Software Piracy

Kushagra Sharma
Department of Computer Science
Indian Institute of Technology
Gandhinagar, Palaj, 382355
kushagra.sharma@iitgn.ac.in

Abstract

The illegal use of software or software piracy as known more formally, is one of the most growing problems in computer science today. This paper examines the agent based model of software piracy based on prior researches conducted by various scholars. The agent based model can be used by organizations and industries to curb the practice of software piracy leading to intellectual theft. The model was simulated on watts strogatz and preferential attachment networks while varying several parameters. The results indicate that software costs have a positive effect on software piracy. The more the cost of a software, the more benefit in distributing the pirated software. Subjective norms or peer pressure also plays a positive role in software piracy if the peers are supportive of piracy. These results can be incorporated by firms and organizations to develop strategies to mitigate the effects of software piracy.

Keywords: software piracy, agent based model, netlogo, watts strogatz network, preferential attachment, computer science.

1 Introduction

Software piracy leads to loss of billions of dollars to the software industry annually. It is defined as "the unauthorized copying of an organization's internally developed software or illegal duplication of commercially available software to avoid fees" (Wagner Sanders, 2001, p. 163). In the Computer Software Copyright Act of 1980, software was recognized as intellectual property, thus enabling compiled applications to be copyrighted (Craig & Burnett, 2005). Although software piracy is considered to be a federal offense (Craig & Burnett, 2005), the Business Software Alliance (BSA) established in 1988 as an anti-piracy alliance, reported in 2016 that 39% of computers had pirated software installed on them (Wu, Nan, & Li, 2018). According to the No Electronic Theft (NET) law passed in 1997, individuals who violate it are subject to up to five years in prison and $250,000 in fines (Craig & Burnett, 2005).

But why are people willing to readily download pirated software despite such punishments in place? Is it due to negligence of the laws or due to inherent behaviour? What affects the choice of individuals to download pirated software? Understanding the behaviour patterns of individuals leading to downloading of pirated software can help organizations prepare measures to counteract them. The agent based model described here is based on the research "Software Piracy in the Workplace" (Peace et al. 2003). The model tries to simulate very basic behaviour of individuals based on some portions of the proposed theories, namely expected utility theory and the theory of planned behaviour (Peace et al. 2003).

2 Methodology

The precise equation to model software is debatable but Peace et al. (2003) discusses theories about individual behaviour leading to software piracy. Peace et al. (2003) proposes the theory of reasoned

action which further evolves into the theory of planned behaviour (TRB). According to the theory of reasoned action (TRA), an individual's attitude is formed by his/her beliefs about the consequence of his/her actions. If the consequences are believed to be favorable, the attitude will be favorable towards the action leading to the actual behaviour (Peace et al. 2003). A study by Christensen and Eining (1991) states that the attitude towards piracy and subjective norms or peer norms are directly related to the software piracy behaviour. The theory of planned behaviour is developed from the theory of reasoned action by adding behavioral control to it (Peace et al. 2003). The theory of planned behavior posits three hypotheses, two of which are dealt in this paper.

H 1: *A more positive attitude toward software piracy will lead to greater intention to commit software piracy.*

H 2: *A higher level of subjective norms supportive of software piracy will lead to greater intention to commit software piracy.*

Apart from the belief of the consequences of actions, economic factors like cost and benefit can affect the decision making process of individuals (Peace et al. 2003). According to this theory, a rational individual will try to maximize his/her utility at the crossroads of difficult choices (Peace et al. 2003). In relation to software piracy, an individual's attitude towards piracy is affected by the economical factors like cost of the software as well as other factors like the waiting period for a new version release. Several other parameters like behavioral control in the theory of planned behavior and material consequences like punishments, separate utility calculating functions etc. in expected utility theory have not been covered in the present version of the agent based model described in this paper and may be incorporated for future work.

Peace et al. (2003) states that the factors from the expected utility theory can be incorporated into the theory of planned behavior. For example, a higher cost of the software can lead to a positive attitude towards piracy, thus leading to the following hypothesis.

H 3: *Software cost will have a positive effect on attitude toward software piracy.*

2.1 Research

The above three hypotheses are modeled using agent based modeling in Netlogo taking some assumptions described below. The model represents people as a breed of turtles called individuals and links between the turtles are represented as networks.

Individual

Each individual has parameters for ethical value or attitude called *morality*, *obtained-software?* determining whether he/she has obtained any software either original or pirated, *license-period* determining the license duration of the original software for legal buyers, *obtained-version* describing the version of the software obtained by individuals either original or pirated, *wait-period* denoting the maximum amount of time a certain individual will wait before changing his/her decision about getting software legally or illegally and *price-range* which stores the budget of each individual and determines their behavior to buy software legally or download illegally.

Networks

Links between individuals represent the network of individuals. The model currently has two networks: Watts Strogatz and Preferential Attachment. The described networks were chosen since they resemble closely to real world networks and can represent real world scenarios.

The attitude towards piracy as described in Peace et al. (2003) is depicted by the *morality* parameter of individuals. The assumption is that individuals with low morality or ethical value will have an inherent positive attitude towards piracy while individuals with high morality or ethical value will have a negative attitude towards piracy. Thus, the *morality* parameter is the depiction of ethical value of an individual which is associated with his/her attitude towards piracy. The parameters *obtained-software?*, *license-period* and *obtained-version* are used to keep track of the described properties and help in the determining the decisions of individuals. The *wait-period* and *price-range* parameters are used by individuals to measure their utility at each time step. Utility in the model is calculated for each individual by examining the values of these parameters with the new version release intervals (both original and pirated for respective individuals) and price of the software respectively.

Thus, the first hypothesis (H1) proposed by Peace et al. (2003) is modeled by the use of the parameter *morality* and *waiting-period*. Since a more positive attitude towards piracy means low ethical value and thus greater intention for piracy. This attitude is affected by the waiting period of the individual. If the version release interval is greater than the waiting period then the attitude of the individual towards piracy changes. More factors can be added in future work to make the attitude change more realistic. The second hypothesis (H2) is modeled by the use of the global variable *Crack-Distribution-Radius* and the created network between individuals. The second hypothesis (H2) is related to the peer pressure experienced by each individual. In other words, pirated software can only be distributed/downloaded if individuals who are supportive of piracy have a strong connected network. The model assumes that if an individual with low ethical value wants to get a pirated copy of the software but is not within the *Crack-Distribution-Radius* of other such individuals, he/she will not commit to software piracy due to lack of means. The third hypothesis (H3) is modeled by the use of parameter *price-range*. So, ethical individuals having low budget or high price of software will have a positive attitude towards piracy.

The third hypothesis (H3) of extended utility theory modeled using *price-range* affects the attitude of the individuals towards piracy modeled by *morality* which is given in the first hypothesis (H1) of theory of planned behavior. Thus, the extended utility theory has been incorporated into the theory of planned behavior as given in Peace et al. (2003).

2.2 Simulation

Behaviour Space of Netlogo is used to analyze the runs of the model. The parameters are varied in a chosen range for each of the three hypotheses and multiple iterations are done so as to average out the stochastic nature of the parameters. Each simulation is run for 10 years or 36000 ticks assuming that 10 years is the life of an average software in the market. The simulations are run at the given parameters since the model is calibrated around the tipping point. At the end of each run, profit and loss are reported in a csv file by Behaviour Space. The graph of average profit and average loss are plotted and analyzed.

At the start of each simulation, the parameters of individuals are initialized with the proper values and a random ethical value is assigned to them. Then at each time step, depending on the described parameters (price and waiting period) they either change their ethical value or retain it. After deciding their attitude towards piracy, the respective individuals either buy the software legally or download it illegally. This process leads to profits and losses to the organization respectively.

3 Results

The third hypothesis (H3) deals with varying the cost of the software, thus the simulations are run by varying the *price* parameter of the model from 1 to 20 incrementing by 1 at each simulation while keeping the other parameters constant. Each individual has a budget or price threshold which is a random price between 1 and 20. Multiple runs are done for the mentioned case and the averaged out profit and loss values for the two networks, Preferential Attachment and Watts Strogatz are plotted (shown in fig. 1 & 2).

As seen in the plots, when the cost of the software increases the profit starts decreasing and the loss increases. This is due to the fact that the software cost exceeds the budget of the individuals. After a certain threshold the losses surpass the profits earned. There is little variation in the described pattern in the Watts Strogatz and Preferential Attachment network. This can be understood from the fact that the network plays little or no role in determining the affect of cost on individual behaviour. Individuals are affected by cost change directly irrespective of its affect on their neighboring links.

The second hypothesis (H2) deals with the connectedness of the pirated software distribution network. So, the simulation are run by varying the *Crack-Distribution-Radius* parameter from 1 to 10 and incrementing by 1 at each simulation while keeping the other parameters constant to analyze its affect. Multiple runs are done for the mentioned case and the averaged out profit and loss values for the two networks, Preferential Attachment and Watts Strogatz are plotted (shown in fig. 3 & 4).

As seen in the plots, when the radius of pirated software distribution increases the the loss starts increasing. There is little variation in the profits because currently the influence is assumed to be restricted to non ethical individuals. The loss increase due to the fact that individuals with low ethical

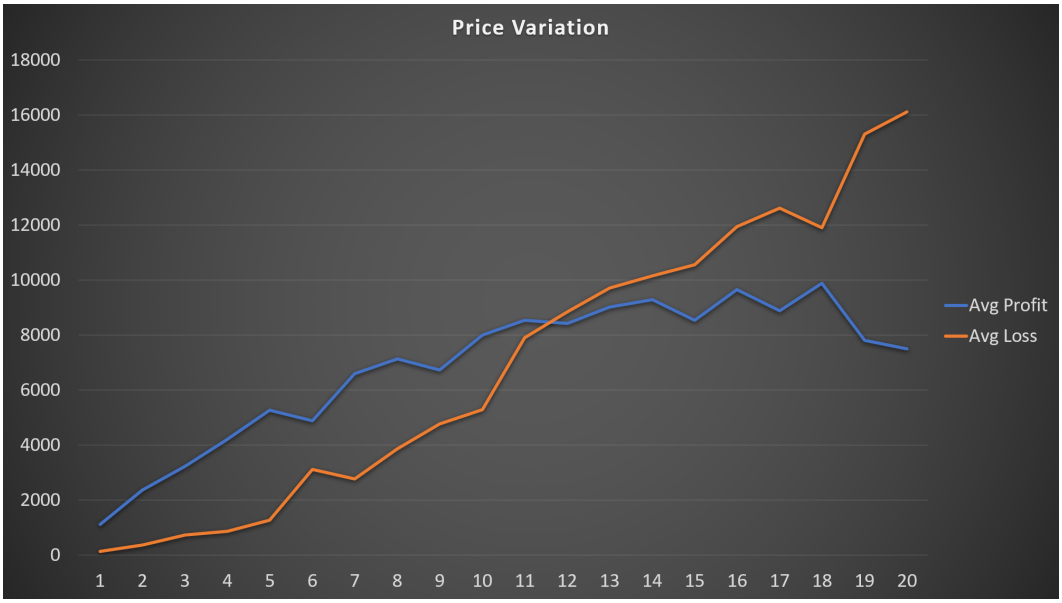

Fig. 1 Price Variation in Preferential Network

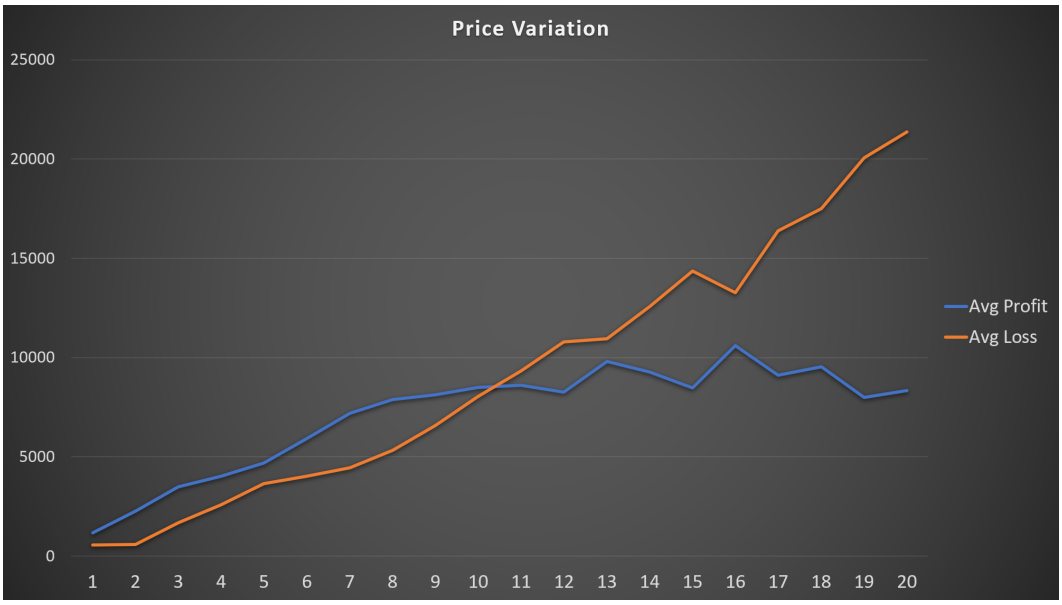

Fig. 2 Price Variation in Watts Strogatz Network

value can influence like minded individuals with a greater reach. The assumption here is that non ethical individuals can influence links in the defined radius of distribution and not just the neighboring ones. After a certain threshold the losses surpass the profits earned. In this case however, there is much difference in the threshold required for losses to increase. Although the pattern is same, losses surpass profits much before and increase at a steep rate in Watts Strogatz network than Preferential Attachment network. This is because Watts Strogatz network is strongly connected and the influence of individuals is increased greatly by a small increase in distribution radius.

The first hypothesis (H1) deals with the attitude of the individuals towards software piracy. So, the simulation are run by varying the *Months-To-Crack* and *New-Version-Release-Interval* parameters from 1 to 12 each and incrementing each by 1 at each simulation while keeping the other parameters constant to analyze its affect. The described parameters are varied because the variation of these parameters leads to the change in the morality of individuals due to their waiting threshold. Thus,

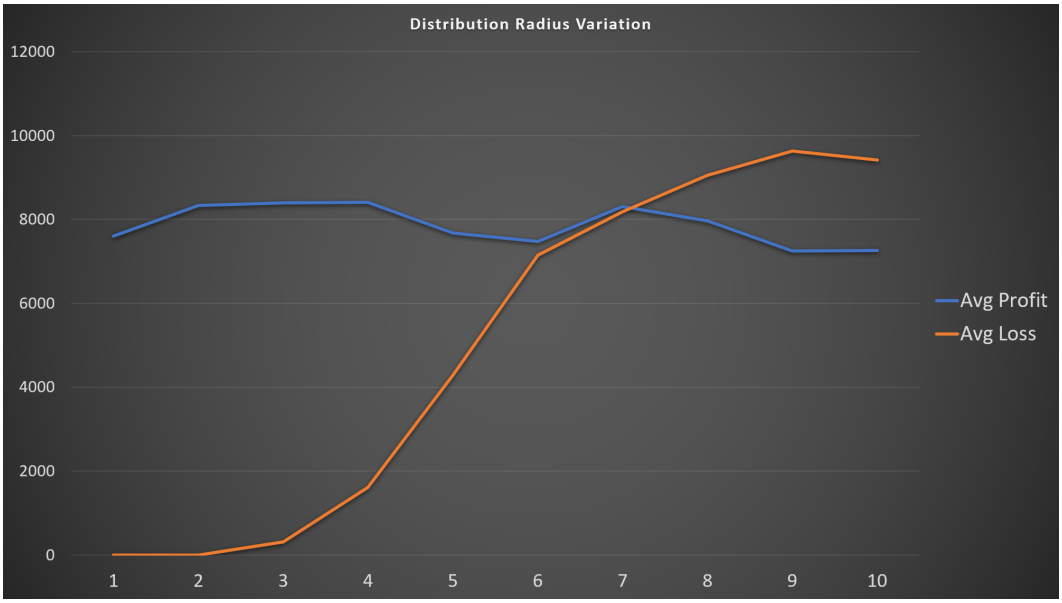

Fig. 3 Radius Variation in Preferential Network

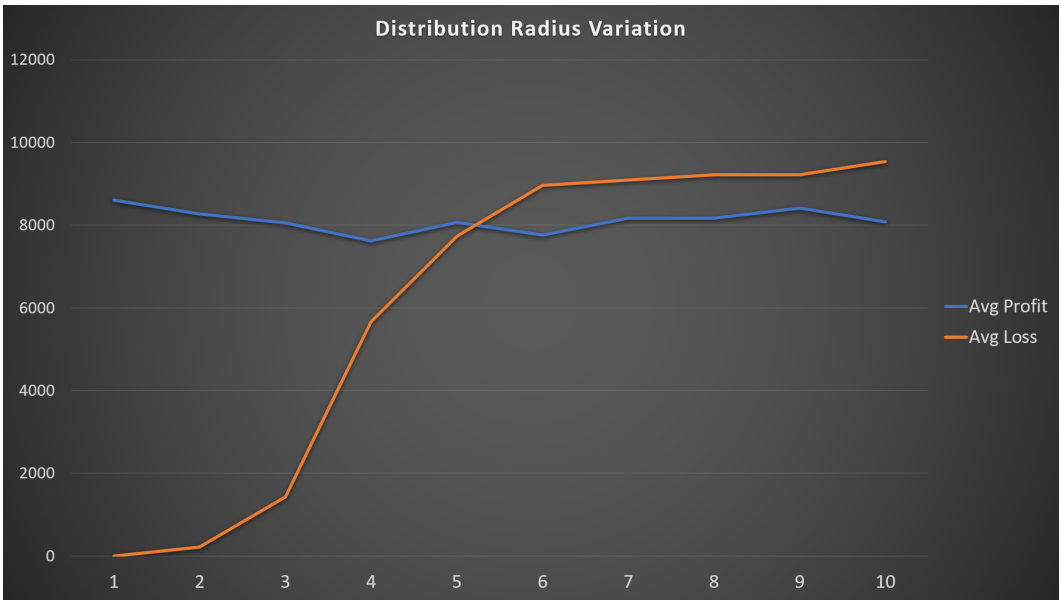

Fig. 4 Radius Variation in Watts Strogatz Network

during the run of the model some individuals change their morality since the release intervals become greater than their waiting thresholds and hence affect their attitude towards software piracy. The simulations are done with the assumption that each individual (ethical and non ethical) tries to obtain a newer version of the software as soon as possible. Multiple runs are done for the mentioned case and the averaged out profit and loss values for the Preferential Attachment network are plotted (shown in fig. 5 & 6).

The plots represent profits and losses averaged out for 144 tuples. Each tuple has coordinates varied from 1 to 12 months. The x axis is for *New-Version-Release-Interval* and the y axis is for *Months-To-Crack* while the z axis represents profit and loss values. The plots are created by varying the *New-Version-Release-Interval* parameter from 1 to 12 while keeping the *Months-To-Crack* parameter constant and then incrementing the *Months-To-Crack* parameter and repeating the process. As seen in Fig. 5 & 6, when the version release interval of original software and pirated software are close

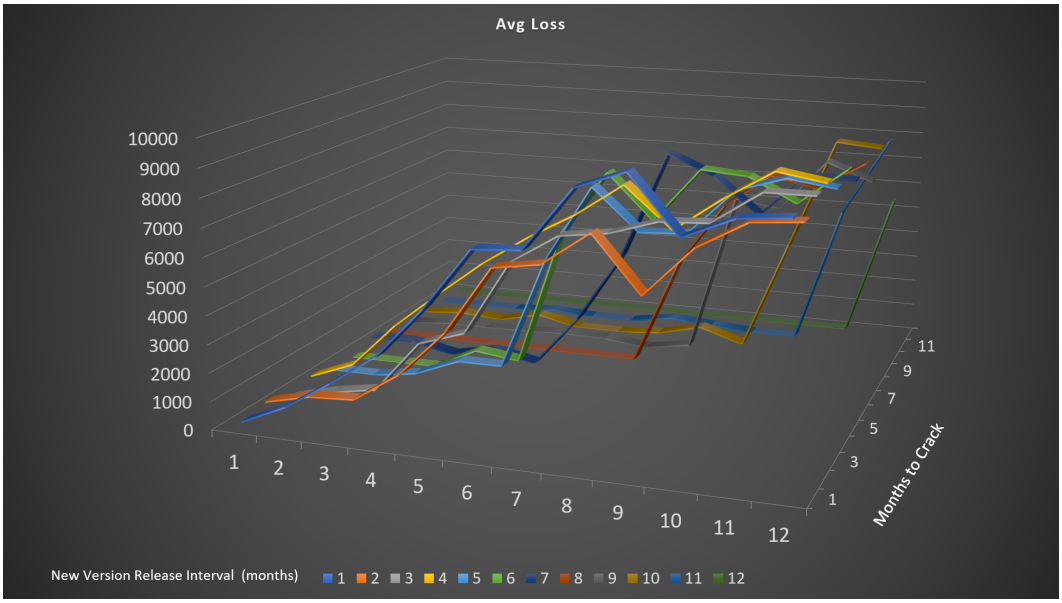

Fig. 5 Average Loss Incurred

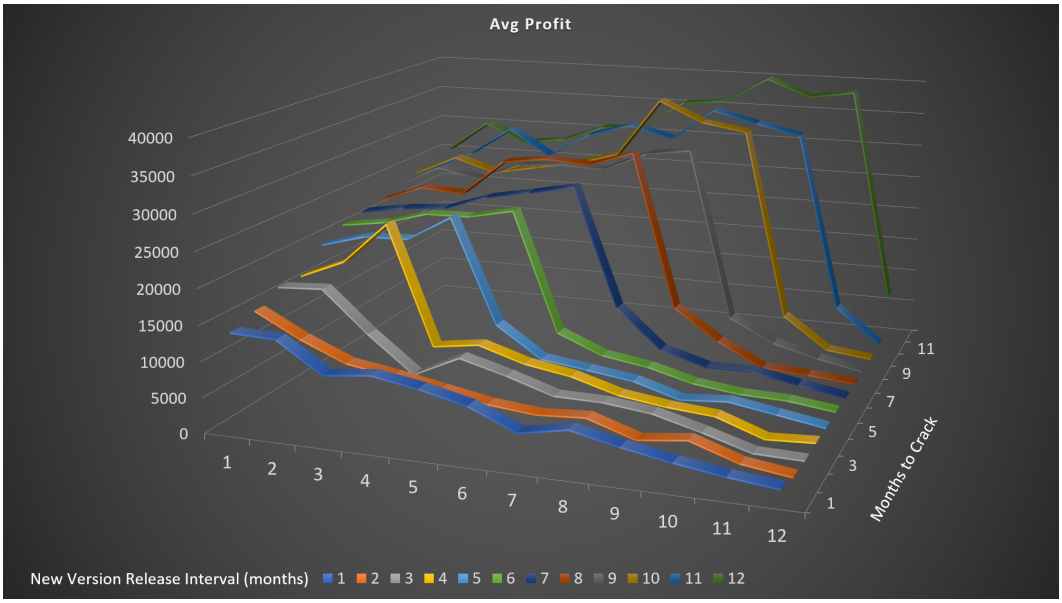

Fig. 6 Average Profits Earned

to each other, the profits are either higher or close to the losses. The profits start decreasing as the version release interval of original software is increased while the pirated software is kept constant (travelling along any one line in Fig. 6). This is because pirated versions become available more frequently than the versions of original software and the waiting threshold of ethical individuals become smaller than the release intervals leading to their change in morality. So, while the profits decrease in this scenario, the losses increase (travelling along any one line in Fig. 5). All the 12 lines in both the figures follow the same trend with the variation that as the duration of pirated version release interval are also increased, the shift from overall profit to overall loss is after later point in the plots. In other words, when the pirated version release interval is higher than the original version release interval (the furthest line in both the plots), the losses are minimum for a long time and profits are higher. The losses start to increase only when the original version release interval approaches the pirated version release interval (travelling along any one line in Fig. 5).

The results are in accordance with the results mentioned in Peace et al. (2003). Peace et al. (2003) found using user experiments that the software costs have a positive effect on the attitude towards piracy in individuals along with the subjective norms supportive of piracy, which were also the results using the simulations of the model. Thus, all hypothesized relations appeared to hold.

4 Discussion

The current model takes various assumptions in mind and simulates very basic characteristics of individuals. The model can be extended for simulating alternate hypotheses and the results from such simulations can be analyzed to give conclusions. Peace et al. (2003) also describes a deterrence theory which states that the attitude of individuals towards piracy is dependent on the severity and certainty of punishment for piracy. If individuals feel that their actions can lead to severe consequences, they hesitate from committing to those actions. The given hypothesis can be incorporated into the model for more realistic results.

Bae & Choi (2006) propose a mathematical side to the piracy model with a short run and long run analysis. They provide a benchmark for optimal pricing of the software and software quality with and without piracy. The equation given can be used to create an agent based model to determine an optimal pricing policy for the software given that piracy exists. Both the researches can be utilized to better understand the dynamics of software piracy in society.

5 Conclusion

The model has a limited scope of working currently. It models very simplistic scenarios and tries to simulate the individual behavior in these scenarios. Although the simulations were run with multiple assumptions in mind, the model can be easily extended to simulate more concrete real world scenarios. Various modifications can be made to the model to make it more realistic. Weights can be added to links to represent the measure of influence on individuals. The ethical value of individuals can be modeled to vary in a certain range rather than being either completely ethical or non ethical. Nevertheless, the current model explains the dependence of various factors on the attitude of individuals towards piracy and their impact on the profits and losses of an organization. From the perspective of an organization, the model can provide a means to create policies against software piracy or provide evidence against policies which have no effect. "Software Piracy" in effect is a phrase that is open to different interpretations by different individuals. Thus, defining a concrete definition and causality relations may not be a trivial task and requires further research.

References

[1] Peace, A. G., Galletta D. F. & Thong, J. Y. L. (2003). Software Piracy in the Workplace: A Model and Empirical Test. Journal of Management Information Systems, 20:1, 153-177, DOI: 10.1080/07421222.2003.11045759.

[2] Bae, S. H., & Choi, J. P. (2006). A model of piracy. Information Economics and Policy, Elsevier, vol. 18(3), pages 303-320, September.

[3] Corwin, J.A. (2018). Preventing Pirated Software Use within an Organization.

[4] Craig, P., Burnett, M. (2005). Software piracy exposed. Rockland, MA: Syngress Publishing, Inc.

[5] Eining, M., & Christensen, A. (1991). A psycho-social model of software piracy: The development and test of a model. In R. Dejoie, G. Fowler, and D. Paradice (eds.), Ethical Issues in Information Systems. Boston: Boyd Fraser, pp. 182-187.

[6] Wagner, S. C., & Sanders, L. G. (2001). Considerations in ethical decision-making and software piracy. The Journal of Business Ethics, 29(1/2), 161-167.

[7] Wu, D., Nan, G., Li, M. (2018). Optimal software upgrade strategy: Should we sell products or premium services in the presence of piracy? Electronic Commerce Research and Applications, 28, 219-229. http://linkinghub.elsevier.com/retrieve/pii/S156742231830022X