

Establishing Factors to Consider While Adopting the Agile Approach in Manufacturing Companies

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Abstract. Due to the current fast-paced business environment, new approaches to product development (PD) have been requested. In that matter, the agile approach has gained interest among researchers and practitioners. Based on its positive results in the software industry, it has started to be adopted in the manufacturing industry. Nevertheless, there are factors that manufacturing companies must consider while adopting the agile approach, and there is a lack of in-depth empirical studies about those factors. In that matter, this paper presents the preliminary findings of a single case study of a large manufacturing company. The data collection consisted of fifteen semi-structured interviews with persons with key roles in different organizational functions. The identified factors were analyzed and presented according to a product development system (PDS) perspective which encompasses people, process, and technology and tools subsystems. For the people subsystem, the study identified factors related to cross-functional integration and coordination, cross-functional communication, organizational culture, understanding of the agile approach, definition of roles and responsibilities, and people involvement and support. In respect of the process subsystem, the study identified factors associated with workload leveling and development interfaces. Regarding the technology and tools subsystem, the study identified factors related to the integration of information systems, and technology and manufacturing readiness levels. As a result, the study contributes further to the establishment of the factors that may influence the adoption of the agile approach in the PDS of a large manufacturing company.

Keywords. Integrated product and production development, agile, factors, product development system, manufacturing company.

1. Introduction

Nowadays, companies are operating in a fast-paced environment [1, 2]. Challenges and trends such as competition for shorter time-to-market, higher customer demands for innovation, customized and sustainable products, have called for the introduction of new technologies into companies [3]. That has brought uncertainty and complexity to companies' operations, and consequently to their product development (PD).

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The uncertainty and complexity have opened spaces for new approaches to companies' PD. Among those approaches, the agile approach has raised interest among researchers and practitioners. It was introduced in the software development sector during the late 1990s-2000s, and in its simplest form, the agile approach is based on adaptative planning, evolutionary delivery, and time-boxed iterative execution of the development activities [4, 5].

Guided by the positive results in the software industry, the agile approach started to be adopted in the manufacturing industry. By studying the adoption of the agile approach in the manufacturing industry, some authors have been able to identify benefits, such as improvement of communication and coordination among team members [4, 5], team motivation [4, 5], and better response to changing customer requirements [4, 6].

Despite the benefits, there are several factors that need to be considered when adopting the agile approach. In the present study, a factor is understood as "a fact or situation that influences the result of something" [7]. In that sense, some of those factors have to do with the transformation from a linear approach commonly used in industry [8], also denoted as the stage-gate or waterfall approach, to the agile approach, and all the changes that it implies, for instance, to the organizational culture, working attitude, traditional hierarchies, etc. [9]. Other factors deal with the necessary modifications of agile methods for being suitable for product development (e.g., constraints on physicality, sprint length, etc.) [10].

Furthermore, the adoption of the agile approach in manufacturing companies is still immature and there are only few in-depth empirical studies about it [4, 10, 11]; moreover, there is a lack of studies on factors that may influence the adoption of the agile approach in the PD of manufacturing companies. Therefore, the purpose of the study presented in this paper is to identify and describe such factors by exploring the experiences of different functions involved in PD.

Those factors are presented taking the product development as a system (PDS) perspective given by Morgan and Liker [12], who describe it as the integration of three subsystems people, process, and technology and tools. The subsystem 'people' is related to leadership style, organizational structure, organizational culture, etc.; the subsystem 'process' comprehends all the required tasks and events, for bringing the product from a market opportunity to its introduction to the marketplace; and the subsystem 'technology and tools' refers to all the technologies and tools that are used for developing the products, and for supporting people in problem-solving, standardization of practices, etc.

The remaining sections of this paper are organized as follow. The next section presents a literature review of the agile approach. The third section presents a general description of the company under consideration and explains the research methodology followed during the study. Then, the findings based on the empirical data and their analysis are presented in the fourth section. Finally, the last section presents a brief discussion and conclusion of the study.

2. Frame of reference

This section presents the results of a literature search of the agile approach, its history, definition, practices, and adoption in manufacturing companies.

2.1. The agile approach

The agile approach appeared in the late 1990s, with the objective of offering alternatives to software development driven by documentation, planning, and heavyweight project management [13].

The approach is described in The Agile ‘Software Development’ Manifesto [13]. In it, agile is defined in terms of values and principles. On the one hand, agile values individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation, and responding to change over following a plan [13]. On the other hand, the agile principles embrace customer satisfaction through frequent delivery of functional components, changing requirements, daily interaction between stakeholders, team motivation and trust, sustainable and constant pace of work, face-to-face conversations for conveying information within the team, attention to technical excellence, simplicity, self-organized teams, and team reflections and behavior adjustments [13].

Nevertheless, authors such as Moran [9] point out the difficulty of defining what is meant by ‘agile’ and characterizing it purely by referring to its principles and values. Instead, he presents agile as a discipline or a loosely structured solution development paradigm that copes with rapid change and embodies core values through iterative development and incremental delivery driven by business needs.

In practice the agile approach is carried out by a small team of specialists that can perform different kind of tasks, and work closely together with collaborative customer representatives [13]. Moreover, the agile teams perform a series of events such as, stand-up meetings, iteration and release planning, testing, continuous integrations, retrospectives, and burndown charting; although the name of those practices may vary according to different agile methods [9].

2.2. Adoption of the agile approach in manufacturing companies

The agile approach has gained interest among manufacturing companies [11]. Authors such as Conforto et al. [14], Cooper and Sommer [15], among others, have studied the experiences of manufacturing companies in the adoption of the agile approach in their PDS.. Those studies have been conducted in large multinational and SMEs companies in different technology intensive industrial sectors, such as heavy equipment, consumer electronic, etc.; moreover, they cover topics such as the integration or transition from the linear to the agile approaches, how it improves PD performance, and the identification of agile best practices in manufacturing industry.

Based on those studies, authors have identified common benefits on the adoption of the agile approach in PDS, such as better communication and knowledge sharing [15, 16]; transparency (visibility) [6, 16]; improved process visibility and the goals definition[6]; flexibility and responsiveness [6, 17]; resource consumption [6] and team motivation [6, 17].

Despite those benefits, the adoption of the agile approach presents challenges related to organizational and technical aspects. Regarding organizational aspects, there are challenges such as the allocation of full-time teams [10, 14]; co-location of teams [6, 10, 15]; assignation of specialized staff [14, 17]; changes in the organizational culture and the establishment of an ‘agile’ mindset [6, 17]; and the executives’ sense of loss of power and control due to a flattening hierarchy [17]. Moreover, challenges related to technical

aspects encompass the necessary modifications of agile methods for being suitable for product development (e.g., constraints on physicality, sprint length, etc.) [6, 17].

Even though the studies have not been focused on the identification of factors to consider while adopting the agile approach, in their articles, some authors mention them. For instance, Conforto et al. [14] claim that factors such as the use of small cross-functional teams managed by experienced project leaders, the tendency of having less formalized process, and the empowerment of the team with some degree of autonomy for making decisions, may favor the adoption of the agile approach. Furthermore, Edwards et al. [5] mention that factors such as the availability of technical and managerial skills, management commitment, and team integrity and dedication, are crucial factors for the obtention of the benefits from the agile approach. Moreover, Sommer et al. [6] found that the “fear to failure” and a culture secrecy, are factors that may influence the adoption of the agile approach in manufacturing companies.

3. Research methodology

This section explains the research methodology followed in the study, which comprises a literature search and a single case study. Regarding the last one, the section presents a general description of the case company.

As a first step, the frame of reference presented in the section 2 was based on a literature search on product development approaches, models, and processes; although for this paper, the selection of literature was based on the criteria that it should address the agile approach explicitly. For identifying the literature, Scopus and Web of Sciences were used as databases. The string search was defined iteratively by the researchers, and it includes research and review articles in English, from 2000 to 2020. Further literature was identified from the aforementioned articles.

Because the present study is seeking for the identification and description of factors that may influence the adoption of the agile approach, a case study is considered an appropriate research design; as is mentioned by Säfsten and Gustavsson [18], a case study is suitable when a in depth-knowledge or description of a situation, event, or phenomenon, is desired.

The empirical material of this paper is based upon a single case study of a worldwide leading manufacturer that delivers product solutions to customers in different industry segments, such as aerospace, automotive, energy sectors, among others. The company is present in several countries and has over seven thousand employees. Its extensive investments in R&D, together with a close collaboration with customer and partners, allow the company to introduce several products to the market each year.

The company is primarily executing development projects by following a linear approach composed by four phases and five milestones. Nevertheless, the top management saw the opportunity to gain benefits from the adoption of the agile approach; therefore, they decided to start an initiative for adopting ‘agile ways of working’ in the company. The initiative was decided to be led by the IT function (a support function not fully integrated in physical product development) due to its experience and need to get closer to the business functions. Moreover, it was decided that the adoption would be carried out without modifying the company’s functional organizational structure. Recently, the initiative started to be implemented through the creation of agile teams composed by people from R&D and IT. The initiative is planned

to be extended to the other company functions. All these elements make this company very suitable for the purpose of this study.

The empirical data was gathered through fifteen semi-structured interviews with employees in different roles (functional managers, leaders, project managers, etc.) in different organizational functions (offer management, R&D, IT, and supply—a function including manufacturing operations). The interviews were conducted in English via a video-conference tool, and each of them lasted between 45 to 60 minutes. All interviews followed a predefined interview guide. Since the overall ambition of the research study is to explore how people in different organizational areas understand and perceive product development methods or practices, as well as their application, the interview guide was designed to cover different aspects of product development (e.g., critical decisions and activities, organization, and methodologies in PDS); however, it has an emphasis on experiences from or expected potentials of the agile approach. In this paper, the analysis focuses on factors to consider while adopting the agile approach in a PDS.

The interviews were video/audio recorded and complemented with written notes taken by the authors. As a first step, the notes taken by the authors were extended by listening and watching the interviews recordings again. Then, the notes were reviewed, and facts were identified based on explicit interviewees' answers to questions related to the adoption of the agile approach or based on their recurrence among different interviewees. Those facts were then grouped into factors according to their relations; the identified factors were organized according to the PDS subsystems. Finally, those factors were once again reviewed by the researchers. Those steps represent an iterative process in which the authors came back and forward as it was necessary.

For assuring the quality of the study some actions were performed. First, for improving reliability, interviews notes, transcriptions, analysis decisions, etc., were continuously discussed by the researchers. Second, for improving the study's validity, the interviewees represented key roles in the adoption of the agile approach in the company. Furthermore, the company was granted the opportunity to review the paper before it was submitted to publication.

4. Results and analysis

This section presents the study findings organized according to the PDS described by Morgan and Liker [12], who understand it as the integration of three subsystems, namely, people, process, and technology and tools. Excerpts of the empirical data that illustrates the findings are summarized in tables at the end of each subsection.

4.1. Factors to consider: the people subsystem

The first factor and one of the most mentioned among the interviewees is related to the cross-functional integration and coordination. Even though in general the company follows a linear approach when executing development projects, interviewees mentioned that functions adopt different approaches according to their work specialization. For instance, whilst the R&D function adopts a linear approach, the supply function adopts principles based on Lean Manufacturing, and the IT function adopts agile, linear, or hybrid approaches according to the project type. This may affect the coordination of cross-functional requirements because each of the functions creates requirements and expects deliveries according to the approach that it uses.

The second factor is related to cross-functional communication. The interviewees mentioned that, due to the work specialization of the functions, the employees adopt technical languages that affect the communication between different functions. Moreover, since the company's functions are located worldwide, that may influence the direct communication between the different functions.

The third factor has to do with the organizational culture which is characterized by being risk-avoidant and management-driven. On the one hand, having a risk-avoidant culture implies that the company is protective of what has been working well hitherto and that it is a slow-mover. That may influence the adoption of the agile approach in the company. As it has been mentioned, at the general level, the company is still working based on a linear approach. According to the interviewees, this approach has proved to be effective. Moreover, some interviewees mentioned the importance of having a linear approach for compliance with the ISO qualifications, management governance and control, and for having a common and simple internal language for knowing the status of the development projects. That perception of the effectiveness of the linear approach may influence possible changes on it.

On the other hand, being a management-driven company means that it is a company in which the employees expect managers to take decisions. That affects the empowerment of people, one of the agile principles, from two different angles. The first one is that employees do not dare to take decisions by themselves, and they think that - unless they are managers- they do not have the power to do so. The second angle is that, for taking decisions, the business strategic information is concentrated in strategic level, creating a barrier for the execution levels to access it, and consequently, creating a gap between the strategic and the execution levels. Adopting agile supposes higher accessibility to all information in the different organizational levels; that, from the managers' points of view, could be perceived as a loss of control and power.

The fourth factor is the understanding of the agile approach. This factor is further impacted by the fact that the organization has different teams working with agile in diverse maturity levels. Based on the conducted interviews, the understanding of agile may differ according to the function that people belong to. The different interviewees' understandings about agile vary from visual management, cross-functional work, continuous development, iterative way of working, mindset, among others.

The fifth factor is related to the definition of the roles and responsibilities. As it has been mentioned, the agile approach is being implemented by keeping the functional organizational structure; that means that roles such as line managers, project managers, will remain. Therefore, when adopting agile, it is important to consider those roles and how they would change. Questions regarding the redefinition of those roles and their responsibilities, and the scope of the agile teams, must be responded. Moreover, some interviewees mentioned that even though there has been (some) talk of the 'agile ways of working', they do not know exactly what it means and how it will change the way they perform their tasks and activities.

The last factor in the people subsystem is related to the people involvement and support. That factor is influenced by the source of the agile adoption initiative, meaning whether it is a top-down or a bottom-up initiative. For this specific case, the adoption of the agile approach is a top-down initiative, in which the top management decided to initiate a transformation towards 'agile ways of working'; all of that led by the IT function due to its previous experience with agile and its need to become closer to other business functions.

According to the interviewees, the fact that it was driven as a top-down initiative has made it more difficult to filter down to other organizational levels. Moreover, since the initiative is led by one specific function, it has been difficult to get other functions involved because they do not feel responsible for the initiative and because they are busy with their “day-to-day” work.

Table 1. Factors to consider: the people subsystem

Factors to consider: the people subsystem	Quotes – illustrative examples
Cross-functional integration and coordination	“Functionally we are a strong company. If you think on R&D in their own functions, they are quite strong; if you think in supply in their own function, which is machining mostly, we are quite strong, but we are not that integrated as a company [...] So we are not as good as, so to say, horizontally as a company. We are really good in our own functions, and we are efficient in that, but when it comes to the integration of the supply chain, we are not as good.” (Interviewee 14)
Cross-functional communication	“Communication! Design talks about designing language and production talk in production language, it is a bit tricky sometimes.” (Interviewee 6)
Organizational culture	“We talk about the core business. The core business is what delivers value, money, and protecting that one is very central to us. But that protective thing, is sometimes a little bit limiting because you have to be careful. That money generating motor has been exceptional for [...] years. So, you do not mess around with the business model without having a very good plan of what to do.” (Interviewee 8)
Understanding of the agile approach	“It is a bit tricky to understand the agile way of working, I think it is such a big shift for our company, and that is in all levels, IT organization and on the business side. We struggle a bit explaining why, why we are doing this [...] [there are a lot of things] that need to be explained.” (Interviewee 1)
Definition of the roles and responsibilities	“I have a question mark, how that will work and look like if we fully implement this agile way of working. Will it be something that us as managers will be involved in the delivery part? Because the line organization will be there, we will not move responsibility for people management [...] to the teams themselves [...]. So, of course, there will be a number of roles that will be affected [...]. It is really needed that we need to define the scope of those [agile] teams, so we understand what they will take responsibility for.” (Interviewee 03)
People involvement and support	“One of the issues that we are trying to solve is one of the issues that we are struggling with because we have an agreement on this level [strategic level] but it does not filter down to the bottom layer. When you come with this change it is really difficult to get people onboard.” (Interviewee 1)

4.2. Factors to consider: the process subsystem

The interviewees mentioned two factors that may influence the adoption of the agile approach and can be related to the process subsystem; those are, workload leveling and development interfaces.

First, the workload leveling factor can be reviewed taking different angles. The first angle corresponds to the initiation of projects. That is closely related to the mandate that each of the functions has. According to the interviewees, functions have enough budget and independence for starting their own projects, also called ‘line projects’, which has created an increasing incoming flow of projects. Itself, that may represent the creativity and entrepreneurship culture of the company; nevertheless, interviewees claimed that some of the functions lack personnel for carrying out that number of projects, causing a piling up of projects. This factor is exacerbated by the projects’ interdependencies.

According to the interviewees, the functions initiate projects according to their own priorities, and they do not always consider the business' priorities or the projects that are run by other functions, which may cause a lack of coordination among the projects.

Another angle for reviewing the workload leveling factor is related to the project definition and prioritization. On the one hand, interviewees mentioned that it is important to have a clear definition of what a project is, meaning when an initiative is complex and big enough for being considered a project, who should be involved, and so on. Currently, the company is categorizing as 'projects' initiatives that, according to the interviewees, should not be considered and treated as so; that ends up increasing the number of projects that are undertaken by the company. On the other hand, the interviewees mentioned that there is a need of having a strict and clear prioritization of projects. This prioritization must be aligned with the business goals and objectives, and coordinated with the interdependencies among the planned, undertaken, and completed projects.

The last angle encompasses the launching strategy and the way it affects the company's workload leveling. Based on the data collected during the interviews, for years the company has launched its products frequently; even though it has worked properly, it has affected the company's resource utilization. Due to its strategy, in some of the organizational functions the work is accumulated in certain periods of the year. Moreover, the launching strategy places pressure on having the products ready for the launching date because if the product is not ready for that date, it would be delayed until the next launching date. Even in some cases, the company has decided to launch the product although its development is not fully completed; that, in turn, creates the need of having further developments once the product is already in the market, which according to the interviewees, is more difficult.

The agile approach embraces a sustainable and constant pace of work, which may suppose changes in the workload leveling of the company, meaning in the initiation and prioritization of the projects as well as in its launching strategy.

The second factor is related to the development process interfaces. For instance, there are challenges when it comes to prototyping and industrialization activities. The interviewees mentioned that those activities require several manual tasks that are time-consuming. Moreover, they mentioned that, in some cases, the equipment that is used in prototyping is not the same that the one used in industrialization, creating discrepancies in the interfaces associated with those activities. Concretely about full production, the interviews said that some of the production steps require a 'trial and error' approach and need to be done in real production setting, which is costly and time-consuming.

Since the agile approach embraces changing requirements, even late in the development, it supposes the pass of the product through the interfaces several times, and consequently constant changes on activities such as prototyping, industrialization, etc. If those changes are made manually and take time, this factor ends up influencing the adoption of the agile approach.

Table 2. Factors to consider: the process subsystem

Factors to consider: the process subsystem	Quotes – illustrative examples
Workload leveling	“There are several functions, and the functions normally own their own projects, and they start a lot of projects. We start an enormous [number] of different projects, and we are not so many people, so it is piling up. It is fun to start new projects, but we are not so very good at closing projects. And if we have [considerable number of] prioritized projects, it is very difficult to get things done [...] You should not have so much on the table at the same time, especially if they are related or have implications on each other, then you get into big troubles [...]” (Interviewee 12).
Development interfaces	“I think the main challenges are the handover points. We have an R&D department, designing our products [...] and they are not located at the production unit [...], and then you have a handover to the production technology department, [which] is doing technology development and adapting the product to fit our processes. And then you have a handover to production. And [those] are two sort of handovers that not really go hand-in-hand, it is not that we develop a product, and then we industrialize it, so we do a lot of middle work.” (Interviewee 7)

4.3. Factors to consider: the technology and tools subsystem

The technology and tools subsystem encompasses two main factors, the integration of the information systems, and the technology readiness level (TRL) and manufacturing readiness level (MRL). For the first factor, it is important to mention that the company has several legacy information systems which have been developed by itself over the years. Nevertheless, those information systems are not always integrated, meaning that for taking decisions, people must aggregate the data from several systems to achieve the right information. In that matter, the company is currently undertaking an initiative for implementing an ERP system developed by an external organization. The interviewees mentioned that the system encompasses several interfaces that cover most of the functional areas, which will support a transparent flow of information among them and other organizations.

Nevertheless, there are concerns regarding the future limitations of the ERP and the required demands from the different functions. Some interviewees are concerned about relaying the business into a system that might be not flexible enough for coping with the future demands and changes of the business and the ‘agile ways of working’. For instance, one interviewee pointed out that setting up teams and managing the coordination and dependencies between them may be challenging when having an ERP platform.

The second factor related to the technology and tools subsystem has to do with the TRL and MRL. The company has decided to reach a readiness level of at least six for implementing new technology. According to the interviewees, during the feasibility check in the initial phases of the development projects, there is an over expectation when defining the time for reaching the required TRL and MRL; in some cases, the reaching of those takes more time than expected, which causes delays in the overall development project. Moreover, there are discrepancies between the TRL and MRL, meaning that even though the TRL is fulfilled, it can take years until the MRL reaches the required level to implement the new manufacturing technology. This discrepancy clearly implies a linearity in the development process that can limit the use of the agile approach.

Table 3. Factors to consider: the technology and tools subsystem

Factors to consider: the technology and tools subsystem	Quotes – illustrative examples
Integration of information systems	“So [the information systems] is a project planning and project execution tool [...]. Then you have the HR system [...] and then you have the financial system [...]. So, all of those need to be combine and integrated [...] but not always they are fully integrated to each other and harmonized. That means, you have local drivers, local controllers, and if you are running a project for a product development in several sites, you have to integrate those with each other as well.” (Interviewee 10)
Technology and manufacturing readiness levels	“We have the technology readiness level, and we have what we call MRL, manufacturing readiness level. So, it can be that you have a technology readiness level of six, but the manufacturing level is on two, because nobody has the capability to produce it in the factory in the way that you would like to have. So, you have the TRL OK, but you have the MRL, which is another type of people, another type of thinking, that they need to adapt the machines, adapt the process to make this technology [...]. So, usually proving the technology is easier because it is a small factory we have here, but then, if you would like a big factory, you would need to fulfill other kind of requirements.” (Interviewee 5)

5. Discussion and conclusions

The current business context recalls for new approaches to PDS. In that matter, due to its benefits in the software industry, the agile approach has raised interest among researchers and practitioners in the manufacturing industry. Nevertheless, there are several factors that companies need to consider when adopting the agile approach.

By studying a large manufacturing company that is undertaking an agile transformation initiative, this paper presents factors that may influence the adoption of the agile approach in a manufacturing context. Those factors were categorized by using the PDS introduced by Morgan and Liker [12], which is composed by three subsystems: people, process, and technology and tools.

For the people subsystem, the present study identifies factors associated to (1) cross-functional integration and coordination that is related to the different specific approaches that the functions adopt according to their work specialization; (2) the cross-functional communication which is affected by the functions technical languages and company's worldwide location; (3) the organizational culture that is characterized for being risk-avoidant and management-driven, which prevents the company to undertake new changes and to empower people to take decisions; (4) the understanding of the agile approach which is related to the difficulties to define and explain the agile approach, as well as the different agile maturity levels in the different functions; (5) the definition of the roles and responsibilities, meaning the clarification of how the different organizational roles may change when adopting the agile approach; and (6) people involvement and support, which has to do with the source of the agile adoption initiative and how it can be filter across the whole organization.

Regarding the process subsystems, two factors are identified (1) workload leveling, which is related to projects initiation, definition and prioritization, and the company's launching strategy; and (2) the development interfaces, their challenges, and how they affect execution of the development projects. Those factors influence the incorporation of agile principles related to sustainable and constant pace of work and changing requirements, respectively, and consequently the adoption of the agile approach.

Third, the technology and tools subsystem covers factors related to (1) the integration of information systems through an ERP system, and its potential benefits and limitations when coping with future requirements of the business and the ‘agile ways of working’; and (2) the technology and manufacturing readiness levels, the potential discrepancies between them, and how the linearity that they suppose might influence the adoption of the agile approach. The Figure 1 exhibits an overview of the identified factors and their respective PDS subsystems.

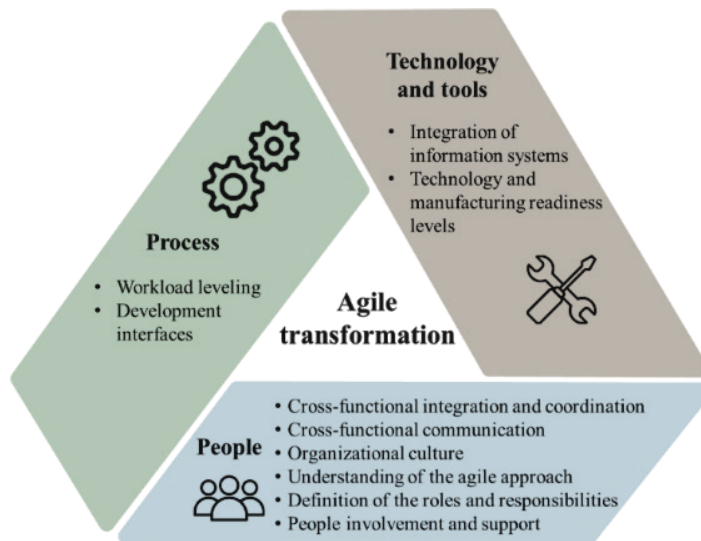


Figure 1. Factors to be consider when adopting the agile approach in manufacturing companies.

Some of the identified factors confirm findings in prior studies. That is the case of the organizational culture, which in the company is characterized by being risk-avoidant and management-driven. Being risk avoidant is related to the “fear to failure” culture, and being management driven is related to the team empowerment to make decisions and the accessibility to strategic information, which are identified by Conforto et al. [14] and Sommer et al. [6], as factors that influences the adoption of the agile approach. Another repeated factor is related to the people involvement, albeit with a different direction. While authors such as Edwards et al. [5] point the importance of the management involvement and commitment, the findings of the present study point to the difficulties to involve people at lower levels in the organization when it is a top-down initiative led by one specific function. Factors related to the process and technology and tools subsystems have not been mentioned in the reviewed literature. Further investigation is needed to establish whether they are general or specific to the studied company.

As it can be seen from Figure 1, most of the factors belong to the people subsystem. Bearing in mind that this paper presents a preliminary analysis of the empirical material, one should be cautious to draw any conclusions from that. Still, it may indicate that the people subsystem is critical to address for a company that intends to make an agile transformation, where aspects related to leadership style, organizational structure, organizational culture, among others, should be addressed.

It is important to mention that the identified factors are not independent of each other; contrarily, they may overlap or be interrelated within and between the subsystems. For instance, the people involvement and support may be impacted by the understanding

that functions have about the agile approach, or the factor development interfaces may be related to the factor cross-function integration and coordination. Moreover, the study indicates existing and future-oriented factors; for instance, while cross-functional communication is an existing factor because it is a situation that is happening, the definition of the roles and responsibilities is a factor that the company must consider in the future, thus it is future-oriented.

The study contributes to the establishment of the factors that may influence the adoption of the agile approach in the PDS of a large manufacturing company. It also contributes to practitioners as factors may function as a “check list” when entering in an agile adoption initiative. Further studies are needed to confirm those factors and to identify more, also to see whether any of the subsystems are more critical than others.

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