THE ADOPTION OF THE AGILE-STAGE-GATE MODEL UNDER CONTEXTUAL CONDITIONS OF STARTUPS

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ABSTRACT

One of the new product development methods that has been proved with empirical evidence of its effectiveness is the agile-stage-gate model. A lot of research presented positive outcomes of the implementation of the agile-stage-gate model in well-established firms, throughout the new product development cycle, particularly in the stages of creation of the business case, development, and testing of the new product. However, in the context of the technology-based startups that faces with contradictory pressure of flexibility and predictability and challenges of resource constraints and high uncertainty, the agile-stage-gate model adoption needs investigation. To understand the implementation process of the agile-stage-gate method in a startup setting, this research drew on a qualitative longitudinal case study of a successful technology-based startup company in Thailand. At this selected startup, there were both successful and unsuccessful team projects that used the agile-stage-gate method in their product development process. In this research, the focal units of analysis were these team projects. Multiple comparative case studies were conducted in order to understand actions underlying the successful implementation and thus develop the processual model of the agile-stage-gate method implementation in startups. Based on the findings, the results show the similarity and contrast in terms of the agile-stage-gate implementation in startups versus well-established firms with the additional newly presented of the perpetual balance checking and team alignment components to deal with the startup context. The proposed model, the dual-pressure balancing model for new product development in startup, enhances the practical implication and guidance for startups to use the agile-stage-gate model effectively.

Keywords: Agile-Stage-Gate, New Product Development, Technology-Based Startups, Multiple Comparative Case Study, Dual-Pressure Balancing Model.

INTRODUCTION

Technology-based startups, also called deep-tech startups in the non-academic world, refers to emerging companies with an intense focus on science and technology in various fields e.g., healthcare, automotive, aerospace, etc. (Belz, 2020) In the new product development (NPD) of intangible products in startups, the agile manifesto concept or the daily scrum process are widely utilized (Buffardi et al., 2017). This concept greatly increases the speed of the development from the intense corporation with all of the product stakeholders e.g., users, company, and development team (Beck et al., 2001). But for the technology-based startups, the agile manifesto and the agile-stage-gate model are still a challenging pathway for the team to overcome since the characteristics of the NPD process between the tangible and intangible products are not the same (Cooper & Sommer, 2018). With the different context of the product

industry, and also the product initiator, there is no 'one size fits all' NPD model (Cooper, 2014). Due to the slow response to changes and hard to adapt to new goals due to their complex work procedure and organization hierarchy, the well-established firms were entitled to choose the NPD model with more agility enhancing to the development. And one of the chosen models was the agile-stage-gate model with its benefits of product development agility and the characteristics of adaptability and flexibility (Cooper & Sommer, 2016; Cooper & Sommer, 2018). With the advantages of the development speed, this model enhances product's time-to-market which is considered as key goals for the NPD in high technology industries (Tidd & Bodley, 2002). But the speed comes with consequences; the company needs to fully dedicate the resources to the agile implemented project. Evidence of the transformation to the agile-stage-gate in the well-established firms has been studied for a period of time (Sommer, 2019; Sommer et al., 2015), and it was found that even the big firms have suffered from the resource and budget dedication to the agile project, and also the development team members' attitude on the transformation (Flouri & Berger, 2010; Karlstrom & Runeson, 2005; Sommer, 2019). Compared to the well-established firms, the apparent difference between these firms and startups is the budget and resource allocation (Gopalakrishnan & Bierly, 2006). The giant firm has advantages on the investment scale in research and development, various business units, and dedicated resources to each unit or department. Other than the resources allocation issue, startups need to deal with Stinchcombe's liability of newness, which expected that the younger age firms have higher death rate relative to old ones (Yang & Aldrich, 2017). Due to various of new activities, like low level of trusts from customers, or unfair competition with the well-established firms, startups tend to have higher failure rate in both the business and the NPD than the big firms. The agile-stage-gate model's benefits on the participation with the users and stakeholders, which simultaneously gaining the legitimacy to the firms and developed products, have persuaded startups to use the model in the NPD. However, the results of using the agile-stage-gate in the startups are still questionable (Ashmore et al., 2018). With the motivation of the successful implementation of the agile-stage-gate model to develop the tangible products in the well-established firms, this research objective is to study the effects of applying the agile-stage-gate model in the NPD process of the technology-based startups using the benefits shown by applying the agile-stage-gate in the well-establish firms, a multiple comparative case study of the project teams in a technology-based startup has been explored longitudinally.

LITERATURE REVIEW

New Product Development Life Cycle

In the NPD life cycle, the NPD model mostly consists of five to seven stages starts from product planning until launching the product (Cooper & Kleinschmidt, 2001; Eppinger & Ulrich, 2015). In the BAH model, with seven stages of development, the first phase starts with new product strategy, idea generation, screening and evaluation, business and analysis, design and development, testing, and commercialization. Compared to Ulrich and Eppinger's model with six phases of product development (Eppinger & Ulrich, 2015), the BAH model seems to have more focus on the front-end development also the product commercialization part. While Ulrich and Eppinger's model enhancing more on to the design and development part and the manufacturing part. Whilst the Cooper's stage-gate model comes with more similarity to the BAH model than Ulrich and Eppinger's model. The stage-gate model, with six development stages, starts with idea generation, idea scoping, build business case, development, testing and validation, and launch (Cooper & Kleinschmidt, 2001). The only two differences of these two models are the

product strategy or planning phase which the stage-gate model considered as the project scope of the project management, and the decision gates after every phase. These three NPD models are considered mainly to initiate new products both inside the organization and the collaborative projects with the firms' partners and research organizations. As there are many NPD models were proposed based on these three, but what those models have in common is the life cycle of the new product development.

Based on the six development stages of the stage-gate model, two stages were identified as the highest agile intensity period, the development and the testing stage (Cooper & Sommer, 2018). The result from prior phase of the development stage is a complete business case concept, then all of technical details have to be put in the prototype for testing in the next stage (Cooper & Sommer, 2018; Tidd & Bodley, 2002). Also, sometimes there is not only one concept have passed the screening gate through the development stage. Many versions of the prototype are created and wait to be tested with the users or according to standard compliance (Elverum et al., 2016; Gibson, 2006). And when the problem occurs, the development team has to close the gap between the current design version and the user requirements fast enough to maintain the project timeline, in the design-test-build cycle (Tidd & Bodley, 2002). Furthermore, for the testing stage of medical products, only user requirement is not enough since the products have to be used with human life and the safety of the user is the first priority. The products have to pass the sub-stages in the testing stage likes product risk assessment, pre-clinical testing in laboratories, and clinical investigation in human to confirm the safety and effectiveness of the products (Commission, 2017; Stern, 2017).

Agile-stage-gate Model

The introduced concept and framework of the agile-stage-gate model in Cooper and Sommer's research (Cooper & Sommer, 2016; Cooper & Sommer, 2018) are influenced by one of the early initiations of combination of the agile manifesto and the stage-gate model in Karlström and Runeson (Karlstrom & Runeson, 2005). In 2014, Cooper (Cooper, 2014) suggested direction of the future research and model development of the stage-gate model in which the integration of the agile manifesto and the stage-gate model was one of the suggestions. Later, with popularly used of the agile manifesto in both software and hardware new product development, there is sufficient research evidence to present the concrete approach of the integrated model which is called the agile-stage-gate model (Cooper & Sommer, 2016; Cooper & Sommer, 2018; Sommer et al., 2015). The model clearly shows benefits of the decreasing of rigidity and linearity of the stage-gate model, and simultaneously gaining the agility, adaptability, and flexibility of the NPD model (Cooper & Sommer, 2018).

The core concept of the agile-stage-gate model execution is the power of nines which consists of three groups of essential components for agile execution i.e., three artifacts, three distinct roles, and three tools (Cooper & Sommer, 2016). The three artifacts discuss the project's framework and how fast the incremental product launched to the market; the sprint which is time-boxed period, the daily scrum meeting, and the retrospective meeting or project improvement in the next phase. The three distinct roles are considered essential ingredients of the development team, which the responsibility of each member taking an essential part in project execution which consists of the product owner or project leader in the traditional project management, the scrum master or the facilitator, and the development team member. The last essential component, the three tools, is the visual tool to help manage the projects; the product backlog or project backlog, the sprint board or sometimes called the Kanban board, and the burn-down chart, which is used to track the days of works remaining.

RESEARCH METHODOLOGY

Empirical Data

This research followed Yin's articles (Yin, 2011) on the case study methods, conducted a qualitative multiple case study of team projects at a medical technology startup in Thailand, Meticuly. Meticuly focuses on patient-specific medical device development and manufacturing, which considers using technology-based as its core competency. Considering only its new product development, more than thirty projects had to be accomplished each quarter to accelerate its growth and valuation. With less than thirty members to handle this amount of project, one member needs to lead about one to three projects also participate in another project with their responsible routine tasks have not been counted yet. A qualitative case study of Meticuly's new product development project has been set to analyze how the team deals with the assigned tasks using the agile-stage-gate model as the fundamental work process.

Background of the case studies: This research focused on the two team projects (one successful team and one unsuccessful team in using the agile-stage-gate method to develop a new product) with the aims at understanding actions underlying the successful implementation of the agile-stage-gate model. The first focal project was started in 2017 with the company's standard working principles, design prototypes were accepted by the key opinion leader: KOL (approximately similar to the term *"lead user"* in the common new product development field, but the KOL sometimes does not modify the medical device due to the legitimate ethics and regulations), the project was put on *"pause"* since the prototypes cannot be manufactured. The resources were allocated to other projects that were determined more important. It was restarted again on March 2020 and the goals were set from the three aspects of user perception to accept the medical product as the screening gate of the development phase; the product-oriented on the critical function, the stakeholder-oriented on the KOL acceptance, and the market-oriented on the available market (Altieri et al., 2017; Choi, 2015; Hatz et al., 2017; Moultrie et al., 2015; Shluzas & Leifer, 2014). The agile-stage-gate model was facilitated to the project and a new set of team members was assigned to achieve the goals. On the second case, the unsuccessful agile implemented project, the project had started at the end of September 2019 with the expectation from the management level of the company to expand the new business unit. At the beginning, the project was struggled from no clear goal, and most of the team members were suffered from the impromptu agile transformation. Without focus, team morale had declined, and team dynamics was not flow.

Data Collection

` The use of multiple data collection sources enabled triangulation of data, which strengthen this research's analysis and assertions for the findings (Yin, 2011).

Semi-participation observation: The first data source was semi-participant observation. This data collection strategy allowed the researchers to investigate in situ challenges and how team members responded to those challenges during the time of implementing the agile-stage-gate model. Semiovert participation encompasses joining the organization while letting organizational members know of the researcher's dual role as an employee and as a researcher (Pratt et al., 2006). Some of the essential components for agile execution were modified viz, a) the daily scrum and the time-boxed tasks update were changed to weekly with one-hour meeting, and b) all of the three tools were combined to the online communication platform. All of the rest of the essential agile components were implemented. With the agile role assigned to each member, the participated researcher acted as both the product owner and the scrum master.

Table 1
TEAM CHARACTERISTICS AND INTERVIEWEES' DETAILS

Code	Team/Positions	Department	Agile role	Interview conducted	Project task responsibility
CTO	Chief Technology Officer	Technology, R&D	N/A	1st interview/ model validated	Review
S1	Successful team (S)	R&D	Team member	1st interview	Materials mastery
S2	Successful team (S)	Technology	Team member	1st interview/ model validated	Device design
S3	Successful team (S)	Technology	Team member	2nd interview	Device design
S4	Successful team (S)	Technology	Team member	2nd interview	Mechanical properties
U1	Unsuccessful team (U)	Business	Product owner	3rd interview/ model validated	User requirements/ Backlog creation
U2	Unsuccessful team (U)	Technology	Scrum master	3rd interview	Team facilitation/ Device design
U3	Unsuccessful team (U)	R&D	Team member	3rd interview	Materials mastery
U4	Unsuccessful team (U)	Technology	Team member	3rd interview	Device design

Semi-structured interviews: Another main data source was interviews, five aspects of advantages and challenges of using agile in new product development were concluded and converted to the semi-structured interview protocol; agile transformation, communication within team, knowledge sharing within team, adaptability, and flexibility (Ashmore et al., 2018; Begel & Nagappan, 2007; Cooper & Sommer, 2018; Flouri & Berger, 2010; Karlstrom & Runeson, 2005; Sommer et al., 2015; Ungar & White, 2008). Team characteristics and interviewees' details were shown in Table 1 with the interview conducted on the successful team, and those in the unsuccessful team. And all of the interviews had the duration between forty to eighty minutes.

Archival Data

The third data source was online archives using the company web-based communication platform and shared database. All of the files were separated into three types i.e., first, the design and development files including CAD files, the second type was references from available products brochure, patents, and academic papers, and the last type was online board for updated tasks and progress. In total, there are 353 files of archives used for the study.

Data analysis

Stage 1

All the interviews were recorded upon the interviewees' consent and transcribed verbatim. The transcribed interview was analyzed using the content analysis, with the keywords extracted from the literature of the agile-gate-stage model implementation. During this stage, the interviewees provided comments and their suggestions were taken into analysis and added into the model. After the second interview, result from both the first and the second interview was analyzed with the same keywords. The output of the second interview was added to the third interview protocol. Then the qualitative content analysis was conducted all over again.

Stage 2

The data set of the successful team was reexamined and analyzed using a theory building approach, involving moving from highly personal accounts to one that is more abstract, theoretical, and generalizable. Following the qualitative data coding techniques, the data were

grouped into an initial concept or first-order categories. Through this process, the first-order categories were grouped in a more comprehensive and concise manner, resulting in 21 categories (see Figure 1).

Stage 3

The researchers then engaged in Strauss and Corbin's 'axial coding' (Moghaddam, 2006), by searching for relationships among first-order categories, collapsing those with similarity and contrasting those with distinctiveness, and grouped them into second-order themes. The second-order themes that emerged from the first-order categories presented actions needed for implementing the agile-stage gate in a technology-based startup.

Stage 4

The researchers continued engaging in axial coding, to identify similarities and dissimilarities, as well as relationships among them. In this process, the second-order themes were grouped into aggregate theoretical dimensions. The themes and the dimensions were then used to formulate the processual model of the agile-stage-gate implementation in a technology-based startup. The aggregate theoretical dimensions were created and concluded to the final suggested model with the relationship between each aspect in the model illustrates how the agile-stage-gate should successfully implement in the technology-based startup. The final model was corroborated and triangulated with the key informants and the findings from the previous research. Figure 1 presents the data structure, highlighting first-ordered categories, second-ordered themes, and aggregate dimensions. Figure 2 shows the processual model of the agile-stage-gate implementation in technology-based startups.

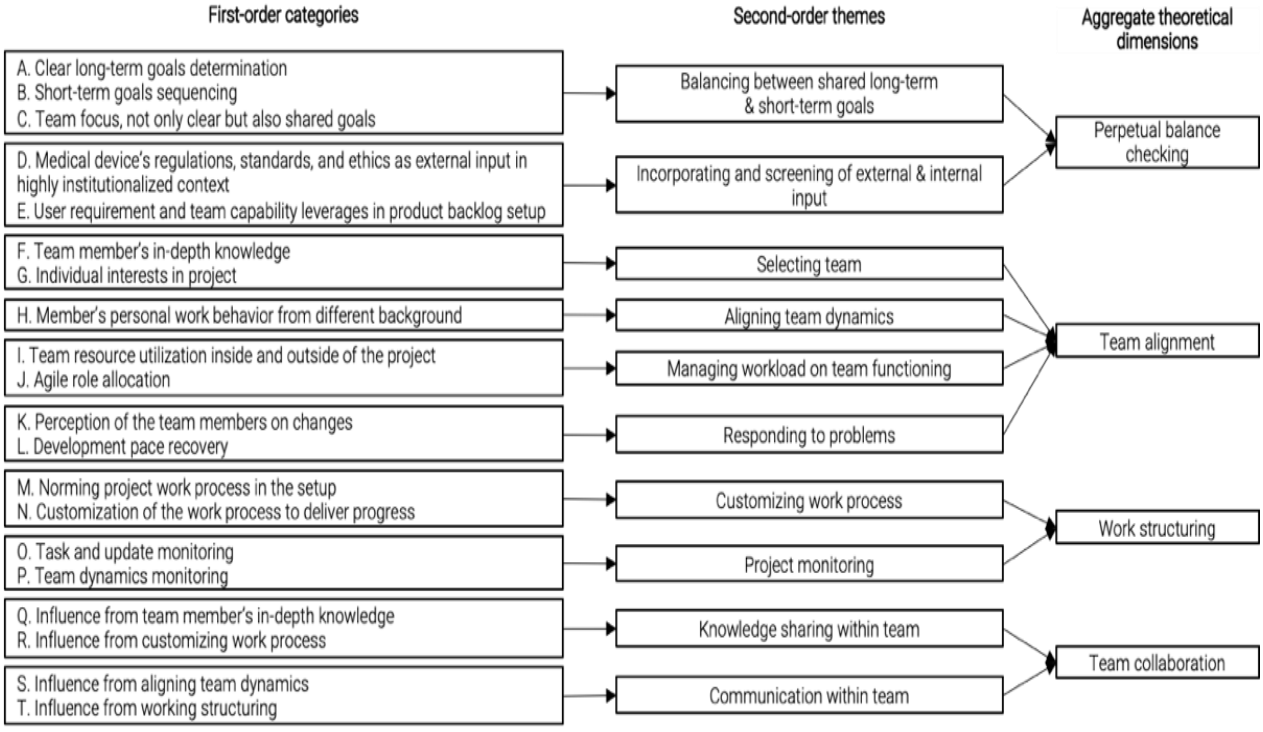

FIGURE 1
DATA STRUCTURE: FIRST-ORDER CATEGORIES, SECOND-ORDER THEMES, AND AGGREGATE THEORETICAL DIMENSIONS

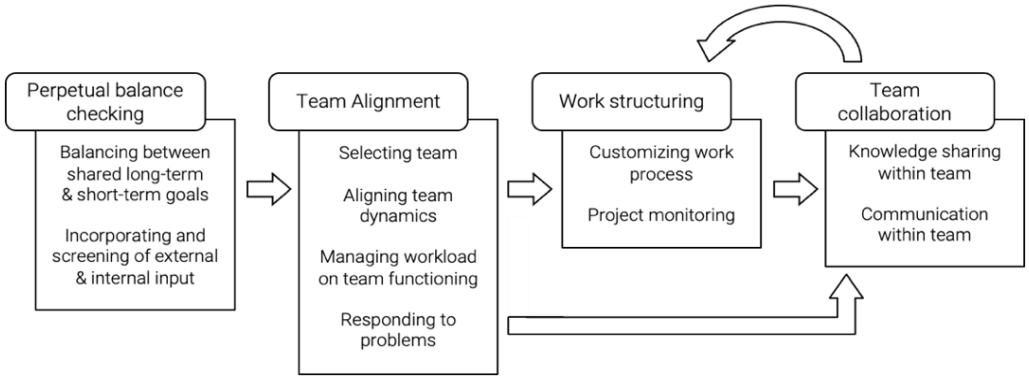

FIGURE 2
THE DUAL-PRESSURE BALANCING MODEL FOR NEW PRODUCT DEVELOPMENT IN STARTUP

DISCUSSION AND CONCLUSION

Perpetual Balance Checking

This component comprised with two themes, the balancing between shared long-term and short-term goals, and the incorporating and screening of external and internal input. In agile framework, the user requirements have changed over time and the situation resulting in a change of goals as well. In order to gain their focus on the project progress, these goals must get across their intention as the shared goals: *"In this project, everyone realized the progress and know where we were at the situation… This is the difference (from other projects), everyone has the same aligned goal and work with the same progress… (S4)"*. The interviewees from all groups mentioned in the same direction that lack of the vision of goals should cause complications to project progress, and the short-term goal gave the speed to development and focus to the team members: *"… if there is no small goals and tasks defined from the product backlog in to do list, team probably sitting confused with the conversation of what to be done first (S2)"*. While the long-term goals made them stable to the direction with adding the barrier to the changes: *"Goals of this project are clear at the beginning then I did not realize the changes in project goals (S2)"*. More concerns from the interviewees on the external input were the extreme user requirements. Since most of the KOLs are experienced surgeons, their ideas or concepts of development were too advanced to be completed in short period of time. *"User requirement only is not appropriate criteria to put as project, management level needs to concern about knowledge or capability of the team member (U1"*. In the first component, the team needs to deal with the dual pressure between contradictory goals and inputs, including user requirements and team capability. The product owner must accurately translated user requirements to the product backlog then set the long-term goals for the project. The project constraints like time, budget, institutionalized criteria, desired team knowledge, available company capacity, and outcome were filled to the project canvas, also the to-be-developed product features from the backlog. Unlike other members, the potential members with the support and facilitating characteristics had to be identified by the company and listed for the product owner to discuss and persuade the members as the scrum master to the project.

Team Alignment

In the second component, the team alignment was also taking significant part on aligning team members together to make them deliver the best project progress. This component comprised of four themes as follows, selecting team, aligning team dynamics, managing workload on team functioning, and responding to problems. To enhance the agile-stage-gate model in startup context, each member workload outside of the project is needed to pay attention too. *"If there is no good resource planning, when project has no clear timeline or obvious progress, team members are gathered to other projects that defined more important (U2)"*. It is more severe for a startup which operates under more pressure arising from limited resources and liability of newness. In the practical implications, the rest of the team as the role of the development team members were gathered based on their in-depth knowledge and interests in the project with one of the most effective approach, project pitching to the company. With the volunteered members, team would have more motivation than assigned members. And before assigning the task responsibility, the scrum master needed to check their duties on other jobs outside of the project and balance the tasks in the optimum level that each member can deliver the best progress.

Work Structuring

There are two themes in this component; the customizing work process, the and project monitoring. The second project utilized the daily scrum at the beginning and the members were suffered from too much meeting with no project results to update. Anyhow, with the natural agility characteristics of startup, the team customized the scrum period to solve the problem. "In the early stage of the project, all members were suffered from the intense meeting period and the framework considered 'fail'. Then the team learned how to deal with the problems, and then the schedule was changed to have more room to complete the tasks (U1)". When the development team members are completing their tasks, the scrum master has to monitor both the progress and the team dynamics in each scrum meeting, and when changes occurred, the scrum master had to make sure that the team members can respond to changes well enough and recover the development pace as fast as possible. Hence, using the daily scrum in the big firms has no or less impact on the routine tasks since they have enough resources to dedicate to the project. In the other hand, startup companies cannot dedicate full resources to a project since they have to create as much as possible alternatives to make them survive in the industry.

Team Collaboration

Team collaboration is the consequent of the team alignment and the work structuring. With two themes; the knowledge sharing within team and the communication within team, team members from both projects agreed that the component gave benefits to the project progress. However, there was a quote mentioned from the U team on the knowledge sharing that each member could not equally gained the shared knowledge due to the task responsibility. *"Even lots of knowledge had been shared in the meeting, if the member has no in-depth knowledge in the field, knowledge will not be shared effectively (U2)"*. For the communication within team, with the different work behavior of members, sometimes the scrum master has to enforce members to communicate. *"Sometimes with different member's work behavior due to different background, communication within team is not occurred naturally, even the work process forced updates daily. Sometime the scrum master needed to ask for their opinion, then they talked (U4)"*. In the

practical implications, this activity could be used as one of the monitoring tools to check the appropriate of the work structuring and the team dynamics activities.

CONCLUSION

The study findings and discussion showed that the implementation of the agile-stage-gate model for the technology-based startups is different from the well-established firms. Though the organizational structure and the NPD of the startups suited with the agile-stage-gate adoption, resources utilization, both the human, time, and budget, is still the critical challenge to overcome. The two newly presented activities, the perpetual balance checking and the team alignment, takes part as the detailed in-depth supplement to the agile-stage-gate model in each phase of the NPD life cycle. The personality of the scrum master and the product owner should be studied further to affirm the adoption of the agile-stage-gate model in the startup context. Also, with facing two main challenges including resource constraints and highly fluid structures that require employees to engage in hyper multitasking, more detailed study on the perpetual balancing and tools to deal with multitasking problems should be concerned. While existing research highlight flexibility, agility, and transparency in making a product, this researches the same attributes and elaborated how to develop such an effective team for the agile-stage-gate implementation.

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