What Stabilizes Corruption? A Game Theoretic Approach

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Thesis

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Certificate

This is to certify that this dissertation entitled "What Stabilizes Corruption? A Game Theoretic Approach" submitted towards the partial fulfillment of the BS MS Dual Degree Program at the Indian Institute of Science Education and Research, Pune, represents original research carried out by Shambhavi Vashishtha at the Department of Mathematical Sciences, Indian Institute of Science Education and Research Pune under the supervision of Prof. Milind G. Watve during the academic year 2010-2011.

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Abstract

Corruption is known for its deep rooted clutch on the society. From a road side traffic police constable to the highest echelons of political, bureaucratic and corporate sector, every stratum is suffering from the rots of corruption. It is difficult to incorporate the whole structure and different facets of corruption in one model hence our concentration is on a specific section but on a strong premise. We here analyze the corruption in public sector through a two person game. In Prisoner's dilemma defection is stable and a lot of work has been done to find conditions where co-operation is stable, we in our model have addressed the paradox *i.e.* co-operation is stable in corruption and we have suggested a few ways to destabilize it. Social policing has been discussed and suggested as one of the possible measures to eliminate corruption. Another suggestion made and discussed is the presence of Anti Corruption Cell, which is a constituted authority to check corruption in the population but even Anti Corruption cell is not considered incorruptible. Finally a comparison has been made between social policing and anti Corruption Cell under specific parametric ranges. Thresholds have been discussed for the social policing and Anti Corruption Cell. It turns out that even if corruption is prevalent in Anti Corruption Cell it is able to eliminate corruption in other sections of the population under the given parametric ranges.

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Chapter 1

Introduction

Corruption is one of the major organized anti social elements in the society; it has made its presence felt in almost all the spheres of public sector and corporate sector. Although there have been studies which argue that in some instances corruption has helped to promote economic development and efficiency [1]. Corruption belittles the cause of a government, leads to public mistrust and undermines the value of the constituted authority [2]. Corruption has its roots in almost all sections of society viz; administrative, public, private etc. Giving money to speed up the clearance of an application, Contracts and tenders given to those who help rigging the elections or have a huge stake in the campaign money, using one's position in government office to fill up their personal coffers, Incumbent officials showing lax in services making the public indulgence in bribing them constitute the common forms of corruption.

All of the above examples are of corruption where the public office has been misused by the functionary officials. Corruption in private sector can be seen under the guise of extortion, racketeering etc but our focus is on the public sector. Corruption can be loosely classified into following categories; Bribery, Nepotism, Fraud, Embezzlement. Corruption as a whole has far reaching consequences and affects the whole working of an economy, a whole large chunk of money meant for betterment of the poor, building of schools, health centers etc never see the light the day rather they are siphoned off to people in power or to their relatives.

As mentioned earlier, there are many stages of corruption i.e. it can be at bureaucratic level, political level or can simply be at peon's level. It depends on the gravity of the work that has to be done. Initially bribe was given to get an illegal work done but the recent picture, in some countries, is that bribe is also being given to get the legal work done, which is sobering and such are the clutches of corruption. The paradox which we want to address in this study is that of the stability of co-operation. Corruption has been able to take root in the society because of the organized co-operation which persists amongst the individuals who indulge in corruption. The basis of prisoner's dilemma is crime and co-operation cite{pound [3]. However co-operation is unstable in prisoner's dilemma where stability of corruption is our b noire here. The model that follows does not cover the whole spectrum of corruption rather considers a simple but at the same time very pertinent premise. We have endeavored to simulate the situation where there is one seeker (person who is seeking to get his work done, the work is legal), the other person is the worker (the one who is a public official and is hired by the Govt. for the service of the common) and anti corruption cell. Now as said earlier that these days bribe is rampant for the sectors where legal work is being done, we have considered the same case here. Which leaves the seeker with two choices i.e. he can give the bribe or he may not give the bribe, similarly the worker class also exercises the choice of accepting a bribe or refusing it in the case of bribe being offered.

The rest of the thesis has been organized as follows. In chapter 2 we talk about the basic structure of the model developed. Chapter 3 elaborates on the tools employed in the analysis of the model. Finally in chapter 4 we discuss the mathematical model in detail, the results obtained for various cases of the model and conclude with the discussions and future plans in the fifth chapter.

Chapter 2

The Model

We consider an infinite population where a pair of individuals interacts as a two person game. Initially we assume that there is interaction between two sections of population viz. seekers and workers. We assume that a seeker wants to get his work done and in order to get his work done he interacts with the worker which is in turn is assumed to be working in a public sector office. Seeker section is sub divided into categories, bribe givers and non-givers. The givers are of two kinds i.e. perpetual givers and discriminators whom we call intelligent seekers in the model. The non givers have two kinds of players one being indifferent to the players who ask them for bribe and the other one being punishers who punish the players who ask bribe from them. (Table 1) Similar to the seeker section, the worker section is also divided into two categories i.e. venal (bribe takers) and clean (non takers). The takers are further sub categorized into cooperators, defectors and discriminators. The non takers are categorized into indifferent non-takers, who do not take bribe but it does not affect them if somebody does offer them, and punishers are the ones who will not take bribe but will punish the one who offers them. (Table 1)

All through the model it has been assumed that the worker is seeking to get a legal work done. Ideally there shouldn't be any reason for bribe in such cases but this is belied in the real life scenario and reason can be as simple as to avoid unnecessary red-tape, to expedite the process or mere greed. The punishers in the seeker and worker categories punish via a judicial channel in which the punisher makes a formal complaint to the judicial system and then the punishment is meted out.

Chapter 3

The Mathematical and Analytical Tools

3.1 Replicator Dynamics

To analyze the development of different strategies in the model we wanted to study the pattern over the generations and hence we chose to employ replicator dynamics. The evolutionary replicator dynamics can be used to simulate evolutionary processes that are dependent on the frequency of players using different strategies. Since the payoffs of the players are highly interlinked it is safe to assume that frequency of an individual playing a certain stipulated strategy will change as per the average payoff of the population and hence the selection of replicator dynamics will facilitated the change of frequencies as follows [4], [5], [6]:

$$\dot{f}_i = f_i(E_i - \overline{E})' \tag{3.1}$$

Where E denotes the payoff (fitness) of a certain strategy and f denotes the frequency for the same. The replicator equation describes deterministic but frequency dependent selection dynamics. The payoff, E_i, of type i is a function of the frequencies of all strategies viz.

$$\vec{f} = (f_1, f_2, \ldots, f_n). \tag{3.2}$$

In the beginning we have assumed that the frequencies of the all the players adapting different strategies are equal. The replicator dynamics ensures that the frequencies change and converge to a Nash Equilibrium, if it exists [4], [7]. If a particular strategy is giving better payoff than the average payoff of the population then the replicator dynamics will ensure that in the next generation more individuals adopt that strategy than the other strategies.

3.2 Plackett and Burman Designs

Since the sheer number of parameters involved in the model is very high so to reduce the number of trials Plackett and Burman (PB) designs are used. The PB designs are most efficient when only the main effects are of interest. In Plackett and Burman designs the number of trials is in the multiples of four rather than the powers of two. When we are investigating more than five independent variables, the Plackett-Burman design may be used to find the most important variables in a system, which is then optimized in further studies [8]. Placket and Burman gave a number of designs for up to one hundred experiments using an experimental rationale known as balanced incomplete blocks. These designs facilitate for the analysis of $(n-1)$ variables by n experiments. The only condition that needs to be satisfied is that n should be a multiple of 4. According to the requirement, one chooses the number of variables needed in the investigation and then accordingly selects the Plackett-Burman design which meets that requirement most closely in multiples of 4. Any extra factors which are constant can be designated as a dummy variable.

Chapter 4

How The Game Works

The seeker approaches a worker to get his work done. If the work is done the benefit of the seeker is b, if the seeker belongs to the giver class he bribes the worker to get his work done which is represented by c. The giver seekers are also of two kind viz. givers S_g and intelligent givers S_i, the givers bribe every worker. The intelligent seekers can discriminate between cooperators, defectors, punishers in workers. The cost of discrimination for intelligent seekers is d_1. The non giver section of seekers consist of punishers S_{npun} who punish the workers who ask for bribe them, cost of punishment is x and the indifferent seekers S_{ni} who do not bribe but do not punish when workers ask for them.

The workers who take bribe are cooperators W_{tc}, who will cooperate whenever provided with bribe c, the defectorsW_{td} will always defect *i.e.* keep the bribe and do not do the work and there are discriminating takers W_{tdis} who can discriminate between punishing seekers and non punishing seekers so they always perform the work for punishing seekers without the bribe. The cost of discrimination for such workers is d_2. The other category of workers is non-takers which are further categorized in indifferent workers W_{ni} who work for all kind of seekers without any bribe and the punishing workers who punish the seekers who try to bribe them; the cost of punishment is m. Figure 4.1 depicts interactions between different sections of population.

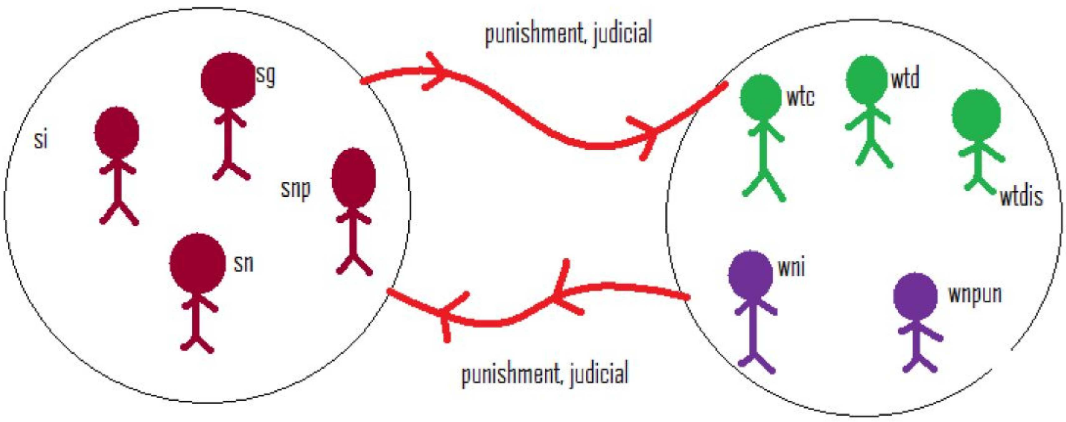


Figure 4.1: Interaction between Different sections of population.

Based on the above explanation the payoffs of the different players are as follows:

For Seekers:

i. $E_{si} = f_{wn}b + f_{wtc}(b - c) - d_1 + f_{wtdisc}(b - c)$

ii. $E_{snp} = f_{wn}b + f_{wtc}(-x) + f_{wtd}(-x) + f_{wtdisc}b$

iii. $E_{sn} = f_{wn}b$

iv. $E_{sg} = f_{wni}b + f_{wnpun}(b - y) + f_{wtc}(b - c) + f_{wtd}(-c) + f_{wtdisc}(-c)$

For Workers

i. $E_{wni} = i - j$

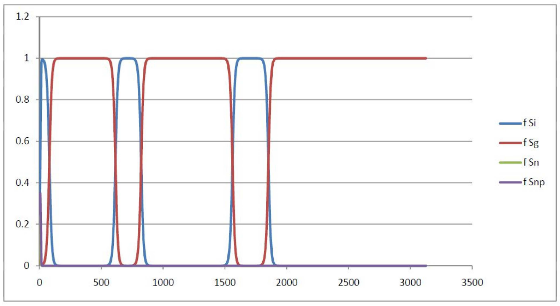
ii. $E_{wnpun} = i + f_{sg}(-j - m) + (f_{si} + f_{sn} + f_{snp})(-j)$

iii. $E_{wtc} = 1 + (f_{sg} + f_{si})(c - j) + f_{snp}(-n)$

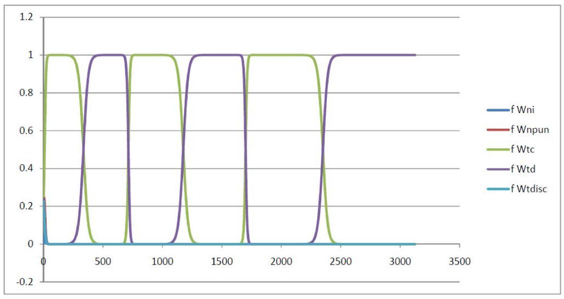
iv. $E_{wtd} = 1 + f_{sg}(c) + f_{snp}(-n)$

v. $E_{wtdisc} = 1 + f_{si}(c - j) + f_{sg}c + f_{snp}(-j) - d_2$

The above payoffs and respective frequencies were simulated using Replicator dynamics and Plackett-Burman designs.



(a) Frequencies of strategies of seekers



(b) Frequencies of strategies of workers

Figure 4.2: Frequencies of strategies of workers plotted (on vertical axis) against number of generations (on horizontal axis). Figure 4.2a shows that only intelligent seekers and perennial givers are surviving and oscillating. Figure 4.2b shows that only takers (venal workers) are surviving and amongst those too only defectors and cooperators are surviving and oscillating. The parameters are b=1, c=0.2, x=.01, y=1, $d_1 = 0.1$, m=0.1, n=0.4, j=0.06, $d_2 = 0.19$

We have assumed that initially the population in both the sections *i.e.* seekers and workers has been equally divided amongst all the present strategies of their respective groups, so as we can see from figure 4.2, the intelligent seekers S_i evolve first because they have definite edge when defectors and co-operators are both equally present in the worker population but as the S_i peak the population of worker co-operators, W_{tc} also increases and eventually peaks. This renders the discriminating edge of the S_i useless and hence the givers, S_g evolve. When the S_g have peaked the defectors in the worker population start coming up as the S_g are known to give bribe without discriminating and hence defectors have an upper hand over the co-operators. Now the S_g perishes because of the loss incurred by them due to excess defectors in the system, which again paves way for the intelligent seekers to evolve. Once the defectors are sufficiently large in the population S_i get their edge over S_g back and hence the cycle goes on, thus explains the oscillations.

There were eight runs with seven parameters (placket and Burman design) and in all the results corruption was seen to be robust.

4.1 With Social Policing and Blackmailing

In society we see that people tend to keep an eye on others' activities for many reasons, be it gossiping, curiosity or envy [9] social policing is not a new concept people have worked on this and there are results which show that in societies people tend to watch over others. This comes with a cost; there is effort which goes into social policing so why does social policing exist at all? The reason is that these people who indulge in social policing can indulge in opportunistic blackmailing [9]. This in turn increases their payoffs.

Social policing is nothing but keeping an eye on the fellow members, whether or not they are indulging in any unconstitutional act and if yes then the social policing population blackmails the wrong doer to increase his/her own payoff. Now the question is why a wrongdoer must give in to blackmailing? Blackmailing derives its stability from punishment. In our case the blackmailer threatens to reveal the corrupt to the judicial authority which in turn mete out punishment. Now the amount that the corrupt has to give to the blackmailer is less than the amount of punishment he/she is going to receive from the authorities and hence to save some damage to his/her payoff the wrong doer would comply.

We considered that half of each of the two populations, seeker and worker, involve in policing i.e. they keep a check on the behavior of the rest of the population (which costs policing population some amount) and they blackmail the venal population to reap benefits of policing. Half of all the categories of seeker class $(S_{pg}, S_{pi}, S_{pni}, S_{pnpun})$ indulge in policing which costs them p, the benefit that the policing class enjoys through blackmailing is g, multiplied with frequency of the bribing section of seekers indulging in bribing. So the benefit to a policing individual would be:

$$[f^*_{si}(f^*_{wtc} + f^*_{wtdisc}) + f^*_{sg}(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})]g \tag{4.1}$$

Similarly the loss to bribing seekers because of policing population is a multiplied by the frequency of policing population and by the frequency of the worker class whom they bribe. For example the loss to the S_i individuals due to blackmailing is:

$$(f^*_{wtc} + f^*_{wtdisc})(f_{ps}(-a)) \tag{4.2}$$

Similar to the seeker class half of all the categories of worker class ($W_{pni}, W_{pnpun}, W_{ptc}$, W_{ptd}, W_{ptdis}) indulge in policing which costs them q, the benefit that the policing class enjoys through blackmailing is r multiplied to the frequency of the takers section of workers indulging in bribe taking. The benefit of policing to an individual would be;

$$[f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r \tag{4.3}$$

The loss to corrupt workers because of policing population is v multiplied to the frequency of policing population and the frequency of individuals who bribe these workers. For example the loss due to blackmailing to W_{tc} would be:

$$[f^*_{sg} + f^*_{si}][f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v) \tag{4.4}$$

The assumption is that all the individuals who are involved in policing will definitely indulge in opportunistic blackmailing, this assumption can be explained as the group that performs just policing will have to pay a cost associated with it but they will not receive any benefit from this service hence they will not evolve at all in the system. Payoff of the worker and seekers, after inclusion of blackmailing and policing would be given as follows:

For Seekers

i. $E_{si} = f^*_{wn}b + f^*_{wtc}(b-c) - d_1 + f^*_{wtdisc}(b-c) + (f^*_{wtc} + f^*_{wtdisc})(f_{ps})(-a)$

ii. $E_{psi} = f^*_{wn}b + f^*_{wtc}(b-c) - d_1 + f^*_{wtdisc}(b-c) + (f^*_{wtc} + f^*_{wtdisc})(f_{ps})(-a) - p + [f^*_{si}(f^*_{wtc} + f^*_{wtdisc}) + f^*_{sg}(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})]g$

iii. $E_{sg} = f^*_{wni}b + f^*_{wnpun}(b-y) + f^*_{wtc})(b-c) + f^*_{wtd}(-c) + f^*_{wtdisc}(-c) + (f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})(f_{ps})(-a)$

iv. $E_{psg} = f^*_{wni}b + f^*_{wnpun}(b-y) + f^*_{wtc})(b-c) + f^*_{wtd}(-c) + f^*_{wtdisc}(-c) + (f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})(f_{ps})(-a) - p + [f^*_{si}(f^*_{wtc} + f^*_{wtdisc}) + f^*_{sg}(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})]g$

v. $E_{sn} = f^*_{wn}b$

vi. $E_{psn} = f^*_{wn}b - p + [f^*_{si}(f^*_{wtc} + f^*_{wtdisc}) + f^*_{sg}(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})]g$

vii. $E_{snp} = (f^*_{wn} + f^*_{wtdisc})b + (f^*_{wtc} + f^*_{wtd})(-x)$

viii. $E_{psnp} = (f^*_{wn} + f^*_{wtdisc})b + (f^*_{wtc} + f^*_{wtd})(-x) - p + [f^*_{si}(f^*_{wtc} + f^*_{wtdisc}) + f^*_{sg}(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})]g$

For Workers

i. $E_{wni} = i - j$

ii. $E_{pwni} = 1 - j - q + [f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r$

iii. $E_{wnpun} = 1 + f^*_{sg}(-j-m) + (f^*_{si} + f^*_{sn} + f^*_{snp})(-j)$

iv. $E_{pwnpun} = 1 + f^*_{sg}(-j-m) + (f^*_{si} + f^*_{sn} + f^*_{snp})(-j) - q + [f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r$

v. $E_{wtc} = 1 + (f^*_{sg} + f^*_{si})(c-j) + f^*_{snp}(-n) + [f^*_{sg} + f^*_{si}][f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v)$

vi. $E_{pwtc} = 1 + (f^*_{sg} + f^*_{si})(c-j) + f^*_{snp}(-n) + [f^*_{sg} + f^*_{si}][f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v) - q + [f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r$

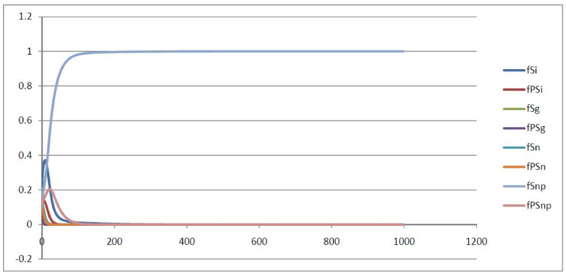
vii. $E_{wtd} = 1 + f^*_{sg}c + f^*_{snp}(-n) + f^*_{sg}[f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v)$

viii. $E_{pwtd} = 1 + f^*_{sg}c + f^*_{snp}(-n) + f^*_{sg}[f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v) - q + [f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r$

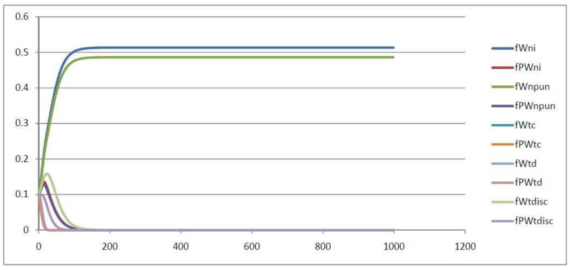
ix. $E_{wtdisc} = 1 + f^*_{si}(c - j) + f^*_{sg}c + f^*_{snp}(-j) - d_2 + (f^*_{si} + f^*_{sg})[f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v)$

x. $E_{pwtdisc} = 1 + f^*_{si}(c - j) + f^*_{sg}c + f^*_{snp}(-j) - d_2 + (f^*_{si} + f^*_{sg})[f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v) - q + [f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r$

The above Payoffs and respective frequencies were analyzed using replicator dynamics and Plackett and Burman designs for 15 parameters. A total of sixteen trials were made and a few results are analysed below (and shown in figure 4.3):



(a) Frequencies of strategies of seekers

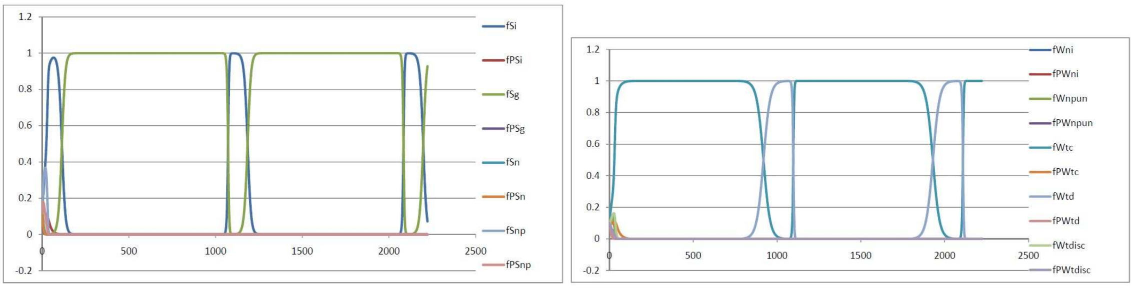


(b) Frequencies of strategies of workers

Figure 4.3: Frequencies of strategies of workers plotted (on vertical axis) against number of generations (on horizontal axis). Figures 4.3a shows evolution of one strategy among seekers (seekers who are non takers and punishers) whereas 4.3b show an evolution of two strategies worker population 1. non-takers, indifferent; 2. non-takers, punishers. The parametric values employed were parameters: b=1, c=0.3, x=0.05, y=1, $d_1 = 0.01$, m=0.1, n=0.5, j=0.05, $d_2 = 0.11$, p=0.05, g=0.1, a=0.6, q=0.05, r=0.1, v=0.6.

We assume for simplicity that the policing is restricted to the same section of the population i.e. policing seekers keep an eye on all the seekers and not workers and similarly policing workers just keep an eye on the workers and not the seekers. Earlier, figure 4.2, corruption came out to be strong and robust, but after inclusion of policing individuals in the same section of the population the corruption has been destabilized, figure 4.3.

Of sixteen trials (by Plackett and Burman design) apart from two of them the results are same as figure 4.3. The two outliers are fragile and with a little variation in the parameters they become similar to figure 4.3.



(a) Frequencies of strategies of seekers

(b) Frequencies of strategies of workers

Figure 4.4: Frequencies of strategies of workers plotted (on vertical axis) against number of generations (on horizontal axis). Figures 4.4a and 4.4b show resurfacing of oscillations of corrupt strategies as the parametric values are below threshold. The parametric values employed were parameters: b=1, c=0.4, x=0.001, y=0.4, $d_1 = 0.1$, m=0.01, n=0.4, j=0.05, $d_2 = 0.19$, p=0.1, g=0.04, a=0.01, q=0.1, r=0.01, v=0.1.

After inclusion of policing and blackmailing candidates, even though they themselves have not evolved, the evolution and stability of clean strategies in both, seekers and workers, is facilitated by them.. The results are parameter specific and the ranges of different parameters used have been elaborated in table 2. When we reduce the benefit due to blackmailing to policing individuals below a threshold and/or increase the cost of policing above a threshold, corruption resurfaces and we get oscillations amongst corrupt individuals similar to figure 4.2 as shown in figure 4.4.

4.2 The Anti-Corruption Cell (ACC)

When a crime becomes too rampant there is a need to put an authority in charge to curb or eliminate the same. For corruption it need not be stated how rampant it has become and to keep it in check some countries have specialized cells which keeps vigilance over money dealings and possible corruption for example Central Vigilance Commission in India, Korea Independent Commission Against Corruption. To analyze the role of anti corruption authorities we introduced a third section of population in our model which was Anti Corruption Cell (ACC). The ACC is responsible for looking over the collective population; its job is to take the corrupt people to task. These individuals are authorized to punish the people who are caught giving or taking bribe, the punishment meted out by them is given by i. Assuming that the ACC is incorruptible would be a loss of generality as that is not the case in real life. So we assume that the section of ACC which is corrupt *i.e.* unethical group A_n takes bribe from apprehended corrupt individuals to not punish them; total income by the bribe is dependent on the frequency by which of corrupt people are apprehended in the collective population, and is given by:

$$[\beta(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc}) + \alpha(f^*_{sg} + f^*_{si})](l - t) \tag{4.5}$$

α and β are the probability by which the corrupt workers and corrupt seekers are caught by the ACC. Amount of bribe given by corrupt individual to the unethical ACC is l. The amount of effort which goes in not punishing corrupt individuals is t. ACC is also authorized to take the corrupt ACC officials to task and loss to A_n due to ACC vigilance is given by:

$$[f^*_{Ae}(\beta(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc}) + \alpha(f^*_{sg} + f^*_{si})](-i) \tag{4.6}$$

The ethical ACC has two kinds of individuals the indifferent A_{ei} ones are those who just mete out the punishment stipulated by law *i.e.i*, the punishing ethical A_{ep} type go ahead and give extra punishment to those who on being apprehended on the charges of corruption try to bribe ACC. The loss due to this extra punishment is s, and the amount of punishment is k.

Based on above discussions the payoffs of the different strategies in ACC can be given as follows:

i. $E_{Aei} = \gamma$

ii. $E_{Aep} = \gamma + [\beta(f^*_{wtc} + f^*_{wtd}) + (^*_{sg})](-s)$

iii. $E_{An} = \gamma + f^*_{Ae}[\beta(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc}) + \alpha(f^*_{sg} + f^*_{si})](-i) + [\beta(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc}) + \alpha(f^*_{sg} + f^*_{si})]z$

Where γ is the basic salary of the ACC officials, and it has been kept constant. After addition of the ACC the payoffs of the whole system would be given as:

For Seekers

i. $E_{si} = f^*_{wn}b + f^*_{wtc}(b - c) - d_1 + f^*_{wtdisc}(b - c) + (f^*_{wtc} + f^*_{wtdisc})[(f_{ps})(-a) + \alpha(f^*_{Ae}(-i) + f^*_{An}(-l))]$

ii. $E_{psi} = f^*_{wn}b + f^*_{wtc}(b - c) - d_1 + f^*_{wtdisc}(b - c) + (f^*_{wtc} + f^*_{wtdisc})[(f_{ps})(-a) + \alpha(f^*_{Ae}(-i) + f^*_{An}(-l))] - p + [f^*_{si}(f^*_{wtc} + f^*_{wtdisc}) + f^*_{sg}(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})]g$

iii. $E_{sg} = f^*_{wni}b + f^*_{wnpun}(b - y) + f^*_{wtc})(b - c) + f^*_{wtd}(-c) + f^*_{wtdisc}(-c) + (f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})[(f_{ps})(-a) + \alpha(f_{Aei}(-i) + f_{Aep}(-i - k) + f_{An}(-l))]$

iv. $E_{psg} = f^*_{wni}b + f^*_{wnpun}(b - y) + f^*_{wtc})(b - c) + f^*_{wtd}(-c) + f^*_{wtdisc}(-c) + (f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})[(f_{ps})(-a) + \alpha(f_{Aei}(-i) + f_{Aep}(-i - k) + f_{An}(-l))] - p + [f^*_{si}(f^*_{wtc} + f^*_{wtdisc}) + f^*_{sg}(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})]g$

v. $E_{sn} = f^*_{wn}b$

vi. $E_{psn} = f^*_{wn}b - p + [f^*_{si}(f^*_{wtc} + f^*_{wtdisc}) + f^*_{sg}(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})]g$

vii. $E_{snp} = (f^*_{wn} + f^*_{wtdisc})b + (f^*_{wtc} + f^*_{wtd})(-x)$

viii. $E_{psnp} = (f^*_{wn} + f^*_{wtdisc})b + (f^*_{wtc} + f^*_{wtd})(-x) - p + [f^*_{si}(f^*_{wtc} + f^*_{wtdisc}) + f^*_{sg}(f^*_{wtc} + f^*_{wtd} + f^*_{wtdisc})]g$

For Workers

i. $E_{wni} = i - j$

ii. $E_{pwni} = 1 - j - q + [f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r$

iii. $E_{wnpun} = 1 + f^*_{sg}(-j - m) + (f^*_{si} + f^*_{sn} + f^*_{snp})(-j)$

iv. $E_{pwnpun} = 1 + f^*_{sg}(-j - m) + (f^*_{si} + f^*_{sn} + f^*_{snp})(-j) - q + [f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r$

v. $E_{wtc} = 1 + (f^*_{sg} + f^*_{si})(c - j) + f^*_{snp}(-n) + [f^*_{sg} + f^*_{si}][[f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v) + \beta(f_{Aei}(-i) + f_{Aep}(-i - k) + f_{An}(-l))]$

vi. $E_{pwtc} = 1 + (f^*_{sg} + f^*_{si})(c - j) + f^*_{snp}(-n) + [f^*_{sg} + f^*_{si}][[f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v) + \beta(f_{Aei}(-i) + f_{Aep}(-i - k) + f_{An}(-l))] - q + [f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r$

vii. $E_{wtd} = 1 + f^*_{sg}c + f^*_{snp}(-n) + f^*_{sg}[[f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v) + \beta(f_{Aei}(-i) + f_{Aep}(-i - k)) + f_{An}(-l)]$

viii. $E_{pwtd} = 1 + f^*_{sg}c + f^*_{snp}(-n) + f^*_{sg}[[f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v) + \beta(f_{Aei}(-i) + f_{Aep}(-i - k)) + f_{An}(-l)]] - q + [f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r$

ix. $E_{wtdisc} = 1 + f^*_{si}(c - j) + f^*_{sg}c + f^*_{snp}(-j) - d_2 + (f^*_{si} + f^*_{sg})[[f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v) + \beta(f_{Aei}(-i) + f_{Aep}(-i)) + f_{An}(-l)]]$

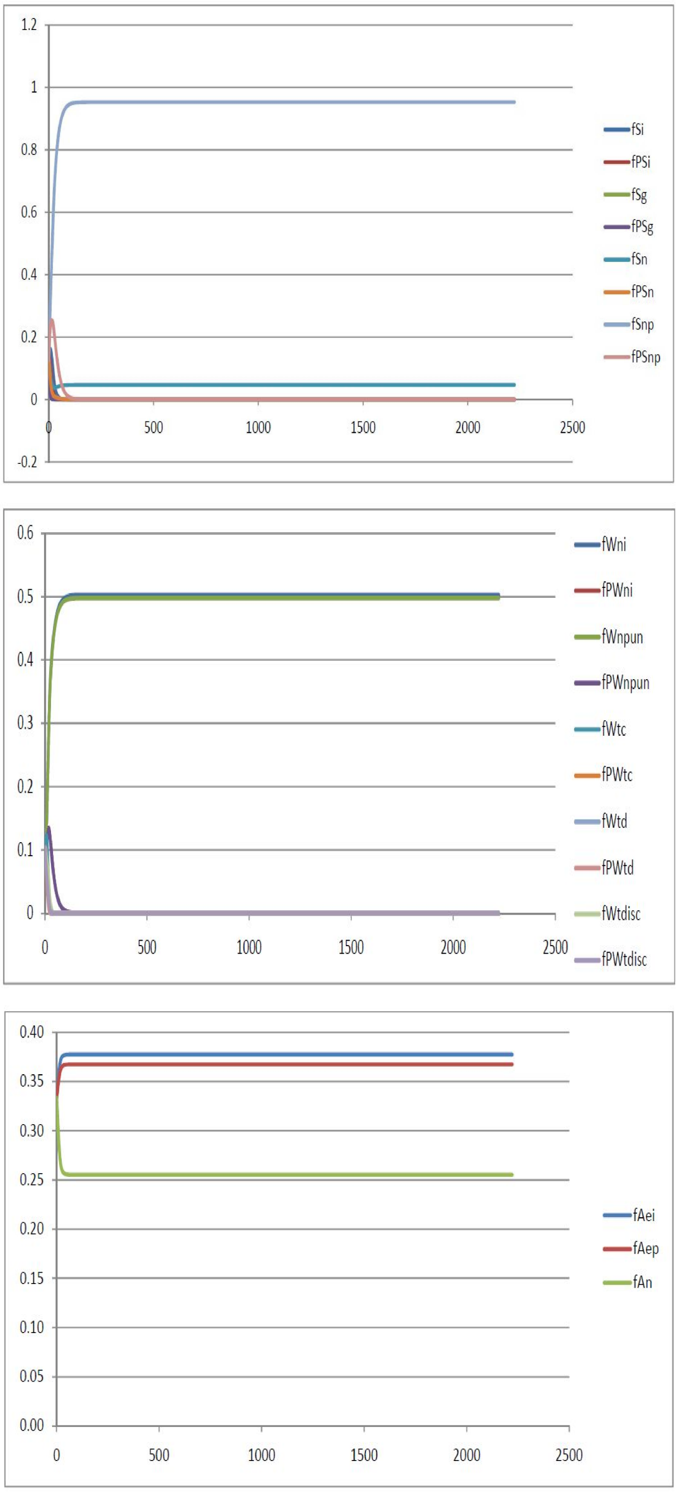
x. $E_{pwtdisc} = 1 + f^*_{si}(c - j) + f^*_{sg}c + f^*_{snp}(-j) - d_2 + (f^*_{si} + f^*_{sg})[[f_{pwni} + f_{pwnpun} + f_{pwtc} + f_{pwtd} + f_{pwtdisc}](-v) + \beta(f_{Aei}(-i) + f_{Aep}(-i)) + f_{An}(-l)] - q + [f^*_{wtc}(f^*_{sg} + f^*_{si}) + f^*_{wtd}(f^*_{sg}) + f^*_{wtdisc}(f^*_{si})]r$

The above payoffs were then analyzed using Plackett and Burman designs and replicator dynamics. Now the number of parameters has risen to nineteen, so we had a total of twenty trials and the results, under the specified ranges of parameters, were similar to those in figure 4.3. For example we have figure 4.5

When all the three sections of population are interacting, figure 4.5, for a few generations some corrupt strategies in worker and seeker classes have survived which had resulted in the shown distribution of ACC officials. Since the punishment meted out by ACC when caught in corruption, i, is greater than the bribe received by the Non ethical ACC officials they have a disadvantage overall which brings them down till the time there are corrupt people in the population and once the corrupt population has diminished the payoffs for all the ACC officials becomes the same i.e. γ, and hence the frequencies of the ACC populations remains constant thereafter. The reason for the frequency of the A_{ep} to be slightly lower than the A_{ei} is because the former punishes the corrupt, who after being apprehended try to bribe A_{ep}, from their own pocket which slightly lowers their payoff.

Further investigations were made to analyze whether ACC could eliminate corruption when social policing and blackmailing has given in to the parametric thresholds, figure 4.4. So to delve deeper into results we ran Plakett-Burman for just seven parameters (changed from the initial respective ranges) *i.e.* cost of policing for workers and seekers, punishment due to blackmailing for workers and seekers, benefit of blackmailing for workers and seekers and bribe money given to unethical ACC. Now we already had twenty trials when all strategies were present and for each trial we ran eight more trials per former twenty trials with above mentioned changed parameters *i.e.* now we had hundred and sixty trials.

We increased the cost of policing and decreased the benefit and punishment due to blackmailing to find the threshold below which intra section policing would give in to the corruption. And then we enabled ACC to check if it was able to cull out corruption. The results have shown that ACC is able to eliminate corruption, for stipulated parametric values, even when intra-section policing is unable to. An example is the same is shown in figure 4.6 and 4.7:

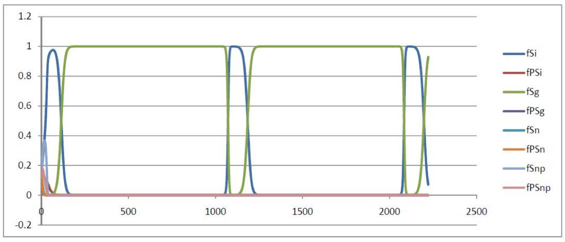


(a) Seekers

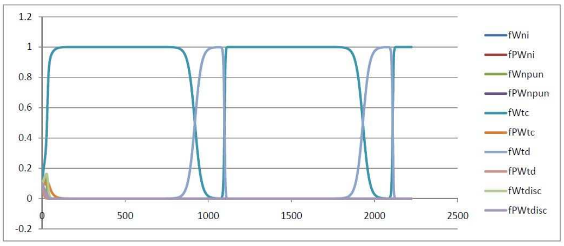
(b) Workers

(c) Punishers

Figure 4.5: Evolution of seekers, workers and punishers. In seekers non-giver punishers have evolved, in workers non-takers indifferent and punishers have evolved and in ACC all strategies are stable with Aei having the highest frequency. Parameters are b=1, c=0.4, x=0.01, y=1, $d_1 = 0.01$, m=0.1, n=0.4, j=0.05, $d_2 = 0.12$, p=0.01, g=0.5, a=0.6, q=0.05, r=0.1, v=0.2, $\gamma = 1$, $\alpha = .4$, $\beta = 0.4$, s=0.01, i=0.4, l=0.4, t=0.05, k=0.1



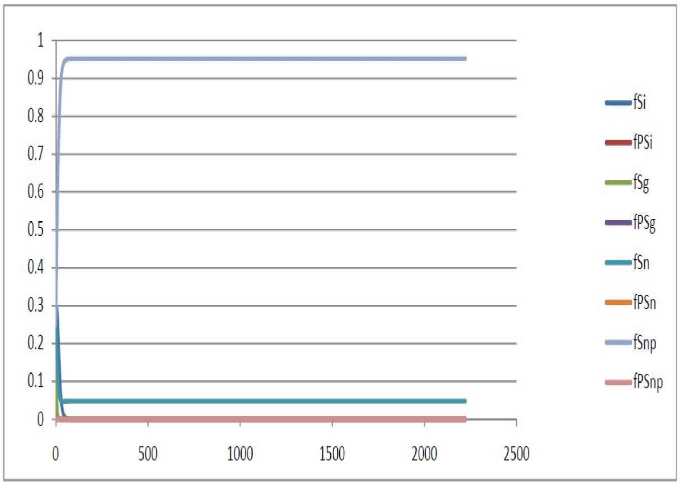
(a) Frequencies of strategies of seekers



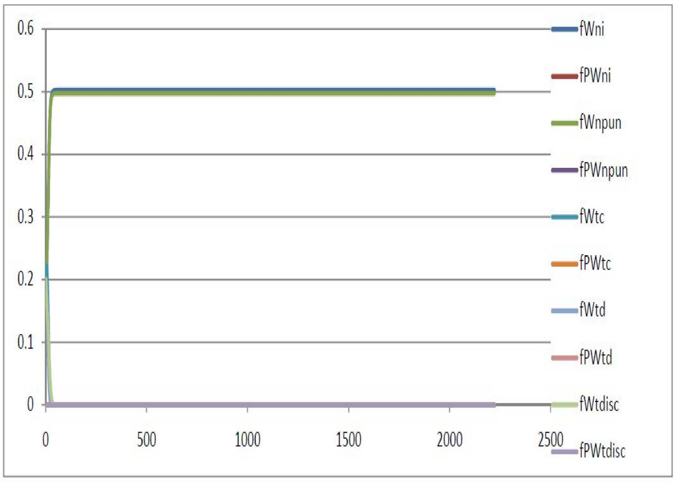
(b) Frequencies of strategies of workers

Figure 4.6: Frequencies of workers (figure 4.6b) and seekers (4.6a) before inclusion of ACC, when plotted against generations. Frequencies of strategies of workers plotted (on vertical axis) against number of generations (on horizontal axis). The parameters were b=1, c=0.4, x=0.01, y=1, d1=0.01, m=0.1, n=0.4, j=0.05, d2=0.12, p=0.07, g=0.01, a=0.01, q=0.07, r=0.01, v=0.02, $\gamma = 1$, $\alpha = .4$, $\beta = 0.4$, s=0.01, i=0.4, l=0.4, t=0.05, k=0.1.

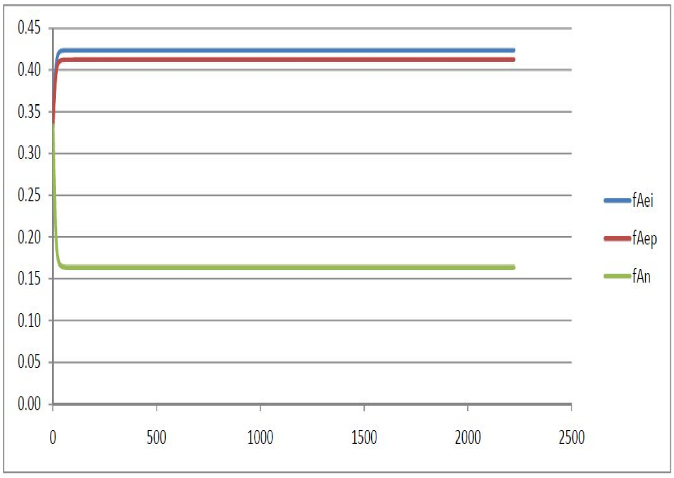
In the total of hundred and sixty trials the variations in results were minimal and hence it is safe to generalize that ACC is able to eliminate stability of corrupt strategies under the stipulated range of parameters.



(a) Seekers



(b) Workers



(c) ACC

Figure 4.7: Evolution of seekers, workers and ACC. Frequencies of seekers, workers and ACC after inclusion of ACC, plotted against generations. The parameters were b=1, c=0.4, x=0.01, y=1, d1=0.01, m=0.1, n=0.4, j=0.05, d2=0.12, p=0.07, g=0.01, a=0.01, q=0.07, r=0.01, v=0.02, $\gamma = 1$, $\alpha = .4$, $\beta = 0.4$, s=0.01, i=0.4, l=0.4, t=0.05, k=0.1.

Chapter 5

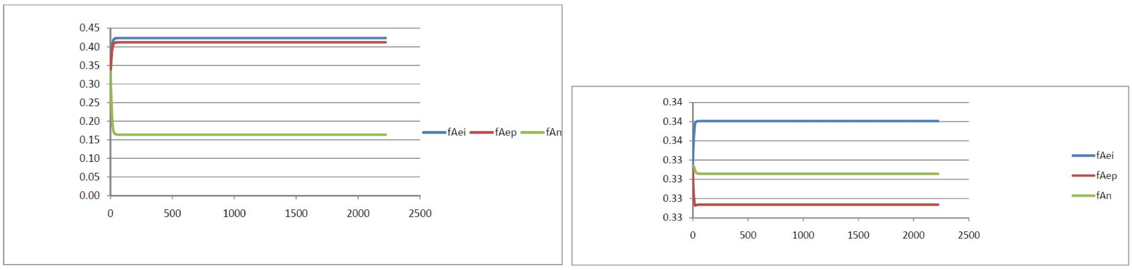
Discussions

Corruption is a multi-form system and incorporating all its form in a single model is close to impossible. We have focused on a specific sector i.e. the Public sector. In the proposed model, we have tried to emulate the real life dynamics of corruption in the public sector offices, though the dynamics had been simplified a lot but the foundation remains the same. The model has a few limitations in the sense that it is parameter specific, although a lot of thought has been put into deciding the parameter ranges so as to bring the model close to reality. The model has been successful in rendering some important insights into the dynamics of corruption. Initially when we started modeling, we just had two kinds of players, workers and seekers, with a few strategies which were proxies to the basic motivation behind bribing and receiving psyche of the society. And as we structured it, corruption came out to be strong and robust figure 4.2 which is true in real life scenario. One type of defection is oscillating in Worker population i.e. W_{td} is in oscillation with W_{tc}. In classical prisoners dilemma defection is stable and leads to punishment of the other player which destabilizes co-operation in prisoner's dilemma while this is not true in corruption although corruption is also about crime and co-operation.

Then we considered what would deter people from indulging in corruption, what came to mind was diminution of reputation. To bring the dimension of reputation we considered social policing which is not fictional as there are people in society who keep an eye on the others, which might be the result of curiosity, envy or urge to gossip. There have been instances where altruistic policing has been studied but in our model the sheer number of parameters was already high so we did not investigate the effect of altruistic policing as this strategy wouldn't have evolved because policing would have cost some amount of effort. An alternative argument in favor of social policing in our model is that people want to keep an eye on others because if an individual gets a work done by bribing the official that reduces the chance of others' work to be done, for example A and B both have filed a tender notice but B has bribed the official to pass his quotation for the tender then it is a loss to A when there is a good enough chance that quotation by A was lower than that of B. so had A done policing he could have saved the damage to his payoff. This motivation to compete and maximize one's own payoff drives the presence of social policing. Proxy for benefit of policing has been done through blackmailing; once an individual indulges in bribing, the policing individual can blackmail him with dire consequences and as a let-go token the blackmailed individual shares some amount of benefit with the blackmailer thus saving the corrupt from dire consequences and also increases the payoff of the blackmailer, this way both the individuals maximize their payoffs. The concept of social policing has worked well in our model, under parametric constraints table 2; the oscillations of the corrupt strategies were converted to stability of single strategy with the inclusion of policing and blackmailing. Even though the policing strategy has not evolved but the presence of policing strategies has resulted in elimination of corruption and stability of non-takers and non-givers figure 4.3.

The penetration of corruption in the modern day society has led to formation of special task authorities which are responsible for a specific deed that is to keep an eye on graft, corruption and other forms of bribery. Almost every country has a constituted authority to crackdown on corruption, to translate this into our model we came up with Anti Corruption Cell (ACC) which is responsible for fencing corruption in the whole population including the ACC officials. The ACC has the authority to apprehend the corrupt and punish them. ACC in itself is not incorruptible, had it been so corruption would not have become omnipresent and corrupt individuals would not be corrupt with brazen impunity. The strategies in ACC are defined so as to bring every possible strategy into its ambit. And hence three broad strategies were defined for ACC, figure 4.5. Again under the parametric constraints, frequency of ethical indifferent ACC individuals was highest, though the other two were also there but with lesser frequencies. The next step was to check the thresholds of the social policing strategy and whether ACC would be useful when social policing does not work. To find out the threshold for the social policing we changed the values of cost of policing for workers and seekers, benefit due to blackmailing and punishment due to policing linearly and observed at what combination the oscillations of the corrupt strategies resurfaces. After observing a sharp threshold we enabled ACC to check if elimination of corruption is possible under the given parameters and found out that it is. The other threshold which we wanted to investigate was that of ACC. Since the punishment i is greater than the bribe received by A_n, i.e. l, the pay off of the A_n remains lower than the other two till the time there are corrupt people in the population, once the corrupt individuals are eradicated the frequencies of the three strategies in ACC become constant. Now to find the threshold below which A_n would be the highest frequency bearer was evaluated by reducing the i and increasing l. On increasing the l we saw that as the value of l nears the value of i, frequency of A_n goes up.

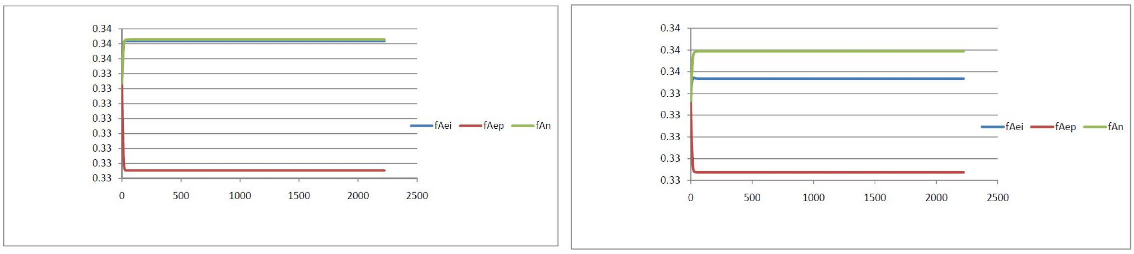
As shown in figure 5.1 and 5.2 there has been a shift in the frequencies of the ACC strategies and even when A_n has the highest frequency *i.e.* corrupt individuals are high in ACC, it has been able to eliminate corruption from other sections *viz.* seekers and workers. So even though there is corruption in the ACC itself which causes some loss to the government, it saves a lot otherwise by curbing corruption in the seekers and workers section.



(a) First threshold for ACC

(b) First threshold for ACC

Figure 5.1: Threshold values for the ACC. Figure 5.1a and 5.1b show the shift of frequencies in the ACC, when a change is introduced in the amount of bribe received by the A_n. Figure 5.1ahas l=0.2 where A_n has the lowest frequency, Figure 5.1b has l= 0.314, here A_n is above A_{ep} but below A_{ei}. However i has been kept constant at 0.4.



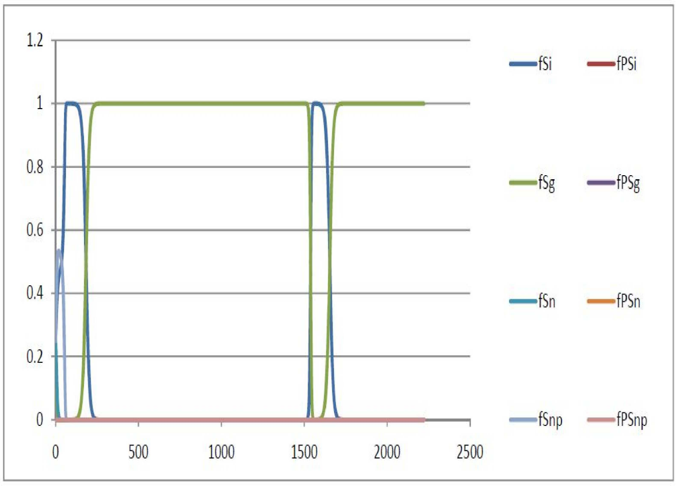
(a) First threshold for ACC

(b) First threshold for ACC

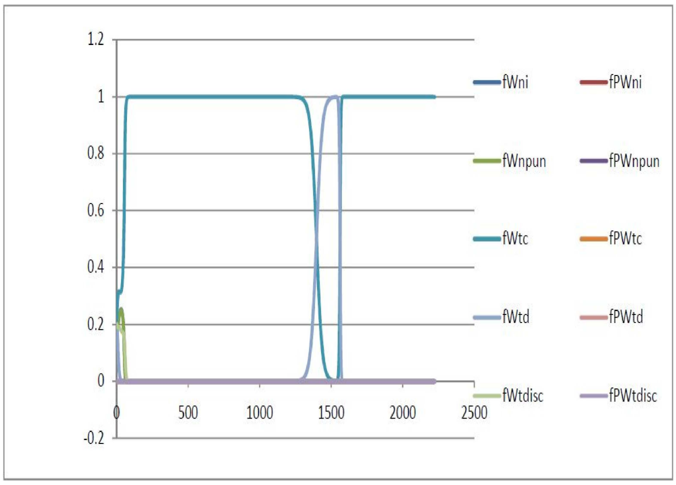
Figure 5.2: The transition of ACC frequencies when the value of l is changed. In the first graph the value of l is 0.3161 here the frequencies of A_{ei} and A_n are equal and greater than that of A_{ep}. In the second graph the value of l is 0.317 where frequency of A_n is the highest. The value of I has been kept constant at 0.4.

To check the limitations of ACC we had to turn off social policing and analyze the threshold, below which corruption in Seekers and Workers would resurface. The parameters studied were: punishment given by ACC, i, bribe taken by A_n, i and the extra punishment meted out by A_{ep} k. The constraint on l was that it should be lower than i. Since i and l were both punishments for the corrupt population amongst workers and seekers hence to encourage corruption both needed to be reduced simultaneously. The results were in accord with the argument that on reduced punishment corruption should resurface. The results are discussed below, figure 5.3:

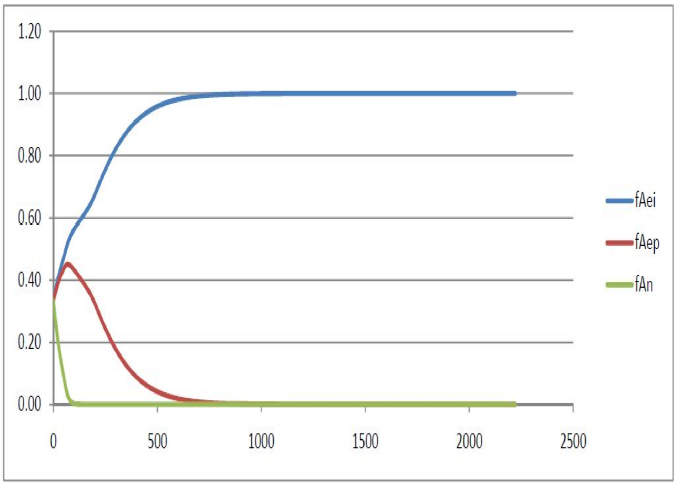
ACC was effective even when frequency of A_n was higher than A_{ep}, A_{ei} but ACC gives in to corruption when punishment meted out by them to the corrupt is very



(a) Seekers



(b) Workers



(c) ACC

Figure 5.3: Shows the frequencies of seeker, worker and ACC strategies against generations when social policing is turned off and following parameters were employed: i=0.05, l=0.01, k=0.01.

low. In this situation if social policing is turned on (for the given parameters) then corruption can be eradicated.

Now we wanted to know the threshold of both ACC and social policing when both are active simultaneously. So the parameters which were of major concern are: $p, g, a, q, r, v, i, landk$. we observed that for both ACC and social policing the threshold has further decreased *i.e.* both working together are able to contain corruption for larger range of parameters. We may say that ACC and social policing will complement each other given that thresholds for both the systems, acting simultaneously, are not reached otherwise the oscillations for corrupt strategies would resurface.

As we have elaborated on all the possible thresholds it is worth noticing that below every threshold it is evident that in workers and seekers sections coexistence of corrupt and clean strategies is impossible. There is a clear demarcation through parametric thresholds between survival of corrupt and clean populations. Once the parameters encourage the corrupt strategies, there is a lot of pressure on the non corrupt individuals to adopt corrupt strategies in the coming generations to maximize their payoffs and hence explains the extinction of clean strategies, which is also true in reality. It is also interesting to note that this exclusivity is not necessary in Anti Corruption Cell as the only difference in their pay offs is caused by presence of corrupt strategies, once they have been eliminated the frequencies of the ACC strategies becomes constant and hence the co-existence. The An extort money from the corrupt individuals to hide their identity, this extortion is represented by l and the punishment given by ACC to the caught corrupt individuals is given by i. In principle the A_n can extort money till l almost equals i. As a result even corrupt ACC should be almost as effective in curbing corruption in other sectors. However, this assumes that both bribe gives and takers are rational. Experimental game theory research has shown that human behavior may work with different motivations. In the ultimatum game for example the offers and acceptance levels are governed not by rationality but by fairness or other social factors [10]. Also the long term benefit of A_n will be in keeping an optimum l considerably smaller than i. This may ensure survival of corruption that can keep on giving long term returns to A_n. If the value of l is close to that of i then the benefit to the A_n would be high but short lived. If the value of i is very low then value of l would be lower and because of the low punishments ACC becomes toothless and hence facilitates corruption to evolve, in such a scenario those A_n who keep l considerably low would evolve. As mentioned earlier that i is the limit on l, we must elaborate here that when i is sufficiently large it doesn't even matter what is the value of l to eradicate corruption from worker and seeker sections. So one need not worry about corruption in ACC to curb corruption elsewhere, just value of i should be above the threshold value. Although ACC have been able to curb corruption, but this wouldn't be presumptuous to suggest that social policing is a much better option than ACC as far as corruption is concerned because constituting an ACC in itself is a gigantic responsibility and then smooth working of ACC requires a lot of effort from the government and also from the members of ACC. The remuneration given to ACC members is again unnecessary if social policing is in place. Social policing, though has its own limitations, is a low maintenance option. From all the discussions and results one may conclude that the problem of corruption is complex but the solution is simple; increase punishment!

5.1 What can be done?

Studying Corruption is a humongous task and an onerous responsibility. A lot of factors, sometimes apparent and sometimes hidden, play a very vital role in its structure and being ever evolving make it even more difficult to be studied in its entirety. Although generalizing corruption is not completely unfounded but a lot of vital facts are missed upon generalizing. To start with we may comment that every country has a different hierarchy and the chemistry between different strata is altogether a different study which is a crucial link in deciphering the corruption dynamics in a society. Corruption Rackets have a different working altogether and can be studied in detail.

References

[1] O. P. Dwivedi, Bereaucratic corruption in developing countries, Asian Survey 7 (1967) 245–253.

[2] H. L. Alatas, The sociology of corruption, Donald Moore Press lLtd. l, 1968.

[3] R. D. Luce, H. Raiffa, Games and decisions, John Wiley and Sons.

[4] J. Haufbauer, K. Sigmund, Evolutionary games and population dynamics, Cambridge University Press.

[5] J. M. Smith, Evolution and Theory of Games, Cambridge University Press.

[6] M. A. Nowak, K. Sigmund, Evolutionary dynamics of biological games, Science 303 (2004) 793–799.

[7] H. Gintis, Game theory evolving, Princeton University Press.

[8] R. L. Plackett, J. P. Burman, design of optimum multifactorial experiments, Biometrika 33 (1946) 305–325.

[9] M. Watwe, A. Damle, B. Ganguli, A. Kale, Evolution of Co-operation When the Strategies are Hidden: The Human Mating Game, Nature Precedings, 2007.

[10] M. A. Nowak, K. M. Page, K. Sigmund, Fairness versus reason in the ultimatum game., Science 289 (2000) 1773–1775.

Table 1

Intelligent seekers (S_i)	These are the class of seekers who can differentiate amongst the worker venal class and the worker non venal class and then can accordingly plan their move. They are also capable of differentiating between ethical and non ethical anti corruption cell officials.
Policing Intelligent seekers (PS_i)	In addition to the qualities of Intelligent seekers, this batch of people indulges in policing which in turn is to benefit from opportunistic blackmailing.
Givers (S_g)	This class of seekers is predisposed to give bribe without discrimination among the workers.
Policing Givers (PS_g)	Apart from being perennial bribers this batch is also involved in policing and benefiting from blackmailing.
Non-Givers (S_n)	This class of seekers will never bribe the worker to get the work done.
Policing Non-Givers (PS_n)	This batch will never bribe but will police and blackmail others who do.
Non givers but punishers(S_{np})	This class of seekers will not bribe the worker but will punish the worker if he asks for a bribe to get the work done
Policing Non givers but punishers(PS_{np})	Same as S_{np} apart from being involved in policing and opportunistic blackmailing.
Takers-Cooperators (W_{tc})	They will get the work done once they receive the payment.
Policing Takers-Cooperators (PW_{tc})	This batch takes the bribe but involves in policing and opportunistic blackmailing.
Takers-Defectors (W_{td})	They will defect i.e. will not get the work done but will keep the bribe money
Policing Takers-Defectors (PW_{td})	Same as W_{td} but involve in policing and opportunistic blackmailing.
Takers-Discriminators (W_{tdisc})	This class of takers can discriminate between the kinds of seekers i.e. they will cooperate with the punisher class of seekers, otherwise they are defectors by default.
Policing Takers-Discriminators (PW_{tdisc})	This class of people is same as W_{tdisc} except for that they do policing and opportunistic policing
Non-takers-Indifferent (W_{ni})	This is the class workers who are non acceptors but are impervious to the character of the seeker i.e. they will do their work irrespective of the kind of seeker they encounter but will not accept the bribe.
Policing Non-takers-Indifferent (PW_{ni})	Same as W_{ni} but indulge in policing and blackmailing.
Non-takers-Punishers (W_{npun})	This class of workers takes the seekers, who try to bribe them, to task.
Policing Non-takers-Punishers (PW_{npun})	Same as W_{npun} but do policing and opportunistic blackmailing
Ethical-indifferent (A_{Ei})	These batch of people are ethical in nature and do not resort to any kind of bribery but at the same time they are indifferent if someone tries to bribe them i.e. they just mete out the stipulated amount of punishment and no additional punishment for those who, on being caught on the charges of corruption, try to bribe anti corruption cell too.
Ethical-punishers (A_{Ep})	These people are same as above but when offered bride by an apprehended corrupt person they mete out additional punishment for which they pay by some fraction of their own payoff.
Non Ethical (A_n)	This batch of people although belongs to the anti corruption cell but it indulges in taking bribe to spare the apprehended corrupt people by using their position in the anti corruption cell.

Table 2

Parameter (seeker)	Description	Range
b	benefit of the seeker if the work gets done	1
c	The share of the benefit of the seeker which it shares with the worker (bribe)	[0.2,0.4]
d_1	cost of discrimination for the intelligent seekers who can discriminate between cooperators, defectors, punishers.	[0.01,0.1]
y	of punishment received by the bribing seekers when the encounter punishing workers.	[0.4,1]
x	cost of punishment incurred by the punishing class of seekers.	[0.01,0.1]
p	cost of policing	[0.01,0.05]
g	Benefit of policing (via blackmailing)	[0.1,0.5]
a	Punishment received (via blackmailing)	[0.2,0.6]
Parameters(workers)	**Description**	**Range**
d_2	this is the cost of discrimination incurred by the discriminating worker	[0.11,0.19]
m	cost of punishment incurred by the punishing non taker class of workers.	[0.01,0.1]
n	amount of punishment received by the takers in case they encounter the punishing class of seekers!	[0.4,1]
q	cost of policing	[0.01,0.05]
r	Benefit of blackmailing	[0.1,0.5]
v	Punishment received (via blackmailing)	[0.2,0.6]
j	Amount of work done by the worker	[0.01,0.1]
Parameters (ACC)	**Description**	**Range**
i	amount of punishment given by ACC to corrupt people	0.4
k	Extra punishment given by anti corruption cell to the apprehended corrupt people who in turn tried to bribe A_{ep}	[.05,0.1]
s	cost of extra punishment given by A_{ep}	[0.01,0.05]
l	amount of bribe paid to anti corruption cell by corrupt personnel	[0.2,0.4]
t	amount of work done by A_n to hide the identity of bribing people	0.05
γ	Basic salary	1
β	Probability of corrupt workers being caught	[0.4,0.6]
α	Probability of corrupt seekers being caught	[0.4,0.6]