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Modeling a Digital Platform for Hackathons:

How do hackathons characteristics and participants motivation factors affect participation?

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Abstract

In the fast-paced environment of innovation, hackathons serve as critical platforms for brainstorming and developing new technologies and solutions and bring together talented participants to foster innovation. This thesis explores the dynamics of hackathon participation, focusing on how various characteristics of hackathons and motivational factors of participants influence engagement. An agent-based model is developed to simulate a series of hackathons in a digital platform, allowing for the manipulation of hackathons characteristics and participant motivation to observe their effects on engagement. Findings suggest that structured tasks, opportunities for social affiliation, and significant incentives such as career advancement strongly influence participation rates. The study provides valuable insights for hackathon organizers and digital platforms on how to optimize hackathons to increase participant engagement and foster a robust ecosystem for innovation.

Keywords

Hackathons

Participation

Motivation

Innovation

Abbreviations

ABM – Agent Base Model

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1. Introduction

In the dynamic landscape of today's business world, companies are constantly pressured to innovate, keep up with evolving customer needs, and identify and exploit new opportunities. Hackathons have found their space in the business world, as they serve as an accelerated platform for brainstorming and developing innovative projects. Hackathons are competitions that gather relevant talent to collaborate and compete in an intensive session aimed at forging new and exciting business ventures. Hackathons offer a unique blend of creativity and efficiency, providing companies with the possibility of innovating quickly and effectively, positioning them advantageously in a competitive market.

The emergence of this new breed of contests, since the first ever named “hackathon” in 1999, is capturing the attention of both the academic community and corporate entities, since this date (Chau and Gerber 2023). This burgeoning interest is driven by the unique capability of these contests to aggregate diverse talent pools and swiftly generate a set of perspectives on a given problem or idea (Taylor and Clarke 2018). Unlike traditional problem-solving approaches, these contests leverage the dynamism and diverse expertise of participants from various backgrounds, encouraging a collaborative yet competitive environment where innovative solutions are not only encouraged but needed. The format of these contests, often characterized by tight deadlines and challenging outcomes, fosters an intensive brainstorming process that accelerates the generation of ideas and solutions.

Despite their potential, the effectiveness of hackathons is not fully realized, and many projects fail to transition into viable market solutions, raising questions about the organization, attractiveness, and outcomes of these contests (Nolte, et al. 2020). The focus of this research emerges from the observation that while hackathons are popular, there is a significant

knowledge gap in understanding how their characteristics, as well as motivation factors, influences participant engagement, especially in digital platforms with multiple hackathons.

This study seeks to bridge this gap by providing insights into how different hackathon characteristics, mixes of participants and incentives affect participant engagement within ecosystem where multiple hackathon opportunities are available. The implications of this research are far-reaching, potentially informing organizers on how to structure hackathons more effectively and how they should incentivize participation. By identifying the key drivers of engagement for innovation, this research aims to contribute to the enhancement of hackathon mechanisms for incentivizing participants, fostering a more robust innovation ecosystem.

Reflecting on the complex interplay of variables in hackathon design and participation, this thesis is anchored by the question: How do different hackathons characteristics and participant's motivation factors affect participation in hackathons?

To answer this question, an agent-based model is developed, simulating an online platform where multiple hackathons are hosted. This approach allows for the manipulation of variables underlying task complexity to observe their impact on participant engagement and diverse participants mixes of motivation factors on the innovation competitions. The model's robustness in reflecting diverse participant motivations and hackathon structures presents a unique opportunity to analyse these phenomena in a controlled, dynamic and manipulated setting.

The rest of the paper is organized as follows: first there's a review on prior literature on hackathons, different motivations driving participants, and hackathons set ups to provide a foundation for a learning perspective on participation engagement. Then, a description of the model and its key results on participation are reported, followed by a set of recommended manipulations that can change engagement dynamics.

2. Literature Review

Hackathons

Hackathons, as collaborative and competitive platforms, have been studied to understand the factors that drive participant engagement and innovation.

Hackathons, often organized by companies or other organizations, are innovation contests that aim to engage participants in problem-solving activities, typically with a focus on technology and development, where the concept started from. These events are not just about sourcing new technologies but also about fostering collaboration between different stakeholders, such as companies and communities, to understand and solve specific problems (Pihlajamaa and Merisalo 2021). They are intended to stimulate continued development of innovative solutions through multidisciplinary collaboration.

The unique ecosystem of hackathons where competition and cooperation coexist was explored, concluding that while competition is driving individual effort and creativity, it is the cooperative elements—such as team collaboration and knowledge sharing—that significantly enhances the quality and innovativeness of the solutions developed (Bullinger, et al. 2010).

The significance of knowledge transfer within innovation ecosystems is facilitated by open innovation contests like hackathons and how they can spark coupled open innovation and catalyze cross-border knowledge transfer without reducing the ecosystem's generative capability was studied (Smith, Burden and Hjalmarsson 2016). This research even proposed and concluded that for innovation to be deployed and solve problems, more measures are needed to sustain and aid the implementation of the ideas beyond contests.

In today's world, companies and organizations primarily organize hackathons to improve their

business activities by getting new ideas, prototypes or business plans for their internal problems or possible improvement opportunities. With the aim of maintaining competitive advantage, responding to competitor's offerings, and even exploiting emerging business opportunities, some companies find themselves stuck in building efficiency cycles. Hackathons surge as a way to unleash creative thinking because of how they pick up people who are new to the topic at hand (Komssi, et al. 2014). In addition, these events can be also used to leverage platforms and build a community of users around them (Valença, et al. 2020), and it usually happens on tech companies trying, for example, to launch new software or libraries. On top of that, these contests are not just for problem-solving, but also serve as a medium to attract and identify talent (Raatikainen, et al. 2013), having become even more common to do it by targeting universities and college students as an employer branding initiative beneficial for the company.

By addressing key areas such as participant motivation, community building, event design & structure, task complexity, and knowledge transfer, hackathon organizers can create events that generate innovative solutions and provide a rewarding and engaging experience for all participants and stakeholders. The sum-up of these elements, if well thought out, has been studied as a way of having successful hackathons that ensure creative problem-solving.

Motivation

One of the major topics studied in academic literature is the reasons why individuals participate in such events. Most literature emphasizes the role of both intrinsic motivations, such as personal interest and the joy of problem-solving, and extrinsic motivations, including rewards, recognition, and potential career opportunities (Lakhani, et al. 2007). In fact, multiple articles agree that the motivation of participants in hackathons can be quite diverse but sustained in these most broad and all-encompassing motives. For example, a different study presents the

factors differently but accordingly, saying they range from technical motivation (e.g. skill acquisition, social motivation), to individual motivation (e.g. autonomy and enjoyment, to business motivation factors (e.g. publicizing work, establishing partnerships (Melo, et al. 2018).

In fact, most literature divides participant's motivation factors into four major categories.

One of the most predominant motivation factors among hackathons participants is the willingness to learn and even develop a new skill or competence. Even though there is a competitive nature behind these events, it is concluded on the huge learning opportunity there is in a hackathon, shown in disruptive new forms of learning outside of the traditional academic methods. Peer-learning effects, as well the practical applicability of the gamified format of the contests, showed that not only developing these new skills is a high motivation factor, but also learning a new skill is a consequence of the participation (Nandi and Mandernach 2016).

Building on the motivational aspects, literature also consistently underscores the critical role of community and social connections. The sense of belonging to a community and opportunities for networking and collaboration not only motivate deeper engagement but also contribute to a richer, more fulfilling hackathon experience. This effect was studied among some participants and proved that meeting new people and expanding one's network is one of the main motivations (de Almeida Melo 2018). This interaction not only provides immediate benefits but also establishes lasting connections that lead to collaborations and opportunities.

A study developed an integrative model of job search and employee recruitment and mentioned that it is likely that the forms and content of recruitment activities are influenced by the characteristics of the job and the organization (Acikgoz 2019). It was even studied the example of tech companies, when targeting their candidates they organize successful recruitment events, mainly hackathons, where they get to know participants competences, as well as software

students and engineers that go to events sponsored by their target companies in order to promote themselves and get to know their software or ways of working.

The impact of monetary rewards was examined on the transition of individuals from being mere members to active participants in crowdsourcing contests, employing the extrinsic motivation theory (Patel, Husairi, et al. 2023). Building on the fact that higher monetary rewards amplify tangible benefits (e.g. acquiring material goods or ensuring financial security), and intangible benefits (e.g. enhancing social status and demonstrating competence), appealing to performance-driven individuals that enjoy the possibility of performance feedback, reinforcing desired behaviors and promoting participation among individuals striving for recognition and success in design crowdsourcing contests, they are trying to show it thereby motivates participation. Their conclusions indicate that the increase in the value of monetary rewards boosts the likelihood of contest participation, supporting the hypothesis that higher rewards lead to increased submission rates among contest members. However, their findings underscore the importance of not only increasing rewards but also enhancing participation among individuals with relevant skills and experience to counterbalance the trade-off effects effectively.

Selection

These problem-solving competitions may vary in different kinds of objectives, structure, and collaboration, affecting participation motivation depending on complexity. In a specific study, task complexity was described and classified depending on three major characteristics: task structuredness, necessary commitment and interdependence (Pee, Koh and Goh 2018). This study focuses on the influence of task complexity on participant engagement. By classifying task complexity into the three characteristics (unstructuredness, interdependence and commitment), it is demonstrate how each one of them is interconnected with a motivation factor

that a participant demonstrates. Participants with a primary motivator of developing competence participate in contests where task commitment is needed, since it reflects on how much effort and resources are required to complete it. On the other hand, task interdependence is a major consideration for the participants willing to foster social affiliation, because of the need of collaboration on the tightly coupled task activities. Lastly, when it regards participants with more extrinsic and distal motivation factors, such as rewards, payments or job-market opportunities signaling, these kinds of motivations are converted into an intrinsic motivation of demonstrating competence which is strongly uncorrelated to unstructured tasks that don't have clearly defined outputs making it harder to demonstrate competence. This model helps the definition of participation motivation, according to most of the literature on the topic, but really demonstrates the interconnections of these with hackathons-selection being vital for this study.

Performance

In the dynamic and often unpredictable realm of hackathons, where challenging problems with no clear solutions are the norm, there's a compelling argument made by (Boudreau, Lacetera and Lakhani 2010) regarding the impact of increasing competitor participation on overall contest performance. Their research, besides studying the effects of uncertainty and competition in innovation contests, finds out that introducing more competitors into these contests systematically enhances the collective problem-solving capacity, fostering a more competitive environment that drives innovation and creativity. This assertion is rooted in the idea that diverse perspectives and skills contribute to a richer pool of ideas, facilitating the development of more comprehensive and effective solutions. By comparing various hackathon outcomes and doing an empirical analyses, this research illustrates how the addition of competitors catalyzes an environment where participants are pushed to not only think outside the box but also to refine

and adapt their strategies in response to the evolving landscape of ideas and solutions being generated. This results in a marked improvement in the quality and ingenuity of solutions to problems that are inherently complex and open-ended, underscoring the value of broad participation in hackathons (Boudreau, Lacetera and Lakhani 2010).

3. Model

To investigate the participation engagement in digital platforms for hackathons it was modelled the platform as a complex adaptive system where participants have different motivations. In fact, this research adopts an agent-based modelling (ABM) approach to explore the dynamics of participant engagement in hackathons. ABM is a class of computational models that simulate the actions and interactions of autonomous agents with a view to assess their effects on the system (Salgado 2013). Agent-based model applications have seen a consistent rise since it's a model that can be applied in multiple business problems (Bonabeau 2002).

The implementation of the ABM was carried out using an open-source python package called [cadCAD](#), which provides a robust environment for modelling complex systems with a high degree of detail. The implementation involved coding the behaviour of the agents, to reflect the literature details, and setting up the environment to represent the hackathon platform.

In the context of the problem, a digital platform for hackathons offers an overview on contests happening soon and the possibility of registering for them, therefore agents represent individual participants and platform users with varying motivations and thresholds for participation. The suitability of ABM for this study lies in its capacity to model complex, adaptive systems like a platform with a set of hackathon opportunities, where participant behaviour and participation is influenced by a multitude of factors including task characteristics.

The model has three main entities – participants, hackathons, and the platform.

Participants

These agents represent people interacting with the platform and participating in some hackathon. In this specific context, the characteristics of the participants are defined by a combination of motivational factors, activity levels, past participation, time availability, participation threshold, and awareness of the platform (in this case simulating [Taikai](#)).

Each participant is unique and randomly built within the model (Figure 1), with their motivation being a complex interplay of competence development, social affiliation, job market signalling, and reward seeking, each one randomly modelled uniformly in a scale between 0 and 1. This diversity in motivation reflects the varied personal and professional goals individuals bring to the platform. Other characteristic is their awareness and relevance given to the brand hosting the event, that is quantified on a scale from 0 to 1, where 0 represents no impact on motivation considering organization's brand, and 1 represents a high relevance given to it. The model keeps track of participants activity status with a boolean value and their past participation history with a list of ids for each hackathon they participate overtime.

There are some constraints for a participant to choose to participate in hackathons via the platform: each participant has a limited availability for hackathons, measured in a discrete number of substeps ranging from 1 to 7 and representing the limit number of days they are available for participating; and a participation threshold, further explained in the participation selection section below, that represents participants individual minimum standard for willing to participate in an hackathon and is directly challenged and influenced by personal motivations.

These characteristics, supported by literature reviewed for this research, create a rich mix of participant types, enabling the simulation of complex interactions and behaviours that mirror the nuanced decision-making processes of individuals in real-world environments, crucial for

analysing the dynamics of participation and the factors driving engagement.

Hackathons

In the agent-based model, hackathons are also designed as dynamic entities characterized by several key features that encapsulate the complexity and diversity of real-world events. Each hackathon is described by its unique complexity, which supported by the literature reviewed, is uniquely defined by its degree of unstructuredness, the level of commitment it demands from participants, and the extent of interdependence required among participants. Each of these characteristics assumes a random uniform number between 0 and 1 (see Figure 2).

Unstructuredness ranges from zero, highly structured, with clear guidelines and expectations, to one, highly unstructured, encouraging creativity and self-direction, reflecting the spectrum of environments that hackathons may present. This dimension captures the balance between providing a framework for development and allowing creative freedom, influencing the types of projects that can emerge.

The commitment level, also on a scale from 0 to 1, indicates the intensity and duration of effort required from participants, with higher values signalling events that are more demanding in terms of effort and resources. This factor is crucial for matching participant capabilities and availability with hackathon requirements, affecting both learning outcomes and performance.

Interdependence among participants is quantified similarly, from zero, favouring individual work, to one, emphasizing teamwork and collaboration. This characteristic defines the extent to which participants must rely on each other to achieve their goals, highlighting the importance of collective effort and the integration of diverse skills and perspectives. Another notable factor included in the hackathon's profile is the brand recognition of the hosting company or organization. This refers to how well-known the host is among potential participants.

Furthermore, hackathons vary in length, typically ranging from a single day to a full week, which includes additional time for registration that can go from a week (7 days) to a month (31 days) to be able to plot some relevant but closer to reality outcomes in the simulation.

The 'state' of a hackathon (registration, active, or ended) and the current timestep further contextualize its timeline within the model, providing a mechanism to simulate the progression and lifecycle of each event.

These features, informed by literature on hackathon complexity, allow for the simulation of a wide range of hackathon experiences within the model.

Platform

The platform keeps track of number of participants in each hackathon and current rate of new hackathons in the system to be able to help the simulation understand the status of the platform.

The probability of knowing Taikai introduces an additional layer of diversity, capturing the real-world scenario where only a fraction of potential participants is aware of specific platforms and opportunities. In this case, the simulation's assumption is that the probability of them knowing the platform starts in 5%, within the simulated population of 10000 participants, and is updated according to the environment changes and participation/engagement.

The environment depicts the platform ecosystem and is responsible for the aggregation of agents in the model, executing the three major update functions every substep of the simulation: new hackathons submissions, participants hackathon selection, hackathon conclusion.

New Hackathon Submission

In the simulated environment of our agent-based model, the process of hackathon submission on the platform is designed to emulate real-world dynamics of event creation and participation.

For that, an analysis of the platform supporting this research ([Taikai](#)) was made. By web scrapping the platform website and creating a database of the opportunities available, some analysis and conclusions were drawn to support the model assumptions. The introduction of new hackathons was assumed at a steady rate, grounded in the first year of the platform average rate per month. Therefore, the rate is assumed to be 4 hackathons per month, and a probabilistic method runs every substep of the simulation. This method ensures a baseline level of activity and opportunity on the platform, mirroring a consistent availability of such events. The simplicity of this approach serves as a fundamental mechanism to maintain engagement and provides a constant stream of opportunities for participants, ensuring the simulated environment remains dynamic and populated with events, although presents itself as a limitation of the study.

Participants Hackathon Selection

The participant hackathon selection process within the agent-based model is a decision-making mechanism that simulates how individuals choose hackathons to participate in, based on a series of strategic evaluations and personal preferences. This process is articulated through a multi-step policy that assesses both participant awareness and interest in engaging with available hackathons on the TAIKAI platform. The process runs for every participant and hackathon in every simulation substep, following these approach (see Figure 3 for a visual representation):

1. Awareness and Active Participation Check: every step of the simulation starts by assessing whether a participant is aware of the TAIKAI platform and if they are not already actively participating in a hackathon. This step ensures that only those who are both informed about the platform and currently available can consider new hackathon opportunities.
2. Hackathon Interest Evaluation: once the participant is a platform user and can access

the information about the available hackathons, a selection process starts to reach the hackathons fulfilling participant's thresholds. First, the model goes through all available hackathons currently in the registration period and performs a careful evaluation of each hackathon's characteristics against each participant's preferences and time availability. The core of this matching process lies in evaluating how well a hackathon aligns with the participant's motivations (such as competence development, social affiliation, job market signalling, and reward seeking) considering the correlations proposed by (Pee, Koh and Goh 2018). This evaluation considers the hackathon's demand for commitment, its level of structuredness and required interdependence among participants. Furthermore, the brand of the hackathon's host and the participant's relevance given to it is also part of the evaluation criteria and included in this matching process. Based on the correlations proposed by previous research, the model then calculates a "grade" for each hackathon, that represents the degree to which it aligns with the participant's motivations.

3. Threshold for Interest Decision: the participant decision in registering for the competition is firstly based on this hackathon's grade that is then compared with the participant individual threshold. This threshold represents the minimum level of interest or benefit a participant requires before committing to an event, ensuring that decisions to participate are not just based on availability but on a genuine alignment of interests and event characteristics. If the hackathon fulfils this threshold, it's grade is compared with the "grade" of the hackathon that is currently the most interesting hackathon for the participant. If the grade ends up being the highest grade among all hackathons available, it is saved as the participant's best interest alongside its "grade".

4. Hackathon registration: once the registration period of a hackathon is about to close, the participants who saved it as the most interesting hackathon available register for it.

This nuanced decision-making policy encapsulates the complexity of real-world participation choices, where individuals weigh their own goals and constraints against the opportunities presented by different hackathons.

Hackathon Conclusion

The last update function on every simulation encapsulates the final phase of the hackathon lifecycle, concluding on hackathon effects on the ecosystem including updating the probability of participants knowing the platform.

In the end of an hackathon, the model updates the probability that participants are aware of TAIKAI, considering that the participants who just participated will generate a network effect and buzz around the participation opportunity, recommending the experience to at least one friend, driven by the emotional feeling provoked by the experience (Goh, Adam and Hoe 2014).

In the end, participants' active participation status is reset, allowing them to engage in future events. The hackathon's state is then updated to 'ended', and its current timestep is reset, officially concluding the event within the simulation.

This function, therefore, not only manages the conclusion of hackathons but plays a crucial role in simulating the social dynamics of the TAIKAI ecosystem, fostering engagement, and spreading awareness among participants.

4. Simulation Results

The model described above was used to run a series of simulation experiments that examine the research question. These simulations were performed over 300 time periods to picture a one-

year timeline for the analysis and each model represents an aggregation of 3 monte carlo runs embedded in the ABM settings of cadCAD simulations.

The base model of the agent-based simulation fulfills the characteristics described to simulate the complex engagement behaviors on the TAIKAI platform or analogous digital innovation-fostering platforms and stands as the comparative benchmark for subsequent experimental simulations. It represents the spectrum of participant interactions within such ecosystems, and by analyzing core metrics such as average participation rates, the dynamics of platform awareness, and the interplay of hackathon features with participant decisions, it paves the way for a series of focused simulations where specific changes on participant attributes and hackathon configurations are manipulated. These manipulations aim to dissect the underlying mechanisms that can be leveraged to amplify engagement, offering a structured approach to isolate the effects of strategic interventions within the platform. In doing so, the base model provides an essential reference point, anchoring the experimental simulations that seek to unveil actionable insights into enhancing participant involvement and interaction.

Base Model

To analyze the base model, some metrics were considered, and were challenged against the reality now perceived in platforms like TAIKAI, whose data was collected as part of this research to better evaluate the performance of the base model.

The main metric to be evaluated that surely has more impact on the platform, mainly for its clients but also for the organization recognition, is average participation overtime (see Figure 4). It is clear that, in the base model, average participation per hackathon overtime is characterized by peaks of participation and no clear trend. These peaks represent active hackathons that differ from each other with the bigger ones reaching over 300 participants

possibly indicative of specific hackathons that possess highly appealing attributes. As said, the analysis of the average participation flow does not reveal a predictable pattern or trajectory, mirroring the diversity of participant engagement decisions, but highlights the challenge in having a stronger participation trend. Despite this irregularity, the mean in participation stands at 83.5 participants per hackathon over the 36 hackathons in the simulation timesteps. It is also interesting to show that not more than 3 hackathons (see Figure 5) occur at the same time showing dispersed participation and lowering the occurrences of hackathons not having participants, which only happens 4 times during this period (see Figure 6). These situations though show signals of misalignment between certain hackathon features and participant motivations, possibly reflecting extreme situations.

The base model results closely align with the empirical data collected from the TAIKAI platform, validating the model's ability to simulate a real-world scenario (see Figure 7).

Another metric to look at is how the population awareness about the platform increases overtime among the 10000-population simulation in the dataset. The climb from 5% of 10000 to 3545 participants shows a steady stepwise increase in the number of participants who are aware of the TAIKAI platform as time progresses. (Notice that this metric does not reflect in number of participants that participated in the hackathon which was 1257). However, this awareness incremental growth is supported by the model assumptions, as it tries to simulate the dissemination of the platform through the participants that actually end up participating in hackathons generating a feedback effect to lead to a wider recognition of the platform.

Hackathons Characteristics Manipulation

As studied in academic literature, different characteristics can influence participation in hackathons. Therefore, the simulations performed show that by manipulating and maximizing

or minimizing these characteristics, participation can be increased. Each characteristic has been manipulated, and the impact can be seen in the average participation in Figures 8 and 9. Unstructuredness. Figure 9 shows that when the hackathons are manipulated to be highly unstructured, the average participation is negatively affected (to 41.31, almost 50% less than the base model). As expected, when unstructuredness is manipulated positively (i.e., more structured), participation increases significantly to 134.76. This indicates that adding structure to hackathons is likely to increase participation by approximately 61.4%. When structuredness is analyzed over time, it does not have a clear trend, although it is clearly a characteristic that consistently outperforms the base model, and its average participation is not just supported by one or two peak hackathons that drive participation. In fact, it is the only feature that is able to reach an average of 300 participants more times.

Interdependence. When interdependence is negatively manipulated (no need for collaboration), participation drops to 57.02 from the base model, a decrease of about 32%, but not as much as in unstructured hackathons. When the need for collaboration is promoted in each hackathon, the average platform participation reaches 133.01, which represents a similar effect as promoting a clear output as a result of the hackathon. Interdependence over time has no clear trend, and its average is supported by a hackathon that is able to aggregate a lot of participants, since most of the time the average is around the 150-participant range. As far as interdependence is concerned, this characteristic is the one that culminates in less awareness of the platform. Even when positively manipulated, only 5994 participants become aware of the platform (about 800 people less than the other hackathon characteristics), and less than 500 participants participate (see Figure 10).

Commitment. The negative impact on commitment (less commitment required) leads to a

decrease in average participation (57.55). However, it is the only feature with a smaller impact on this average. The impact is similar when more commitment is required from participants, only averaging 114.27 participants. Over time, commitment shows no clear increase or decrease trend to highlight but supports a more stable participation rate and is able to have an average of 300 participants in 6 periods in the period studied.

Brand Recognition. Although this characteristic is the one with the strongest impact on participation, negative or positive (30.24 and 148.75 average participants respectively), it is not easy to manipulate because it is strongly linked to the platform's customers. However, this analysis shows how important they could be for the platform to reach these large customers.

In all of these extreme cases, the average of the characteristics of participants who did or did not register for hackathons was also evaluated, but it did not show any differences in terms of motivational factors. The only difference would be that participants with higher thresholds for participation would be affected by these changes and would be more likely to register.

Participants Motivation Factors

The motivational factors of the participants are studied as a key factor for engagement in hackathons. The simulations performed to manipulate the type of population and crowd interacting with the ecosystem allow us to study how finding these types of participants can increase the number of participants for the platform (see Figure 11 and 12).

Competence Development. The graph shows that when the population is manipulated to target only people with a high level of willingness to develop any skill or competency, the average participation in hackathons increases by 124.28 compared to the base model. It is important to note that when no participant in the population is willing to develop any competency, the average participation stays around the same value as the base model. A similar effect can be

seen for the total number of participants in the hackathon and for those who are aware of the platform. Both numbers are above the base model, for the two types of population available, although the population most willing to develop skills brings significantly more participation (2462 actual participants and reaches 6234 participants aware of the platform, see Figure 13).

Job Market Signaling. When participants are looking for job opportunities, they participate in hackathons in large numbers, averaging 154.07 participants per hackathon, and on the other hand, when this is not part of the motivation, a negative impact on this average is felt, reaching only 52.52 participants. Although, over time, this motivation factor seems to slightly increase the average participation, it is a smaller scale because this average of 154.07 is supported by a specific clear peak seen in Figure 11, which can be indicative of an outlier and not represent the underlying impact of this population.

Reward Seeking. Rewards seem to be the least effective motivator to bring people to hackathons when highly manipulated, meaning that the mix of reward seeking participants in the common population is preferential. When the crowd is negatively or positively manipulated to have people who strongly seek rewards or not, the average number of participants per participant is lower than when no manipulation is done (66.74 and 71.39, respectively). Although the average participation is lower, the reach in terms of number of participants and percentage of the population aware of the platform is higher in the two manipulated populations than in the base model (2038 and 2726 for both low and high reward seekers in total number of participants in hackathons and 5593 and 6486 in number of participants aware of the platform, respectively).

Social Affiliation. This motivation factor is shown as the most prominent and strongest in driving participation, both in the overtime overview and in the average participants (161.88), consistently reaching more than 500 participants. It is also the only participation factor that

brings more participants to participate in the platform (4900 participants), being able to reach a record in the simulation of 8819 participants to raise awareness of the platform.

Brand Awareness. This specific characteristic of a participant is not a motivating factor, but it can influence participation if participants care about the brand name of a hackathon organizer. Therefore, it is clear that the weight given to brand names can lead to more participation for hackathons on the platform (average 215.04 participants) and if participants do not really pay attention to brands, it can also influence participation and make them more selective, only averaging 26.47 participants per hackathon.

This analysis of extreme cases of platform crowd manipulation is a study that increases knowledge about how these motivational factors can contribute to platform participation among participants. It does not translate into any manipulation to be done by the platform but can translate and suggest some efforts from the platform to incentivize and target certain types of participants when pitching the ecosystem and presenting hackathon opportunities.

5. Discussion

This chapter discusses the implications of the simulation results obtained from the agent-based model. The simulations were designed to explore participant engagement in digital platforms for hackathons, supported by the fact that more participation leads to a higher probability of fostering innovation by generating more ideas. Through analysis and comparison with some empirical data, the study has revealed several key insights into how different hackathon configurations and participant characteristics influence overall engagement. Building on these findings, this chapter outlines practical recommendations for improving hackathon design and participation strategies, proposes actionable managerial interventions for platform operators, and identifies promising avenues for future research.

Building on the findings of the base model, the simulations focused heavily on the average participation metric to identify potential improvements in the number of participants for platform customers. The base model results, with an average of 83.5 participants, mirrored real-world hackathon engagement, also by showing high variability in participation rates between different hackathons, in agreement with the analysis done on the TAIKAI platform.

In addition, the base model simulation showed that while multiple hackathons could occur simultaneously without significantly diluting participation, there were observable periods of inactivity - times when no hackathons were scheduled. These downtime periods could be further researched to potentially highlight an opportunity for platforms to drive engagement more consistently by understanding these dynamics better and identifying when sales efforts could be more needed, which in turn could attract more platform customers.

Further analysis of the base model reveals an interesting insight: the network effect driven by word-of-mouth among hackathon participants is crucial for the growth of the platform's user base. This effect, when studied in more detail and in other ways, applied to this specific context, could illustrate how participants' experiences and recommendations can naturally increase platform awareness and attract new users. Nevertheless, this organic spread of information can be leveraged by platforms by implementing referral programs or gamification techniques to incentivize and track referrals and consequently benefit from higher engagement.

When examining specific hackathon setups, the simulation results underscore a critical finding: structure significantly drives participant engagement in hackathons. Specifically, clarity about expected deliverables and outcomes, preferred formats or methods, and a well-defined problem statement all contribute to higher participation rates. This finding suggests that participants are more likely to engage when they have a clear understanding of what is expected of them.

In practical terms, platforms like TAIKAI can capitalize on this finding by enhancing their user interface to better communicate these elements. One strategic action would be to include a dedicated tab for deliverables and key questions on the hackathon event pages. In addition, including a brief description of the expected deliverables and the primary question or challenge in the brief overview of each hackathon could further clarify the purpose and goals of the event. Not only will this help participants make informed decisions about their participation, but it will also align their efforts more closely with the hackathon's goals from the outset. It is also true that some hackathon organizers may believe that strict guidelines could limit creativity, but the platform can inform them about this trade-off.

The simulation data reveals an interesting aspect regarding the feature of interdependence in hackathons. Although this feature promotes collaboration among participants, it results in fewer individuals becoming aware of the platform compared to other hackathon characteristics. This observation could lead to an assumption on a potential pattern of behavior: circles of individuals within specific communities may tend to remain insular, promoting hackathon opportunities primarily within their established networks rather than branching out. This assumption leads to an interesting hypothesis that could be further explored.

Building on the finding that interdependence in hackathons leads to a more insular sharing of opportunities within specific communities, it's important to recognize the role this characteristic plays in attracting participants who value social settings. The literature confirms that fostering interdependence can significantly increase social interaction among participants, which in turn has been shown to lead to better engagement results for platforms like TAIKAI. This suggests a compelling strategy for platforms seeking to increase participation and community building: emphasize the social aspects of their offerings. To capitalize on this, platforms could promote

themselves as vibrant communities where like-minded people gather to compete, collaborate, and connect. Enhancing features that support social interaction, such as integrated chat, community badges, and others, can make the platform more attractive by enriching the participant experience and fostering a sense of belonging. These features not only help retain participants, but also turn them into active promoters of the platform within their networks.

In addition, given the tendency of these communities to remain somewhat closed, targeted marketing efforts could be particularly effective. Platforms could proactively reach out to potential participants where they already congregate (e.g. online forums, educational institutions, and workplaces). By tailoring efforts to these communities and their specific interests and needs, platforms can effectively draw them into the broader ecosystem.

The analysis of external motivators, such as job opportunities and rewards, reveals their differential impact on participants' engagement in hackathons. In particular, job market signaling emerged as a strong motivator that significantly drove participation. This suggests that individuals participate in hackathons not only to showcase their skills, but also to connect with potential employers and improve their career prospects. In contrast, the simulation data suggests that while rewards are still a factor in attracting participants, they are not as compelling a motivator. This finding is critical for platform strategy, as it suggests that rewards alone may not be the most effective way to drive participation.

Given the strong influence of job market signaling, platforms should strategically emphasize this aspect in their marketing and operational approaches. For example, promoting hackathons as prime opportunities for networking and professional development could attract a larger and more engaged audience. Implementing specific activities to facilitate networking, such as mentorship sessions, industry talks, or team-building exercises, can increase the value of

participating in hackathons, especially for those seeking job opportunities.

Moreover, targeting specific demographic segments such as students can be particularly effective. Students often look for opportunities to build their portfolios and make connections that could lead to internships or jobs. Therefore, promoting the hackathons as avenues for significant career development and networking, platforms can attract this eager and motivated segment, not only increasing participation but also enriching the talent pool within hackathons.

The influence of brand recognition on hackathon participation is powerful. Well-known, reputable brands have the power to attract participants from diverse demographics, significantly increasing engagement levels. This presents a valuable opportunity for platforms to leverage their established brands to attract both participants and other clients. To capitalize on this and attract great clients, platforms should rely on their large and active user base to showcase the platform's reach but also its potential to provide substantial exposure. Beyond presenting participation statistics, platforms can share insights derived from participants data. By analyzing and collecting engagement patterns, motivation factors, and participant feedback, platforms can leverage detailed analytics to inform more targeted engagement strategies.

In conclusion, this study has identified critical strategies for enhancing engagement on digital hackathon platforms like TAIKAI, based on comprehensive simulation results. It has addressed the research question on how to drive participation since it shows that, by leveraging the knowledge provided on hackathons set-ups, with more structured outputs and even promoting more interdependence in the platform, the platform will be able, by targeting participants looking for job opportunities or willing to participate in community building settings, to attract the kind of participants that engage and promote participation in hackathons.

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7. Appendix

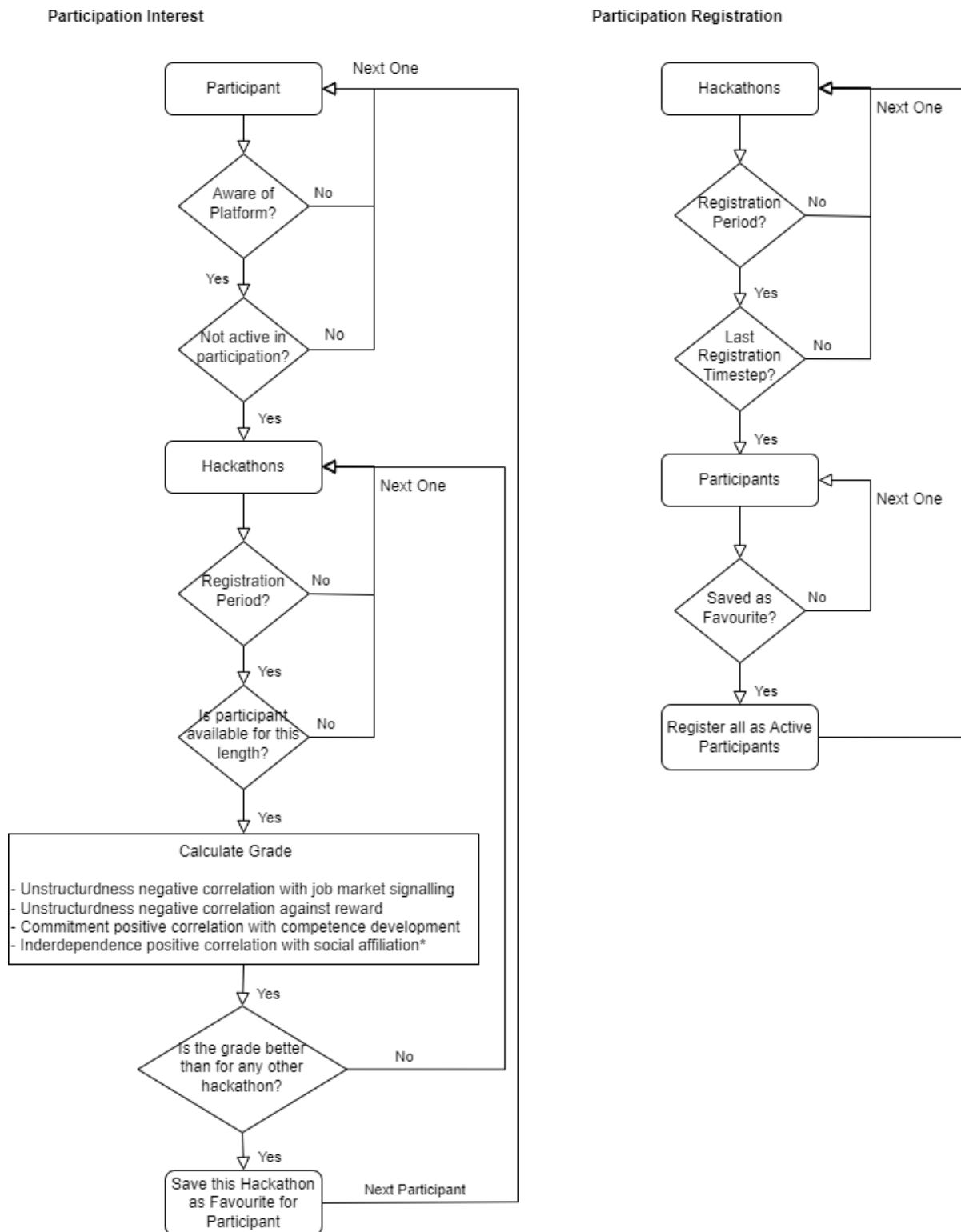
Figure 1. Participants Agents Characteristics and Values

Participants Characteristics	Value
Motivation Factors	Each uniformly random Between 0-1 <ul style="list-style-type: none"> • 0 represents lower level of motivation due to that reason • 1 represents higher level of motivation due to that reason
Competence Development	
Social Affiliation	
Job Market Signalling	
Reward Seeking	
Brand Awareness	Uniformly random between 0-1
Activity Status	Active / Inactive (Boolean)
Past Participation	List of hackathons IDs
Availability	1-7 days (same as hackathon length)
Participation Threshold	Uniformly random between min grade and max grade (based on correlation values)

Figure 2. Hackathons Agents Characteristics and Values

Participants Characteristics	Value
Unstructuredness	Uniformly random between 0-1 <ul style="list-style-type: none"> • 0 represent high structuredness • 1 represents high unstructuredness
Interdependence	Uniformly random between 0-1 <ul style="list-style-type: none"> • 0 represent low interdependence • 1 represents high interdependence
Commitment	Uniformly random between 0-1 <ul style="list-style-type: none"> • 0 represent low commitment required • 1 represents high commitment required
Brand Recognition	Uniformly random between 0-1 <ul style="list-style-type: none"> • 0 represent not recognized brand name • 1 represents top recognized brand name
Participation Threshold	1-7 days
State	Registration / Active / Ended

Figure 3. Participation Decision Mechanism (Visual Representation)



*Correlations based on values presented by Pee, Koh and Goh, 2018

Figure 4. Average Participation Overtime (Base Model)

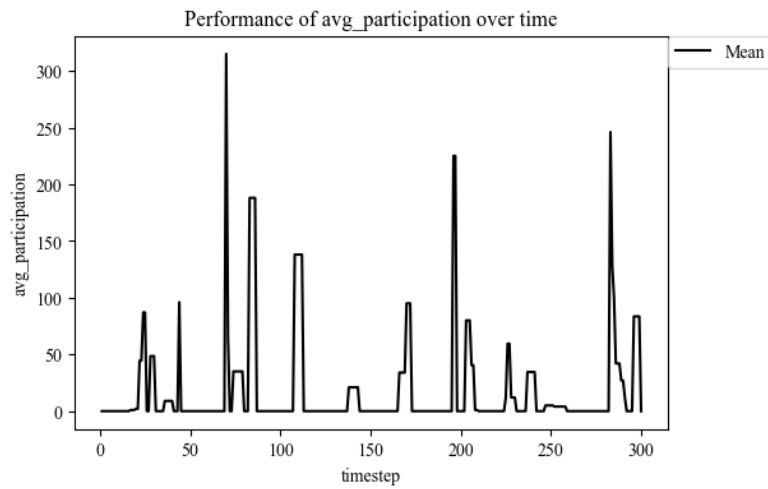


Figure 5. Active Hackathons Overtime (Base Model)

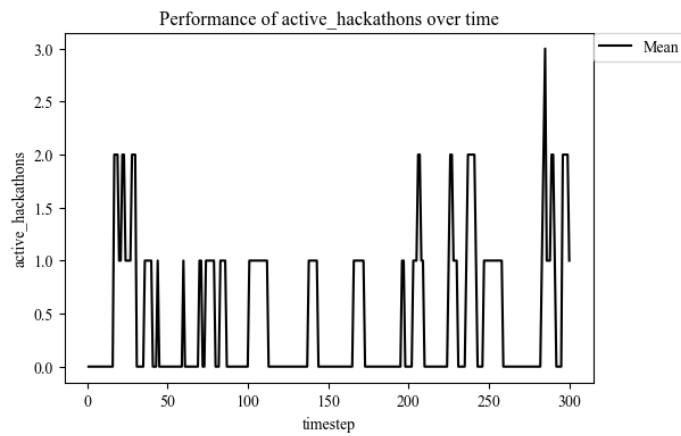


Figure 6. Active Hackathons with no Participants Overtime (Base Model)

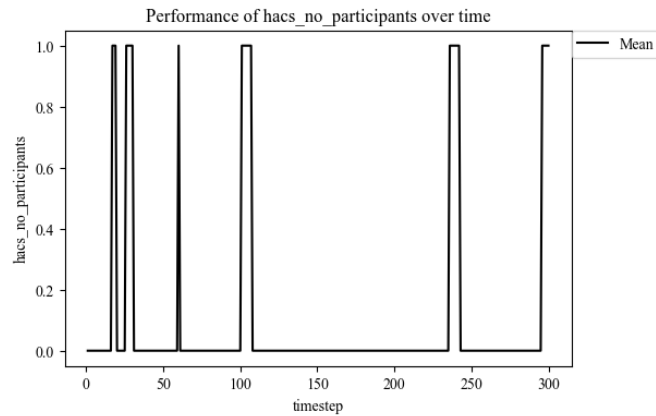


Figure 7. Number of Hackathons and Average Participation in TAIKAI platform in comparison to the Base Model of the simulation

TAIKAI Platform over the years	Number of Hackathons	Average Participation
2021	42	116.0714286
2022	42	111.9047619
2023	51	142.2941176
Simulation Base Model	36	83.5

Figure 8. Average Participation Overtime (manipulated hackathons characteristics that positively affect participation compared to the Base Model)

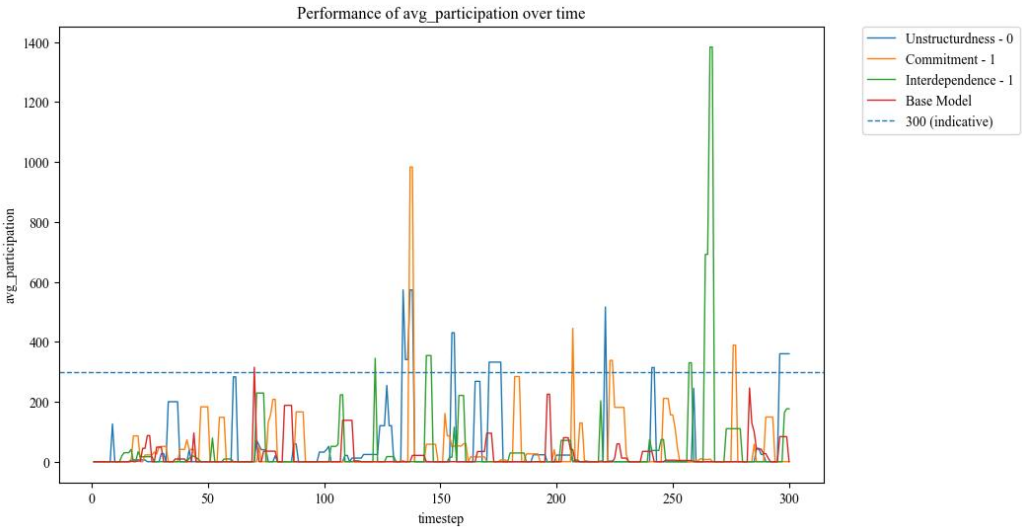


Figure 9. Average Participation per Simulation (manipulated hackathons characteristics compared to the Base Model)

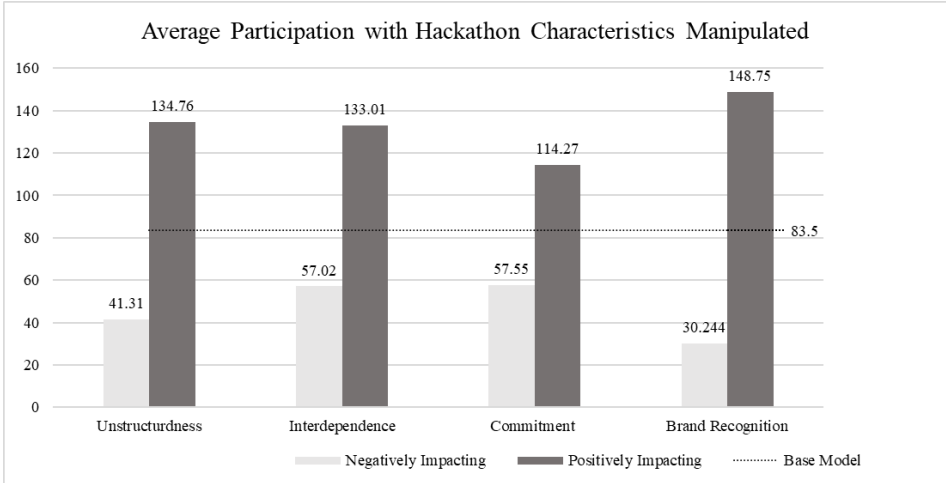


Figure 10. Total Participation per Simulation and Total Awareness Created (manipulated hackathons characteristics compared to the Base Model)

Hackathon Characteristic	Simulation Manipulation	Total Participants	Total Population Aware of Platform
Base Model	-	1257	3545
Unstructuredness	High structure	3154	3165
	Low structure	980	6748
Interdependence	High interdependence	2552	5994
	Low interdependence	1453	4241
Commitment	High commitment	3007	6825
	Low commitment	1341	3824
Brand Recognition	High brand recognition	2761	6588
	Low brand recognition	529	2119

Figure 11. Average Participation Overtime (manipulated participants motivation factors levels to positively affect participation compared to the Base Model)

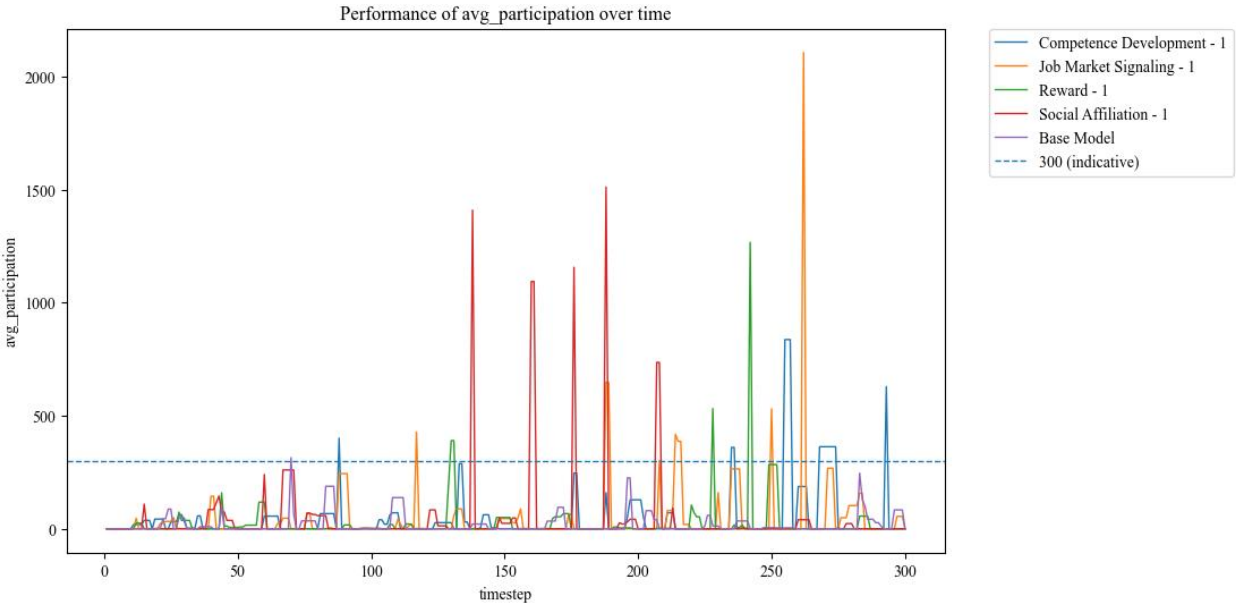


Figure 12. Average Participation per Simulation (manipulated participants motivation factors levels compared to the Base Model)

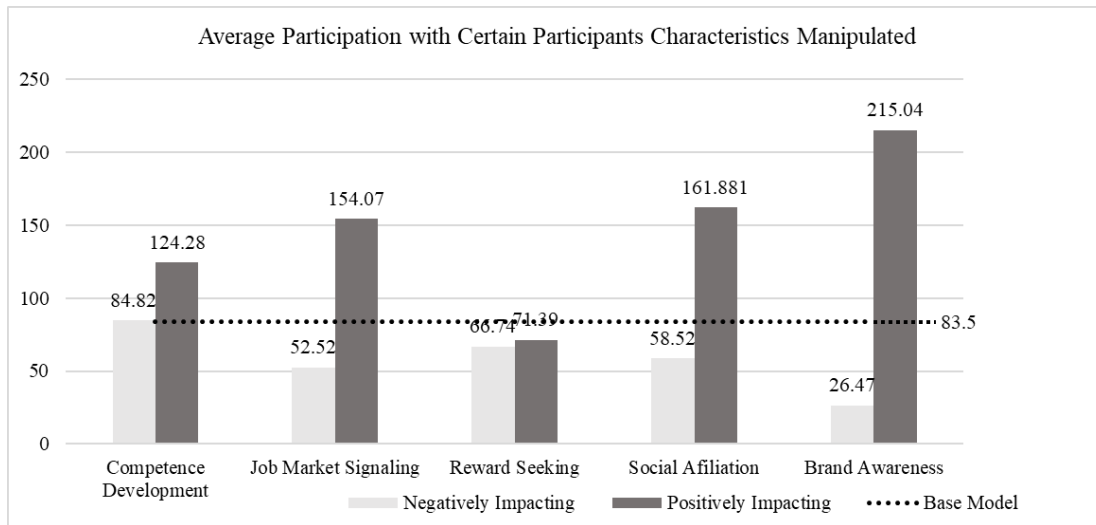


Figure 13. Total Participation per Simulation and Total Awareness Created (manipulated participants motivation factor levels compared to the Base Model)

Participation Motivation	Manipulated Impact	Total Participants	Total Population Aware of Platform
Base Model	-	1257	3545
Competence Development	High desire	2462	6234
	Low desire	1643	4674
Job Market Signalling	High motivation for	3474	7906
	Low motivation for	1691	3827
Reward	Highly seeking	2726	6486
	Lower seeking	2038	5593
Social Affiliation	High motivation for	4900	8819
	Low motivation for	995	3289
Brand Awareness	High awareness	4002	6722
	Low awareness	676	2551