trello offers kanban-based tools that help in creating boards to keep track of the project’s status. Jira, instead, is broader and helps agile teams in the various phases of the projects.

While Atlassian experienced a sharp decrease in its stock price during the first months of 2022, the stock seems to be rising again. One of the reasons for the decline could be the increased competition from other companies, such as ClickUp, Asana, and Miro. For example, Miro offers several Agile Workflows templates. Among them, there are Kanban boards (see Figure 22) and boards to conduct a Sprint Retrospective (see Figure 23).

Benefits of Agile

Among the several benefits that come with agile, there is the empowerment it gives to the teams (McKinsey & Company 2020). Contrary to teams that follow a traditional approach, agile teams are empowered to make decisions autonomously and own their tasks (Keita 2022) so that they can deliver results quickly and shorten the feedback loop (McKinsey & Company 2020). This is particularly significant during disruptions that force people to work from home. Indeed, when teams work remotely, it becomes more difficult to coordinate with the other members and with the project managers because of the different availability. Furthermore, having to always check with the project manager in charge every time something occurs can lead to delays since communication

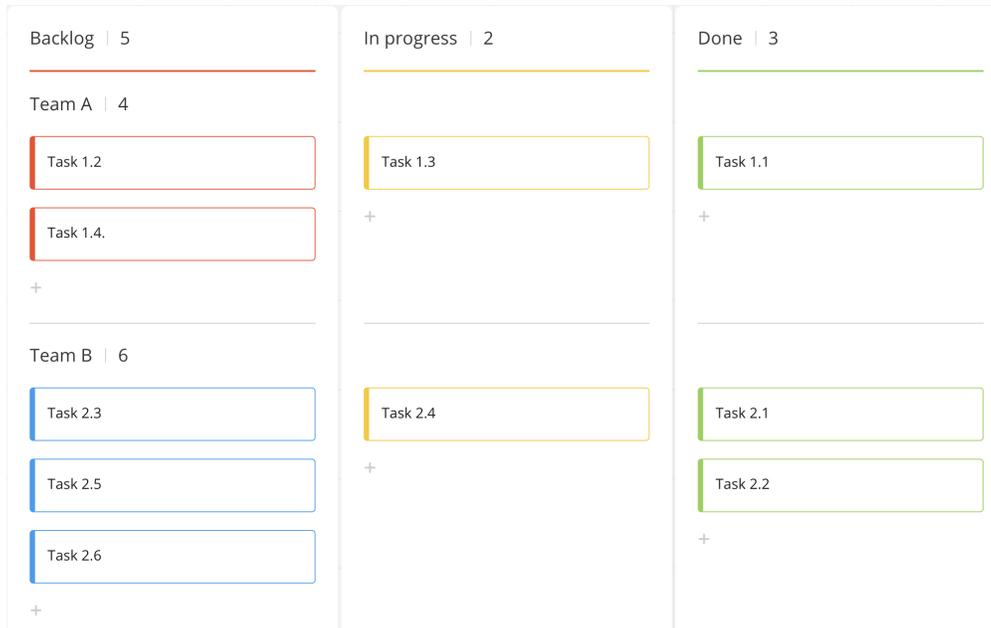


Fig. 22. Example of a Kanban board created with Miro

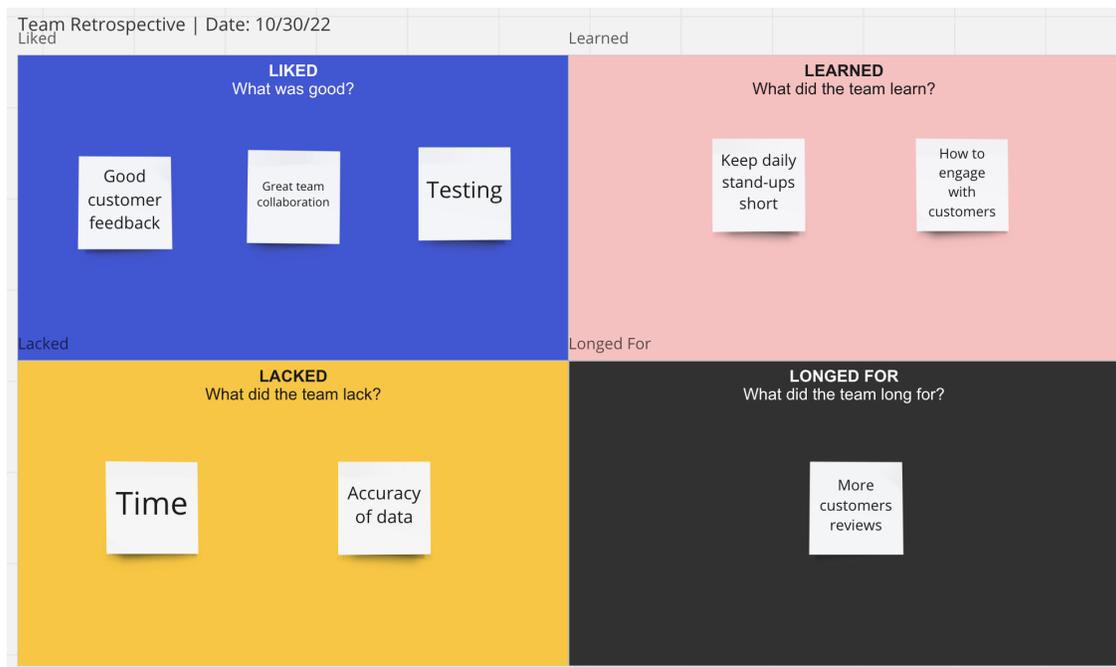


Fig. 23. Example of a Sprint Retrospective board created with Miro

is less frequent than in the office (McKinsey & Company 2020).

Remote work also led to signs of disengagement from employees (McKinsey & Company 2020).

One way of boosting engagement, according to McKinsey & Company (2020) is, indeed, an agile

transformation: they can learn new skills, work together closely with other team members, and support the new operating model.

A more modern approach other than agile, as Švecová and Mastný (2021) suggests, can be described as hybrid project management, a combination of agile and waterfall frameworks. Consequently, companies can tailor existing frameworks to capture their specific needs (Revutska and Antlová 2022).

To decide which approach fits best each project, it is crucial to understand whether agile can be applied or not. Indeed, not every project can be developed using such an approach. However, during periods characterized by disruptions and uncertainties, agile could be the only effective way of avoiding a project's abandonment or failure, whereas, when conditions change, it might be possible to go back to the predictive approach. The following is an example in which the complexity of the situation forced the project managers to use a hybrid approach. The project under analysis is about deploying vaccination centers for COVID-19 in the Boston area. Two of the main issues were a lack of the necessary amount of vaccines and a shortage of nurses due to the labor scarcity caused by the pandemic. The original idea was to build hospitals for the purpose of vaccinating the population. However, this did not make sense because of the lack of the resources mentioned above. Therefore, the project managers were very good at combining the agile and predictive approaches to find a solution: use mobile units (e.g., truck, bus, van) to visit different locations around the city and plan this last-minute. To get to these creative solutions, project managers need to be innovative decision-makers and must be empowered to make such decisions. Indeed, if the project managers had decided to use the available project funds to build a hospital instead, it would probably have resulted in the project's failure: the hospital would most likely be far from where the low-income population lives and, therefore, these people would not go to the hospital, leading to its abandonment. In this case, the project's goal of accelerating vaccine distribution would have not been accomplished. If the project's conditions change, namely there is enough availability for vaccines and nurses, then the project managers can go back to a predictive approach and can plan in advance where to drive the mobile clinics based on where COVID-19 issues are worse.

Ukraine

As for the conflict in Ukraine, the approach to work can be considered similar to the early stages of the pandemic. Indeed, while people are forced to work remotely because of the war, especially in some regions, some others have to because they relocated to other countries such as Poland to be safe.

As Sniesar (2022) explains, while some companies showed their full support through donations, some others stopped projects with Ukrainians or shortened their employment agreements. Therefore, just like it happened during the pandemic, companies are experiencing project terminations.

Because the environment is extremely volatile and complex due to extremely high uncertainty about the future of the war, adopting an agile approach is critical. Indeed, in a market where the current needs are constantly evolving, it is difficult to imagine being able to adopt a predictive approach. Instead, agile allows doing things last-minute, reducing risks. However, even if risks are reduced, it is still critical to prepare a risk response plan in advance. As for wartime, namely the conflict in Ukraine in this case, it should include reserve infrastructure, relocation routes, creation of response teams, and extra security measures (Solovey 2022).

As Solovey (2022) suggests, one of the ways to keep projects going during wartime is to turn to short-term planning. Indeed, changes happen very quickly and could significantly impact projects, making long-term planning useless. Therefore, not only Waterfall is not advised, but there are also some recommendations for agile projects, such as reducing the duration of the Sprints to allow for more flexibility. Furthermore, like for the daily stand-up for Agile, a daily meeting should be held to keep in constant contact with the stakeholders (Solovey 2022) and to address any questions they might have. Among the common topics that could be included in the meeting are the following, as Solovey (2022) highlights:

- project risks and response strategies;
- impact of the war (or any other disruption) on the project baseline;
- status of the people involved: current location, availability, risks, and performance;
- rotation plan in the event of unavailability of one or more of the team members;

- any other concerns.

Among the other suggestions advised by Solovey (2022), which can be applied both to wartime situations but also to any other disruption, including the pandemic, is a decrease of the team focus factor. The focus factor represents the difference between the ideal and real performance of a team. In normal situations, the value of this coefficient is around 70%. During the war, however, and the same applies to disruptions in general, productivity significantly decreases, as explained in the previous chapters. Therefore, to get a more realistic view of the time and effort needed to complete a project, the percentage value must be lowered. Consequently, the project schedule must be updated and communicated to the stakeholders involved.

CONCLUSION

The outbreak of the COVID-19 pandemic and the war in Ukraine have had a global impact, both from an economic and a political perspective. These disruptions have created significant risks around the world, leaving companies unprepared to deal with them.

In my thesis, I have analyzed the impacts that the pandemic and the war had, and still have, on project management and its practices. In particular, I have researched four critical dimensions—lack of project funding, supply chain disruptions, communication issues, labor scarcity—that can be used to graphically describe the impacts on an organization or on a project. These attributes, as shown in Figure 24, cause uncertainties and add significant risks.

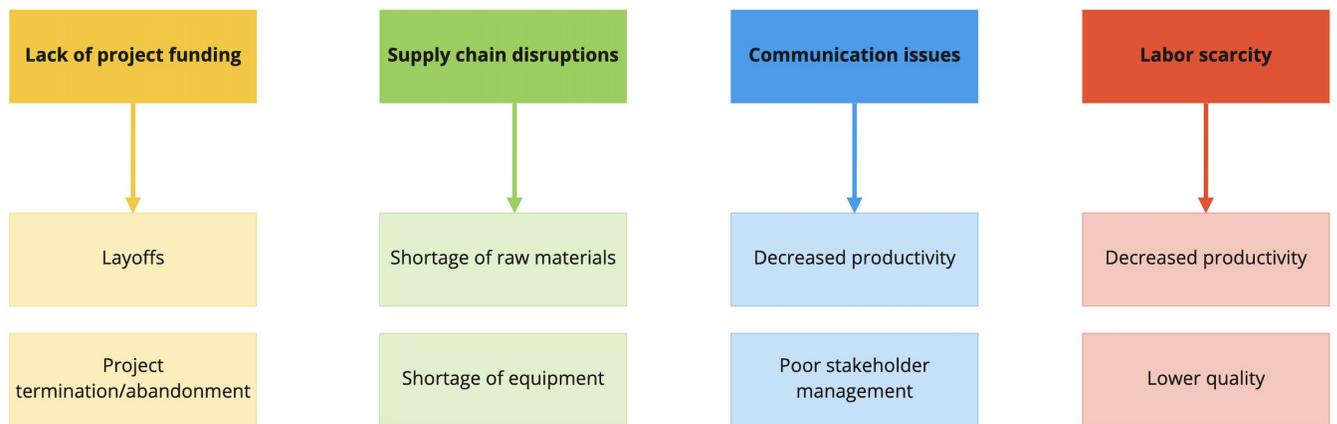


Fig. 24. Four critical dimensions to measure the impact of disruptions

Each of these dimensions has direct and indirect consequences. For example, as Figure 24 shows, lack of project funding forced organizations to lay off employees and led to the termination or abandonment of projects that were deemed to be non-necessary. Another example taken from the graph regards communication issues. Indeed, both the outbreak of COVID-19 and the war in Ukraine caused a high percentage of the population involved to work remotely, making it difficult to communicate with the stakeholders, including the project team. Possible consequences include decreased productivity and poor stakeholder management.

To assess whether a project should be continued or terminated/abandoned, a flow chart like the

one shown in Figure 25 can be a helpful tool.

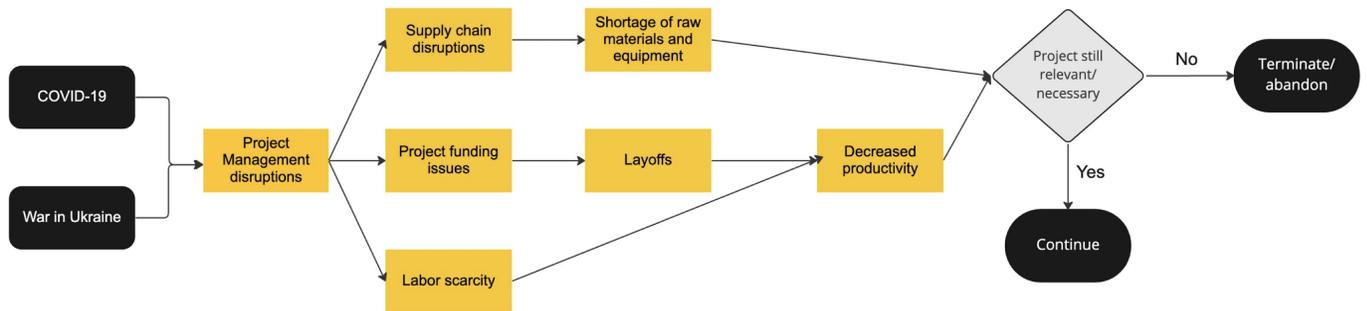


Fig. 25. Flow chart

The chart focuses on three of the critical dimensions highlighted above—supply chain disruptions, project funding issues, labor scarcity. In addition, it shows some of their consequences, such as decreased productivity, which can come as a result of layoffs and labor scarcity. After a company has analyzed what were its critical factors, it should continue with the project if this is still relevant and necessary. Otherwise, termination or abandonment is the right path to follow.

To conclude, Figure 26 shows a framework that companies can use as a measure of the intensity of risk. As Figure highlights, the impact resulting from the disruptions can be:

- code red, if a project is experiencing challenges linked to all the four critical dimensions;
- code orange, if a project is experiencing challenges linked to three of the four critical dimensions;
- code green, if a project is experiencing challenges linked to two of the four critical dimensions;
- code white, if a project is experiencing challenges linked to one of the four critical dimensions.

When assessing the impact, different critical dimensions can be chosen. However, as mentioned above, this thesis focuses on the ones shown in Figure 26. Therefore, for each project, different steps will be taken based on the impact that it is experiencing.

Impact	Lack of Project Funding	Supply Chain Disruptions	Communication Issues	Labor Scarcity
RED	X	X	X	X
ORANGE	X		X	X
GREEN	X	X		
WHITE	X			

Fig. 26. Example of risk framework

Integrating the above risk levels with my earlier process flow provides a guideline for managing projects and programs. Consider Figure 25: code Red projects should be terminated and abandoned. Note that this is a challenge because it is usually a challenge to kill projects, especially when stakeholders have invested much of their credibility in its success. This is described by O’Brochta (2017), who explains that among the various reasons that make a bad project so hard to kill are sunk costs. Indeed, as the author highlights, project managers often fall victim of the fallacy that induce them to pay more attention to sunk costs rather than on future costs and benefits. This means that they prefer to continue with projects in which they have already invested resources. This can lead, as O’Brochta (2017) explains, to an escalation of commitment, meaning that the project managers decide to invest further even though the project is failing. In addition, quite frequently, this would involve the laying off of several dozen project team members, all of whom might not be willing to embrace this approach.

For projects flagged as code Orange, suspend the project for the foreseeable future. The suspension might be worthwhile if the project has passed the 50% status when measured using earned value.

Finally, for code Green risk mitigation plans should be made, and the project might succeed if

a good risk response plan is in place. For such projects, a management reserve of 10% or greater should be set aside to mitigate risks and handle unknown risks. Likewise, for White code projects, we should continue, but only after adequate risk response plans are in place.

In conclusion, my thesis contributes to analyzing projects and programs at risk for situations like a war or pandemic. If organizations have the recommended process and risk color code levels in place to trigger decision-making, it will result in substantial savings of resources and cost.

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