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Full Length Research Article

A SIMULATION STUDY OF THE NEGATIVE EFFECT OF THE COMPETING ABILITY OF INCORRUPT PERSONS ON THE TIME TO EXTINCTION OF CORRUPT INTERACTIONS IN A SYSTEM

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ABSTRACT

The Judicial and Economical approaches employed over the years in combating corruption practices has not been completely successful. This work seeks to complement these approaches as it applied the Sterile Insect Techniques (SIT) in curbing corruption. This was done with the intent of investigating the negative effect of the competing ability (CA) of the incorrupt persons on the time to extinction of corrupt interactions in a system. The model successfully determined the number of incorrupt interaction that will completely prevent the flow of corrupt interactions arising from the corrupt persons in the system. Various scenario of competing abilities were simulated. This begins with CA = 1.0 down to CA = 0.0 with a step size of 0.1. The result showed that for a system of carrying capacity of twenty (20), it takes a time interval of 52 to 492 time units for corrupt interactions to go extinct (with 52 time units for CA = 1.0 and 492 time units for CA = 0.1). The overall result showed that, low competing abilities reflect negatively on the extinctions' time of corrupt interactions in a system. In conclusion, the introduction of persons with unwavering integrity in a system, will reduce the negative effect of extending the time to extinction of corrupt practices in a system.

Keywords: Competing Ability, time to extinctions, Corrupt interaction (N_c), total number of interaction, incorrupt interaction.

INTRODUCTION

The Sterile Insect Technique (SIT) is a biological means of diluting the reproductive potential of insect's population with the sole aim of reducing the population of the wild insects (Knipling, 1955). This is done by introducing sterile insects, typically males into the insect population so that the wild females that mate with these sterile males (fully sterilised) always lay eggs that contain dominant lethal mutations which inhibit the eggs from developing into larvae, hence reducing the population of the next generation of insects (Walker, 2012).

This technique was reported to be a good control strategy for small isolated pest population including Islands and small isolated patches that are not under a constant threat of immigration (Klassen, 2009). The SIT has been successfully applied in this work to curb corruption in a system. Particularly, it is used to assess the negative effect of the competing ability of the incorrupt persons on the time to extinction of corrupt interaction in a system of carrying capacity (K). The basic concept is that, when an optimal number of incorrupt persons is determined and introduced into the system (i.e. the sterile males) they perform the function of blocking corrupt practices (i.e. corrupt interaction) until it goes extinct over time.

Researches on SIT has shown that the sterile male insect competes with the wild males before they have a successful mating with the wild females (Knipling 1955).

This is also envisaged in our case of combating corruption; as the incorrupt persons might have to compete with the corrupt persons before a successful blocking of corrupt interactions. Hence, this work focuses on assessing the negative effect of the competing ability of incorrupt persons on the time to extinction of corrupt interactions in a system via a Monte Carlo Simulation study. The simulation approach was adopted because most model of the SIT are deterministic models and they fail to capture the inherent stochasticity or random interactions in a system (Bogyo, 1974).

Nevertheless, some successes in the application of the SIT has been recorded. They include the eradication of screwworm population in Curacao Island, Netherlands and Antilles (Knipling, 1955), elimination of various fruit flies which include oriental fruit fly, melon fruit fly and Mediterranean fruit fly in Hawaii (Carey and Vargas, 1985) and Tsetse fly eradication in Ethiopia (Kebede *et al.,* 2015). Very few applications were done off Island and that include eradication of screwworm in southern United States (Knipling, 1979). The rest of this paper is organised as follows; method, results, discussion, conclusion and recommendation.

MATERIALS AND METHOD

This section present the application of the working principle of the SIT in curbing corruption in a system. It further presents the algorithm and flow chart for the simulation model.

Population growth model

The general population growth model according to Tsoularis (2001), is as given in equation (1) below

$$\frac{dN}{dt} = rN, N(0) = N_0 \qquad (1)$$

The recurrence relation of equation (1) above is as given in equation (2) according to FAO/IAEA (2016)

$$N_{g+1} = rN_g, 0 < r \leq 1 \qquad (2)$$

where r is the intrinsic growth rate, N_g is the population of insect at time g and N_{g+1} is the population of insect at time $g + 1$. The population in (2) will keep growing if no control measure is incorporated.

In order to bring the population of insect in (2) under control, sterile males are introduced into the model. It is expressed as the ratio of wild male insects to the total male insects (sterile males plus wild males) to supress the generational growth. This is captured in the equation (3) below

$$N_{g+1} = rN_g\left(\frac{M_g}{M_g+S}\right) \quad \text{(Knipling, 1955).} \qquad (3)$$

Equation (3) contains the following quantities; the population size (N), the sterile release (S), the number of wild male (M) and the rate of population increase per generation (r). The quantity $\frac{M_g}{M_g+S}$ is the supressing ability (the ratio of wild males to the total males (wild males + sterile males). Its effect largely depends on the sterile release (S) with full competing ability.
The population growth model for corruption as inferred from .2) above can be re-written as follows

$$N_{c+1} = rN_c, 0 < r \leq 1 \qquad (4)$$

where r is the intrinsic rate of growth of the number of corrupt interactions in the system, N_c is the number of corrupt interactions at time c and N_{c+1} is the number of corrupt interactions at time c+1. The number of corrupt interactions in (4) grows indefinitely since there are no control measure to curtail it.
In order for the number of corrupt interactions (N_{c+1}) in equation (2.4) not to grow indefinitely, we borrow a leaf from Knipling (1955) and re-write equation (4) as follows;

$$N_{c+1} = rN_c\left(\frac{N_c}{N_c+\alpha}\right), 0 < r \leq 1. \qquad (5)$$

We emphasize that in the absence of incorrupt interactions, denoted by α, the population in (4) above is assumed to grow exponentially with r as the intrinsic rate of growth per generation. The ratio term $\frac{N_c}{N_c+\alpha}$ which is the ratio of corrupt interactions to total interactions (corrupt interactions + incorrupt interactions) brings the population under control. Where N_c and α remain as earlier defined. A way of quantifying the competing ability was explained by Phuc *et al.* (2007) in their work on insect sterile method of reducing fertility in female insects. This they called the competing coefficient and they modified equation (2) as follows;

$$N_{g+1} = rN_g\left(\frac{M_g}{M_g+\rho S}\right), 0 \leq \rho \leq 1 \qquad (6)$$

where ρ is the competing coefficient or competing ability and other variables are as earlier defined.
For our corruption, equation (6) becomes

$$N_{c+1} = rN_c\left(\frac{N_c}{N_c+\rho\alpha}\right), 0 \leq \rho \leq 1 \qquad (7)$$

where ρ (the competing ability of the incorrupt persons) is a proportion that take values between 0 and 1. (0 and 1 inclusive). The value ‘0’ indicates no competing ability and the value 1 indicates full or perfect competing ability.

Solving for S in (6), the threshold release value of the sterile male insect becomes

$$S^* = (r-1)M \qquad (8)$$

where M is the steady state population and r is the intrinsic rate of growth.
Equation (2.6) can be summarize mathematically as follow;

$$N_g \to \{0, if\ \ S > S^*\ \infty, if\ S < S^*\ M, if\ S = S^* \qquad (9)$$

For our corrupt case, we have;

$$N_c \to \{0, if\ \ \alpha > S^*\ \infty, if\ \alpha < S^*\ M, if\ \alpha = S^* \qquad (10)$$

where S^* is redefined as the threshold value of incorrupt interactions and M is now defined as the steady state value of the number of corrupt interactions.

Anti-Corruption Simulation Model (ACSIM)

The major parameter in this work are the intrinsic rate of growth (r), the competing ability of the incorrupt person (ρ), proportion of incorrupt interactions (p) and the carrying capacity (K) of the system. The simulation model employs the Monte Carlo Simulation technique in sampling the number of interactions (N) from the Poisson distribution with mean approximated to be $\lambda = \binom{K}{2}$. We assume in this work that on the average, effective interaction is between pairs of persons.

The number of incorrupt interactions (α) is sampled from a successful sample of the number of interactions (N) assumed to have come from the Poisson distribution. The ACSIM utilizes it as the number of trials which in turn, serve as input into a Binomial distribution. This is to help in sampling the number of incorrupt interactions (α) given a success rate (p) and failure rate (q). Binomial distribution is used because, the number of interactions (N) is the sum of corrupt and incorrupt interactions and we treat the incorrupt as success.

Thus, given a system of carrying capacity (K) or staff strength, the number of possible interactions is $\binom{K}{2}$ and is given by;

$$\binom{K}{2} = \frac{K(K-1)}{2}. \qquad (11)$$

Generalizing, we have;

$$K = n_i + n_c. \qquad (12)$$

$$\binom{K}{2} = \binom{n_i}{2} + \binom{n_c}{2} + n_i n_c \qquad (13)$$

$$\alpha = \binom{n_i}{2} + n_c n_i \qquad (14)$$

$$N_c = \binom{n_c}{2} \qquad (15)$$

$$n_c^2 - n_c - 2N_c = 0 \tag{16}$$

Taking the positive root of (2.16), we have

$$n_i = K - \left(\frac{1+\sqrt{1+8N_c}}{2}\right). \tag{17}$$

where K is the system carrying capacity, n_i is the number of incorrupt persons and n_c is the number of corrupt persons. From (12) above, $\binom{n_i}{2}$ is the number of ways two incorrupt persons interact, $\binom{n_c}{2}$ is the number of ways two corrupt persons interact and $n_i n_c$ computes the number of incorrupt interactions arising from the interactions between an incorrupt person and a corrupt person. Hence, the total number of incorrupt interactions is given by $\binom{n_i}{2} + n_i n_c$ while the number of corrupt interactions is $\binom{n_c}{2}$. The number of corrupt and incorrupt persons are respectively determined from the number of corrupt interactions (N_c) and the number of incorrupt interactions (α).

Model Assumptions

i) The intrinsic rate of growth (r) is equal to 1.
ii) The incorrupt persons have the ability to prevent a flow of corruption after interaction with the corrupt person and cannot be negatively influenced.
iii) There are no staff transfer and new employment in the period under consideration.
iv) Effective interactions is between pairs of persons.
v) No residual corruption of the incorrupt person.

Model Algorithm

The algorithm for the simulation model is given below.
The proportion of incorrupt interactions denoted by p takes values between 0 and 1. While the proportion of corrupt interactions is $q = 1 - p$

Step 1: Sample number of interaction N about $\binom{K}{2}$ mean interactions from the Poisson distribution

Step 2: Given this N number of interactions, sample number of incorrupt interaction (α) from the binomial distribution with p success rate and q failure rate.

Step 3: Compute the number of corrupt interactions (N_c) $as\ N - \alpha$.

Step 4: Determine (g) the time to extinction from the growth model as follows

$N_{c+1} = rN_c\left(\frac{N_c}{N_c+\alpha}\right)$;

Continue to apply the growth model above while $N_{c+1} > 0$ and track or note the $'c'$ when $N_{c+1} = 0$ (time to extinction) as well as $N_c\ and\ \alpha$.

Step 5: Repeat steps 1 to 4 for the same value of p using 1000 different random number streams and compute the means, $\overline{\mathrm{c}}$, $\overline{\mathrm{N}}_{\mathrm{c}}$ $and\ \bar{\alpha}$.

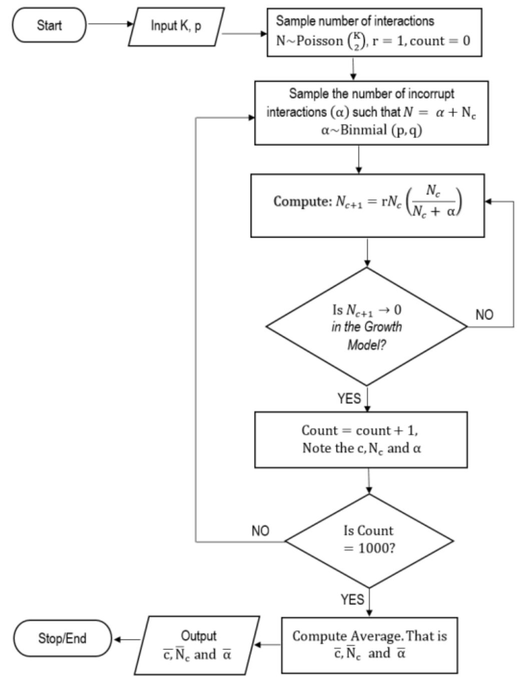


Figure 1: Flow chart for the Simulation Model

Implications of the Law of Large Numbers to the Simulation Experiments

If $\overline{\mathrm{X}}_{\mathrm{n}}$ is the average of n independent random variables with expectation μ and variance σ^2, then for any $\varepsilon > 0$:

$$\lim_{n\to\infty} P(|\overline{\mathrm{X}}_{\mathrm{n}} - \mu| > \varepsilon) = 0 \tag{18}$$

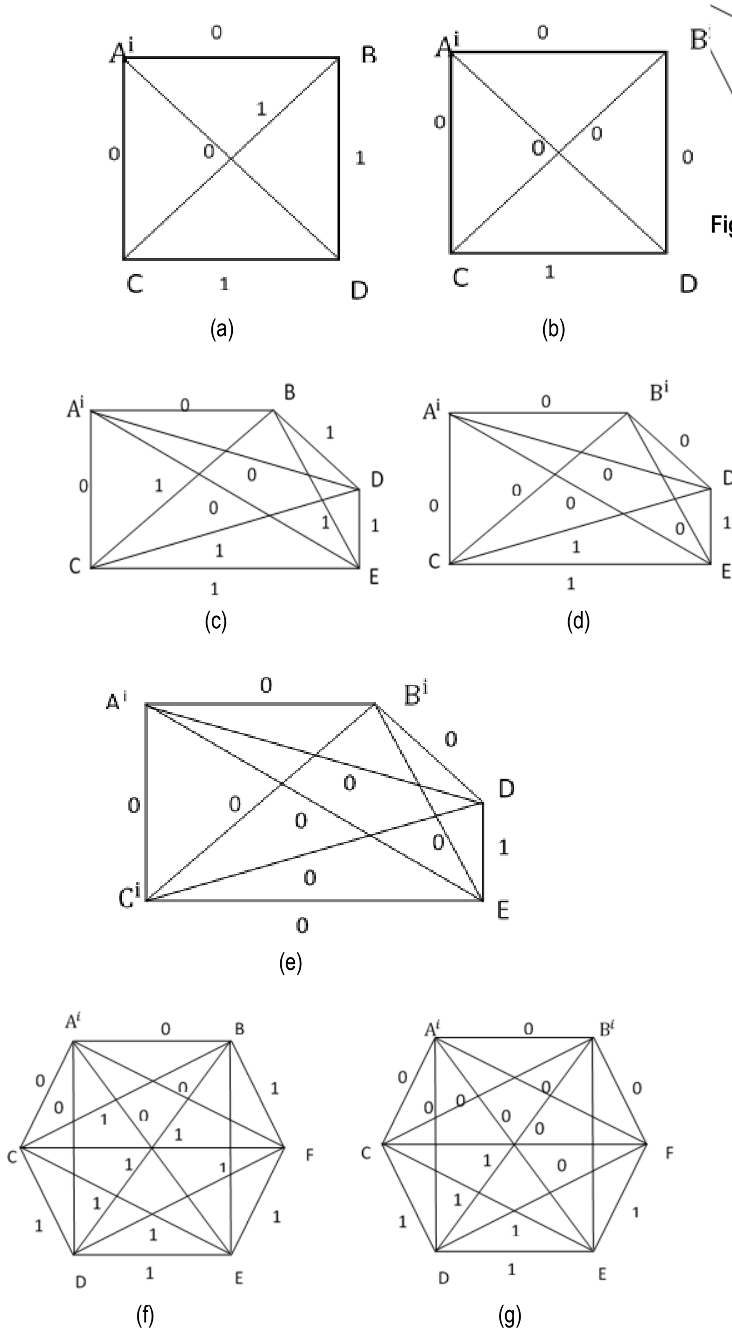
The implication of this law to the simulation experiment is as follows: Suppose we perform the experiment several times, each resulting in an average value $\overline{\mathrm{X}}_{\mathrm{n}}$and n is sufficiently large, then $\overline{\mathrm{X}}_{\mathrm{n}}$ will be approximately close to μ for almost all of the experiments. In this paper, $\overline{\mathrm{X}}_{\mathrm{n}}$represent the mean of the incorrupt interactions using 1000 different random number streams and this mean will eventually converge to almost its actual value if not exact. Hence, $\overline{c}, \overline{N}_c\ and\ \overline{\alpha}$ are computed based on the law of large number.

Verification

The simulation model program is verified for correctness by running the program in modules using stops. This makes it easy to check for correctness of the syntax as well as the semantics of the Pascal programming language used. It also helps to check if each module is meeting systems requirements and meeting them rightly.

Validation

Validation of simulation models has been a huge challenge over the years. This is mainly due to lack of data. In this paper, the researcher made effort to surmount this challenge by creating virtual image of real life systems. This is called the 'virtual system'. The virtual systems are created using the knowledge of graph theory. In these systems, persons are represented by the vertices of a graph while the edges represent interactions. For ease of manual handling/computations, four (4), five (5) and six (6) vertex graphs were selected to represent systems with 4, 5 and 6 carrying capacities as show in Figure 2 below.



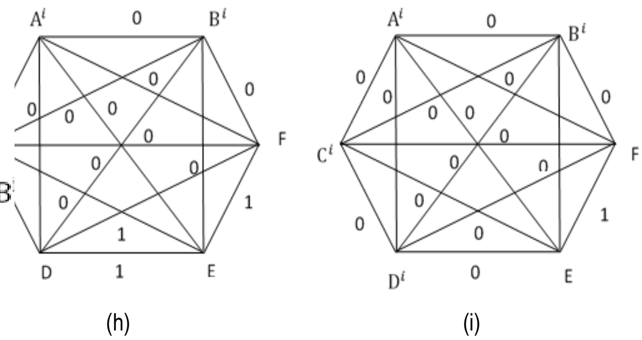


Figure 2: Virtual systems with four (4), five (5) and six (6) carrying capacities
(a) One incorrupt person and three corrupt persons
(b) Two incorrupt persons and two corrupt persons
(c) One incorrupt persons and four corrupt persons
(d) Two incorrupt persons and three corrupt persons
(e) Three incorrupt person and two corrupt persons
(f) One incorrupt persons and five corrupt persons
(g) Two incorrupt persons and four corrupt persons
(h) Three incorrupt persons and three corrupt persons
(i) Four incorrupt persons and two corrupt persons

Figure 2 above represent a virtual system for carrying capacities of four (4), five (5) and six (6) where any vertex (persons) with superscript i denote the incorrupt person(s) whereas those without superscript represent the corrupt person(s). Figures 2a and 2b represent the virtual systems for a carrying capacity of four (4) with the total of six interactions (edges or paths). The paths is the total of both the zeros (0's) and the ones (1's) where the 0's represent the incorrupt interactions and 1's represent the corrupt interactions. The proportion of incorrupt interactions is derived from the ratio of the total number of zeros (0's) to the total number of interactions (0's plus 1's).
Figure 2a denote a virtual system with one incorrupt person and three corrupt persons while Figure 2b denote a virtual system with two incorrupt and two corrupt persons in a system of carrying capacity of four (4).
Figures 2c-2e is the virtual systems with a carrying capacity of five (5), it has the total number of ten possible interactions. Figure 2c contain one incorrupt and four corrupt persons, Figure 2d contain two incorrupt and three corrupt persons while Figure 2e contain three incorrupt and two corrupt persons. Finally, Figures 2f-2i represent a virtual systems with a carrying capacity of six (6) and total of fifteen possible interaction. Figure 2f contain one incorrupt and five corrupt persons, Figure 2g contain two incorrupt and four corrupt persons, Figure 2h contain three incorrupt and three corrupt persons and Figure 2i contain four incorrupt and two corrupt persons.

The number of possible interactions in each virtual system of carrying capacity (K) were determined using equation (2.10) above i.e. $\binom{K}{2}$. Using the number of incorrupt persons (n_i) in the system, the number of incorrupt interactions (α) were also determined for each system.

Observe that the number of incorrupt interaction (N_i) for each virtual system represent an average $(\overline{\mathrm{N}}_i)$ in the simulated system after 1000 iterations.

Input parameters such as carrying capacity (K) and proportion of incorrupt interaction (p_i), in each virtual system were used to run the simulated system, where;

$$p_i = \frac{\alpha}{\binom{K}{2}} \qquad (2.20)$$

The approximate upper bound of the simulated number of incorrupt interactions from the virtual systems were checked to see if they correlated strongly with the actual number of incorrupt interactions from the virtual systems. These was implemented by computing the correlation coefficient between these two sets of data by a graphical comparison of the two sets of data. It is important to mention that since the number of incorrupt interactions in the virtual systems are extreme values i.e. (the maximum number of incorrupt interactions), they were compared with the approximate upper bound of the number of incorrupt interactions in the simulated systems. The term approximate upper bound is used because decimal fractions are treated as full interactions.

If the computed α from a virtual system lie in this interval, then it implies that the simulated system has succeeded in mirroring the virtual system as one of its scenarios. It therefore follows that the simulation model is validated for use in modelling anticorruption in a system.

RESULTS AND DISCUSSION

Before putting the simulation model to use, it is necessary to verify whether the model is a correct representation of the logic, concept or simulation schematics. It is also needful to verify and validate the model. This can be achieved by determining whether the implementation appeal to reasoning as the model respond to the various changes in its parameters

Model Verification

Table 1 is a distribution of mean time to extinction of corrupt interaction across selected competing abilities for a system of carrying capacity of twenty (20) and a growth rate of one (1). This shows the response of the model to competing ability and the proportion of incorrupt interactions as it relates to the time to extinction of corrupt practices in a system of carrying capacity of twenty (20). With a given proportion of incorrupt interaction in the model, observe that the corrupt practices of the corrupt person go extinct at different time points. The evidence can be seen in Figures 3-9. The extinction depend on the competing ability of the incorrupt persons. As the competing ability of the incorrupt person increases, the average time to extinction of corrupt interactions reduces (Table 1 and Figures 3-9). From the above, it become obvious that the logic of the simulation model is correct.

Model Validation

As already mentioned, virtual systems were created for validation purposes. The number of incorrupt persons used in these systems were 1 and 2 for the system of four (4), 1, 2 and 3 for the system of five (5) and 1, 2, 3 and 4 for the system of six (6) carrying capacities. For each system, the following sets of proportions of incorrupt interactions were obtained across the number of incorrupt persons; $\left(\frac{3}{6}, \frac{5}{6}\right)$, $\left(\frac{4}{10}, \frac{7}{10}\ and\ \frac{9}{10}\right)\ and\ \left(\frac{5}{15}, \frac{9}{15}, \frac{12}{15}\ and\ \frac{14}{15}\right)$ respectively (Table 2).

Table 1: A distribution of mean time to extinction of corrupt interaction across selected competing abilities for a system of carrying capacity of twenty (20) for a growth rate of one (1)

Proportion of Incorrupt Interactions	Competing Ability 0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	n_i	n_c
0.10	+∞	492	248	166	125	101	85	73	64	57	52	1	19
0.15	+∞	306	155	104	79	64	54	46	41	37	33	2	18
0.20	+∞	214	108	73	56	45	38	33	29	26	24	2	18
0.25	+∞	160	81	55	42	34	29	25	23	20	19	3	17
0.30	+∞	124	64	43	33	27	23	20	18	16	15	3	17
0.35	+∞	97	50	34	26	22	19	16	15	13	12	4	16
0.40	+∞	78	41	28	22	18	15	13	12	11	10	4	16
0.45	+∞	63	33	23	18	15	13	11	10	9	9	5	15
0.50	+∞	51	27	19	15	12	11	10	9	8	7	6	14
0.55	+∞	41	22	15	12	10	9	8	7	7	6	6	14
0.60	+∞	33	18	13	10	9	8	7	6	6	5	7	13
0.65	+∞	26	14	10	8	7	6	6	5	5	5	8	12
0.70	+∞	21	12	8	7	6	5	5	4	4	4	9	11
0.75	+∞	16	9	7	6	5	4	4	4	4	3	10	10
0.80	+∞	12	7	5	4	4	4	3	4	3	3	11	9
0.85	+∞	8	5	4	3	3	3	3	3	2	2	12	8
0.90	+∞	5	3	3	2	2	2	2	2	2	2	13	7
0.95	+∞	3	2	2	2	1	1	1	1	1	1	15	5
1.0	+∞	1	1	1	1	1	1	1	1	1	1	19	1

$n_i =$ Number of incorrupt persons, $n_c =$ Number of corrupt persons

Table 2: A distribution of number of incorrupt interactions in the Simulated and Virtual systems for a growth rate of one (1)

Proportions of Incorrupt person	Carrying Capacity (K)	Simulated: Average number of incorrupt interaction $(\bar{\alpha})$	95% Confidence Interval $(\bar{\alpha})$ Lower	Upper	*Approximate Upper bound of the C.I for $(\bar{\alpha})$	Virtual: Maximum number of incorrupt interactions
0.50	4	2.73	2.66	2.80	3.00	3.00
0.83	4	3.83	3.75	3.91	4.00	5.00
0.40	5	3.00	3.71	3.90	4.00	4.00
0.70	5	5.00	5.71	5.93	6.00	7.00
0.90	5	3.80	6.97	7.20	8.00	9.00
0.33	6	5.82	4.66	4.87	5.00	5.00
0.60	6	7.08	7.60	7.87	8.00	9.00
0.80	6	4.00	9.95	10.23	11.00	12.00
0.93	6	7.00	11.41	11.69	12.00	14.00

*Decimal fractions are treated as full interaction
**Correlation coefficient between the number of interactions in * and that of the virtual systems ≈ 0.99

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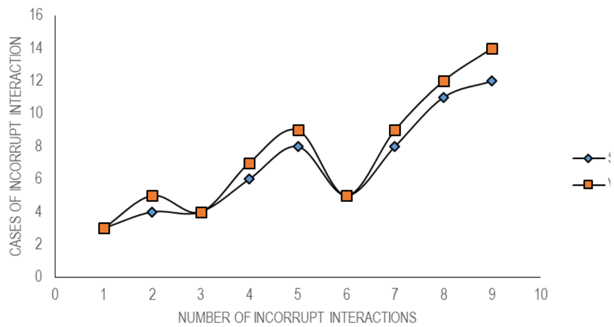
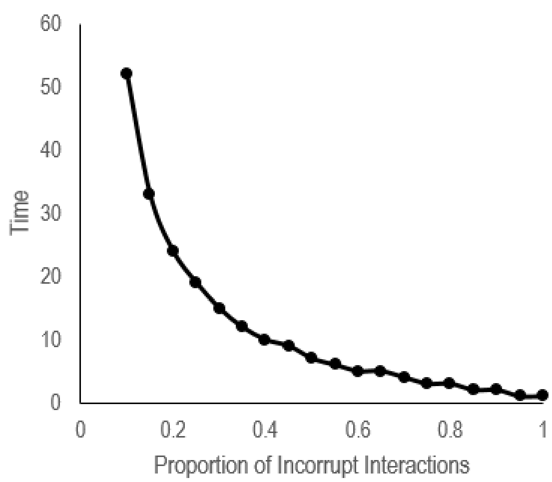
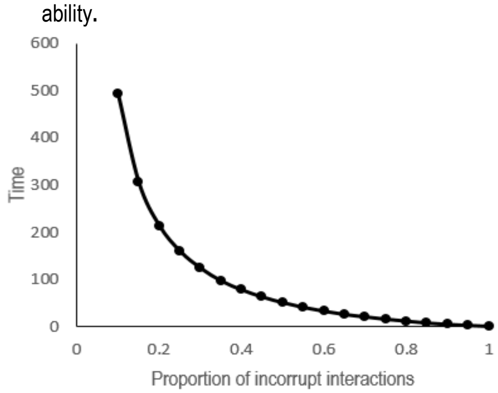


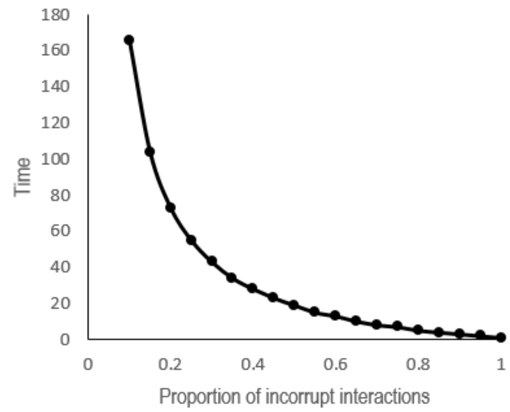
Figure 3: Comparison of the simulated systems and the Virtual systems



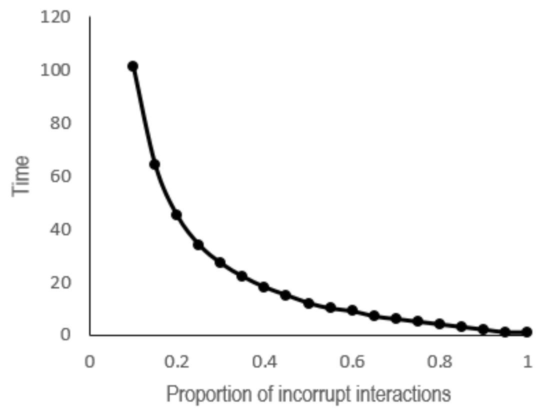
(a). Relationship between proportion of incorrupt interactions and time to extinction of corrupt interactions for the 0.3 competing ability.



(b). Relationship between proportion of incorrupt interactions and time to extinction of corrupt interactions for the 0.5 competing ability.

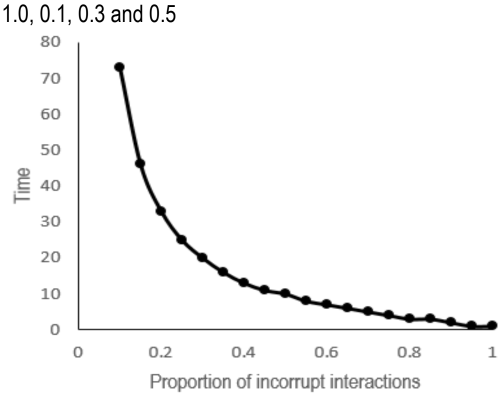


(c). Relationship between proportion of incorrupt interactions and time to extinction of corrupt interactions for the 0.3 competing ability.



(d). Relationship between proportion of incorrupt interactions and time to extinction of corrupt interactions for the 0.5 competing ability.

Figure 4: Relationship between proportion of incorrupt interactions and time to extinction of corrupt interactions in a system of twenty (20) carrying capacity with competing abilities of 1.0, 0.1, 0.3 and 0.5



(e). Relationship between proportion of incorrupt interactions and time to extinction of corrupt interactions for the 0.7 competing ability

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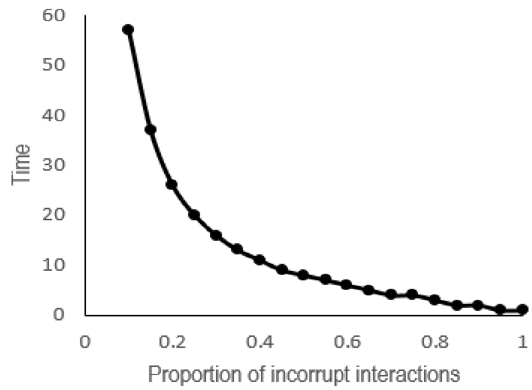

(f). Relationship between proportion of incorrupt interactions and time to extinction of corrupt interactions for the 0.9 competing ability

Figure 5: Relationship between proportion of incorrupt interactions and time to extinction of corrupt interactions in a system of twenty (20) carrying capacity with competing abilities of 0.7 and 0.9.

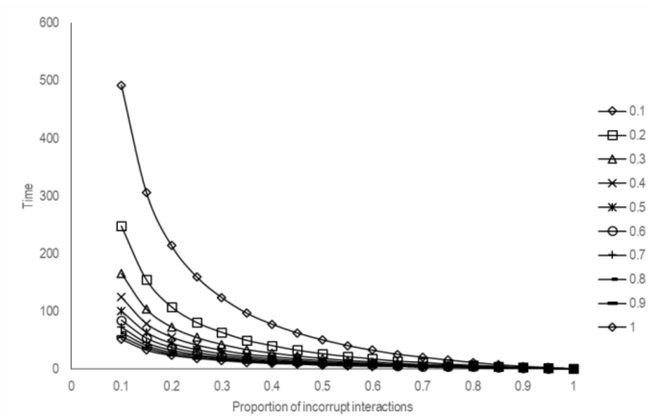

Figure 6: Relationship between proportion of incorrupt interactions and time to extinction across various competing abilities

Table 2 show that the simulation model was ran for each virtual system using the aforementioned parameters (i.e. the carrying capacity, the proportion of incorrupt interaction and the 1.0 intrinsic growth rate). The simulation output of interest is the number of incorrupt interactions required to block the corrupt interactions in the system. These were determined as extreme values and compared with the respective number of incorrupt interactions in the virtual systems which are also extreme values.
The result shows that the simulated number of incorrupt interactions is approximately the same as the actual number of incorrupt interactions in the created virtual systems. This is further confirmed by the graph in figure 3 and the strong correlation coefficient of 0.99 between the simulated number of incorrupt interactions and the actual number of incorrupt interactions from the virtual systems (Table 2).
Table 1 above includes the proportions of incorrupt interaction with 0.05 step size starting from 0.1 all through to 1. The various competing abilities ranging from 0.1 to 1 with the step size of 0.1. The behaviour of the simulation model result were recorded under various scenarios. One of the major features of the simulation model result above is that, the competing ability is inversely proportional to the time to extinction of corrupt interactions in the system. When the CA is 0.1, it takes up to 492 time units for corruption to go extinct (See figure 4b) as compared to 52 when the CA is 1 (Figure 4a). CA equal 1 means perfect competing ability of the incorrupt persons in the system. The unit of time to extinction of the corruption in any system is largely dependent on how the proportion of the incorrupt person is obtained. If the proportion of the incorrupt person is computed based on the yearly data, then one generation (time unit) will be equivalent to one year, also if it is based on months, then one generation (time unit) will be equal to one month.
Figures 4-5 is the graph of the relationship between the proportion of incorrupt interactions and the time to extinctions of corrupt interactions for various competing abilities of the incorrupt person (Table 1). As shown in Figure 4a, the time to extinction for the perfect competing ability is 52 which is less compared to those on Figures 4b-4d and 5a and 5b because it is assumed that all the interactions from the incorrupt person cannot be negatively influenced by the corrupt person since the tendency for them to be corrupt is not certain. Also from Figure 4a, when the proportion of incorrupt interactions is 0.3, the time to extinction of corrupt practice is 15 time units with 3 incorrupt persons and 17 corrupt persons in a system of carrying capacity of twenty (20). This experimentation explains what is meant by perfect competing ability (CA = 1).
The assumption of perfect competing ability might be violated which means that the incorrupt persons might not be able to compete favourably with the corrupt persons. This was considered by our model in equation (2.7). Figures 4b-4d and 5a and 5b presents the graph with various competing abilities. Figure 4b presents the graph of the relationship between the proportion of incorrupt interactions and the time to extinctions of corrupt interactions, for 0.1 competing ability of the incorrupt persons. 0.1 competing ability means that the incorrupt persons is 10 percent empowered to compete with the corrupt individuals. The graph shows the elongation of the time to extinction of corrupt interactions from 52 to 492 time units. This is with equal proportion of incorrupt interactions and the number of corrupt and incorrupt persons. For instance, when the proportion of incorrupt interactions is 0.3, the time to extinction is 124 time units (Figure 4b and Table 1) as against 15 time units in figure 3 with perfect competing ability. Here, the number of incorrupt persons is 3 and the number of corrupt persons is 17. For corruption to go extinct at 16 time units with 0.1 competing ability, the number of incorrupt persons must be increased to 10. This results to the number of corrupt persons been 10 in the system of carrying capacity of twenty while the proportion of incorrupt interactions is 0.75.
For a 0.1 proportion of incorrupt interactions and a competing ability of 0.3 (Figure 4c and Table 1), the time to extinction of corrupt practices is 166 time units against 492 time units where the competing ability is 0.1. Observe also that the time to extinction reduces to 52 time units for the perfect competing ability while maintaining the 0.1 proportion of incorrupt interactions. Furthermore, for the 0.3 proportion of incorrupt

interactions, the time to extinction of corrupt practices is 43 time units against the 15 time units for the perfect competing ability and 124 time units for the 0.1 competing ability. For the time to extinction to be reduced to 15 time units, the proportion of incorrupt interactions has to increase to 0.55. This is in to counter the effect of low competing ability of the incorrupt persons in a system with 6 incorrupt persons and 14 corrupt persons.
In summary, the analysis shows that, as the competing ability of the incorrupt person reduces, the time to extinction increases, showing the negative effect of the competing ability of the incorrupt persons on the time to extinction of corrupt interactions in a system. This negative effect is summarised in Figure 6 for various competing abilities of the incorrupt persons over the number of corrupt interactions, as it affect the time to extinction of corrupt practices in a system. The closer the competing ability is to 1, the smaller the time to extinction of the corrupt practices in the system. This confirm the essence of competing ability in curbing corruption in a system. We therefore state that the introduction of persons with good track record of unwavering integrity into the system, will yield high competing ability. This will in turn reduce the negative effect of extending the time to extinction of corrupt interactions in a system.

Conclusion and Recommendation

The following conclusions were drawn from the study;

i. Using the Sterile Insect Technique (SIT), the simulation model developed has successfully reduced the number of corrupt interactions in a system.
ii. The time to extinction of corrupt interactions is inversely proportional to the competing ability of the incorrupt person.
iii. The proportion of incorrupt interactions is directly proportional to the time to extinction of corrupt interactions.
iv. High competing ability of incorrupt persons in a system, as demonstrated by their unwavering integrity, reduces if not eliminate the negative effect in extending the time to extinction of corrupt practices in a system.

This study recommends that, the model should be applied in curbing corruption in a system.

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