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Operationalizing Agility Improvement Through a Process-Oriented Framework – What Do Practitioners Think?

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Abstract

Agility is a major concern for enterprises across manufacturing and service sectors. This paper supports the claim that process-oriented approaches are useful for agility improvement projects. It builds on an existing process-oriented framework for agility improvement projects to identify agility enabling principles and tools in manufacturing. Collectively, the framework processes, enabling principles and tools contribute the operationalization of agility improvement initiatives. Surveyed practitioners' confirm this general finding as well as the relevance of the framework to middle management, in particular in Small-and-Medium Sized enterprises.

Keywords
Processes, agility, manufacturing, projects, improvement.

1. Introduction
Agility as a concept has been examined in various contexts, including business, enterprise, organizational structure, workforce, information technology, manufacturing, supply chains, and software development (Llamas et al., 2016). It is considered the main strategy for organizations to compete successfully in an unpredictable and constantly changing market (Tseng and Lin, 2011). In manufacturing, agility involves the development of tools and processes designed to empower organizations with the capability to rapidly adapt to consumer demands and evolving market conditions, while maintaining consistent oversight of quality and operational requirements (Sharma et al., 2022). Agile manufacturing is a strategic approach, supported by four core principles: enhancing customer value with unique products offered at mass production costs, structuring operations to excel amid change by competing across various domains with adaptable resources, fostering cooperation both within and between enterprises, and capitalizing on organizational knowledge through cutting-edge technology. Given the rise in market volatility, companies are encouraged to adopt agile manufacturing practices. However, it is difficult for an enterprise to achieve agility due to the lack of an efficient approach for agile development planning (Tseng and Lin, 2011).

The process approach, as explored in (Lahlou et al., 2023), is defined as a key strategy for enhancing operational agility in manufacturing, focusing on process modeling, performance measurement, and the integration of advanced information systems. It has shown success in improving efficiency, reducing cost, as well as enhancing customer satisfaction through upgraded product quality and faster delivery times, thereby reinforcing the agility of manufacturing organizations. Business process reengineering as the rethinking and redesign of business processes to achieve substantial improvements in key performance metrics, involves quickly adapting to changing market demands and customer needs by improving the flexibility and responsiveness of manufacturing processes.

This paper uses a reference a published framework consisting of ten processes including three scope processes, defining what to focus on in the project and seven processes to structure the improvement project (Medini, 2023). The framework aims to support improvement projects within a tactical horizon ranging from few months to two years. Agility improvement projects aim in turn, to pave the ground for continuous improvement towards agile manufacturing within a company or group of companies. This is in line with the agile manufacturing philosophy shifting the improvements from large and long-term projects controlled by few people to more frequent activities involving all company staff (Duguay et al., 1997; Gunasekaran, 1999; Bottani, 2010). Mapping this positioning to decision levels, the framework developed by Medini (2023) is expected to support middle management in implementing strategies and visions coordinated by top management (Stathakopoulos et al., 2019).

Agile manufacturing is inherently an interdisciplinary concept. Literature embraces several domains such as product and process development, information systems, intra and inter-firm collaboration, governance, requirements engineering, etc. Therefore, a value chain approach seems appropriate to define agile manufacturing projects scope, in the sense that it allows to go beyond traditional cost-centric logic. Porter (1985) structures value chain activities into generic categories grouped into primary (Inbound logistics, operations, outbound logistics, marketing and sales, and service) and secondary activities (procurement, technological development, human resource management, and firm infrastructure). According to commonly accepted agility definitions, all these areas are affected by and contribute to agile manufacturing. Porter model provides a shared understanding of the value chain but it has several limitations. These include a focus on a single company and on cost perspective of the value. Several research works were published ever since and introduced some extensions of Porter value chain concepts (rather than its general framework) (Stabell and Fjeldstad, 1998; Fearne et al., 2012). Following these extensions, current study adopts the vision of value chain as a series of inter-firm value adding activities generating, in a collaborative way multi-dimensional value for customer and other stakeholders.

The current paper uses the framework reported in Medini (2023) to identify and map agility enabling principles and tools to each of the framework processes. Practitioners from the manufacturing sector evaluated the processes along with the identified principles and tools. The findings confirm the relevance of the framework to agility improvement. They underline the relevance of the framework to middle managers in particular in Small-and Medium Sized companies.

The remainder of the paper is organized as follows. Section 2 presents the research design. Section 3 reports on enabling principles and tools identification. Section 4 analyses practitioners' feedback and briefly discusses the findings. The paper ends with concluding remarks in section 5.

2. Research design

Agility enablers and tools are identified from previous literature; in particular, 1) some seminal research works about agile manufacturing and agility in general, e.g. agility drivers (Zhang and Sharifi, 2007), tools for implementing agility (Dowlatshi and Cao, 2006; Bottani, 2010), 2) project management body of knowledge (Project Management Institute, 2017), and 3) additional research works providing illustration of methods and tools applied in similar contexts.

In order to evaluate the processes of the framework proposed by Medini (2023) together with enabling principles and tools, the authors used the questionnaire developed by Medini (2023). A Likert scale was used to assess respondents' agreement with the validity evaluation criteria of the framework. These criteria include intelligibility (i.e., the extent to which the framework is clear and related vocabulary is understandable), practicality (i.e., the extent to which the framework is easy to be applied), complementarity with existing practices, tools, and methods (i.e., the potential of reusing existing, practices methods and tools), and finally, agility improvement potential (i.e., the potential of to contribute to agility improvement). The questionnaire was sent to more than 500 potential respondents from the manufacturing sector and belonging to different management layers, e.g. Chief Operation Officer, Head of Department, Director, Section Chief, etc. This resulted in 107 complete and exploitable answers.

In order to explore possible impact of respondents' contexts on the evaluation criteria, correlation analysis and decision trees are considered. However, the former was quickly excluded since several variables representing the rates failed the normality test. Consequently, the only analysis, which will be detailed in the following, is based on decision trees, which employ a tree-like model structure for deducing decision-making processes and their potential outcomes (Breiman et al., 1984). Decision trees method is widely used in machine learning and other fields such as operations research. This method is seen to be suitable for the current study due to its intelligibility and ability to handle qualitative (i.e. job, experience, company size) and quantitative variables (i.e. rates of the activities and of the guideline). In a decision tree, variables are organized at the nodes in order of their impact, while the branches are marked with the values that differentiate the variables at each division point. The leaf nodes represent the outcome of a given path represented through boxplots illustrating the average rates. The decision trees are generated to explore the most influencing factors affecting respondents' views on aspects like the intelligibility, practicality, and relevance of the guidelines to agility, as well as their compatibility with existing practices. In the current study, the trees are generated using the rpart package (Recursive Partitioning and Regression Trees) available from R software repository (Therneau et al., 2019).

3. Agility enabling processes

This section elaborates on a generic pool of enabling principles and tools of the framework processes, which are exemplified using a basic and comprehensive scenario for agility improvement. While the description of these processes is presented in a sequential manner for ease of comprehension, it is important to recognize that in a practical setting, these processes are not strictly linear, they are recursive and frequently overlap, reflecting the dynamic and iterative nature of the framework.

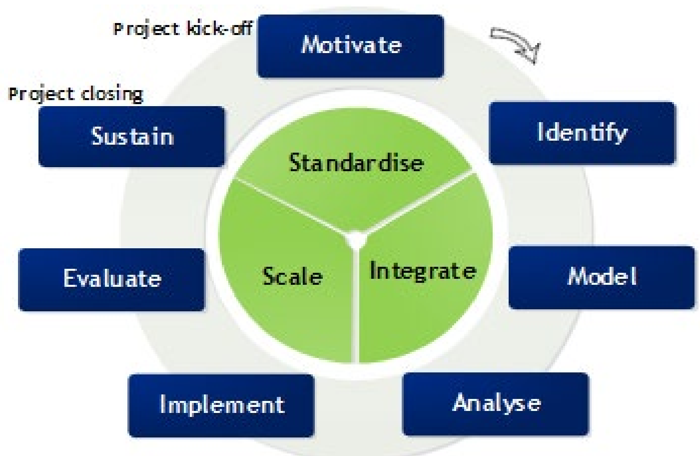


Figure 1. Agility enabling processes, adapted from (Medini, 2023)

Figure 1 visually encapsulates the agility-enabling processes outlined in this section. Adapted from the work of Medini (2023), it serves as a conceptual map, guiding the improvement of agility within production systems.

Motivate can be supported by establishing a business case to justify agility improvement project. The business case should reflect agility priorities as per the company strategy and should be justified based on customer or market requirements, organizational needs, sustainability or legal requirements (Project Management Institute, 2017). Therefore, partnership with customers and suppliers, team-working recognition and reward systems, inspiring management (Zhang and Sharifi, 2007) play an important role in motivating project stakeholders. To complement these efforts, incorporating agile project management practices can further enhance stakeholder motivation by embracing flexibility, iterative progress, and responsiveness to change (Loiro et al., 2019).

This process should be carried out throughout the project by managing stakeholders' engagement and communication (Project Management Institute, 2017). Nudurupati et al. (2021) argue that organization goals should be defined in generic terms and the solution needs to be continuously adapted to the evolving outcome expectations. This articulates perfectly to agility context with demand uncertainty and lack of process knowledge. As a tool, it is considered that management information systems are important to keep stakeholders informed and more generally to create and readily share knowledge.

After obtaining stakeholders' buy-in, project team could move to identify requirements of the relevant stakeholders during Identify process. Customer involvement is a key for this process. This involvement can be supported by tools such as Quality Function Deployment (QFD) (Bottani, 2010), as well as predictive analytics (Table 1).

Table 1. Enabling processes, principles and tools of agile production

Processes	Enabling principles	Enabling tools
Motivate	Business case, effective communication, reward system, inspiring management, partnership, Agile Project Management	Management information system
Identify	Customer focus, customer involvement	Quality Function Deployment (QFD), Predictive Analytics
Model	Information system and traceability	Visualization techniques, Computer aided design (CAD), computer aided manufacturing (CAM),
Analyze	Regular benchmarking Agility strategies and technologies Six Sigma Methodologies Lean Manufacturing Principles	Time-value analysis, Virtual prototyping, Simulation , Value chain analysis,
Implement	Change management	Project management techniques
Standardize	Mass customization enablers	Electronic data interchange, Customization Software
Integrate	Vertical integration, total integration Information system and traceability	Intranet and extranet connections Enterprise Resource Planning (ERP), Internet of Things (IoT)
Scale	Agility strategies and technologies Sustainable Production Practices	Computerized numerical control (CNC) machines, Flexible manufacturing systems (FMS), Automated assembly tools
Evaluate	Information system and traceability, business analytics	Financial and non-financial measures Information technology, Business Analytics
Sustain	Total quality management (TQM), continuous improvement	Training

Once a first set of requirements is clearly defined and understood by the project team Model process can be started. Traceability of the processes and of the changes, ensured by enterprise information system usually allows for tremendous savings of time and cost of the modelling activity (Zhang and Sharifi, 2007). Computer aided design (CAD), Computer aided manufacturing (CAM) and visualization techniques are examples of the useful tools for modelling (Bottani, 2010; Bertoni and Bertoni, 2013). Modelling allows to build the big picture of the as-is situation of the system in question (e.g. product development process, value chain, etc.).

In order to move forward with the improvement actions, analysis should be conducted (Analyse). Regular benchmarking and awareness of agility related strategies and technologies (e.g. Advanced Manufacturing Technologies (AMT)) support this activity (Zhang and Sharif, 2007). Authors such as Stabell and Fjeldstad (1998) promote value chain configuration analysis as means to understand and improve firm's value creation logics. Building on Porter model of value chain (Porter, 1985) they identified three distinctive value chain models namely, chain (transforming inputs into outputs) shop (problem solving) and network (connecting customers). Fearne et al. (2012) discussed how value chain analysis should evolve to consider a broader vision of value creation involving sustainability pillars and multi-stakeholders. Tools such as time-value analysis, virtual prototyping help as well conduct the analysis (Bottani, 2010; Fearne et al., 2012). Furthermore, simulation is among the widely used approaches for the analysis of systems' performance in agile manufacturing (Ruiz et al., 2009; Ferreira et al., 2020).

To further refine the Analyze phase, integrating Six Sigma Methodologies as well as Lean Manufacturing Principles can be highly beneficial, leading to more predictable and efficient manufacturing processes

Implement process follows the analysis where the actions identified for improvement are put into practice. The nature of actions depends heavily on the scope of the project, for instance, standardization, integration or scaling. However, one important enabling principle is to streamline processes as much as possible and focus on change management (Project Management Institute, 2017). During this phase, the use of project management skills, such as facilitation and problem-solving, is also critical to the successful execution of the project.

Mass customization paradigm comes with several practices supporting standardization in general and in particular Standardize process of the framework (Gunasekaran, 1999; Zhang and Sharifi, 2007). Examples of these include modularization and commonality (Lyons et al., 2012; ElMaraghy et al., 2013). The standardization paves the ground for smooth intra- and inter-firms integration. This supports Integrate process of the framework, through vertical and total integration, information system integration and traceability, for instance (Zhang and Sharifi, 2007; Wang, 2009). Intranet and extranet connections, Enterprise Resource Planning systems (ERP) are examples of tools supporting the integration as well as Internet of Things (IoT) which plays an important role in collecting and exchanging data. Once standardization and integration activities are conducted, it becomes more straightforward to scale up or scale down, referred to as Scale process (Vernadat, 2020; Schmitt et al., 2018). This process requires the company to be aware of the agility related strategies and technologies (e.g. high-volume low-mix, low-volume high-mix, step-by-step ramp-up strategies (Slamanig et al., 2011)). The implementation of these strategies relies on tools such as automated assembly systems, Flexible Manufacturing Systems (FMS), Computerized Numerical Control machine (CNC) (Bottani, 2010).

The implementation of standardization, integration, or scaling requires the Evaluate process to measure the success and refine/adapt the project scope if needed. This evaluation depends heavily on the information system, which supports data collection and processing (Zhang and Sharifi, 2007). Gunasekaran et al. (2018) highlighted the role of information technology in general and big data and business analytics in enhancing agile manufacturing and enriching decision-making processes. Complementarily, suitable indicators should be selected for performance monitoring, which include financial (e.g. return on investment, sales, etc.) and non-financial ones (e.g. product development time, time to market, manufacturing cycle time, etc.) (Bottani, 2010). Sustain process is concerned with sustaining improvement actions and relies on deriving lessons learned and defining work procedures, and on continuous training of the staff regardless of their positions (Zhang and Sharifi, 2007). Complementarily, introducing approaches such as Total Quality Management (TQM) and reinforcing continuous improvement culture are a key to sustain agility improvement results (Bottani, 2010).

4. Practitioners feedback analysis

The ANOVA (Analysis Of Variance) method was used for results analysis. The aim is to only provide general insights into most influencing factors, therefore, further comparative analysis of several methods and techniques is deemed unnecessary. The decision trees are presented in Figures 2 to 4. Looking into the decision tree of the relevance to agility criterion (Figure 2) we can notice that the experience is the most differentiating factor of respondents' judgements. In fact, the average rates given by respondents with less than 5 years of experience are generally higher than the ones coming from respondents with more experience, although all rates remain generally above 4. This can be partly explained by the attractiveness of agility concept to junior engineers and practitioners in general. One of the possible reasons is the increasing integration of agility concepts in many engineering curricula.

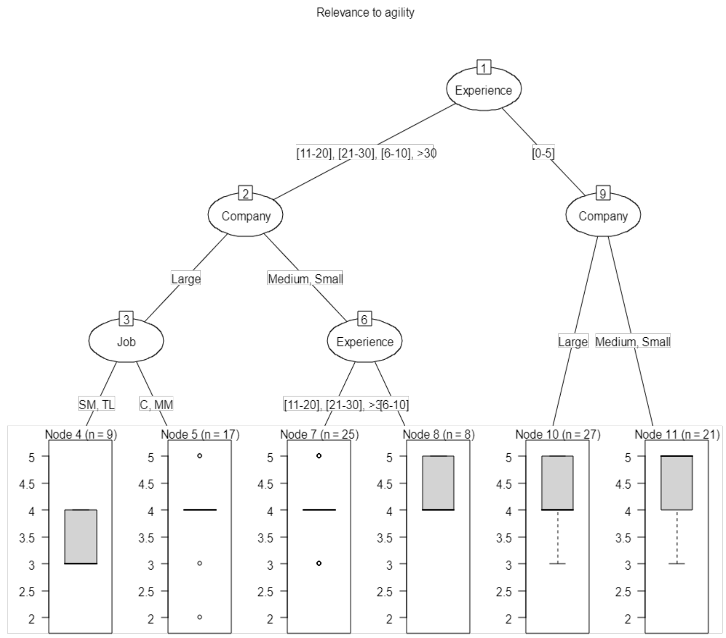
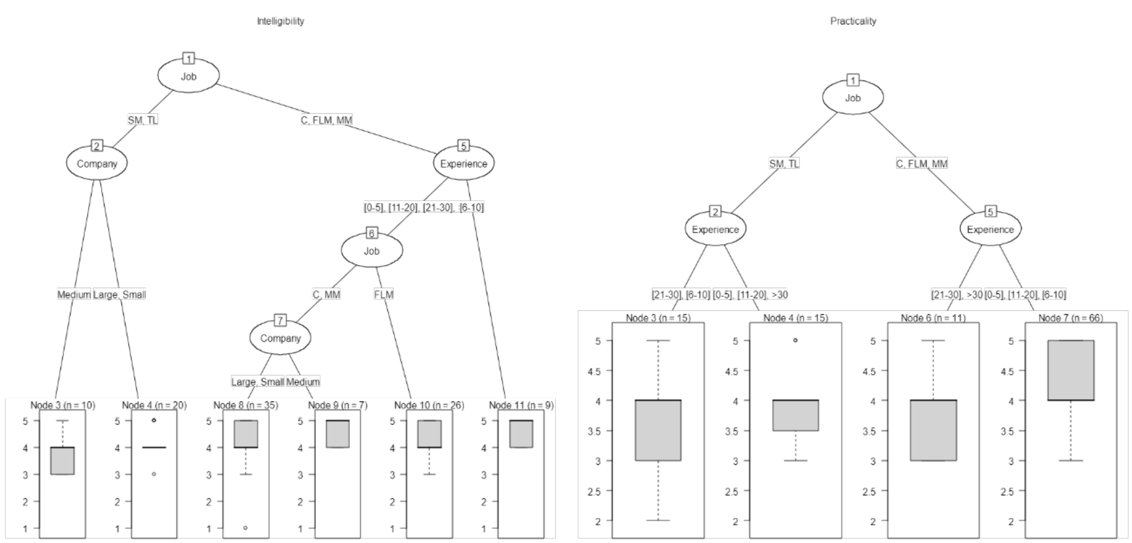


Figure 2. Decision tree of the criterion *Relevance to agility*

In terms of intelligibility and practicality (Figures 3a and 3b), the first differentiating factor is the job category. Interestingly, consultants, middle managers, and first line managers find the guideline more intelligible and practical than senior managers and team leaders do (although all average rates remain generally above 4). This is not contradictory with the rationale of the guideline, intended mainly to support middle management. As seen in Figure 4, generally, respondents are aware of the complementarity of the guideline with existing tools, in particular the ones with less than 20 years of experience. Company size is identified at the second level nodes of the trees as a differentiation factor (Figures 2, 3a and 4). Two clusters can be highlighted, SMEs (including small and medium enterprises) and large companies.



(a) (b)

Figure 3. Decision tree related to (a) *Intelligibility* and (b) *Practicality* criteria

Generally, the rates are slightly higher in the case of SMEs than in large companies, which may reflect possible adequacy of the processes and enabling principles and tools to this category. Another possible explanation could be related to well established procedures and lack of flexibility in large companies making it difficult to adapt to new methods. As a matter of fact, in Figure 4, the leaf node on the left hand side of the decision tree about complementarity with existing tools shows the lowest average rate (although it remains above 3). This means respondents from large companies cannot easily perceive the complementarity of the guideline with existing practices. However, this should be explored further since average rates of respondents coming from both SMEs and large companies are generally above 4 for other criteria.

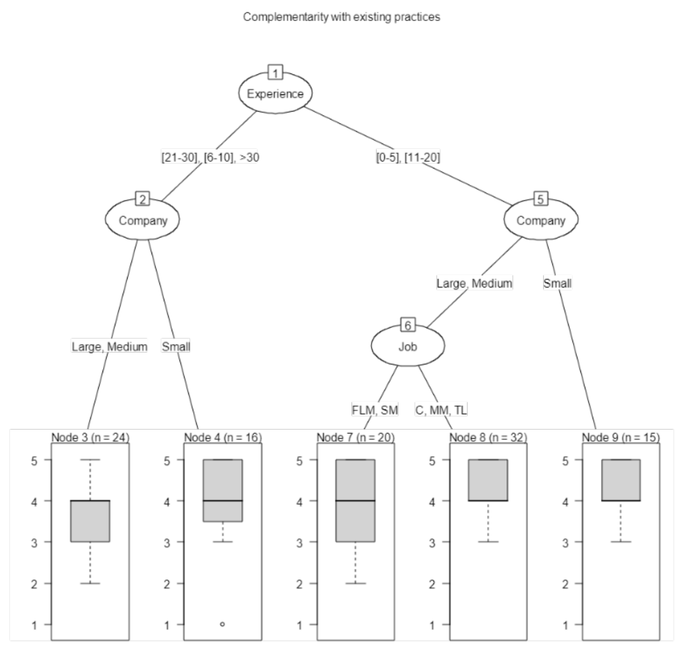


Figure 4. Decision tree of the criterion *Complementarity with existing practices*

One interesting perspective is to refine the mapping of the processes to the enabling principles and tools. This should consider two main factors, company size and manufacturing activity sector. Exploring these perspectives will help provide further guidance to customize the guideline, thus reinforcing its practicality. Another research avenue involves tailoring the processes, principles and tools of the framework to specific projects considering readiness of the company with regard to agility. This could benefit from existing and abundant research works about agility assessment, e.g. alternatives evaluation in a mass customization context (Ren et al., 2009), supply chain agility index (Lin et al., 2006).

One research perspective involves capitalizations and reuse of experiences all along processes to achieve agility. By capitalizing and reusing experiences and knowledge, organizations can continuously improve their processes and adapt to changes in the marketplace (Llamas et al., 2016). In fact, knowledge management can play an important role in improving the way agility improvement projects are planned and executed. Knowledge management practices, such as knowledge sharing and knowledge creation, are positively associated with agility in manufacturing organizations. They help organizations better understand and respond to changes in their environment, which is a key aspect of agility (Soltaninezhad et al., 2021). By facilitating knowledge sharing and collaboration among project team members, project team members will have the information and expertise they need to make informed decisions and take appropriate actions.

5. Conclusion

The paper builds on existing literature as well as empirical investigation to provide a comprehensive framework for planning, implementing and sustaining agility improvement actions. Framework processes, enabling principles and tools help ensure an incremental and sustained progress in the agile production path. Practitioners' feedback confirmed the relevance of the framework to agile production and uncovered some promising research avenues such as tailoring the framework.

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