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Impacts of Project-Overload on Innovation inside Organizations: Agent-Based Modeling

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***Abstract*—**Market competition and a desire to gain advantages on globalized market, drives companies towards innovation efforts. Project overload is an unpleasant phenomenon, which is happening for employees inside those organizations trying to make the most efficient use of their resources to be innovative. But what are the impacts of project overload on organization's innovation capabilities? Advanced engineering teams (AE) inside a major heavy equipment manufacturer are suffering from project overload in their quest for innovation. In this paper, Agent-based modeling (ABM) is used to examine the current reality of the company context, and of the AE team, where the opportunities and challenges for reducing the risk of project overload and moving towards innovation were identified. Project overload is more likely to stifle innovation and creativity inside teams. On the other hand, motivations on proper challenging goals are more likely to help individual to alleviate the negative aspects of low level of project overload.

***Keywords*—**Innovation, Creativity, Project overload, Agent-based modelling.

I. Introduction

MULTIPLE project strategy is applied inside organizations in order to make use of resources in an efficient manner. However multiple project involvement brings advantages that seem to be positive for creativity. Prior research shows that many creative advances have resulted through combinations of already existing ideas [4]. That is one rationale for having creative teams that work on multiple projects at the same time. On the other hand, project-overload can come out of multiple projects setting if lack of opportunities for recuperation, inadequate routines, scares time resources, and a large number of simultaneous projects happen [6]. Project overload also carries the weight of high-level of psychological stress reactions, less time for improvement, low development of skills and no adherence to time schedule [6].

In order to foster innovation, managers should match people with assignments that play to their expertise and their creative thinking skills, and ignite their intrinsic motivation [2]. Challenging goal means matching people with the right assignments, which is one of the key elements for organizational creativity [3]. Perfect matches stretch employees' abilities. The amount of stretch is crucial: not so little that they feel bored and lose their motivation but not so much that they feel overwhelmed and lack of focus.

One of the weaknesses of organizations is to not pay careful attention to matching employees with right challenges or design an appropriate team, while still paying attention to the fact that employees also are brought in to fulfill duties. Organizations do not consider employees category in terms of capability to handle multiple projects and also their true passion while assigning them to several projects simultaneously. In this paper the results out of simulation with ABM testing would help to argue that project overload is more likely to actually limit creative actions.

It would be emphasized that innovation and creativity inside organizations should not be a function of chance; in return, culture of innovation should be the core of their business model.

Advanced Engineering (AE) project is committed to work on concepts such as energy efficiency for new machines in which more than 80 employees are building the core teams. Although research shows some benefit of sharing experts in different projects rather than just sitting at one project, the risk of limiting creativity because of being in too many projects seems also high. The current paper assumes that there is an optimum level as the middle ground amount of projects for each person that creativity is more likely to happen in that, not too much to be out of control not too less to be boring.

Agent-based modeling (ABM) is applied as facilitator for better understanding of the case study in which bottom-up perspective helped to look at micro-macro level of organizations to better understand the problem. From the bottom level of organization agents are the elements working together in cooperation, by coordinating and negotiating to make decisions [7].

II. Innovation, Creativity and Project-Overload

Creativity is defined as the ability of thinking and generating novel valuable ideas or solutions [5]. Organizational creativity can be interpreted as work of individuals together in order to create a useful new product, service, idea or process in a system [5]. Today the main concern of worldwide companies and organizations is economic growth [4]. Since the technological innovation is a major force in economic growth [4], many researches and experts have been trying to investigate on the questions on how to be innovative and how to move towards innovation. Sustainability is playing a new role in competitive landscape too, which brings the pressure to companies to think

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differently about products, technology and their process, which satisfies environmental issues [10]. For brining sustainability as new frontier inside organizations, innovation would be needed in order to move ahead of the competitors [10].

Considering knowledge and creativity as two important ingredients for innovation [1], it is argued that if a company could get use of knowledgeable experts and highly creative environment to motivate experts and spark their creativity this company is more likely to be innovative [1]. This paper mostly is dealing with one question; "What is the impact of project overload on creativity? Or how team members' creativity is affected by working simultaneously on several projects and therefore, how the team's innovation is affected by that". There is a tendency in organizations to grow with a multi-project strategy from a single-project and share the certain expertise [11] [6]. There are advantages and disadvantages in multiple project commitment, which have strong impact on individual level in teams. Lack of opportunity for recuperation, psychological stress reaction and time pressure are namely negative factors on individual performance in project overload setting [6].

Challenge, freedom, resource, group work feature, supervisory encouragement and organizational support are the facets discussed in Amabile's theory as important influential factors on creativity inside organizations [2]. It is also supported that in organizational psychology similar factors has direct relationship with creativity, namely; challenge, freedom, idea support, trust/openness, dynamism/liveliness, playfulness/humor, debates, conflicts, risk taking and idea time [3].

Challenge means that people are matched to the task they are involved with and they emotionally feel engaged with the goal of the project. Individuals experience high positive challenging climate when they enjoy their work, their task is meaningful for them and they do not suffer from lack of interest [3]. It is important that person is assigned to the perfect matches that stretch the employee's ability not too little and not too much [2].

III. Agent-based Modeling

Building simplified representations of social phenomena is almost all social science research progress [13]. These representations can be purely verbal or more formal and statistical or mathematical equations. Agent-based computational modeling is a relatively new tool for empirical research [12]. Agent-based modeling (ABM) basically differs from other simulation methods since its fundamental key units are the agents or individuals. Agents are in fact collective of heterogeneous entities that are interacting together or with their environment [12]. Agents influence each other's micro-decisions and from the interaction between agents macro-scale group behavior emerges. Agents are the individuals populating the simulated environment. These agents, either in aggregate or as individuals are the units of analysis. Each agent has some states that would be described here as well. In the current research this preliminary model tries to understand and analyze the relationship between involvement in multiple projects and likeliness of creativity and innovation. There are several positive and negative facts affecting teams creativity related to multi-project involvement. Two important factors of creativity are relevant knowledge and intrinsic motivation. Multi-project involvement brings along gathering knowledge from social network and can affect the intrinsic motivation as well. In this model challenging work has been chosen as important factor of analyses from several other elements have impact on intrinsic motivation. Related to current case study, it is assumed that Agents are divided to three categories, which would define their capabilities to handle multiple projects;

1: Full-time agent, whose perfect challenge is working just on one project at the time

2: Two-project agent, whose perfect challenge would be working on two projects simultaneously.

3: Three-project agent, whose perfect challenge would be working on three projects simultaneously

This simulation is trying to bring the project overload situation into the computational modeling equations, therefore in order to separate the fact of "multiple-project" setting and "project-overload" those three categories above are assumed. It interprets the project-overload phenomenon a) based on individual characteristics, capabilities, and interests in addition to b) the nature of the projects and challenges. If the project has an appropriate challenging goal as well as good group-feature and proper team structure people would find it as a perfect challenge, therefore light project overload would be manageable.

Agent's attributes:

1) Individual-category: IP. Agents can have one IP based on three category mentioned above.
2) Relevant Knowledge: K(T) .All agents' relevant knowledge and skill would be set as random at the beginning of the model because in reality also individual's knowledge in the area of the new project differs and also is not infinite. For sake of simplicity the knowledge would be distributed between agents as random-normal. In this model relevant knowledge does not represent the whole level of knowledge of human being, but the knowledge and skill that agents may have about the project domain they are committed to. During the project and after interacting with other agents and environment, agents start to gather data and improve their relevant knowledge. Since the time-length of project is limited, the knowledge gaining about the project domain is also not infinite.

$$\textit{Normal distribution: } \boldsymbol{y = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}} \quad (1)$$

3) Level-of-pressure: if agents suffer from project overload their pressure is high. If they are bored the pressure is minus.

Level-of-pressure represents the difference of agent capacity and the number of projects he is involved with.

Level-of-pressure: P(t)

4) Level-of-motivation: "0" when agent has completely lost his motivation, "2" when he is highly motivated and "1" neutral.

$$M_i(t)=\{y \mid -0\leq y\leq 2\} \quad (2)$$

where it represents the motivation of agent I in the time t.
Level of motivation of all agents' at the beginning would be a random distribution between 0 and 2. "0" or "1" or "2". But during the project this motivation could increase or decrease.

P(t) would have impact on M(t).

5) Number-of-projects: NP. Number of projects agent is work in simultaneously.

Environmental attributes:

Communication-level: it represents the level of freedom to have communication with social network inside organization. Higher communication-level means that agents have more autonomy to hold debates and exchange ideas, to take time for discussion and contributes in skill improvement.

Rules:

1) Level-of-pressure:

$$P(Agent) = IP_i - NP_i \quad (3)$$

Level-of-pressure of agent (i) would increase if the number of his project were higher than his capacity (IP).

As it is assumed that agents are in three categories based on capacities on handling project-overload, if the number of projects is lower than their level-of-pressure means that they have not met their challenge and still their work is not match with their capabilities, therefore their motivation may be low. But still environmental and other agents attributes can increase or decrease their motivation towards their projects. On the other hand, if the level-of-pressure is higher than their capacities there is the risk of project-overload means that when this pressure is one unit across their capacities there is the likeliness to stretch their capabilities and moderate the pressure only if the challenging project is close to their interest and if there is a supportive group-feature; group-work feature represents mutual supportive environment in which people are working together where there is high level of communication and supervisory encouragement.

2) Number of other agents that each time agent can interact with:

$$B_i(t)=(NP) * \text{random (communication-level)} \quad (4)$$

Number of other agents that they can meet and have interaction with is based on their communication-level that is an environmental attitude.

B_i would define the number of links between agents each unit of time.

3) Relevant Knowledge: relevant-knowledge of agents could be a function of natural logarithm

For sake of simplicity, here in this model knowledge would increase statically base on time.

The differences between highest knowledge and lowest knowledge inside the individual social network while working on the projects is shown by PM(t). The difference between knowledge will exponentially decay from the beginning point of its execution, as follows:

$$PM(t)=\boldsymbol{\lambda}\left(\mathbf{1}-\left(\boldsymbol{e}^{-\propto(\boldsymbol{t}-\boldsymbol{t1})}\right)\right) \quad (5)$$

Relevant-knowledge: $\boldsymbol{k(t)=k(t1)+K(t1)PM(t)}$ (6)

Where t1 is representing one unit time before time t.

Each time that agents meet another agent with higher relevant-knowledge they would improve their relevant-knowledge, therefore number of their projects indicate their social network and the times they can meet other agents and gain knowledge.

Note 1: The more often people exchange ideas and data by working together, the more relevant-knowledge they will have [2].

Note 2: one of the characteristics of project overload is the limitation for improvement.

4) Level-of-Motivation :

If ($P_I < 0$) then $M_i(t) = 1$
If ($P_I > 0$) then $M_i(t) = 0$
If ($P_I = 0$) then $M_i(t) = 2$

if ([M(t)] of partner >= 2) and (K(t) of partner > K(t) of myself)[
M(t) =M(t-1) + 1

For agents with pressure either positive or negative there is the risk of losing motivation:

If $P_I(t)$!= 0 [
if (M(t)of partner <= 0) and (K (t) of partner < K(t) of myself)[
M(t) = M(t-1) - 1

Note: information sharing and collaboration heighten peoples' enjoyment of work and thus their intrinsic motivation [2].

5) Likeliness-of-creativity:

$$C_i(t) = M_i(t) * K_i(t) \quad (7)$$

Creativity in each individual is a function of knowledge and motivation; means that as motivation goes up the likeliness of creativity goes up and as their knowledge around the related domain there are working goes up the likeliness of creativity enhance.

[Ford, 1996] proposed that creativity is a function of motivation multiplies by knowledge and ability [9].

IV. Results

In this simulation some teams of agents are created in order to interact together and illustrate the teams' likeliness of creativity. Teams are made up of agents with different

percentage in commitments and some are involved in multiple projects simultaneously. In the Table I, both teams (team1 and team2) are built randomly which means that the most eligible agent has got assigned to the open project without taking care of designing the team based on perfect matches, challenges and group-feature. In addition, there are agents who are involved in three, four or five projects simultaneously; therefore the risk of project overload is relatively high. The model can be run several times and different results can be captured, here the results are not satisfactory yet in terms of creativity.

In the next two tables-Tables I and Table II- teams are made up of agents who got assigned to the project randomly not based on their category. The risk of project overload is also so high. The result of likeliness of creativity seems disappointing.

TABLE I
RANDOMLY

Category	Team1 (Randomly)
One-project-agents	9
Two-project-agents	5
Three-project-agents	5
Four-project-agents	5
Five-project-agents	5
Team size	29

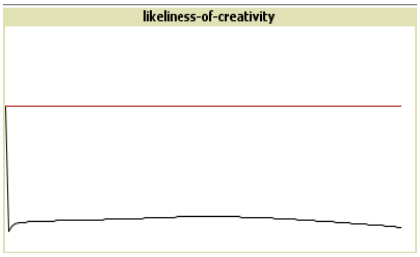

Fig. 1 Black: team1, Red: zero line

TABLE II
RANDOMLY

Category	Team2 (Randomly)
One-project-agents	9
Two-project-agents	5
Three-project-agents	5
Four-project-agents	5
Five-project-agents	5
Team size	29

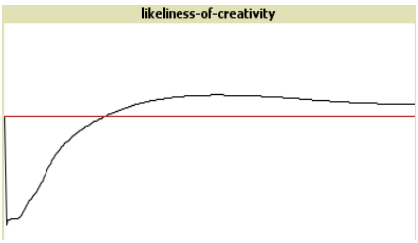

Fig. 2 Black: team2, Red: zero line

In the next simulation test -Table III-, five agents with 5 different projects are eliminated from team and instead one full-time agent is replaced. Similar to the previous tests, both teams are built randomly. As it is illustrated in the likeliness of creativity curve, the results are improved in compare with previous table with the high risk of project overload. Even in the first curve a satisfactory result would be observed. The significant problem still remains here, which is the fact that creativity is still a function of chance, it may happen but may also not happen. More we reduce the number of agents with risk of project overload better results would happen but still based on chance.

The more you reduce the risk of project overload with cutting off the projects individuals are assigned to, the more the likeliness of creativity would be! But, still creativity is a function of chance.

TABLE III
RANDOMLY

Category	Team1 (Randomly)
One-project-agents	10
Two-project-agents	5
Three-project-agents	5
Four-project-agents	5
Five-project-agents	0
Team size	25

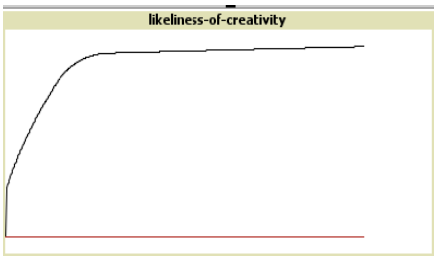

Fig. 3 Team1

TABLE IV
RANDOMLY

Category	Team2 (Randomly)
One-project-agents	10
Two-project-agents	5
Three-project-agents	5
Four-project-agents	5
Five-project-agents	0
Team size	25

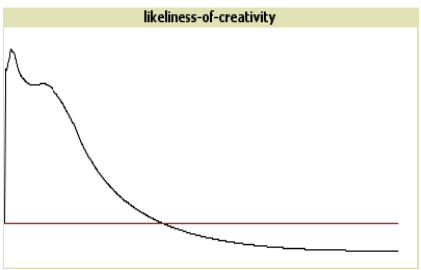

Fig. 4 Team2

The Table V below demonstrates the comparison of two different teams with different scenarios; first random assignments and second matching with right challenges. The first team is created randomly as it was explained in the last two tables. The second team, in return, is built based on the accepted criteria for a creative team which are matching agents with perfect challenge and designing a good group-work feature. The likeliness of creativity is observed when the risk of project overload is high and the result was not satisfactory. Here in the upcoming table the difference of likeliness of creativity when the risk of project overload is relatively low has been shown. In the team1 with black curve still the creativity is a function of chance. On the other hand, the team2 with red curve when the culture of creativity – challenging goal- exists shows that the likeliness of creativity is always satisfactory.

TABLE V
RANDOMLY

Category	Team1 (Randomly)
One-project-agents	10
Two-project-agents	3
Three-project-agents	2
Four-project-agents	0
Five-project-agents	0
Team size	15

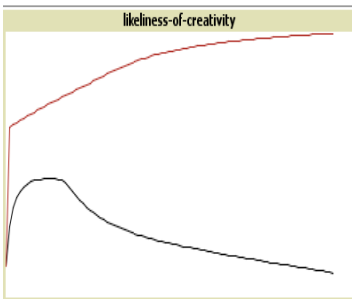

Fig. 5 Black: team1, Red: team2

TABLE VI
MATCHING

Category	Team2 Match agents with category
One-project-agents	10
Two-project-agents	3
Three-project-agents	2
Four-project-agents	0
Five-project-agents	0
Team size	15

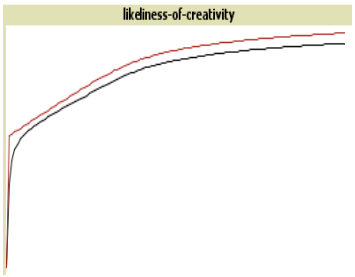

Fig. 6 Black: team1, Red: team2

Ideal likeliness of creativity is when all agents are fit with their category based on project overload. Team2 is made up of agents who do not suffer from project overload and they are more likely to be creative. Team1 is created of agents who got assigned to the project stochastically not based on their category. They are less likely to be creative; and this is also observable that more the number of agents with high projects involvement, lower the probability of creativity would be.

V. Discussion

Project-overload is happening when the employees are simultaneously involved in too many projects [11]. One of the significant variables that can alleviate the risk of project overload for individuals and increase the likeliness of creative actions is a right challenge related to their expertise [6]. Perfect matches stretch individuals' abilities; hence the amount of stretch is crucial [2]. In this paper it is assumed that involving employees with multiple projects makes a higher risk of not assigning them to the right challenge, and that is due to complexity of the multi-project settings [11]. Project overload brings along the risk of fragmentation, lack of opportunity for recuperation and low development of skills [6], which in the current research it has been investigated whether it would limit creativity or not.

ABM is used in this research as a tool for the refinement of the theory and help to build a preliminary model in order to better understanding the current phenomena. The role of simulation usually is not to create a facsimile of any particular social system or organization that could be used for prediction, but to use simulation to assist better understanding and help in the exploration of the consequences of several assumptions and initial conditions [14].

Relevant-knowledge and motivation-level as agents' attributes are the main parameters defined based on researchers assumptions for sake of simplicity. This simulation is seen as preliminary model that in the future studies could be developed with reducing the assumptions as much as possible in order to bring more comprehensive reliable results.

VI. Conclusion

This paper has focused on the impacts of project overload on innovation inside VCE organization and aimed to identify the pros and cons of multiple project involvement. Creativity inside organizations is a function of various factors, namely; appropriate challenge and good group-work feature. Creative climate inside organizations has been seen as common

perception arising from interaction between organization's members. In addition, the main characteristic of multiple project setting is simultaneous projects involvement since companies tend to use human resources in an efficient manner by using scarce resources in many projects. There are advantages in terms of creativity in this strategy, however in the individual level working on several projects at the same time would bring the risk of project overload and may cause disruption and fragmentation from work as well as high level of psychological reactions for people. Switching frequently between several projects is interrupting the focus and would cost considerable amount of set-up time. In this research it has been observed that teams with project overload show unsatisfactory results in creative actions, however light project overload could be moderated by appropriate challenging goal and good group-feature. This could be interpreted as follows: employees should be able to focus on their work the fact that could be limited by project overload due to work fragmentation therefore project overload is more likely to hinder creativity. If culture of creativity exists and organizational strategy ignites intrinsic motivation of employees, negative aspects of light project overload could be moderated. In addition, organizations should pay careful attention to the design and structure of their project teams. What would be necessary is a mutual supportive group with right diversity of perspectives that all members express willingness to help each other through difficult situations and share the excitement to reach the shared goal together [2]. Creating such a team requires that managers have a deep understanding of their people in order to make the best matches between both individuals and the task in projects.

This thesis discussed that creativity should be a culture inside organization not a function of chance. Organizations that have the goal of creating an everyday creative culture should consider their employees as individuals with specific characteristics and do not treat them as robots. Assigning so many projects to employees disturb their focus and kill the time needed for recuperation and reflection. Many great ideas usually linger on, for a while, in the back of peoples' mind, where it is called incubation time. Project overload because of its circumstances such as tight time schedules or no enough time for incubating ideas, is more likely to hinder creativity.

In the future studies for creativity inside AE project, it is essential to investigate on the communication part of projects. Appropriate communication, idea debate and support is known as a key element for creativity and innovation, therefore the disadvantages and shortages of not being located at the same place should be under consideration. Next step for VCE could be defined as developing a culture of creativity and innovation. The precondition for technological innovation could be seen as organizational innovation. Organizations that want to be ahead in terms of technology and product innovation need to bring a revolutionary approach in their culture and climate in order to spark creativity and innovation inside the teams. Innovation no longer should be seen as a moment of insight, but as a daily culture inside organization.

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