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Integration of Lean and Agile Principles into Innovation Management

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Abstract Innovation, is located in the center of construction management literature for decades and accepted as an important determinant of competitiveness. Agility and leanness, on the other hand, are two indisputable courses of competitiveness in construction. Today, in order to sustain an advantageous position in the global market, construction companies should focus on adopting innovative approaches together with lean and agile principles. This study aims to gather all these concepts into same ground and improve construction industry's innovation capabilities through integrating lean and agile principles. With this aim, twofold research was conducted with interdisciplinary and international and professionals. In the first part, participants' innovation and innovation barrier perceptions were determined through a questionnaire survey. Then, in the second part, by taking the survey results into consideration, the ways to integrate lean and agile principles into innovation process were discussed. Findings of this study is expected to contribute to construction management practice and literature by developing a roadmap for diffusion of lean and agile concepts into innovation field.

Keywords: *innovation capacity, innovation process, lean, agile, integration, construction industry*

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1. Introduction

Today's "hypercompetitive" business environment forces industry professionals to develop quick and adaptive strategies and construction industry seems to have no exception. According to Horta and Camanho [1], in addition to technological evolution and industrial regulations, globalization is the major reason of increasing competition in construction market. Despite competitiveness was measured by productivity in early times [2] nowadays, performance of construction organizations highly depends on their response readiness to rapidly changing market conditions – agility [3,4,5] and their ability to value creation – leanness [6,7].

The role of innovation in gaining competitive advantage, on the other hand, has been emphasized in a number of studies [8-9]. However, the lack of innovation in construction industry was claimed frequently [10] due to the high number of actors involved in projects, project-oriented nature of construction industry and unwillingness of project owners to pay for innovation [8].

Taking all these into account, this study aims to draw a roadmap to increase innovation capabilities of construction organizations through integrating lean and agile principles into the innovation process. Findings of this twofold study are expected to deepen the understanding of important role of lean and agile in more competitive construction management practice.

2. Innovation and Innovation Capacity

Innovation refers to a new idea, practice or an object [11]. Despite Fischer [12] claims innovation as a complex and multiple meaning concept, recent study of Winby and Worley [13] describes innovation as "the creation and implementation of new value through business models, products, services, processes and systems in an organization". According to Rothwell [14], there exist five generations of innovations which were formed due to the specific changes that innovation environment faced throughout the time. Although the increasing awareness and investment on innovations, researchers suffer from lack of unsatisfactory profit or competitive advantage of a huge number of these initiatives for organizations [15].

Innovation capacity can be described as "continuous improvement of the overall capability of firms to generate innovation for developing new products to meet market needs" [16]. According to Miles et al. [17], a new business model for continuous innovation is an increasing concept and to understand the innovation success of a firm, the interaction between innovation initiatives and core organization should be well examined [18]. Timeus and Gasco [19] explain innovation capacity with the following

organizational capabilities; (1) capabilities for idea generation, (2) a knowledge management system to acquire and use new information, (3) a human resource strategy focused on innovation and (4) the intensity of technology use in the organization. Despite there four factors are important for organizations, it is agreed that more involvement of human resources in innovation process has a special importance [19]. In order to increase their involvement to innovation process, first, what the human resource of an organization know about innovations and what barriers they perceive should be well examined.

3. Agile and Lean Concepts

Agility, as an emerging concept, refers to being flexible against rapid changes. It is possible to find various definitions of agility in literature. According to Naylor et al. [20], agility is a business strategy which helps organizations to cope with ever changing market conditions. On the other hand, Lee [21] and Erickson et al. [22] emphasize the importance of rapid response against sudden market changes when explaining agility. Despite studies about agility started earlier, it gained popularity among researchers after the Agile Manifesto was declared by Agile Alliance in 2001. Inventors of Agile Manifesto not only brought the agile methodologies into industries attention but also defined four values in order to increase customer satisfaction and project effectiveness. These values are; individual interactions over process and tools, working software over comprehensive documentation, customer collaboration over contract negotiation and responding to change over following a plan [23]. With the help of agile methodologies, agile practices aim to "frequent, sustainable iterative deliveries by facilitated multi-functional, self-organizing intercommunicative teams" [24].

Lean, as another concept, refers to delivering of value. It firstly emerged as a production philosophy for Toyota company [25] and spread to other industries very fast. Despite there exist various definitions of lean concept, Simons and Mason [26] provide the simplest definition of lean as "doing more with less". The basic principles behind lean can be concluded as; increasing the customer value with eliminating wastes in the production flow [7,25,27]. According to lean philosophy, customers will to pay only value-adding actions or process, thus non value-adding actions considered as wastes which should be eliminated. In 1987 Ohno defined these wastes into seven categories as; overproduction, waiting time, transportation, over processing, inventory, unnecessary movement, making defective work [7]. However, Hines [28] emphasizes assigning tasks to workforce without considering their skills and capabilities and explains loss of human talent as an additional waste type.

4. Research Method

The aim of this study is to set a road map for construction industry by means of integrating lean and agile approaches into innovation process. Considering this motivation, authors of this study performed a twofold research.

4.1. Study 1-Questionnaire Survey

In the first study, the primary focus was to understand the innovation perceptions of participants and which barriers they detect in the way of innovation. Data for this study were collected through a questionnaire survey which aims to determine; (a) innovation adoption tendencies, (b) innovation adoptions obstacles, (c) perceptions about innovation and (d) demographic characteristics of the respondents. Respondents of the questionnaire survey were selected from a group of architecture and engineering students in Istanbul Technical University as well as a group of international and interdisciplinary students of the ATHENS/Socrates programme carried out under the coordination of the first author of this paper at the Faculty of Architecture at the Istanbul Technical University.

In the first section of the questionnaire, innovation adoption tendencies of the respondents were assessed with the 10 statements adopted from Rogers' Diffusion of Innovations Theory [11]. In the second section, the aim was to understand what barriers do respondents perceive in the way of innovation. After a deep examination of the studies explaining the possible barriers for innovation, highly confronted 8 barriers were selected and re-organized as separate statements. In the third section, respondents' thoughts about innovations were determined with the 12 statements adopted from Savery [29].

In addition to the thirty statements above, the set of questions were designed to clarify the sample characteristics. In the demographic information section of the questionnaire, respondents were asked to indicate their gender, major, grade and experience level in terms of internship, part-time job and full-time job alternatives. In all sections, except demographic information section, respondents were asked to indicate their level of agreement with each statement on a five-point scale (from 1=strongly disagree to 5=strongly agree). Table 1 shows the main characteristics of a total of 70 respondents who participated in the questionnaire survey.

Table 1. Characteristics of questionnaire survey respondents

Demographic variables	Categories	Number of responses	Percentage (%)
Nationality	Turkish	44	63
	European	26	37
Gender	Female	28	40
	Male	40	57
Education	Undergraduate	48	68
	Graduate	22	32
Professional experience	Full-time/Part-time	25	36
	Internship	26	37
	None	19	27

Sample consisted of 63% Turkish students who have been studying in architecture or engineering fields in Istanbul Technical University. The remaining 37% were European students who have been studying in similar fields in their home-countries and have been in Istanbul Technical University as a part of international student exchange program. As seen in Table 1, majority of students (68%) were enrolled undergraduate programs and

have limited or no professional working experience in their fields of study.

4.2. Study 2-Focus Group Discussion

In the second study, the primary focus was to develop certain strategies for the integration of lean and agile principles into innovation process in the construction industry. To this end, a structured focus group discussion was conducted with 15 construction professionals who have varying years of experience –at least 3 years to 15 years– in construction industry. The discussion sample was selected purposely from professionals who have certain level of education about leanness and agility concepts and their applications areas in the construction projects. They were at the same time taking a PhD course (in the field of leagility in the construction project management) lectured by the first author of this paper. These professionals also have been studying in the doctorate program of Project and Construction Management of Istanbul Technical University.

Discussion group participants were firstly taken a briefing session about innovation, innovation process, innovation management concepts and influential factors on innovation diffusion within the construction company. Then, they were shortly informed about the obtained results from the questionnaire survey study. After briefing session ended, participants were encouraged to indicate their opinions about the integration of lean and agile practices into innovation process and possible contribution of lean and agile innovation process to diffusion of innovation practices in the construction industry.

5. Findings and Discussion

Figure 1 shows the innovation adoption tendencies of respondents according to classification defined in Diffusion of Innovations Theory [11]. In his theory, Rogers defines five adopter categories, namely; innovators, early adopters, early majority, late majority and laggards. According to Rogers [11], only 2.5% of a general population have innovator and relatively small percent (16%) have laggard characteristics, however a majority of them fall into middle groups and these groups can adopt innovations with the help of different promoting strategies. For example, innovators are risk-takers and they want to try new technologies first. Opposite to innovators, laggards are risk-avoider individuals and they always have doubts about new technologies. Early adopters also tend to accept new ideas – like innovators and enjoy to share their experiences with the remaining part of the population. Early majority individuals are open to innovations but they need some evidence about the new technology's benefits. Finally, individuals in the late majority group accept innovations, however, they wait the majority of the population to try and convince about the effectiveness of that innovation.

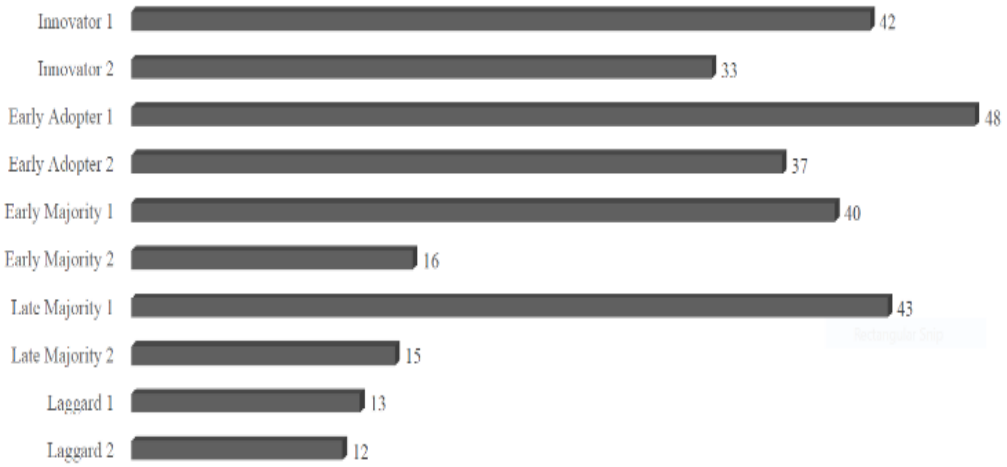

Figure 1. Innovation adoption tendencies of respondents

Table 2. Innovation perceptions of respondents

Perceptions about innovations	N	%	Rank
Innovations have relative advantage and be better than what have been used before	49	70	5
Innovations are consistent with existing values and needs	32	46	9
Innovations are easy and simple to learn	21	30	10
Innovations are tested/experimented deeply before they are implemented	37	53	8
Results of using innovations are visible within org./univ. where it has been emerged	48	69	6
Results of using innovations are visible within industry	48	69	6
Using innovations enhance people's image or status at professional life	46	66	7
Using innovations enhance organization's image or status at professional life	52	74	3
Pre-high school education plays important role on innovations' development & diffusion	50	71	4
High school education plays important role on innovations' development & diffusion	56	80	2
University education plays important role on innovations' development & diffusion	61	87	1
Org. training plays important role on companies' innovations development & diffusion	49	70	5

As seen in Figure 1, a great number of respondents can be defined as early adopters according to Rogers' theory. Contrarily, only a small number of respondents placed themselves into laggard category. Considering the displayed results, it can be concluded that the study sample showed limited consistency with Rogers' theory [11] as 18% of respondents were tend to be laggard. On the other hand, there exist an important tendency to both early adopter and innovator categories in the sample. However, this result may not be surprising as the sample consists of undergraduate and graduate students.

Table 2 shows the perceptions of respondents about innovations through percentages of given responses between strongly disagree to strongly agree.

According to the results, it can be concluded that, respondents consider high school and university education as important antecedents of innovations' development and diffusion compared to pre-high school education. Additionally, they perceive innovation as an important indicator of organizational status in business life. However, despite the majority of the sample consist of innovators, early adopters and early majority individuals, only a small number of respondents think that it is simple and easy to learn innovations. This is interesting, because as general characteristics of respondents are open to innovations, they were expected to find innovations easy to learn [29].

Table 3. Innovation barrier perceptions of respondents

Barriers in the way of innovations	N	%	Rank
Innovations are costly to implement	46	68	4
Innovations generate need for technical support	63	90	1
Innovations generate training requirements	50	71	3
Innov. generate necessity to follow new versions	55	79	2
Innovations generate privacy problems	22	31	6
Innovations generate security problems	22	31	6
Innovations cause additional stress on industry prof.	24	34	5
I don't think there exist obstacles to innovation within the industry	11	16	7

In Table 3, the barriers perceived by respondents in the way of innovations are shown. According to table, the most important barrier against innovations is agreed as the need for technical support (90%), followed by need for following up updates (79%), training requirements (71%) and implementation cost (68%).

In the following session of the survey, first, a brief presentation of obtained results about innovation perception and innovation barriers was performed to 15 construction professionals in the focus group discussion and they were asked to indicate their solutions for better innovation practices and competitiveness of the construction industry. The main focus of the discussion was to develop a better understanding and execution of innovation process within the industry. According to the general discussion, respondents agreed to consider agile and lean strategies simultaneously for increased performance and competitive advantage within the industry.

Respondents in the discussion session suggested to think wastes that may occur during the different periods of innovation process and suggested to handle these wastes as the solution for more improved innovation performance. Table 4 shows possible distribution of wastes in each phase of innovation.

Table 4. Wastes which can occur in the different periods of innovation process

Lean Wastes	Innovation Process				
	Id.	Pl.	Re.	Im.	Res.
Defects	·	·	·		
Overproduction		·		·	·
Waiting time		·		·	
Non-utilized talent			·		
Transportation					·
Inventory					
Motion					
Extra processing		·			

*Id.:idea, Pl.:plan, Re.:research, Im.:implement, Res.:result

First, in the idea period of the innovation, the most important waste is agreed to the wrong definition of idea and it was associated with defect concept of lean wastes. If the innovation idea defined wrong, then the final product of that innovation would be defective. Second, in the research period of innovation, conducting incorrect/unnecessary research to collect information is defined as defect and categorized into lean wastes. Additionally, if inadequate human resource will be assigned to the research for innovation, this would end with non-utilized talent type of waste in the process.

Third, in the planning period of innovation, redundant research for information is agreed as the most important waste of the process. In lean principles, this waste is associated with overproduction or extra processing. Following the redundant research, excessive human resource planning and incorrect planning of innovation are discussed among other important wastes of the process and associated with defect type waste. As a result of unnecessary human resource in the process, long waiting time of stakeholders becomes another waste according to lean principles. Then, in the implementation period of innovation, unnecessary production of prototype is determined among possible wastes and considered as overproduction type of waste according to lean. Furthermore, waiting of production due to wrong planning of production process and defective production are agreed as other wastes of the implementation period. Finally, in the result or marketing period of innovation, non-value adding production of innovative products and over transportation of products from production place to target market are considered among overproduction and transportation types of wastes.

6. Conclusion

Lean and agile are two inseparable concepts for competition in construction industry. Construction professionals are aware of the importance of lean and agile approaches to survive in increasingly competitive construction market conditions. Besides, innovation is accepted as another important indicator of competitiveness.

Despite construction industry shows great difficulty to keep up with the latest developments, there are increasing number of studies and applications focusing on more innovative construction practices.

Considering today's market conditions, it is believed that integrating lean and agile approaches to innovation process will provide competition advantage for construction companies. Focusing on this integration, this study adopted a twofold approach to understand innovation and innovation barrier perceptions of respondents through questionnaire survey and possible wastes that vitiates innovation process through focus group discussion. Findings reveal that, respondents see innovations as an important indicator of business status for organizations and emphasize the high school and university's role on innovations' diffusion. Furthermore, respondents perceive technical support and update needs, training requirements and cost issues as the most dominant barriers against innovations. On the other hand, there found various wastes which harms the different phases of innovation process in different ways. In order to have an efficient innovation process, construction industry professionals are recommended to eliminate these wastes, which will also help companies to increase their business performance, correspondingly.

Further studies are recommended to replication of this twofold approach with huge numbers of experienced professional from construction industry. Understanding the points of view of industry professionals about innovation issue and discussing possible solutions for elimination of process wastes for more value adding innovation process is expected to increase construction companies' competitiveness in the global market. Additionally, more integration of project stakeholders into innovation process and more communication between stakeholders are also expected to increase innovation performance of the industry.

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