Response from Authors to Reviewer Comments in the second revision

We would like to thank the reviewers for their comments and suggestions, and the editor for giving us an opportunity to revise our manuscript. We believe this revised version addresses all the comments made by the reviewer.

We follow the following convention in this document:

- Review comments: black italicized font.
- Response to review comments: black regular font.
- Modifications made in the paper: blue regular font.

Comments from Reviewer 1:

1. *However, since you are averaging 10 trials, you should be able to report on the variability of those 10 trials in the form of standard deviation, confidence interval, error bars, or something equally appropriate. If there is zero variability, then I'd worry about how the randomness is being handled.*

   The following table and text has been added to indicate the variability of the model.

   <Page 9, Table 4>Variability of the situational experiments

   <Page 9, Section 3B, Right Column, line 11>The variability of these experiments in terms of the variance of customer acquisition cost ξ and conversion ratio Θ is shown in Table 4. The variance was computed for the ten trials. The low variability indicates the robustness of the model to small random variations and the validity of results and conclusions for given conditions.

Comments from Reviewer 3:

1. *The Abstract section is too long. Please reduce and include the instruction of the proposed method, the advantage of the method, and the main results*

   The authors thank the reviewer for the suggestion. The abstract has been shortened while maintaining the quality of its content. It is now around 250 words as suggested by the IEEE TCSS. It has also been modified to mention the advantages of the method.

   <Abstract, Line 14>Our system is a probabilistic graph-based model that provides the additional advantage to incorporate real-world factors such as customers' interest in a

product, customer behavior, the willingness to pay, a brand's investment cap, influencers' engagement with influence diffusion, and the nature of the product being advertized viz. luxury and non-luxury.

2. *Authors need to add a table of used symbols in the paper to make the paper read easier.*

   The authors thank the reviewer for the thoughtful suggestion. Table 1 has been extended to include all symbols.

3. *The author should clearly state what is the difference between their study and the existing similar works.*

   This comment has been addressed in the paper as follows:

   <Page2, Paragraph 2, Line 5>In this work, we modify and build upon the basic models mentioned above and present the design of an agent-based model (ABM) to simulate influencer advertizing campaigns in social networks. The social graph with agents at vertices forms our base framework. We incorporate real-world characteristics in the form of novel agent and model parameters that are essential in the influencer marketing context but are absent in the current literature. These include the different kinds of influencers with their respective engagements [36], the customers' interest in the product, and the customers' willingness to pay. The interactions of individuals in the social network are modeled as two types of agent behavior - influencer-follower and inter-follower interactions.

   <Page2, Paragraph 3, Line 1>We use our model to study the performance of different kinds of influencers in a social network under varying circumstances, which has also not been attempted before.

4.

   a. *the authors should analyze how to set the parameters of the proposed methods in the framework.*

      The authors thank the reviewer for bringing this to our notice. The text has been modified to provide more insight for specific parameters that lacked clarity.

      <Page 3, Section 3A, line 21>A high value of μ is used to simulate a scenario where the customers' interest in the product is high and a low value of μ is used to simulate a scenario where the customers' interest in the product is low.

      <Page 3, Section 3B, line 32>Active networks can be simulated using high values of a and less active networks using lower values.

b. *Do they have the "optimal" choice?*

The purpose of this work is to design a realistic model for the simulation of influence propagation and advertizing in social networks and obtain insights about various influencer marketing strategies. Such models serve as a foundation for further studies in influencer marketing. The purpose of this work is not to propose an algorithm (or multiple ones) to identify optimal influencers in a social network. Thus, optimality is not an issue here. (In general, agent-based models are appropriate for simulation, not for optimization problems.)

The following modification has been made to indicate the robustness of results.

<Page 9, Section 3B, Right Column, line 11>The variability of these experiments in terms of the variance of customer acquisition cost ξ and conversion ratio Θ is shown in Table 4. The variance was computed for the ten trials. The low variability indicates the robustness of the model to small random variations**.**

5. *for a novel method, there exists two aspects will be considered to verify the performance of the algorithm, such as accuracy and computational complexity. This Manuscript just give experiments for the improvement of accuracy of identification. It is better to add the analysis of computational complexity to verify the performance. It is suggested to consider the efficiency of different algorithms by their running time.*

In line with what we have noted in response to #4, computational complexity is not an issue per se; the efficacy of agent-based models is judged based on their ability to produce conclusions that are of use in real life, not their computational complexity.

The text has been modified to address this:

<Page 6, Section 4, Paragraph 2, line 1>We take an agent-based modelling approach similar to [10][36] and analyse the effectiveness of the model in simulating advertizement campaign dynamics instead of the space or time complexity of the algorithm itself.

6. *The description of the algorithm is useful but much better would be to provide the code as supplementary material, which would facilitate the use of this algorithm to those who are not experts on machine learning, but would nevertheless use it gladly in their own research.*

The code is available at: ronak66/ABM-Influencer-Follower-Advertising-Framework (github.com)., as referenced in the paper.

7. *Figure captions need to be expanded to make them self-explained.*

   The following modifications have been made to the figure captions to make them self-explanatory.

   <Figure 3, Page 9>Simulation results for a non-luxury product with respect to different types of influencer sets, and their corresponding size n. The horizontal axis represents categorical data. The customer acquisition cost is found to decrease when using smaller types of influencers whereas the conversion ratio increases.

   <Figure 4, Page 9>Simulation results for a luxury product with respect to different types of influencer sets, and their corresponding size n. The horizontal axis represents categorical data. (a) The customer acquisition cost is found to increase when using smaller types of influencers whereas the conversion ratio decreases. (b) When the customers' interest in the product is already high, both the customer acquisition cost and the conversion ratio decrease when using smaller types of influencers.

   <Figure 5, Page 10>Results of the parametric sweep for the Twitter graph represented as a contour map: the dashed line represents the boundary between celebrities (in blue) or nano-influencers (in red) being the better performers. The gradient represents the magnitude of their difference.

   <Figure 6, Page 11>Results of the parametric sweep for the synthetic graph represented as a contour map: the dashed line represents the boundary between celebrities (in blue) or nano-influencers (in red) being the better performers. The gradient represents the magnitude of their difference.

8. Supply some insightful future research suggestions in your conclusion section.

   This has been addressed as follows.

   <Conclusion, Paragraph 2, line 13> An important direction in which this work can be extended is to understand the mechanisms by which fake news, hate speech, and malicious gossip are spread in social networks through influencers. This in turn can lead to a better understanding of how myths, rumors, and misunderstandings are propagated by influencers, and can help devise strategies to counter such malicious influencers.

9. Section experiment, it would be good to have more information about how experiments have been conducted. What tools/software has been used?

The text has been modified to mention what tools were used for experimentation.

<Page 7, Section 4, Paragraph 6, Line 1>The Mesa library in Python was used to design the model and run experiments.

10. The discussion section in the present form is relatively weak and should be strengthened with more details and justifications.

    The authors have mentioned the important literature in the background section. In addition, relevant literature and justifications have been given whenever a new parameter, attribute or concept has been introduced in the paper. Some more works relevant to agent-based modelling have been discussed:

    <Page 1, Paragraph 3, line 10>Agent-based modelling approaches include - word-of-mouth marketing [10][22], and modelling of opinion dynamics [36].

11. *The Literature citation is not adequate, and the related work to the spreader nodes should be discussed:*

    The following addition has been made to the text.

    <Page 3, Background Section, Paragraph 2, Line 7>Other literature tries to identify influential nodes in a graph or ‘’opinion leaders" in a social network, and uses techniques based on graph centrality [8][7] for this purpose. However, our work is not concerned with identifying specific individuals as influencers, but aims to analyze how using influencers big and small affect advertising campaigns.