Supporting agile innovation and knowledge by managing human resource flexibility

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1. Introduction

Agile approaches to innovation and new product development (NPD), -self managed teams making rapid innovations experiments with customer involvement at every stage-, have been a mainstay of the software industry since the turn of the XXI[st] century with the *Agile Software Movement*. Nevertheless, organizations outside this industry have been painfully slow to adopt agile practices for innovation management, largely because they disrupt the established product development processes. While both agility and innovation are considered key capabilities for a firm's performance in today's turbulent environments, their interplay, i.e., the use of agility in the innovation process, has been little studied outside the software industry (Beaumont *et al.*, 2017). Recently, some non-software companies like Hewlett-Packard, Adidas or Lego have successfully combined agile and non-agile methods in a complementary way to pursue innovation (Denning, 2012; Cooper and Sommer, 2016, 2018; Birkinshaw, 2018; Rigby *et al.*, 2018). However, not all agile experiences are positive and agile practices may sometimes difficult "individual learning, ideation, and exploitation capabilities" (Annosi, Foss and Martini, 2020, p. 61), because there are not defined structures or standardized managerial practices to handle hybrid approaches (Eljayar and Busch, 2021).

The purpose of our paper is to analyze how the firm's level of human resource (HR) flexibility and absorption capacity (AC) of knowledge may support agile innovation. We base our discussion and conclusions on a meta-analysis of the Web of Science's Collection in the period 1997-2021 to develop research propositions and outline some organizational changes and analytical tools to pilot transitions to agile. The focus, first, on HR flexibility is because employee matters are one of the main pillars of agile innovation and a driver of organizational changes (Krstić, Skorup and Lapčević, 2018; Walter, 2021; Melián-Alzola, Domínguez-Falcón, & Martín-Santana, 2020). The way to manage HR flexibility is a key element of innovation processes since the tacit knowledge that resides in multi-skilled employees and external research and development (R&D) experts is required to accelerate sprints (iterations in agile innovation). At the same time, the performance of agile innovation teams relies on peer-to-peer interactions of knowledge exchange and, as a consequence, how the firm develops and manages its AC may facilitate transitions to agile. The way to absorb external knowledge and managing employees' contributions to new products and processes are key elements of innovative organizations (Cohen and Levinthal, 1990; Sjödin, Frishammar and Thorgren, 2019).

There are already studies that have analyzed the relationship between HR flexibility and innovation, and also between AC and innovation. A few of them have even explored interrelationships among these variables but all of them have been carried out in the context of traditional stage-gate innovation projects but not within agile innovation outside the software industry (Beaumont *et al.*, 2017). Although a few manufacturing companies have adopted agile methods to accelerate their innovation processes (e.g., Cooper ad Sommer, 2018; Lichtenthaler, 2020), there is a lack of empirical studies that analyze the interrelationships of HR flexibility, AC and agile innovation in manufacturing.

Then, the specific purpose of this paper is to study the differences of HR flexibility and AC in agile innovation versus traditional stage-gate innovation (Cooper, 1990) in manufacturing contexts. However, this is not an empirical study but a first step towards that goal throughout a meta-analysis

of the Web of Science Collection (period 1997-2021) that enables to develop research propositions and a framework of analysis to pilot transitions to agile in manufacturing innovation according to the firm's levels of HR flexibility and AC. The research propositions are important to, according to the meta-analysis results, further validate which HR flexibility dimensions are the most beneficial when agile initiatives are adopted in the innovation process. In turn, the proposed dynamic evolution towards agile innovation may contribute in two different ways to the diffusion of agile innovation practices in manufacturing. First, it would help managers to link innovation and HR strategies along the firm's transformation path to agile. Second, the right combination of HR flexibility and AC would anticipate the level of competitive advantage that can be created through each typology of agile innovation.

There are five sections in the paper. After this introduction, we describe in brief the concepts and instruments related to agile innovation, HR flexibility and AC. The third section explains the meta-analysis carried out to develop the fourth section's discussion about how HR flexibility and AC may support agile innovation. The fifth section outlines a matrix of transitions to agile from different types of innovation and explains some analytical tools that can be helpful for managers to pilot transitions: metrics and organizational changes and practices. We end with concluding remarks and future lines of research.

2. Agile innovation, knowledge and human resources flexibility

For those who may be unfamiliar with these concepts, this section briefly describes the main concepts and instruments related to agile innovation, HR flexibility and AC that will be used in the meta-analysis for the construction of research propositions and a framework of analysis to pilot transitions to agile.

2.1. Agile innovation in manufacturing

Agile capabilities -held by firms ready to embrace the change with rapid and proactive responses to their environment- may be found in different areas such as supply chain, manufacturing, innovation, human resources or strategy, to name a few. We focus on agile innovation that has its roots in the *Agile Software Movement*, initiated in 2001 by a group of programmers who proposed a new way of organizing their work (Beck, K., Beedle, M., van Bennekum, A., Cockburn, A., Cunningham, W., Fowks, M, Greening, 2001). The agile philosophy asked organizations to work collaboratively as much as possible with the entire organization and users to provide ideas and solutions while unlearning, learning and relearning along the way (Boccardelli *et al.*, 2017).

Following the experience from the software industry, hybrid and parallel models that integrate agile methods with traditional gating approaches or run them side by side have been used by some manufacturing and services international firms (e.g. Beaumont *et al.*, 2017; Rigby *et al.*, 2018; Lichtenthaler, 2020). A gating process is a disciplined approach to NPD that breaks every project into discrete stages from idea to launch with clear objectives in terms of what is required to move forward to the next stage. For instance, by combining agile and stage-gate models, Cooper and Sommer (2016, 2018) reported benefits such as much more responsiveness to changing customer needs or reduced cycle time.

There are several agile methods. One of the most frequently used is the agile-scrum method (Figure1), a series of rapid, iterative learning loops or sprints of about 2-4 weeks in length. At the beginning of each sprint, the product development team holds a short planning session to define the specific goals such as a list of product features to be developed in the next 2-4 weeks and map out how the team will achieve those goals. Once the sprint starts, daily short (i.e., 15 minutes) stand-up meetings, called scrums, are held where each team member explains which problems they have and what they did since the previous 24 hours and what they will do in the next 24 hours.

Figure 1. Agile-scrum elements

The result of each sprint is a tangible output that is a potentially releasable product (although it usually takes several sprints to create a real deliverable). When the sprint ends, the team shows the result to the customer (or to an internal stakeholder who is acting as the customer) and seeks feedback and validation; negative feedbacks may require changes in requirements or even in direction. Then, the next sprint initiates with a new sprint planning session and the entire cycle starts again. And so the product development team moves quickly, sprint by sprint, scrum by scrum, until a goal is achieved. The learning process is also iterative because reoccurring reflections help to adjust the team behavior in agile methods (Karrbom Gustavsson and Hallin, 2014). Even though there are a few other agile methods available, we will keep the agile-scrum in mind throughout most of our discussion because of its implications to HR flexibility and knowledge management.

There are already a few agile innovation experiences outside the software industry. For instance, an automobile prototype called *Wikispeed* (Denning, 2012) was developed in just three months using off-the-shelf parts and achieved their goals on a shoestring budget by using the agile

innovation elements (https://wikispeed.org/). Some manufacturing firms have integrated agile into stage-gate traditional models (Cooper and Sommer, 2016) like the Danish firm LEGO that incorporated sprints and scrums into the *Story Starter* project during the development and implementation phases with the participation of teachers from more than 50 schools in product trials who enhanced team members' productivity due to much better communication. The international bank BBVA started agile innovation in 2014 with the first sprint-scrums that develop a mobile app and five years later, in 2019, was the first large Spanish firm to implement agile worldwide with agile teams and communities of experts that share knowledge and develop solutions for the entire group.

Other firms incorporate agile only just before or right after the main stage-gate NPD (hybrid agile innovation) like the sportswear manufacturer Adidas that rely on agile ideation in the early phases of innovation: they leverage the benefits of sprints and immediate customer feedback before developing their innovations with their established gating processes. Similarly, innovation managers may use agile after gating to immediately respond to customer feedback in new product launch activities in order to make late adaptations. There are firms like Hewlett-Packard that have a partly parallel agile path along the stage-gate process (parallel agile innovation) and set guidelines to help the project team choose the right product development model. In any case, either of these approaches (agile within gating, agile before gating, agile after gating, or agile alongside gating) have implications for the management of HR flexibility and AC.

2.2. HR flexibility and knowledge management for agile innovation

The next paragraphs address the role of HR flexibility and the AC of knowledge that we analyze in the context of agile innovation. It is even more important to define the concepts of HR flexibility and AC because they are core elements in the meta-analysis that will develop the research propositions and conclusions of the paper.

Starting with HR flexibility, firms usually rely, when needed, on internal and external sources of flexibility (Atkinson, 1984). Internal HR flexibility contributes to increase the firm's ability to adjust uncertainties by modifying the employees' level of skills or the organization of work, whereas external HR flexibility uses changes in the external labor market through temporary employees. Employers and unions also differentiate sometimes between numerical flexibility (variation in the number of employees or working hours) and functional flexibility (enhancing the multiskilling level of employees or hiring external R&D experts).

These categories of HR flexibility have been commonly used in practice but there is another way to differentiate between dimensions of flexibility that is more suitable for our discussion. That would be to distinguish how each HR flexibility dimension can contribute to develop, absorb or diffuse knowledge inside the firm. Innovative firms invest in in-house R&D but also use external knowledge. However, firms cannot benefit from external information, unless they have the capacity to recognize and integrate external knowledge within the firm's internal innovation processes. That capacity is entitled absorptive capacity of knowledge (AC), and it is a dynamic capability of firms because it can change depending on their organizational life and strategic factors.

According to the knowledge-based view of the firm (KBV) that highlights the relevance of a very rare and valuable resource -the firm's knowledge (Barney, 2001)-, we might expect that those HR flexibility dimensions abler to enhance knowledge's development and diffusion should be in a better position to contribute more in innovative environments. A firm's knowledge is a strategic resource based that it is developed from the employees' tacit knowledge because it is not easy to observe and codify for subsequent uses which makes it more difficult to imitate by other firms (Grant, 2013), and provide sustainable competitive advantages.

Some HR flexibility dimensions like multi-skilling or hiring external R&D experts are highly intensive in knowledge whereas others can be categorized as low-knowledge dimensions such as flexitime or hiring temporary employees for short-term replacements. The separation of HR flexibility

dimensions according to their influence on the firm's knowledge help managers to assess the impact of the transition to agile innovation. Agile firms are more flexible, adaptive, and rapid to respond to external social, economic, and market threats. A main pillar of agile management is precisely that the changes in the firm's level of HR flexibility could impact on its innovative performance.

By using these concepts as theoretical boundaries, we have carried out a meta-analysis to study the relationships between agile, HR flexibility and AC, and discuss how firms can support agile initiatives in innovation considering their HR flexibility and AC. The next section explains the methodology.

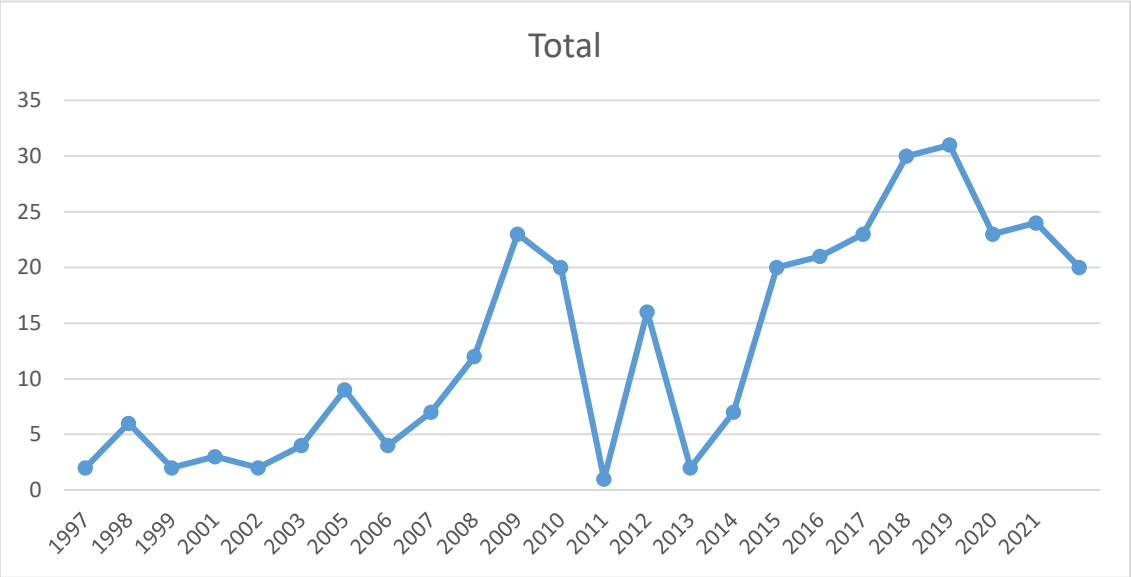
3. Methods

We have carried out a meta-analysis because it is a most adequate method to provide evidences of "relationship between variables while uncovering relationships not studied in existing studies" (Donthu *et al.*, 2021, p. 287). At the same time, meta-analyses are able to handle large amounts of literature offering a short-term forecast of the studied topics (Wallin, 2005) and standardized set of indicators (Van Raan, 2005). The scope of the study was broad and the dataset small but adequate, considering that our topic is a cross-field research.

The workflow is consistent with Zupic and Čater (2015) by defining first a research question that determines the design of bibliometric data and compilation. Our question is: *How firms can support agile initiatives in innovation considering their HR flexibility and AC?* The Web of Science Collection has been consulted in three steps with several search strings. The first search responded to the term "agile innovation*", with an output of 39 articles, reviews and book chapters since the year 2017 to 2021; the second one included "Human resource* management*" AND "flexibility" with 93 results since the year 1997 to 2021; and the final third search string was "Absorptive capacity*" AND "Knowledge management*" AND "New product* development*" with 29 results since the year 2005 to 2021. The analysis of these 161 references without duplicities in the period 1997-2021 provides

the foundations for exploring our research question. Top sourcing journals from these references are, for instance, *Journal of Knowledge Management* (9 references) or *International Journal of Operations and Production Management* (6 references). The considered topics have gained relevance since 2017 (Figure 2) although the issues related to new ways of management remain unexplored (The Annex contains more data about the bibliometric analysis).

Figure 2. Evolution of the references included in the meta-analysis



Our meta-analysis links HR flexibility and AC to hybrid and parallel agile innovation. Hybrid agile innovation incorporates agile practices at the early or late stages of a stage-gate new product development whereas parallel agile innovation involves adding a partly parallel agile path along the stage-gate process for specific projects. The next section relies on the meta-analysis to develop the research propositions that emerge from the state of the art in the links between HR flexibility, AC and innovation throughout agile initiatives. These research propositions will be important to further validate which HR flexibility dimensions are the most beneficial when agile initiatives are adopted in the innovation process. Two are the main topics that arise from the meta-analysis. First, the relationship evidences between innovation, HR flexibility and AC. Second, the key players for agile

innovation that contribute to hypotheses construction with employees as the main player but also external R&D experts, NPD schemes and AC. This in turn translates in the interpretation of issues about managing the transition to agile innovation: Evaluating the transition to agile; Adapting the agile transition to the type of innovation; and Organizational dynamics for embracing agile innovation.

4. Supporting agile innovation through HR flexibility and AC

4.1. Innovation, HR flexibility and AC

The references of empirical studies on HR flexibility and innovation show substantial agreement about the positive contribution of internal HR flexibility (core full-time R&D employees, training, multi-skilling) to innovation, whereas the contribution of external HR flexibility is positive with high-knowledge dimensions like external R&D experts but negative with low-knowledge dimensions as temporary employees (De Spiegelaere, Van Gyes, & Van Hootegem, 2014; A. Martínez-Sánchez, Vela-Jiménez, Pérez-Pérez, & De-Luis-Carnicer, 2011; McKeown & Cochrane, 2017; Rodríguez-Ruiz, Fernández-Menéndez, Díaz-Martínez & Fossas-Olalla, 2021). Firms may use external R&D experts to obtain knowledge and new ideas that combined with their own knowledge can trigger innovation projects. However, temporary employees are usually left out of innovation activities because they have lower organizational commitment than permanent employees; moreover, the percentage of temporary employment seems to be negatively related to employee trust which may negatively influence the process of knowledge assimilation and transformation (Cetrulo, Cirillo and Guarascio, 2019; McKeown & Cochrane, 2017; Rodríguez-Ruiz, Fernández-Menéndez, Díaz-Martínez & Fossas-Olalla, 2021). Although these relations have been tested in traditional stage-gate

environments, their theoretical foundations may still work in agile innovation because they strongly concern to the knowledge flows that firms have to manage.

Regarding the relationship between HR flexibility and AC, a few references in the meta-analysis indicate that HR flexibility dimensions that are more knowledge-intensive are more influential on the development of AC (e.g., Martínez-Sánchez, Vicente-Oliva, & Pérez-Pérez, 2020). This is important because agile firms may need even more external knowledge than other firms, due to the *almost-instant-knowledge* that their activities demand. The more AC a firm develops, the higher its innovative outcomes are (da Costa *et al.*, 2018) but this also has implications for the combination of HR flexibility dimensions. For instance, Abualoush (2020) found that human capital mediates positively the relation between AC and innovation. Thus, multi-skilled employees and external R&D experts play a vital role in generating the firm's AC because they are able to integrate the internal and external knowledge for the development of a new one.

Following these typologies of HR flexibility, Martínez-Sánchez, Vicente-Oliva and Pérez-Pérez (2021) conceptualized a 'Good' and a 'Bad' mix of HR flexibility according to the combination of functional flexibility (both internal and external) and external numerical flexibility (temporary employees). 'Good' and 'Bad' relates to the degree of knowledge's acquisition, accumulation, integration, and exploitation associated to each HR flexibility dimension. On the one hand, 'Good' HR flexibility is for low temporary employment and high functional flexibility (training effort, multi-skilled employees and external R&D experts). On the other hand, 'Bad' HR flexibility is for high temporary employment and low functional flexibility. We use this framework in the next sections of the paper because it enables to focus the discussion on the most important variables that interrelate in the link HR-AC-innovation but in agile contexts. Consequently, the 'Good' HR flexibility emphasizes the importance that multi-skilled employees and external R&D experts may have for agile innovation: external R&D experts (external functional flexibility) contribute to knowledge development within the firm whereas multi-skilled core employees (internal functional flexibility) contribute to the

diffusion of knowledge throughout multifunctional teams that develop product and process innovations.

4.2. Key players for agile innovation

Brand, Tiberius, Bican & Brem (2021) in their review of agility as an innovation driver found that employees need a certain level of flexibility, knowledge and training, and that agility-enhanced employees are confident and unbiased thinkers; actually they emphasize that employees who are open minded about new technologies and/or markets/possibilities are a key attribute to a successful use of agile at the front end of innovation. Sprint teams are also more autonomous and are more in need of multi-skilling than traditional stage-gate teams because they might involve and cover a greater number of stages and in a shorter time. This forces to organize sprint teams with employees who are focused full-time on their own sprint and abler to contribute with expertise, knowledge and skills in a close environment.

Martínez-Sánchez, Á., Pérez-Pérez, M. & Vicente-Oliva, S., (2019a) found in their survey of manufacturing firms that the implementation of agile started first in the supply chain but followed closely by developing capabilities in HR such as employee skills development, teamwork or flexible structures. This study also reinforces the importance of employees and tacit knowledge's contribution to innovation performance. Agile firms invested more percentage of sales in R&D and employees training, hired more external R&D experts, had lower percentages of temporary employment but had greater levels of AC than non-agile firms (Martínez-Sánchez, Pérez-Pérez & Vicente-Oliva, 2019b) which points out that 'Good' HR flexibility is important indeed for agile firms.

Whenever there are tight deadlines or the R&D is too complex, in-house employees are sometimes not enough which requires to incorporate knowledge from external R&D experts because they may stimulate exploration of innovative ideas beyond the firm's knowledge stock and enhance

the team's agility behavior. External experts in a more fluid and limited-time basis can help firms to develop their core competences and integrate them with outside knowledge. These experts are more familiar with the best external knowledge or at least have the tacit knowledge required to improve, for instance, the technology acquired by the firm in machinery or equipment. Martínez-Sánchez, Vicente-Oliva & Pérez-Pérez (2020) found that HR flexibility dimensions which are more knowledge-intensive like external R&D experts and multiskilling ('Good' HR flexibility) are more influential on the development of AC, and also found that the mediator effects of 'Good' HR flexibility and AC are positively related to innovation performance, suggesting that firms may combine them more effectively with R&D efforts to enhance innovation which is relevant for transitions to agile.

The positive impact of 'Good' HR flexibility on innovation would be more important in agile than in stage-gate innovation because agile employees are a key innovation driver (Rigby *et al.*, 2018; Brand et al., 2021). The comparison between hybrid and parallel agile innovation regarding HR flexibility suggests that parallel innovation must be more autonomous and self-reliant than hybrid innovation that can still rely somehow in the existing gating process. It means that parallel agile innovation should have more dedicated teams of multi-skilled employees along the whole process of innovation, on the contrary than hybrid innovation teams which can operate in a more structured way in non-agile stages. According to all these previous argumentations, we suggest the following research proposition:

P1. 'Good' HR flexibility is greater in agile innovation manufacturing (parallel agile being greater than hybrid agile) than in stage-gate innovation.

Regarding external R&D experts may even become sprint members, but because of the different models of agile innovation (hybrid at early or late stages of the process or a whole parallel agile innovation process), these specialists may need to be more numerous and diverse than in traditional stage-gate innovation processes where processes, tasks, and responsibilities are more

structured. Due also to time pressures in agile innovation, team members might have more difficulties to transform their experiences into learning which would reinforce the need to get inputs from to a more diverse and numerous group of external R&D experts (Lichtenthaler, 2020).

Similarly, parallel innovation might require more and diverse external experts than hybrid innovation because parallel needs more multi-team meetings to coordinate activities which reduces time to transfer knowledge (Annosi, Foss and Martini, 2020). Then, external experts offer parallel agile teams the possibility to work systematically with people outside their teams and inject knowledge from outside along the whole innovation process. According to these arguments, we suggest:

P2. External R&D experts are more diverse and numerous in agile innovation manufacturing (parallel agile being greater than hybrid agile) than in stage-gate innovation.

We now turn our focus to AC. First, it is important to take into account that in comparison to traditional stage-gate models of innovation, agile teams are allowed a shorter time window to quickly deliver goods highly valued by customers with rapidly changing needs (Cooper and Sommer, 2018). This *almost-instant-knowledge* means than in agile firms, knowledge needs to be readily available at both explicit and tacit level. The process of acquisition and assimilation of knowledge (Potential Absorptive Capacity or PAC) should then be more comprehensive and adaptive in agile than in traditional stage-gate approaches because there is not a next stage where to fix or adjust design flaws and because there are not stakeholder representatives of customers in stage-gate processes as they are in sprints (Cooper and Sommer, 2016; Annosi et al., 2021). The process of transformation-exploitation (Realized Absorptive Capacity or RAC) also should be faster and more adaptive in agile than in stage-gate innovation. It is not only that knowledge needs to be more available and in large

amount in agile innovation, but also that knowledge is applied, adapted, transformed or sell it more quickly. The references from the meta-analysis already indicates that firms with high levels of 'Good' HR flexibility had greater values of PAC and RAC, and that agile firms have greater levels of AC than non-agile firms (e.g., Martínez-Sánchez, Pérez-Pérez & Vicente-Oliva, 2019b; Martínez-Sánchez, Vicente-Oliva & Pérez-Pérez, 2020).

Another different issue is if the speeding up of agile innovation practices might perhaps hamper AC which should have implications for piloting transitions to agile. Most of the knowledge creation usually occurs through the individual interactions between sprint members. However, the spread of newly created knowledge outside teams into organizational knowledge requires an ability to systematically integrate the different sources of knowledge that may be hampered by time pressures in agile innovation. There is a risk that sprint members who are too busy with their own deliveries, have little time to attend demostrations designed to provide an overview of the work done by any other single team (inside or outside the firm, such as collaborative projects with partners) at the end of each iteration cycle (Annosi, Foss and Martini, 2020). This means that the management of knowledge in agile firms should avoid loses of tacit knowledge along the way which reinforces the importance of AC in agile innovation.

The comparison between hybrid and parallel agile innovation indicates that the aforementioned cautions about managing AC might be more critical in parallel than in hybrid contexts. The reason is because hybrid agile innovation may keep the existing stage-gate process of innovation with only some stages becoming agile (Cooper and Sommer, 2016; Lichtenthaler, 2020). On the contrary, parallel processes of innovation must transform themselves from gating and open a newly management system based on agile practices. As a consequence, the operation of sprints-scrums would arise the needs of organizing temporary and tacit knowledge in a more critical way in parallel innovation because the support from previous or next more structured stages to accommodate

changes along the innovation process is no longer available (Cooper and Sommer, 2018). Therefore, we suggest our last research proposition:

P3. Absorptive capabilities of knowledge are greater in agile innovation manufacturing (parallel agile being greater than hybrid agile) than in stage-gate innovation.

After this discussion from the meta-analysis' outputs and according to the three research propositions, agile firms would be in need of developing capabilities to enhance agile innovation. The interactions between HR flexibility, AC and agile methods will require tools to pilot transitions to agile which is the purpose and contribution of the next section.

5. Managing the transition to agile innovation

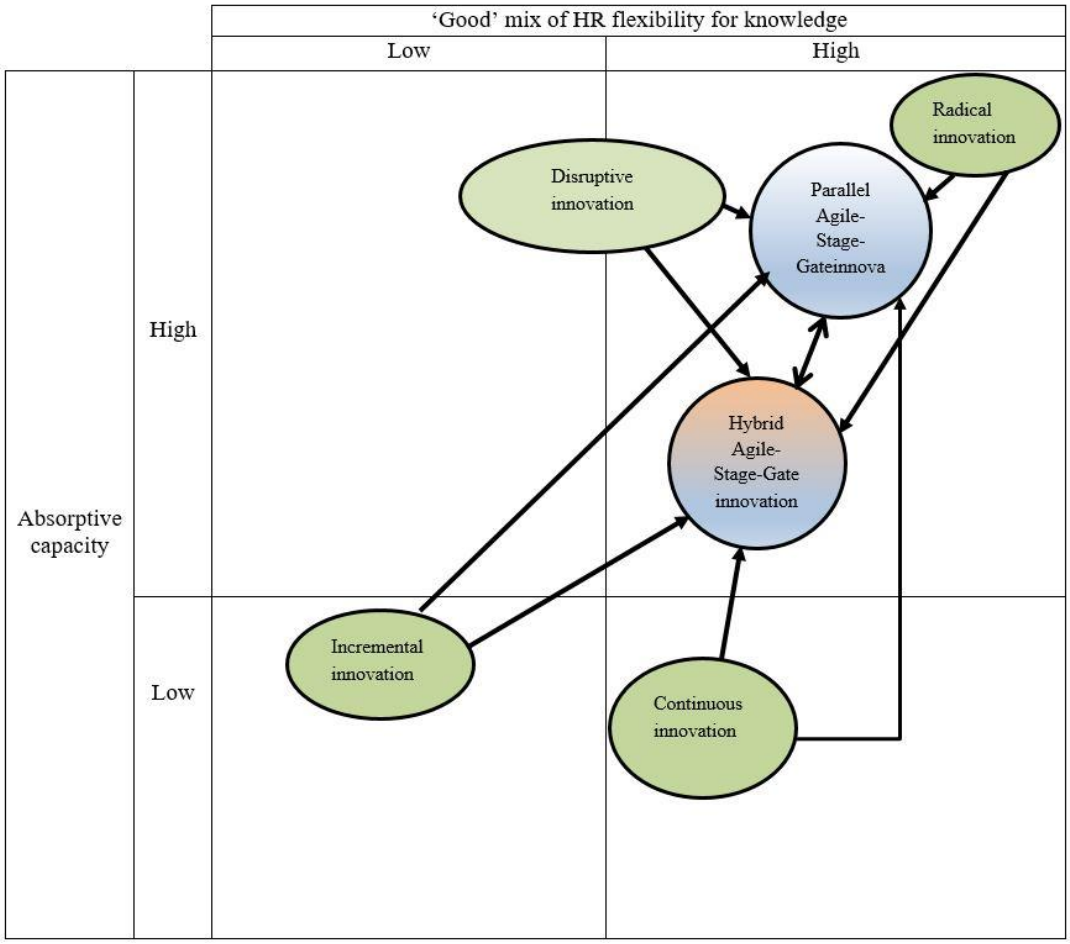
5.1. Moving into agile environments

The previous section has shown the importance of 'Good' HR flexibility and AC for agile firms. Then, in a context of agile innovation, firms would require more external R&D experts and more multi-skilled and trained employees focused on innovation activities. Agile firms adopt agile innovation practices but they may start from different innovation scenarios. We have identified four starting points (Figure 3) from which firms should pilot their transitions to agile:

- Incremental innovations that are ordinary, occur regularly, provide more quality, safety, and lower costs, etc. in the existing process, goods and services.
- Radical innovations which provide totally new functional capability, which is a discontinuity in the current technological capabilities.
- Continuous innovations that develop some new appreciable attributes of the products or make them more valuable for customers.

- Disruptive innovations able to provide a new set of attributes of a new product with some characteristics with lower performance but with other very attractive ones that are greatly appreciated in the market.

Figure 3. Strategic analysis for Agile Innovation of HR flexibility and absorptive capacity.



Note.- 'Good' HR flexibility means high values of internal and external functional flexibility (training, multiskilling, external R&D experts) versus low values of external numerical flexibility (temporary employment).

The first two initial scenarios (*incremental* and *continuous*) involve small improvements in innovative outputs either by isolated events or by continuous processes. In any of them, moving to agile would require to reinforce the firm's AC and 'Good' HR flexibility due to shorter development times and more comprehensive innovation portfolios to accommodate highly demanding customers. The third initial scenario of *disruptive* innovations already requires high levels of AC to explore

alternative technologies as well as market capabilities to search for new customers because disruptive innovations offer new functionalities. Firms with disruptive innovations should improve anyway their 'Good' HR flexible capabilities because the combination of new technologies and the search for new markets will need the support of external R&D experts and the intensive focus of in-house innovation teams. Finally, the fourth scenario of *radical* (breakthrough) innovations is characterized by a high degree of uncertainty that can be supported by every innovation approach although their development depends also on a high 'Good' HR flexibility to achieve successful innovations. As Figure 3 indicates, breakthrough innovations are perhaps the most prepared scenarios for agile since firms with breakthrough capabilities already have the human capital and knowledge portfolios required to operate in agile environments. Although gating systems are more predictable for complex innovations, agile-stage-gate adds the most value when there is high uncertainty because radical innovation can be mastered through incremental product versions and frequent customer involvement.

Transitions to agile innovation are not easy and require resources and organizational commitment. However, as in any other organizational transition, controlling the course and pace of the change is a key issue and therefore the need of implementing metrics from the very beginning. At the same time, transitions to agile would require to accommodate changes in some organizational variables like structure or communications flow. The next sections outline the most important metrics that need to be implemented and some of those organizational changes that should be foreseen in advance.

5.2. Evaluating the transition to agile

It is important to develop and adopt metrics to manage the transitions to agile depicted in Figure 3. Actually, metrics is one of the key practices supported by studies on agile innovation (Table

1). As many firms had implemented Balance Scorecards (BS) as decision support tool, we find that these metrics can be easily integrated into the firms' BS.

Table 1. Key manufacturing management practices to facilitate agile innovation

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These metrics may take into account the influence of HR flexibility and AC, as well as specific indicators from agile innovation. Since they are all related as illustrated by Figure 2, it would be possible to link specific Key Performance Indicators (KPIs) within the strategic maps of BS in order to pilot transitions to agile. Table 2 lists some KPIs commonly used in the studies of HR flexibility. We focus on quantitative KPIs because they are simpler to implement although academic research also uses sometimes constructs assessed through managerial perceptions of employees' flexibility and adaptability to change; these perception measures could also be incorporated into BS if the firm monitors external assessment indicators for their own employees. It is possible to calculate an index of 'Good' HR flexibility (GHRF) as:

$$\mathrm{GHRF} = \frac{\mathrm{S\&T} \cdot \mathrm{ER\&DE}}{\mathrm{TE}}$$

where S&T is the level of skills variety and training in the workforce, ER&DE is the percentage of external R&D experts, and TE is the percentage of temporary employees in the workforce. The values of these variables may be obtained by operating KPIs from Table 2.

Table 2. KPIs of HR flexibility

Regarding KPIs for AC, early studies on AC used single R&D inputs and outputs. Thereafter, academia developed scales based on managerial perceptions to assess the firm´s AC dimensions (acquisition, assimilation, transformation and exploitation) whereas other scholars expanded lists of KPIs. These KPIs have the advantage of being more direct and simpler to implement in a BS. Table 3 lists different KPIs but separately for Potential Absorptive Capacity (PAC) and Realized Absorptive Capacity (RAC). An index of AC can be calculated from KPIs in Table 3 as AC = PAC + RAC, although the ambidexterity has to be attended in order to maintain an optimal level of PAC (for future developments) and RAC (for obtaining the best present performance).

Table 3. KPIs of Potential Absorptive Capacity (PAC) and Realized Absorptive Capacity (RAC) dimensions

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Finally, Table 4 indicates KPIs for agile innovation. Agile is mainly used to speed up project development and execution, although a desire to boost innovation is also a key-driver of adopting agile approaches. Therefore, some KPIs included in Table 4 are related to both time and productivity metrics.

Table 4. KPIs of agile innovation

The transition to agile would imply to reduce times and increase productivities. Average values could be used for most of the time measures in case there is a great variability across innovation projects. We can establish different average values for each category of innovation according to the KPIs related to innovation productivity: product versus process innovations, different type of product

innovations, budget sizes, etc. However, shortening innovation time and enhancing innovation productivity must be carefully controlled in the light of the firm's AC because agile innovation practices may negatively influence individual learning, ideation, and exploitation capabilities. As a consequence, we have also included in Table 4 some KPIs related to knowledge at the agile unit level (project, department, business…) in order to control the global performance of agile innovation.

The three groups of agile KPIs are interrelated. It is then possible to calculate an Agile Innovation Index (AII) by multiplying the three indexes of time (IT), productivity (IP) and knowledge (IK):

$$AII = (\alpha \cdot IT) \cdot (\beta \cdot IP) \cdot (\gamma \cdot IK)$$

where α, β y ɣ are the relative weights of IT, IP y IK. The values of such weights will depend on the type of research project. For instance, basic research projects may focus more on knowledge than on time and thus ɣ>β>α. On the contrary, development projects on contexts of environmental crisis like pandemics should focus more on time than knowledge and thus α>β>ɣ. Regarding the three indexes themselves, IT, IP and IK can be computed as multiples of the items included in each group of indicators. Greater values of AII would indicate a greater firm's capability to innovate with more agility, not only because of speeding up (IT) and boosting (IP) innovation but also because of increased individual learning and ideation activities (IK). Firms where the application of agile innovation practices reduces individual employees' motivation to learn may have high values of IT and IP in the short-term, but with low values of IK resulting in lower overall values of AII which will decrease even further in the long term due to the negative effect of decreasing AC.

It is not possible to increase and sustain high values of AII unless IK values remain relatively high. If sprint team members are unable to transform their experiences into learning, they might eventually become slower and less productive. This would lead to lower values of IK but also to lower values of RAC and even PAC. Decreasing values in IK should lead to enhance the index GHRF

('Good' HR flexibility) by increasing S&T or ER&DE which means that firms should increase investments in skills and training or use external R&D experts to compensate potential losses in knowledge productivity. All these variables are then interrelated and handling them as a comprehensive Balance Scorecard may help firms make transitions to agile if they are used in a properly organizational structure that facilitates agile innovation.

5.3. Adapting the agile transition to the type of innovation

The aforementioned metrics should be adapted to the types of innovation depicted in Figure 2 as departure points for the firm's efforts towards agile. Starting with incremental innovation, its transition to agile raises, among others, the challenge to open the innovation process to external agents without putting at risk the in-house knowledge already invested in the development and production of an existing product. Thus, firms focusing on incremental and continuous innovations should perhaps prioritize the internal HR flexibility dimensions for knowledge versus the external dimensions because for small improvements, firms can rely more easily on the previous stock of tacit knowledge from in-house employees than on external experts without any background whatsoever on the firm´s innovation records. Besides, in the particular case of process incremental innovations, external access could jeopardize even more the secrecy of knowledge because the inherent potential access to tacit manufacturing know-how. In any case, how firms are able to reduce the time development of incremental innovations within the iterative cycle of sprints and scrums will influence which KPIs are more relevant to manage the transition to agile. For incremental innovations, innovation time and innovation productivity indicators would be more important than knowledge indicators and thus $\alpha>\beta>\gamma$ in the calculation of the Agile Innovation Index (AII). There is a lower risk of unwanted transfer of knowledge to third parties from small improvements in product and process innovations since the firm should have time to react and develop many other feasible alternatives. This would be much more difficult for disruptive or radical innovations because tacit knowledge is

the key source of competitive advantage in such cases. Table 5 compares the relative differences of weights within the AII for each type of innovation as well as the relative importance of the broad categories of KPIs.

Table 5. Differences of transitions to agile according to the type of innovation

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Continuous innovations require a steady flow of ideas and knowledge that emphasize the productivity dimension (β) in the AII. Even tough time is always important, it is not nevertheless so relevant here because it is the production of new ideas, prototypes, improvements, etc. which makes the continuous innovations go round. Therefore, there is also need to emphasize RAC versus PAC KPIs because continuous innovations require more practical solutions where agile may contribute to enhance the diffusion process along the innovation value chain. This is also the case for incremental innovations that should pay more attention to the transformation and exploitation of knowledge.

On the contrary than incremental and continuous innovations, disruptive and radical innovations are more in need of broader sources of knowledge because in-house knowledge may be never enough to stay ahead of competitors. Disruptive and radical innovations must rely more on previous stages of access and assimilation of new knowledge because it is precisely that new knowledge which may become the main potential source of new competitive advantages. Therefore, these firms should pay more attention to the KPIs related to PAC versus RAC. Similarly, the focus on knowledge indicators (ɣ) should be more important for disruptive and radical transitions to agile innovation then the issues related to time and productivity (α and β) since the imbedded-knowledge within those innovations are much greater than in incremental and continuous innovations. Disruptive innovations lead new attributes that customers appreciate, therefore productivity is more relevant than

time to release them (β>α). Otherwise, radical innovations lead to new capabilities which brings a discontinuity on what to do before by firms (α> β).

5.4. Organizational dynamics for embracing agile innovation

Piloting transitions to agile innovation would not only require metrics but some organizational changes as well. Keeping in mind our paper's convinced argument that enhancing agile innovation should be based upon greater values of 'Good' HR flexibility (GHRF) and AC to speed up and boost innovation (IT + IP) while maintaining high values of knowledge productivity (IK), this section discusses some of the organizational measures to facilitate transitions to agile, improve the performance of agile teams, and enhance individual proactive behaviors in relation to learning and ideation.

1. **Make horizontal communication the rule and no longer the exception**. Instead of the vertical communication of a more traditional hierarchy environment where those doing the work are eventually told what to do, agile innovation requires horizontal communications, i.e., peer-to-peer. Although scrums have a 'product owner', that person is not a conventional boss. Team members can ask the 'product owner' at any given time and they can get an answer because he/she has identified a clear vision. Establishing new relationships between each team and the adjusted network of stakeholders could help cut development times while keeping knowledge updated all the time. Working in pairs speeds up innovation and so is ultimately less costly. It also cuts training time and reduces the need for documentation because people doing the work routinely share knowledge. The firm's culture has to respond to change, and every person in the team has communication with all of the rest of the members, and

designing the implementation stage of innovations should be in accordance with the implementation strategy to obtain optimal patterns of innovation use.

2. **Make the structure of agile teams even more flexible**. As any other innovation team, agile innovators should have clear roles and responsibilities, as well as the right balance of authority and accountability. However, this is not enough because agile innovators face more time pressures and must deal with wider options, ambiguity and experimentation. Many innovation teams are usually multidisciplinary which means that rising alternatives and ambiguities in agile contexts may require that the number and scope of team specialists should expand and contract depending on their current focus. Conflicting goals should also be balanced through a larger network of agile stakeholders around the team. Then, the composition of agile teams will depend of their current focus: the sprints in the early design stages would require people with scientific knowledge backgrounds, whereas sprints in the product launch stage should involve people with experience and knowledge in finance and sales. That implies a flexible and changing structure of agile teams, with a small core of members who provides continuity and the involvement of anyone who can be valuable for the goal, including external R&D experts in a part-time or limited-time basis.
3. **Create space for external R&D experts**. External R&D experts are going to be more determinant in agile innovation than in stage-gate innovation because their contribution can be more fluid, quick and adaptable than in more stable settings. They could be dedicated full-time to the R&D project, whereas in-house employees usually share two or more R&D projects. Then they could even help to develop mastery of tasks inside the teams by integrating the competing demands of efficiency and learning/ideation into teams' agile practices, and facilitate the transfer of knowledge. Dedicated teams are not the norm in physical product development whereas agile

software development usually relies on small groups of people with every day devoted to the same project. External R&D experts could add flexibility to the cross-functional agile teams that manufacturing innovations require, and also contribute to double circle of learning: in the current project, and in the way to manage future ones, facilitating the retention of employees in innovation areas. Even when an outflow of employees occurs, agile schemes will be more resilient because knowledge flows more easily in this kind of organizations in-and-out and out-and-in.

4. **Develop dynamic structures that can handle both operations and learning**. Prevailing horizontal communications and balancing compositions of agile teams could favor organizational restructuration towards agile. Such new organizational structure should be capable of reducing vertical tensions (e.g., performance demands from managers) and horizontal tensions (e.g., peer pressures) by combining project and learning/ideation tasks and goals, and relocate resources more quickly in case of need (e.g., resource fluidity, fast response). This could be achieved, for instance, by distributing the sprint efforts between operative and learning activities and by having persons responsible for team performance and persons responsible for team learning, and other formal issues that cannot be afforded in the sprints. Connecting iterations would help team members to learn new skills and the time involved could be compensated by reducing the number of stand-up meetings and the number of team reports. Managerial meetings could also embed the coordination of efficiency and learning/ideation activities to enable a bigger picture of new product development activities that had been fragmented in consecutive and different sprints. The integration of operations and ideation could also be facilitated at managerial level by having a coordination layer between operations and innovation managers. Moreover,

the bridge in the current project and the next one, has to be designed by someone defined previously for collecting any research result, idea, etc. for the next projects.

5. **Prepare the organization for a steep learning curve**. Any transition to agile must acknowledge that this is new way of working for both executives and project teams who will have to overcome an adjustment time. Horizontal communication and open dialogue can facilitate dealing quickly with difficulties as they arise along the learning curve. Organizations usually begin their transitions to agile with a single pilot project and that is correct, although they must recognize that agile is new for them and will require senior management attention and sufficient resources. Those organizations more focused on 'Good' HR flexibility and with strong AC resources would already be in a more advantageous situation because they had already laid the foundations for the required in-house training and support of external coaches.

6. Conclusions

Management paradigms are proposed regularly by practitioners and researchers, although practical considerations attending to the different arenas where industrial firms' issues can gain competitive advantage have been practically absent in academic articles. An increasingly interrelated world needs more and more holistic approaches, and the implementation of agile innovation should be explored along different perspectives. The meta-analysis carried out on this paper highlighted that those practices which increase the firm's 'Good' HR flexibility and AC of knowledge should be studied before adopting agile methods in hybrid or parallel schemes.

Experienced consultants find improvement in their projects by researching into academic papers because scholars in turn are interested about how firms adopt their managerial practices and take decisions to improve their innovation performance. This article presents the need to manage the industrial firms' transitions to agile according to their level of 'Good' HR flexibility and AC of

knowledge, as well as what kind of agile innovation needs each firm. Although we cannot still conclude yet in what type of innovation may agile schemes have better results, we can propose consultants and practitioners a few guidelines from our studies for the benefit of their organizations, stakeholders, and employees.

Our study has futures lines of research that can be inferred from the proposed managerial implications: index of 'Good' HR flexibility, index of AC of knowledge with measure of the "good" ambidexterity between potential and realized, and, finally, the agile innovation index calculated for every kind of innovation project that firms carry out considering the peculiar characteristics and nature of firm's needs. In our holistic proposal, other important business areas for innovation could have been underestimated, such as the area of financial management- Our research is explorative, not limitative, and new indexes could be proposed, e.g. related to risk, intercultural collaborations, virtual projects with virtual teams, etc. This paper is also an invitation letter to firms for checking inside and collecting key performance indicators of their activities that are available, affordable and analysable before considering changes in their innovation processes.

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