A system dynamic model for analyzing online question & answer markets

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C H R O N I C L E	A B S T R A C T
	During the past two decades, there have been growing interests on developing websites to build a link between various groups of people to share their knowledge such as Google service. This kind of activity helps fast and reliable distribution of knowledge since someone disseminates a question and various people attempt to provide some responses. This paper presents a system dynamic method for investigating the relationships between various components of a benchmark site. The proposed study develops closed loop dynamic among various components of the survey and provides some necessary actions for development of such systems. The results of our survey have indicated that the new forum could end up having significant number of unanswered questions. Therefore, researchers who work for this forum are suggested to increase their skills and their response rates to reduce the rate of unanswered questions.

1. Introduction

During the past two decades, there have been growing interests on developing websites to build a link between various groups of people to share their knowledge such as Google Answer (GA) service (Edelman, 2004; Shah et al., 2009; Hicks, 2013). This kind of activity helps fast and reliable distribution of knowledge since someone disseminates a question and various people attempt to provide some responses. There are several studies to investigate the behavior of such systems. Jafari et al. (2009), for instance, developed a system dynamics model to analyze researchers' interest in answering questions for an online question and answer (Q&A) knowledge market. By applying a System Dynamics (SD) model, an online knowledge market was modeled as a marketplace where consumers asked and researchers provided responses to questions to make knowledge transactions. In this market, customers gave price to their questions and requested responses, and a firm took care of the online knowledge market by determining the optimal price devoted to researchers.

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Online question-answering services enhance appropriate methods for knowledge exchange by permitting users to ask and answer questions on a wide range of topics. A primary question for designing such services is whether charging a price influences on answer quality. Jeon et al. (2010) performed a study by decomposing the price effect into two levels and reported that a higher price substantially increases the likelihood that a question receives an answer. In addition, they reported that for questions that receive an answer, there was no substantial price impact on answer quality. They also reported that the rater background could make a difference in assessing answer quality.

Panovich et al. (2010) presented an empirical investigation to evaluate the role of tie strength in question answers. They applied previous research on tie strength in social media to build tie strength information between participants and their answering friends, and requested them for feedback about the value of answers across different dimensions. While sociological studies had stated that weak ties were able to provide better information, their findings were significant in that weak ties did not have this impact, and stronger ties could provide a subtle increase in information, which contributed more to participants' overall knowledge.

For years, there have been substantial interests in analyzing complicated problems using system dynamics (SD), which was originally introduced by Forrester (1961) at the Massachusetts Institute of Technology (MIT). SD has been one of the early responses to the insufficiency of Operation Research as well as other management science methodologies for tackling complex problems with large numbers of variables, nonlinearity and human intervention (Sterman, 2000).

SD combines human mind and the power of computer for learning more about dynamic complexity, limited information of problem situation, bounded rationality, flawed cognitive maps, confounding variables and ambiguity, wrong inferences about dynamics, and judgmental mistakes. According to SD, the behavior of a system is basically caused by its structure and various policies. Therefore, the structure of real-world case study is represented by underlying flows of various resources as well as different feedback loops and delays. A SD model consists of "causal-loop diagram (CLD)" and "flow diagram". The casual relationship demonstrates that one element influences another one. A CLD is applied to model this kind of causality relationships. CLD requires additional positive (+) and negative (-) polarity to represent the feedback structure of the related elements.

2. The proposed model

This paper presents a system dynamic method for investigating the relationships between various components of a benchmark site. The proposed study develops closed loop dynamic among various components of the survey and provides some necessary actions for development of such systems.

2.1. Variables names and descriptions

Variable Name	Description
Unanswered Questions	The number of unanswered questions,
Answered Questions	The number of answered questions,
Company Profit	Predicted profit calculated by simulation technique,
Asking Rate	The number of questions at each time,
Answering Rate	The rate of responses to questions,
Profit Rate	The rate of profit per time,
Questions	Sum of all questions, answered and unanswered, up to time t,
Prediction of Answering	Prediction of receiving answer at this site,

Word Count	The number of words used in an answer,
Effort	The amount of effort given to provide answer,
Price	Offering price to receive answer,
Quality of Answer	Quality of response to an answer,
Quality of Answer Lookup	A table function, which demonstrates the quality of responses,
Asker Utility	The utility value calculated for the person who asks the question,
Popularity	The popularity of website,
Tip	Addition fee paid when desirable answer received,
Researcher Utility	The net utility measured by a researcher,
Minimum Income	Minimum utility of income,
Backing Percentage	Percentage of responses, which are given back to researchers,
Proportion of Researcher	Percentage of fee paid to researcher,
Proportion Lookup	A table profit, which shows the relationship between the website profit and researcher's payment,
Company Utility	The net utility of website.

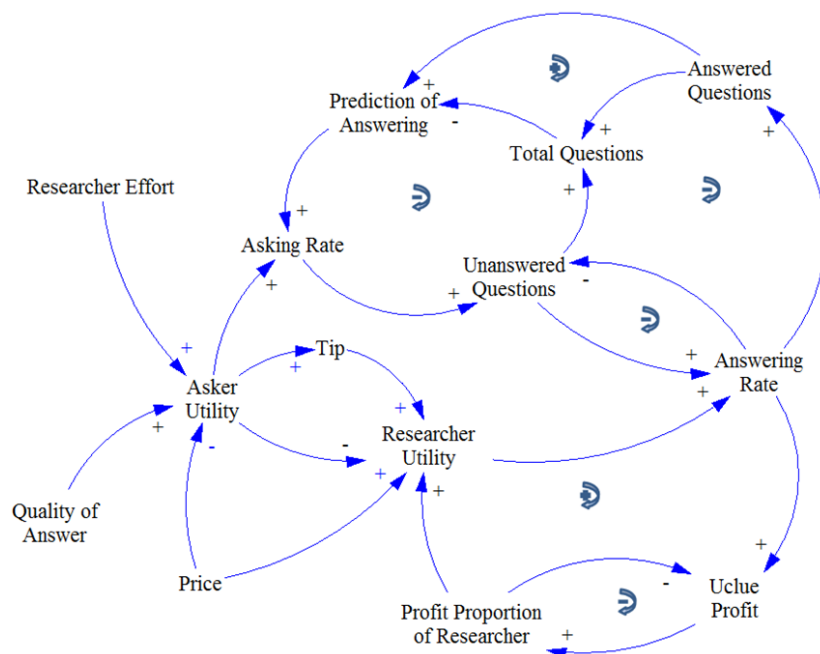Fig. 1 demonstrates the closed loop diagram of the proposed study.

Fig. 1. The closed loop diagram of the proposed study

As we can observe from Fig. 1, researcher effort along with quality of answer influence positively on asker utility while price influences negatively on asker utility. Asker utility, in turn, influences positively on asking rate as well as tip and negatively influences on researcher utility. In addition, asker utility influences positively through an increase on tips. An increase on profit proportion reduces website's profit and any increase in website's profit will increase profit proportion.

Researcher utility increases answering rate and answering rate influences website's profit, which influences on researcher's utility indirectly through profit proportion of researcher. An increase on unanswered questions increases on the rate of the responses to questions, which reduces the number of questions. An increase on the number of unanswered questions increases the number of total questions, which influences on prediction of getting answer and increases the rate of asking rate. The implementation of the proposed model uses the following two relationships

Asker Utility = Effort – Price – Tip   (1)
Researcher Utility = (Proportion of Researcher × Price) + Tip – Effort   (2)

In addition, the proposed study uses the data given by Jafari et al. (2009) for *Minimum Income* and *Backing Percentage.* Jafari et al. (2009) concentrated on the design of a simple model based on Zhang and Jasimuddin's (2008) relationship, which represents the dynamics of researchers' interest in replying questions in a specific type of online knowledge market. For a specific question *m* priced at *p*, if he(she) answers the question, a researcher will receive a net payoff (total payoff) as follows,

$$\pi_r = \alpha p - \theta(p, k_i).q_m,$$ (3)

where α is the proportion of price allocated to researcher for answering each question with price *p* $\theta(p, k_i)$ is the disutility a researcher with knowledge level k_i will face by answering this question, including the effort cost and the risk of getting a bad assessment. In addition, the study adopts the previous studies for statistical observations associated with the rate of input (Harper et al., 2008). Fig. 2 demonstrates the summary of Stock-flow diagram of locking and answering behavior.
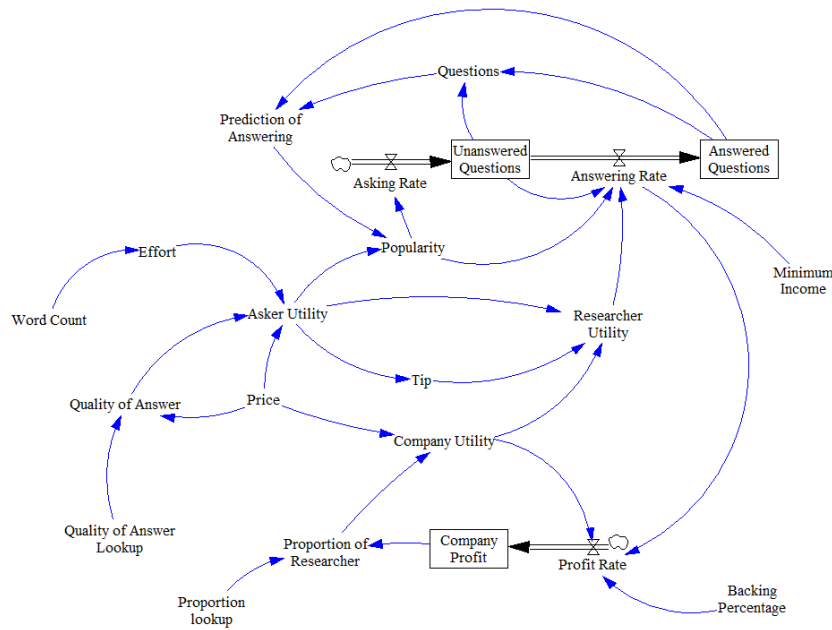

Fig. 2. Stock-flow diagram of locking and answering behavior

3. Simulation results

In this section, we present details of our findings on performing simulation study based on VENSIM software package. Table 1 demonstrates the summary of input variables.

Table 1
The summary of input variables

Variable Name	Unanswered Questions Initial Value	Answered Questions Initial Value	Company Profit Initial Value	Minimum Income	Backing Percentage
Value	1	1	0	0	0.02

In addition, Table 2 demonstrates the summary of parameters tuning of VENSIM software package.

Table 2
The summary of VENSIM parameters

Unit	Initial Time	Final Time	Time Step	Integration Method
Hour	0	4000	1	Euler

Fig. 3 demonstrates the trend of profitability after running the system for 300 hours.
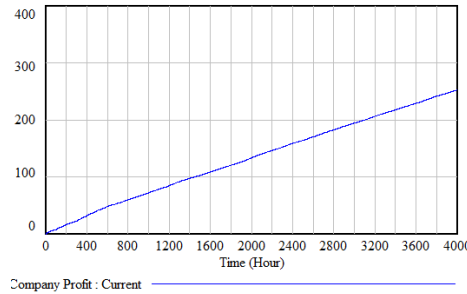
Fig. 3. Company profit after 300 hours

Based on the results of Fig. 3, we can observe that the proposed case study of this paper could make profit after it maintains sufficient number of users. We have expected to observe *S*-shape function on company's profitability but the trend was not apparent on Fig. 3. The reason was because the profit curve was longer than our experiment. Next, we investigate the nature of unanswered questions through Fig. 4.
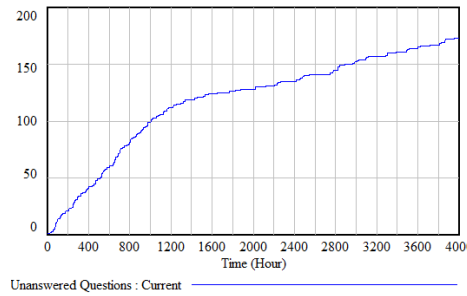

Fig. 4. The trend for unanswered questions

According to the results of Fig. 4, unanswered questions have an increasing trend for the first 1600 hours, stabilize and eventually increase smoothly. The results of Fig. 4 clearly indicate that we may end up having significant numbers of unanswered questions, which must be reduced by applying appropriate methods. Finally, Fig. 5 shows details of our findings for Prediction of Answering.
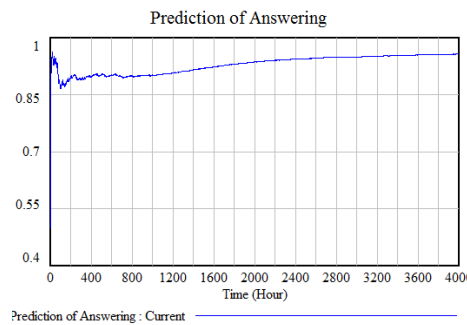

Fig. 5. Prediction of answering

4. Conclusion

In this paper, we have presented a system dynamics method for analyzing the behavior of customers who are looking for an answer for their questions through internet websites. Google Answer was one of the first websites for providing such services and since the first attempt by Google firm was unsuccessful, there was a new firm for building a new form of the service. The proposed study of this paper has tried to do investigate the behavior of a newly promoted forum in terms of different factors such as the number of unanswered questions. The results of our survey have indicated that the new forum could end up having significant number of unanswered questions. Therefore, researchers who work for this forum are encouraged to increase their skills and their response rates to reduce the rate of unanswered questions.

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